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DOI
10.4233/uuid:46a4329f-5d76-41ca-aecd-71c855908bde

Publication date
2017

Document Version
Final published version

Citation (APA)
Haghighi Talab, A. (2017). *Empirical Modelling of Inter-organizational Knowledge Collaboration*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:46a4329f-5d76-41ca-aecd-71c855908bde

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Ardalan Haghighi Talab

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PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof. ir. K.C.A.M. Luyben,
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op woensdag 4 oktober 2017 om 12.30 uur
door

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Master of Science Management of Technology
geboren te Teheran, Iran

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Prof. dr. C.P. van Beers

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ISBN

Cover design: Lizanne Dirkx

Distributed by Delft University of Technology,
Faculty of Technology, Policy and Management,
Jaffalaan 5, 2628BX Delft, the Netherlands.

Printed in the Netherlands by Ipskamp Drukkers.

This dissertation is available online at http://repository.tudelft.nl.

Keywords*:* knowledge, collaboration, inter-organizational, FP7, model, innovation strategy, innovation policy

Dedicated to Christa and Arman

عقل دو عقلست اول مکسبی — که در آموزی چو در مکتب صبی

از کتاب و اوستاد و فکر و ذکر — از معانی وز علوم خوب و بکر

عقل تو افزون شود بر دیگران — لیک باشی تو ز حفظ آن گران

لوح حافظ باشی اندر دور و گشت — لوح محفوظ اوست کو زین در گذشت

عقل دیگر بخشش یزدان بود — چشمهٔ آن در میان جان بود

چون ز سینه آب دانش جوش کرد — نه شود گنده نه دیرینه نه زرد

ور ره نبعش بود بسته چه غم — کو همی جوشد ز خانه دم به دم

عقل تحصیلی مثال جویها — کان رود در خانه‌ای از کویها

راه آبش بسته شد شد بی‌نوا — از درون خویشتن جو چشمه را

There are two kinds of intelligence: one acquisitive, as a child in school memorizing facts and concepts from books and from what the teacher says, collecting information from the traditional sciences as well as from the new sciences. With such intelligence you rise in the world. You get ranked ahead or behind others in regard to your competence in retaining information. You stroll with this intelligence in and out of fields of knowledge, getting always more marks on your preserving tablets. There is another kind of intelligence, one as given, already completed and preserved inside you. A spring overflowing its spring-box. A freshness in the centre of the chest. This other intelligence does not turn yellow or stagnate. This second knowing is a fountainhead from within you. The acquisitive intelligence is prone to blockage. Search within yourself for the spring.

Rumi (1207 – 1273)

Preface

Writing a PhD dissertation takes a great deal of commitment, reconsideration, persistence, flexibility, self-doubt, self-doubt control, focus, broadness, instituting, innovativeness, and many more qualities which may seem contradictory in nature. Nothing is straightforward and nothing is easy. To keep on going one needs both academic guidance and social support.

I feel lucky to have Cees as my promoter and Victor as my copromoter. They both challenged me intellectually and helped me understand what I knew and what I did not know. Thank you Cees and Victor for guiding me in my learning journey.

Fantastic parents, friends, and colleagues nourished my mind with inspiration and filled my heart with assurance while I was needing these the most. I appreciate their kindness and would like to thank them for being truly empowering and being there for me. These include my parents Nazi and Kian, orchestra members of Krashna Musika, and in particular Aaron Hoffman, Alireza Parandian, Amir Delfan, Andreas Ligtvoet, Aniol Lopez, Arman Noroozian, Behnam Taebi, Chris Davis, Chris Holtslag, Christa Hubers, Daniel Hogendoorn, Delaram Haghighitalab, Dena Kasraian, Emilia Pucci, Fardad Zand, Giorgi Bezhuashvili, Hadi Asghari, Jafar Rezaei, Jan-Wouter Vorderman, Marta Bariain, Melanie Studer, Pendar Nabipour, Pietro Galgani, Rene Mahieu, Roland Ortt, Rowan Heisteeg, Salome Khaindrava, Sam Solaimani, Samaneh Tajalizadeh, and Shahin Mesgarzadeh.

My patient then-girlfriend now-wife Christa made this journey mindful and peaceful. She shed light on the aspects that only a sociologist can spot. She also supported me wholeheartedly. My little son Arman had his role too: setting the much needed deadline without which this dissertation would most probably not be ready before 2020!

Ardalan Haghighi Talab, Delft, July 2017

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Doctoral Propositions

1. *Ethical and moral reflection on actions cannot be outsourced. (see Chapter 2)*
2. *Motivation, opportunity, and ability interdependently drive inter-organizational knowledge collaboration. (see Chapter 3)*
3. *Knowledge collaboration's effectiveness is not uniformly defined at academia and industry. (see Chapter 4)*
4. *In inter-organizational knowledge collaborations, geographical proximity becomes relevant to manage only in conjunction with other proximity dimensions. (see Chapter 5)*
5. *International families are the shortest path towards a border-less world.*
6. *Capitalist systems that ignore the essential need for equality are as vulnerable as Communist systems that ignore the indispensability of privileges.*
7. *The negative external effects of burning petroleum as fuel (e.g. environmental and socio-political costs), are underestimated by not taking into account the opportunity costs of the production of valuable products such as aspirin.*
8. *Cultural differences in an international marriage strengthen the bond since the individual differences are expected and accepted a priori and tagged as cultural differences rather than personality mismatch.*
9. *Musical education to children is one of the very few instances of shaping a child's life that parents are morally allowed and even ought to be dictating.*
10. *Having both the International Criminal Court and the International Court of Justice headquarters in The Netherlands is a manifestation of international ultimate trust in Dutch fairness.*

These propositions are regarded as opposable and defendable, and have been approved as such by the promoter, Prof. dr. C.P. van Beers.

Chapter 1:

Introduction

The Importance of Knowledge Collaboration

The most fundamental ingredient of innovation processes is knowledge. Individuals, organizations, networks, and nations alike, strive to make new knowledge, acquire the necessary knowledge, and/or put the available knowledge into practice.

The European Council's report of 2012 asserts that: "Innovation and research are at the heart of the Europe 2020 strategy. Europe has a strong science base but the ability to transform research into new innovations targeted to market demands needs to be improved."[1] This imbalance between the knowledge input and the innovative output in Europe is termed the European Paradox. Moreover, the research landscape in Europe is fragmented. By fragmented research, resources are wasted through dispersion (i.e. tendency towards smaller projects), duplication, and overlapping.

To increase growth, the EU needs to improve its performance in innovation[2]. To tackle the European Paradox, the Innovation Union flagship initiative has put innovation at the center of the EU's economic strategy. The European Parliament also addresses the European Paradox by keeping the Innovation Union high on the political agenda. The Innovation Union initi-

[1] Retrieved from: http://ec.europa.eu/research/era/pdf/era-communication/era-impact-assessment_en.pdf

[2] Innovation union, A pocket guide on a Europe 2020 initiative. Available at http://bookshop.europa.eu/en/innovation-union-pbKI3213062/ ISBN: 978-92-79-28654-4

ative, among other goals, aims to revolutionize the way the public and private sectors work together, notably through Innovation Partnerships.

Collaborative research by academia and industry is a source of innovation (Ambos et al., 2008). The proposal of Innovation Partnerships particularly seeks to tackle the European Paradox and fragmented research landscape through inter-organizational knowledge collaboration. The Innovation Partnerships are expected to help the European Union solve the European Paradox and result in a less fragmented research landscape. On this road, networks or systems which can accelerate knowledge collaborations are of great importance.

Collaborative knowledge creation, dissemination, and use require a close interaction between academia, industry, and government. The Inter-organizational Knowledge Collaboration, IKC, rationale is rather straightforward: teams of people are devised to address the organizational challenges, teams of organizations are needed to address the innovation system's challenges. IKC can actualize potential inter-organizational synergies and thus increase an innovative activity's effectiveness. Efficiency of operations can also be increased by eliminating the duplicated actions performed by multiple organizations. Furthermore, available solutions in one domain can act as dormant potential answers for problems in other domains.

Thus, understanding and being able to manage IKCs is high on the agenda for both organizations and governments. For organizations, the aim is to acquire knowledge resources that cannot be developed internally due to economic and/or technological restraints. For governments and governance structures such as the European Commission, the aim is to stay competitive by solving the European Paradox and to unify the fragmented nature of the European research landscape.

1.1 Problem Definition

The IKC process[3] and its management are complex. Specifically, the process of university-industry knowledge interaction is not straightforward (Graham et al., 2006). The challenges of IKC management are manifold and with various aspects:

First, knowledge is an elusive and slippery concept (Qureshi and Ali, 2014). Managing a process involving an imprecise concept is challenging. Ideally, epistemology can feed into IKC management. Practically, at least an internally and externally consistent taxonomy of knowledge is required to enable organizational knowledge management and inter-organizational knowledge collaboration management.

Second, managing knowledge collaboration (i.e. an organizational level behavior) requires an understanding of its organizational-level determinants. Available theories at an individual level, e.g. theory of planned behavior, by Ajzen and Fishbein (1970) the Cognitive-Affective Processing System, by Mischel and Shoda (1995), and/or the Motivation, Opportunity, and Ability theoretical framework, by Blumberg and Pringle (1982), need to be transposed to an organizational level (Clark et al., 2005) to enable IKC management. Managing the IKC process without knowing its drivers and *how*[4] those drive IKC (Clark et al., 2005) is challenging.

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[3] Looking into the Innovation Union Scoreboard's (IUS) list of metrics (available at: http://europa.eu/rapid/press-release_IP-15-4927_en.htm), several indicators are reported: number of innovative firms, number of innovations by Small and Medium-sized Enterprises (SMEs), number of patent applications, volume of exports of high-tech products, amount of venture capital investments, sales figures of innovative products, amount of human resources, business investments in research and development, and the quality of science and education. By IUS's approach, the focus is solely made on inputs and outputs. The process through which the inputs are transformed to generate the outputs are omitted. This dissertation focuses on the IKC as a process.

[4] i.e. the functional form

Third, another source of complexity is the multi-actor nature of IKC with non-identical and sometimes opposing sets of goals and agendas (Miller et al., 2014). Understanding the role of each organization-type and examining the differences of inter-type relationships (e.g. between two universities versus between a university and a business organization) helps managing IKCs in consortia of organizations.

Fourth, the relative proximity of partner organizations in different dimensions (e.g. geographical, network, and/or social) is known to impact the extent of an IKC. Dimensions of proximity can impose their impact either by facilitation or by inhibition of IKC (Boschma, 2005). What makes contextual arrangements, regarding the proximity, challenging is the joint effect of these dimensions. The joint effect of the proximity dimensions is needed to clarify which dimension's effect is dominant and which dimension's effect can be substituted by the other effects. Arriving at such an understanding is an essential step towards managing the context within which the IKC is executed. Only after the contextual joint effects are understood, the innovation system can be managed by forming and formatting the fabric of the 'proximity space' in which the IKC takes place.

Understanding these aspects of IKC is seen as a prerequisite for its management. Corresponding inferences of each of the above mentioned aspects can enhance inter-organizational knowledge collaborations, i.e. leveraging teams of organizations' capacity to collectively innovate. This is a path toward realizing the Innovation Partnerships' goals of solving the European Paradox and unifying the fragmented research landscape. IKCs can be enhanced by: (1) strategically adapting the knowledge-type portfolio of each organization to stay relevant to the collaboration and competitive to the market, (2) leveraging the organizational-level determinants of knowledge collaboration, (3) modifying the organizational-type composition of the collaborative consortia, and (4) adjusting the partnering organizations' proximity in terms of their geography, network, and social relationships.

1.2 Research Questions

The goal of this dissertation is to empirically examine the following question: how to enhance inter-organizational knowledge collaborations? This objective requires a multi-aspect understanding of the knowledge types, organizational knowledge collaboration behavior determinants and their interplay, plus to define how the extent of that behavior is affected by the proximity dimensions. The enhancement, in accordance with the problem definition in subsection 1.1., comes by knowing the objects, the subjects, the drivers, and the contexts which all jointly determine the extent of an inter-organizational knowledge collaboration. The implications of IKC enhancement are of interest, specifically, for the innovation strategy of the organizations and innovation system policy. The following research sub-questions are posed to achieve this goal:

1. *Which knowledge types are processed by which organizational types? (Chapter 2)*

2. *(a) Which organizational level variables determine the extent of inter-organizational knowledge collaboration? (b) How do those determinants jointly influence the collaboration behavior? (Chapter 3)*

3. *How does organizational type impact the extent of inter-organizational knowledge collaboration? (Chapter 4)*

4. *How do geographical, network, and social dimensions of proximity impact the extent of inter-organizational knowledge collaboration? (Chapter 5)*

5. *What do all these imply for the innovation strategy of organizations and innovation system policy? (Chapter 6)*

1.3 Research Context

Since 1984 (beginning of the first Framework Programme, FP1) till 2013 (end of the seventh Framework Programme, FP7) more than €115 billion was spent by the European Commission as subsidies to inter-organizational knowledge collaborations (see Figure 1.1). An estimated €80 billion[5] is planned to be spent in the Horizon 2020 (H2020) program. Considering the size of these investments, enhancing the efficiency and effectiveness of the IKC process can potentially exert an enormous impact on the involved organizations (see Figure 1.2), the economy, and the society as the recipient of the output innovation.

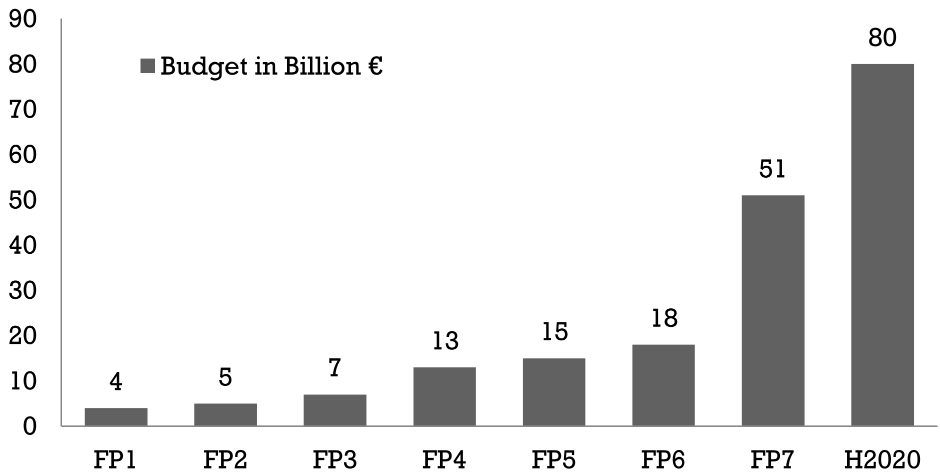

Figure 1.1. Framework Programme Budget[6]

[5] Grove, Jack (2011). 'Triple miracle' sees huge rise in EU funds for frontier research", Times Higher Education, 28 July 2011". http://www.timeshighereducation.co.uk/story.asp?storycode=416952

[6] Data sources: OJ C208 – 04/08/1983 (FP1), OJ L302 – 24/10/1987; 87/516/Euratom, EEC (FP2), OJ L117 – 08/05/1990; 90/221/Euratom, EEC (FP3), OJ L126 – 18/05/1994; No 1110/94/EC (FP4), OJ L26 – 01/02/1999; No 182/1999/EC (FP5), OJ L232 –

Focusing on FP7, due to its size and time window, the sheer number of involved organizations (see Table 1.1) further signals the level of complexity and directs the choice of the unit of analysis of this dissertation. More than 126,000 organizations were involved in FP7. Consider to have on average four individuals of each organization involved in each collaborative project. Roughly, more than half a million individuals have thus participated in the FP7 consortia.

Table 1.1. FP7 Participating Organizations[7]

Type of Organization	Number of Participants
Higher or secondary education	45,285
Private for profit (excluding education)	36,408
Public body (excluding research and education)	6,757
Research organizations	28,650
Other	9,090

It goes without saying that individual level factors contribute in determining the extent of an IKC. Let us assume that the variations of individual level factors can be studied and their impact on an IKC can be found. The management of individual level factors aiming at shaping the innovation system's performance seems impractical since: (a) given that an optimal solution is found, a top-down approach to align individual level factors of all involved individuals to that optimal solution will not be effective, and (b) given the turn-over of involved individuals in the IKC, investments in individual level IKC management are inferior in efficiency to the investments which aim at organizations, consortia, or the innovation system.

29/08/2002; No 1513/2002/EC (FP6), http://ec.europa.eu/research/fp7/understanding/fp7inbrief/structure_en.html (FP7)

[7] Source: ISBN 978-92-79-46323-5, DOI: 10.2777/5745 http://ec.europa.eu/research/evaluations/pdf/archive/fp7_monitoring_reports/7th_fp7_monitoring_report.pdf

Here, facilitating innovation system's performance through IKC management at the organizational level is argued to act as a guideline for organizations who in turn will manage individual level factors. Thus, in the remainder of this dissertation the unit of analysis is an organization. Albeit, individual level theories of knowledge collaboration are not ignored. Indeed, those theories are transposed to better understand the organizational-level determinants.

Project consortia in the FP7 Energy theme (FP7-Energy) constitute the context of research in this dissertation. FP7-Energy is seen as a case for inter-organizational knowledge collaboration: innovative output of each project is a result of multiple organizations' input and knowledge collaboration is at the heart of each project.

Since all FP7-Energy projects are partially publicly funded, project metrics – such as, total cost, EU funding, start/end date, and alike – are available to the public. The public nature of funding in FP7 eases the access to otherwise strategic and most probably confidential information. These metrics, stored and presented by the Community Research and Development Information Service (CORDIS) website (http://cordis.europa.eu/), comprise the data for the empirical studies of this dissertation.

1.4 Dissertation Outline

The remainder of this dissertation is a collection of four researches aiming at answering one of the research sub-questions in each chapter. The linking core of these four chapters is the enhancement of the extent of inter-organizational knowledge collaboration (IKC). The last chapter concludes by stating the implications for innovation strategy and innovation system policy.

Chapter 2, addressing the first sub-question, conceptually describes which knowledge types are processed by which organizational types. This chapter provides a perspective on the objects under investigation and the subjects. Knowledge, as the object under investigation, is mapped by a classical taxonomy; namely, the Aristotelian knowledge taxonomy. Organization, as the subject of investigation, is framed as a knowledge integrating machine in a

Triple Helix representation. Then, a direct association is proposed to show the correspondence between these objects and subjects. In brief, the Aristotelian knowledge taxonomy is shown to correspond to the Triple Helix model. Implications for organizations' innovation strategy include: (a) profiling knowledge integration strategies of organizations through institutional specialization and organizational diversification, and (b) outlining the sources of knowledge-based competitive advantage with regard to the knowledge taxonomy. For innovation system policy, this chapter draws the rational of inter-organizational knowledge collaboration as a meta-integration of knowledge and lists the roles that need to be played by diverse organizational types. Part of these knowledge roles, specifically the ethical deliberation on actions, are a requirement for all organizational types and are advised not to be outsourced.

Chapter 3, addressing the second sub-question, explains which organizational level variables determine the extent of an inter-organizational knowledge collaboration. It also clarifies how those determinants jointly influence the collaboration behavior. This chapter provides a set of determinants to explain variations in the extent of IKC by transposing the Motivation, Opportunity, Ability (MOA) framework to an organizational level and testing its efficacy. The inter-dependence of these three categories of variables, challenging the model specification, is also explained in this chapter. Inter-dependent and thus correlated explanatory variables need a methodological solution to deal with the multicollinearity. Shifting the scholarly consensus built on the Constraining Factor Model (CFM) functional form of the MOA framework, this chapter proposes and tests the inter-dependent functional form for MOA. A Structural Equation Modelling (SEM) methodological solution is found to provide an understanding of how the organizational-level inter-related determinants of IKC act jointly. Implications for organizations' innovation strategy include: (a) leveraging the MOA to enhance the IKC, and (b) leveraging the MOA as an interdependent set rather than isolated factors. For the innovation system policy this chapter implies that: (a) the criteria to approve an organization's fit for funding are better to be assessed by a non-compensatory mechanism rather than a point system, and (b) investing in the organizations' development will be more effective when the MOA are leveraged concertedly.

Chapter 4, answering the third sub-question, provides a comparison of the IKC between diverse organizational types and inter-organizational relationship types to show how organizational type, on nodal and dyadic levels, impacts the extent of inter-organizational knowledge collaboration. The focus of this chapter is to test a hypothetical difference between the universities and other organizational types (including businesses, research institutes, and governmental organizations). This comparison forms a basis to understand IKC variation in light of the differences between the Triple Helix and Mode 2 models. Moreover, the inter-organizational relationship types (e.g. between universities, between businesses, between university and industry, and alike) are systematically compared to provide an understanding of the impact of consortium composition on the extent of IKC. The implications for the innovation strategy regard: (a) collaboration strategy in accordance with the partner's organizational type, and (b) partner selection. For policy the results portray the impact of different innovation system's member organizations. The policy is informed by evidence of the salient role of universities and the unparalleled positive impact of inter-university knowledge collaborations.

Chapter 5 deals with the fourth sub-question and provides an understanding of the effects of proximity (with geographical, network, and social dimensions) on the extent of an inter-organizational knowledge collaboration. The impact of each dimension is estimated through hypothesis testing. Then, the possibility of substitution of the effect of one dimension by the effect of the other(s) is drafted and tested. This empirical investigation of the substitution of effects informs the innovation strategy and innovation system policy to more effectively improve the IKC process by investing more in the proximity dimensions which have a more dominant effect.

Chapter 6 concludes by reflecting on the implications of the research results for the innovation strategy of organizations and innovation system policy. Limitations and future research paths are included in the sixth chapter.

Chapter 2:

Knowledge and Organization[8]

Abstract. Knowledge resources, due to causal ambiguity and inimitability, play a central role in shaping the competitive advantage of organizations. This chapter aims to illustrate a correspondence of knowledge types and organizational types in open innovation networks. It maps the knowledge types which shape the diverse institutions of the economy contained by the Triple Helix model: episteme at the university, techne at the industry, and phronesis at the government. Each organization –beyond its institutional specialization– diversifies to incorporate secondary and tertiary knowledge types in its knowledge integration portfolio. For example, a university may develop technologies and/or a firm may conduct scientific research. The implications of institutional specialization and organizational diversification in open innovation networks are twofold: (a) organizations can gain a competitive edge by diversifying into a unique portfolio of knowledge integration encompassing a novel proportion of episteme, techne, and phronesis, and (b) to achieve the highest level of knowledge integration, organizations belonging to diverse institutions can engage in inter-organizational knowledge collaboration to meta-integrate the three institutionally specialized and organizationally diversified knowledge types.

[8] A version of this chapter is forthcoming as a chapter (co-authored by V.E. Scholten and C.P. van Beers) titled "*Knowledge sharing and open innovation*" in "*Open Innovation and Knowledge Management in Small and Medium Sized Enterprises*" edited by Susanne Durst, Serdal Temel, and Helio Aisenberg Ferenhof to be included in the volume to the book series on "*Open Innovation: Bridging Theory and Practice*" published by World Scientific.

2.1 Introduction

Knowledge plays a crucial role for firms in developing new ideas, novel innovations and eventually sustained competitive advantage. Universities, firms in industry, and governmental authorities collaborate in networks to develop new knowledge, acquire external knowledge, and/or put the available knowledge into practice. Knowledge is the key to the competitiveness of organizations and regions (Huggins and Izushi, 2007). The knowledge base of an economy can be defined as the capacity and capability to create new ideas, thoughts, and processes to innovate products and services. Translating these into economic growth increases the value of an economy and generates wealth (Huggins and Izushi, 2007). From a firm's viewpoint, knowledge can increase the productive capacity of the traditional factors of production by increasing their efficiency and effectiveness via technology as described by the production function. Additionally, knowledge can enable the transformation of the production function to produce new products, services, and processes i.e. the enabling role of knowledge. The resource based view (RBV) of the economy gives knowledge a privileged status compared to the other resources, e.g. material, land, labor, or capital (Peteraf, 1993). This is mainly due to higher causal ambiguity of knowledge resources which enhances inimitability. As well, the idiosyncrasy of each organization further assures inimitability of knowledge-based resources and capabilities. Path dependency of knowledge-based resources and capabilities contributes to the inimitability, further intensifying the role of knowledge in gaining and maintaining a competitive advantage. Unlike the finite resources (i.e. material, land, labor, capital), knowledge as an infinite resource can produce increasing returns (Dodgson, 1993). While the finite resources decrease in the course of the production process, knowledge increases, amongst others by cross-learning via knowledge sharing.

Thus, many organizations have become increasingly dependent on knowledge-based resources to gain sustained competitive advantage (Argote and Ingram, 2000; Argote et al., 2003; Barney, 1991; Grant, 2002; Tsoukas and Vladimirou, 2001). Moreover, due to the increasing complexity of technologies, organizations cannot develop all required knowledge internally and therefore aim to collaborate with external actors (Powell et al., 1996).

Due to the high cost and uncertainty involved in research and development, creating in-house knowledge by a single organization is not always possible (Hardy et al., 2003). In order to acquire resources that cannot be developed internally - due to economic and/or technological constraints - organizations collaborate with external parties (Powell et al., 1996). Inter-organizational knowledge collaboration (IKC), as a domain of Knowledge Management (KM), deals with the challenges organizations face in the co-creation and co-utilization of knowledge resources in open innovation (Laursen and Salter, 2006).

If today's organizations' value creation is mainly knowledge-based and if the core rationale of inter-organizational collaboration in open innovation is to co-create/co-utilize knowledge, the taxonomy of knowledge should be related to organizational types. Also such taxonomy should shape the rationale of open innovation. Understanding the knowledge roles of organizations helps to better align and orchestrate their actions. To understand inter-organizational knowledge interactions, it is necessary to apprehend how the organizational types are associated with the knowledge types.

Instead of epistemology or terminology, this chapter concerns the taxonomy of knowledge. The building of a taxonomy is the first basic step to shape KM activities (Guarino, 1997). This means that a practical taxonomy, even in the absence of philosophical epistemology and/or distinctive terminology (of e.g. data, information, and knowledge) provides common ground for understanding, helping organizations to strategically position themselves in the market and efficiently allocate their internal and external knowledge resources. A consistent taxonomy of knowledge helps in capitalizing on internal resources (i.e. existing knowledge) and it directs the knowledge search strategy to benefit from the matching partners in open innovation (i.e. external knowledge). Taxonomy comprises naming an all-inclusive set of categories to specify knowledge types. A comprehensive taxonomy possesses discriminant aptitude in distinguishing the knowledge types with ideally no overlap (internal consistency), and a one-to-one attachment of those all-inclusive and distinct labels to the real-world cases (external consistency). An internally and externally consistent taxonomy furnishes the practitioners and researchers with valuable perspective and have the potential to help to find an answer to the challenges of inter-organizational knowledge collaboration in open innovation specifically and enhance our general understanding of KM.

Several dichotomous taxonomies have been proposed in the literature: declarative vs. procedural (Minsky, 1975), descriptive vs. procedural (Holsapple et al., 1996), tacit vs. explicit (Nonaka and Takeuchi, 1995), and local vs. global (Novins and Armstrong, 1998). Managing knowledge has been challenging in the past as particular knowledge, e.g. the process knowledge of converting light to electricity, cannot easily be assigned to one side of a dichotomy. In this example, such process knowledge is both declarative and procedural, has tacit and explicit dimensions at once, and is seen as both local and global. Furthermore, the unification or merger of taxonomies is also far from a consensus. This chapter, instead of a dichotomous mutually exclusive taxonomy, provides a link between the Aristotelian knowledge taxonomy (i.e. episteme, techne, and phronesis) and organizational types.

First, the typology of organizations on institutional level (e.g. university as an institution or the institution of business) is critically dependent on and is shaped by the knowledge taxonomy. Universities, firms, and government institutions are primarily specialized to create and utilize knowledge in its distinctive forms. In brief, the Aristotelian knowledge taxonomy is corresponding with the Triple Helix model (Leydesdorff and Etzkowitz, 1998).

Second, organizations (e.g. a specific university or a firm) create and utilize secondary and tertiary types of knowledge. A university may diversify into the world of industries to make technologies. An industrial organization may diversify into the world of universities to conduct scientific research.

Third, extending the view in which 'the *firm* is conceptualized as an institution for integrating knowledge' (emphasis added, Grant, 1996b, p.109), all organizational types, including firms, universities, and governmental organizations are considered as knowledge integrators. It follows that the highest level of integration takes place by meta-integration of knowledge of multiple organizations and organizational types through inter-organizational knowledge collaboration (IKC) in an open innovation setting.

Section two of this chapter outlines the Aristotelian knowledge taxonomy. Also a widely applied taxonomy of know-what, know-how, know-why, etc. in this section is shown to lack internal and external consistency. Section three sketches the link between the Aristotelian knowledge taxonomy and the organizational typology (Triple Helix model) through specialization. Section four illustrates the diversification strategy of organizations with regard to knowledge taxonomy and outlines the cross-tabulation of the knowledge taxonomy and organizational type. The diversified roles of organizations are outlined. Section five extends the taxonomy beyond the boundary of one organization and reflects on inter-organizational knowledge collaboration in open innovation as a meta-integration process. Section six concludes.

2.2 Background

Practitioners and academics, being supposed to act upon knowledge collaboration challenges, need to have an understanding of the types of the objects under their actions. A taxonomy is the main provider of such understanding. Yet, 'the field of knowledge management pay scant attention to the ontological ground of knowledge' (Butler, 2006, p.4). To enable the management of knowledge, the first step is to clarify: What is knowledge? This fundamental question 'has intrigued some of the world's greatest thinkers from Plato to Popper without the emergence of a clear consensus' (Grant, 1996b, p.110). This chapter does not aim to contribute to or settle these philosophical epistemological debates. Instead, it aims to provide a new perspective by integrating the established taxonomies to describe the real-world heterogeneities of organizations and inter-organizational collaborations. An illustration of this approach is: one does not need to know the essence of fire to warm up a pot. This chapter is exclusively about the taxonomy of knowledge, i.e. what are the distinct knowledge types. Internal consistency promises the distinctness. External consistency puts it into test by detecting the real-world distinct manifestations of a distinct type.

Holsapple and Joshi (2002, p.48) argue that 'Commentators on the knowledge management scene often strive to draw distinctions between the notions of data, information, and knowledge. Some of these same commentators, as well as others, proceed to use the terms knowledge and information interchangeably.' There is indeed inconsistency in the definitions and terminologies, and an ongoing debate is challenging the terminology of knowledge, information, and data. For instance, Keen and Tan (2007) believe that while it is important to understand KM terms, it is unproductive for researchers (and even less productive for practitioners) to get focused on trying to precisely define these terms at the expense of furthering KM research. On the same vein, Schwartz (2006, p.11) asserts that 'the distinction between data, information, and knowledge can be conveniently ignored: not treated as irrelevant for a philosophical debate, mind-body discussion, or a metalevel, object-level analysis, but not essential to the fundamental mission of knowledge management.' Investigating a knowledge taxonomy indeed does not necessitate a strict terminology to differentiate between data, information, and knowledge. Thus, apart from the epistemology and the terminology debates surrounding knowledge and knowledge management, this chapter continues by describing a taxonomy and its organizational and inter-organizational implications.

Aristotelian knowledge taxonomy: episteme, techne, and phronesis

In the Book VI of The Nicomachean Ethics (abbreviated hereafter as N.E.: Aristotle, 1976), Aristotle describes five intellectual virtues (p.1139b) of: epistêmê (science), tékhnê (technical reason), phrónêsis (prudence or practice-oriented ethics), sophía (theoretical wisdom), and noûs (intuitive intelligence).

Scholars interpret these virtues differently (e.g., compare Flyvbjerg, 2006, 2001 and Eikeland, 2008). This section describes the knowledge types aiming at a taxonomy that shapes the diverse organizational types and their knowledge interrelationships.

Episteme regards the general universal and eternal knowledge. Its aim is to understand the governing principles that the universe – for the most part (hôs epì tò polú) – works anywhere, anytime. Solely, the aim of epistemic knowledge is for understanding, as the ultimate end regardless of possible applications of such understanding. Of course, epistemic knowledge can be put in action or act as a basis for production.

With Aristotle episteme meant something like studying for the purpose of understanding and truth, without intervening, and without the study being subordinated to or serving to promote any immediate plans for action of any kind.' (Eikeland, 2008, p.46)

Techne (art), is strictly differentiated from episteme by having the main focus on making and producing artifacts by artisans. Techne is the intellectual virtue of production. Products and services are made existent by the artisan owing mainly to her techne. The distinction between episteme and techne does not imply that attaining epistemic knowledge does not rely on techne or vice versa. For instance, nuclear fission power plants as an artifact are rooted in epistemic knowledge of nuclear physicists. As well, the scientists developing epistemic knowledge of nuclear fission heavily rely on artifacts (measurement devices and alike in laboratories and elsewhere) to arrive at the general, universal, and eternal knowledge of nuclear fission. Techne had historically played a crucial role in the development of episteme, e.g. in studies ranging from the galaxies to an individual organic cell by producing a range of devices from telescopes to microscopes. Similarly, techne relies on episteme and is reinforced by it. Looking at building a house (a classic example from Aristotle's explanation of techne) or shipbuilding: there are general epistemic principles, for instance on material science, statics, and/or hydraulics without which an artifact cannot function. Techne is making and materializing which includes and adheres to general principles. In short, episteme and techne, although distinct in nature, are constantly interacting to facilitate and to enable the other. The interplay of episteme and techne is at the core of university-industry interaction in open innovation.

Phronesis is translated to prudence. It is a normative deliberation on action and consequences with regard to a particular situation at hand. The term phronesis can be more precisely defined by contrasting it to episteme and techne. First, phronesis is different from episteme in that it is not derived from a set of general, universal, and eternal principles. Phronesis is much concerned with the particular of here and now, in relation to ethical bearings of *a particular* action in light of the general ethical rules. Phronesis, given the ethical principles, is a deliberation to crystalize the relation between the particular (contingent conduct) and the universal (ethical principle) (Gadamer, 1975).

Thus, well-separated from the invariant principles of episteme, phronesis is not meant to apply anywhere, anytime. This does not imply that phronesis is without principles. Indeed the principles are given by the ethical virtues.

> *[ethical] Virtue ensures the rightness of the end we aim at, prudence [phronesis] ensures the rightness of the means we adopt to gain that end. (N.E., p.1144a)*

> *Nor is Prudence a knowledge of general principles only: it must also take account of particular facts, since it is concerned with action, and action deals with particular things. (emphasis added, N.E., p.1141b)*

While episteme is a deliberation of the universe by which one understands the principles of the universe as an external entity, phronesis regards one's actions and evaluates them based on one's ethical principles that one chooses to adhere to internally. The source of variation in episteme is not in one's control while phronesis variation is chosen by one. 'As two practical intellectual virtues, 'phrónêsis and tékhnê concern things that we ourselves can control, i.e. decide on, choose, initiate, change, develop, or stop, so that the change and variation depends on us.' (Eikeland, 2008, p.79). Variation and choice by phronesis are concerning the circumstances which may defy the general ethical rules and axioms. For example, honest divulging of information as a general ethical virtue 'normally manifested in honest acts, but arguably practical wisdom [i.e. phronesis] in this area does not always mandate honest acts' (Swanton, 2001, p.50) in all circumstances. Several ethical virtues, as universal codes of good conduct may eventually come at a trade-off in a particular situation. Phronesis is the intellectual virtue to settle the case in those circumstances. Phronesis can thus be seen as a normative evaluation of actions on the spot. A directive statement – on the right course of action – is the output of phronesis as a practical intellectual virtue. 'Prudence [i.e. phronesis] issues commands, since its end is a statement of what we ought to do or not to do.' (N.E., p.1143a)

Sophia as the highest level of theoretical intellectual virtues is achieved by combining nous and episteme. Nous regards intuitive intellect whose source is not clear to the knower. Integrating nous (intuition) in the knowledge management context is thus challenging. The mysterious and often serendipitous source of intuition has made it unreachable to scholarly examination in general (Osbeck, 1999) and KM field specifically. The scholarly body of literature considers intuition as an input from the subconscious mind (Agor, 1986; Crossan et al., 1999; Miller and Ireland, 2005). The linkage between intuition and the subconscious opens a door to accommodate intuition in the confines of KM literature. That is, by nourishing knowledge types at conscious level, subconscious intuition will be empowered. Exposure to episteme, techne, and phronesis at conscious level is likely to increase the chance of intuitive understanding at subconscious level. Schwartz (2006, p.13) stressing the interrelationship between techne and phronesis (and 'to a certain extent epistémé') propose that: 'support for the noûs within knowledge management may in fact be derived from our treatment of these two contributing types of knowledge.' Thus, Sophia (wisdom), having nous and episteme as its components, is reliant on the integration of episteme, techne, and phronesis.

Industrial organizations are commonly seen as the integrators of techne. However, the Aristotelian taxonomy opens a room for these organizations to contribute in at least two other distinct knowledge types. They may position themselves to delve into episteme and conduct research as a commercial R&D lab. Consulting firms are a manifestation of taking this path in epistemic knowledge integration. Also, industrial organizations may choose to integrate phronesis and deliberate the ethical bearings of a particular action (or policy). Normatively anticipating the consequences of actions can be found as the knowledge specialization of policy analysts or corporate social responsibility (CSR) consultants.

The know-X taxonomy

The literature of KM frequently utilizes a taxonomy of knowledge including but not limited to: know-why, know-what, know-that, know-how, know-who, know-where, know-when, and so on. This taxonomy is noted as know-

X hereafter. The historical foundation of this taxonomy is not clear and scholars refer to fairly recent notations of this taxonomy. For example Capurro (2004, p. 53) cites the work of Zahn et al. (2000) in linking this taxonomy with that of Aristotle: 'know-how: "techne", know-why: "episteme", know-what: "phronesis" [...] we may add: know-where, know-when, know-who.' The linkage between the latter three knowledge forms and the all-inclusive taxonomy of Aristotle is not described in their work. Similarly, Flyvbjerg (2006) explains that 'whereas episteme concerns theoretical know why and techne denotes technical know-how, phronesis emphasizes practical knowledge and practical ethics' (p. 56). The position of phronesis in know-X taxonomy is not attended in his work. Quite differently, Ryle (1945) discusses taxonomies of knowing-that vis-à-vis knowing-how.

The know-X categories are not as distinctive as the Aristotle's taxonomy, in that, epistemic know-how, explaining the general, universal, and eternal principles of a process, are not clearly distinguished from technical know-how, regarding the execution/making of that process, or phronesis know-how, deliberating on how should an action take place to be an ethically just process. How the universe works, how the universe can be put to work, and how the human actions should be performed are all amalgamated in the know-how category of the know-X taxonomy. In this sense, the know-X taxonomy does not exhibit external consistency. Essentially different real-world manifestations are attached to one conceptual category. For example, how a material can be used to generate electricity from light has: (1) an epistemic side, in the principle of photovoltaic phenomenon, (2) a technical side, in making ingot / photovoltaic cells / photovoltaic panels, as well as (3) a phronesis side, in the socially, environmentally, and economically just manner in which the electricity should be generated from light to be ethical. Know-how hence can pertain different types of knowledge.

Know-what category in this taxonomy also incorporates the three Aristotelian concepts at once and cannot be used in strict differentiation and may confuse KM analysis and understanding: knowing what epistemically (to understand), technically (to make), and phronetically (to be ethically just). Know-when an know-where have similarly three distinct Aristotelian aspects. Put in the context of the previous example, when/where (in principle) a photovoltaic effect yields more electricity, versus when/where a solar power plant yields more electricity, versus when/where should a particular solar-farm be installed.

The know-why of phronesis is attributed to the ethical principles emerging from the ethical virtue. The answer of phronesis know-why is, without any exception, 'good or bad for man' (N.E., p.1140b). Know-why in face of techne concerns the purpose of an artisan or an artifact. The knowledge of "why a techne" defines its application and the purpose behind making it since techne is not an end in itself. Epistemic know-why, in the strict sense of not considering any application, regards the universal and eternal principles and/or causes. Yet, knowing "why a principle holds" or "why X causes Y" stays out of reach of episteme.

> *Scientific Knowledge is a mode of conception dealing with universals and things that are of necessity; and demonstrated truths and all scientific knowledge (since this involves reasoning) are derived from first principles. Consequently the first principles from which scientific truths are derived cannot themselves be reached by Science. (N.E., p.1140b)*

For instance, the principle behind (i.e. why) the values of the physical constants, for instance those of the gravitational constant [G], the speed of light [c], or Planck's constant [h], cannot be reached by episteme. Episteme may find what are those values, but, "why those specific values?" is not epistemically reachable. As well, why matter and energy equate (at all or specifically) by E=mc2 and not any other relationship is out of reach of episteme. In the photovoltaic example, "why photons and electrons interact at all" cannot be reached by science. Thus, know-why in this taxonomy has three distinct aspects: principles, purposes, and ethical virtue in which the epistemic know-why is confined to only provide a mechanism.

Such know-why, as a causal mechanism, itself is an epistemic know-how. The know-why of photovoltaic effect, as an instance, ultimately equates knowing the mechanism by which a photon excites an electron, i.e. an epistemic know-how. In know-X, one explores to attain epistemic know-why and ultimately discovers epistemic know-how. This type mismatch hampers the know-X taxonomy's internal consistency when know-why equates know-how for at least the epistemic knowledge type.

Furthermore, the distinctions between the know-X categories are not described systematically. It is up to the reader to distinguish between, for instance, know-what and know-why in a cause-effect representation: consider A causes B. Is this understanding a know-what as in "knowing what causes B" or a know-why as in "knowing why B". This amalgamation further hampers the internal consistency of the know-X taxonomy. Added to these issues, the set is also not confined to a limited number of types: know-X taxonomy is still open-ended.

To conclude, know-X taxonomy in its current form lacks both internal and external consistency. To alleviate the inconsistencies the know-X taxonomy needs a systematic definition to define and defend the currently blur borders between its categories. Utilization of the know-X taxonomy in understanding, managing, or evaluating knowledge-related practices in industrial, academic, and governmental organizations is expected to be fruitless if not misleading.

2.3 Institutional Specialization

This section aims at sketching a manifestation of the Aristotelian knowledge taxonomy in the real-world to assert its external consistency.

Diverse institutions of the economy are argued to be a manifestation of the Aristotelian knowledge taxonomy. Eikeland (2008, p.45) observes that: 'Western institutions, and their divisions of labor, are undoubtedly partly a product of how Aristotle has been interpreted through the centuries.'

It is however not necessary that the taxonomy shapes the institutions. It is equally possible that the taxonomy of Aristotle was derived through examining institutions relevant and present in the economy in his days. 'When Aristotle illustrates what he means he uses examples from professional disciplines' (ibid, p.39). Either case, the foundation of the Aristotelian knowledge taxonomy and its manifestation can provide an understanding of the knowledge and the institution of organizations at once.

First, knowledge exploration and exploitation derives from combining (integrating) knowledge. In an individual's mind, new knowledge is created by combining it with existing knowledge. Also intuitive knowledge is understood by linking and combining the out-of-the-blue knowledge with existing knowledge to ascribe it a meaning. The need for combination to render meaning sets the rational of conscious exposure to promote subconscious intuition as depicted earlier.

Similarly, a particular episteme, techne or phronesis is meaningful in combination with a set of a priori established knowledge. For instance, knowing that "photons interact with electrons" in isolation, from the knowledge about the electron's orbits of an atom, energy content of a photon, and many more knowledge pieces, inhibits that specific isolated knowledge piece from providing a scientific understanding. Neither a knowledge piece can be utilized in isolation. The process of combination is necessary when knowledge is utilized in techne. Techne needs to be combined with a set of related knowledge pieces to become applicable. In the same example above, in isolation from the knowledge of the semiconductor material, chemistry of the needed impurity for a p-n junction, and many more knowledge pieces, one cannot technically produce any artifact to harness photoelectric energy, e.g. a photovoltaic cell. Thus, exploration and exploitation of knowledge involves "knowledge combination".

Second, from a resourced-based viewpoint (RBV) knowledge is regarded as the paramount source of sustained competitive advantage. 'As the literature makes increasingly clear, a knowledge-based view is the essence of the resource-based perspective. The central theme emerging in the strategic management resource-based literature is that privately held knowledge is a basic source of advantage in competition.' (Conner and Prahalad, 1996, p.477) Reflected from the RBV assertions, it can be derived that: '[R]resource and capability-based advantages are likely to derive from superior access to and integration of specialized knowledge.' (Grant, 1996a, p.376)

Thus, on organizational level as well, knowledge is pooled to achieve a competitive advantage. The combination of knowledge in an organization is rooted in the bounded rationality argument. Simon's bounded rationality assures the insufficiency of *one mind* to possess and process *all knowledge*. Combining knowledge of multiple minds in an organization decreases the restrictions on a single mind's rationality.

> *[T]he "data" from which the economic calculus starts are never for the whole society "given" to a single mind which could work out the implications, and can never be so given. (Hayek, 1945, p.519)*

It follows that since the strategically most important resource of the firm is knowledge, and since knowledge exists in a specialized form between individuals, 'the essence of organizational capability is the integration of individuals' specialized knowledge' (Grant, 1996a, p.375). The conclusion is that knowledge needs a combination at individual as well as organizational levels. Hence, organization can be regarded as a machine to integrate specialized individual knowledge. Knowledge in an organization is constituted of a coalesce of specialized knowledge of organizational members. On the same vein an organization's capacity to generate new combinations of existing knowledge is described by Kogut and Zander (1992, p.391) as 'combinative capabilities'. The resolution is that organizations in general are knowledge integrating machines which first combine individual members' knowledge, and second, integrate external knowledge in light of the initially combined knowledge. Organizations further specialize in integrating specific types of internal and/or external knowledge.

Organizations, as specialized knowledge integrating machines, should resemble the knowledge taxonomy (as their integration object) in their institutional typology. Epistemic knowledge can be seen as the main knowledge type integrated by universities (as an institution rather than a specific university). University's institutional core purpose is to find (for the sake of understanding) the general, universal, and eternal principles with which the universe works. Technical knowledge is leveraged mainly by an integration process in industrial organizations i.e. institution of business. Institution of business mostly concerns the making/production of products and/or services. Phronesis, to deliberate on what is good and bad for a man, is achieved by integrating that type of knowledge as the main purpose of governments and governance institutions. These include the non-governmental organizations (NGOs), societal/environmental activist groups, and alike, all as an institution of governance.

2.4 Organizational Diversification

Although the primary role of each major institution regards one category of the Aristotelian knowledge taxonomy, organizations as members of the institutions are not, per se, confined to combine only one knowledge type. Secondary and tertiary knowledge types are also integrated to a certain degree by each specific organization. Neither all universities are purely theoretical nor all industries purely practical. Organizations integrate episteme, techne, and phronesis in diversified proportions. Indeed a university primarily dealing with integrating epistemic knowledge for the sake of understanding, may find it strategically advantageous to valorize its epistemic knowledge through technology development, i.e. integrating technical knowledge and epistemic knowledge. Technical universities and academic spin-offs are the real-world examples of an organization diversifying in integration of epistemic and technical knowledge types. Commercial R&D centers, as well as consultancy firms, are examples of organizations which diversify in integrating epistemic knowledge into the core technological knowledge integration. Both universities and firms may incorporate phronesis in their knowledge integration operations. Responsible Research and Innovation (RRI) and Corporate Social Responsibility (CSR) are two manifestations, that emphasize the inclusion of stakeholders and the role of considering one's accountability towards others when conducting innovations (Pavie et al., 2014). Table 2.1 outlines examples of these primary, secondary, and tertiary roles played by the diverse organizational types.

To demonstrate the precision of the taxonomy, a manifestation of a complex situation serves as an example: consider an individual active in two organizations with deferent organizational types, for instance; a person doing both academic research and commercial R&D. In the two roles, dictated by the organizational types, that individual will combine the knowledge types in unlike proportions. The knowledge type dealt with and the proportion of knowledge type integration change as (s)he switches between the two organizations. Being at academia, the urge for understanding and an arm's-length from application is dominating since science deals with the general, universal, and eternal. The very same person within the commercial R&D setting deals more extensively with the applicability and making. There, pure understanding without production-potential loses its relevance. This example signals the dominance of organizational-level determinants (based on organizational logic) over the individual-level factors.

Table 2.1. Knowledge Taxonomy and Organizational Roles

	Knowledge Taxonomy		
	Episteme	**Techne**	**Phronesis**
University	1st Role Science	2nd Role Technical Uni.	3rd Role RRI, Ethics
Industry	2nd Role R&D, Consultancy	1st Role Technology	3rd Role CSR
Government	Outsourced	Outsourced	1st Role Legislation

Further, there is a contrast between phronesis and the other two knowledge types: episteme and techne. The contrast regards the possibility of delegation of specialized knowledge to an expert. While episteme and techne can be delegated to the scientist and technologist, phronesis does not escalate by following advices or orders.

> *We do not all study medicine in order to become healthy. Instead we follow orders and recommendations, and get treatment from the experts who have, since medicine is mainly a technical art of making (poíêsis). But in ethics we cannot simply take the orders or advice of others who possess phrónêsis in the same way as we follow the advice from a doctor knowing medicine. Following the advice or orders from other individuals presumed competent is not sufficient in relation to the requirements for ethical virtue. (Eikeland, 2006, p.35)*

Thus, phronesis is the intellectual virtue necessary in every knowledge portfolio and is not delegated as a specialized knowledge to a specialized organization. Conversely, episteme and techne can be sourced out. In other words, although governments can outsource episteme and techne, for instance to get evidence-based decision making and/or infrastructure development, universities and firms cannot (and should not) outsource phronesis and need to deliberate on their actions as part of their organizational internal knowledge integration. This does not mean that there is no need for a specialized institution to safeguard and promote phronesis, in that, not all actors are ethically concerned and the presumption of good-will of all actors does not match the reality. This final note solely posits that phronesis, although being watched over and promoted by governments and governance structures, has to be attended by all organizational types.

For industrial organizations particularly, the integration of phronesis can particularly be seen as a source of competitive advantage. Organizations who proactively deliberate on their operations and perform based on ethical considerations and anticipation of each particular action and its implications (i.e. responsible innovation) are strategically ahead of the competitors who merely comply with the generally set bottom-line regulations. Products and services, which are ethically deliberated, possess an advantage in delivering higher value to the client.

2.5 Knowledge Meta-Integration

As explicated earlier, knowledge combination is the essence of individual and organizational knowledge creation. Organizations, in this perspective, are seen as knowledge integrators of teams of individuals. Open innovation can be similarly seen as a meta-integration of knowledge by teams of organizations. This section aims at sketching a link between the Aristotelian knowledge taxonomy and inter-organizational knowledge collaboration in open innovation.

Wisdom (i.e. Sophia in Aristotle's taxonomy) is a meta-integration of nous (empowered by techne and phronesis) and episteme, hence a coalesce of all Aristotelian knowledge types. Wisdom can be considered the state in which principles, their consequences in practice, and their ethical bearings are known at once in a holistic approach encompassing all types in all fields of knowledge.

> *But we also think that some people are wise in general and not in one department [...] Hence it is clear that Wisdom must be the most perfect of the modes of knowledge. The wise man therefore must not only know the conclusions that follow from his first principles, but also have a true conception of those principles themselves. (N.E., p.1141a)*

Achieving such an overarching repertoire of reinforcing episteme, techne, and phronesis in all fields is indeed challenging, demanding, and time consuming. However, a meta-organization can deliver such knowledge integration by incorporating diverse organizational types specialized in diverse knowledge types. Several fields of knowledge can be integrated within and between the three categories of knowledge. Such overarching integration can be studied in the case of Inter-organizational Knowledge Collaboration (IKC) in open innovation. In IKC, diverse organizational types pool knowledge resources of diverse types and join forces in integrating them to arrive at meta-knowledge, i.e. a coalesce of episteme, techne, and phronesis.

To achieve that level of integration, special attention needs to be directed at idiosyncrasy of cross-boundary knowledge sharing: IKC requires awareness of organizations and organizational members about the processes of absorption and dissemination. In the cross-boundary absorption and dissemination there is a special need to adjust and demonstrate a fit for the frames of understanding and aims of organizational main knowledge type to stay relevant. The double process of dissemination and absorption should be congruent in a sense that the sender takes into account what the receiver can or is willing to understand (i.e. customized articulation of knowledge). As well the receiver should take into account what the sender could actually mean by the conveyed message and with what aim (i.e. correctly inferring knowledge). The receiver should bear in mind the frames of understanding and aim of the sender are in accordance with the specialized knowledge type. Also, to effectively disseminate knowledge, to utilize it elsewhere, one should carefully take into account the prior knowledge escalated in the cognitive system of the recipient and consider the aims of such person in digesting the new input. For example, the Deficit model of knowledge transfer –i.e. shortcomings of decision makers as the recipients to interpret and use research evidence (Ward et al., 2009) –needs to be extended by adding the shortcomings of the knowledge provider in framing the knowledge in an understandable and relevant format (i.e. deficit of dissemination capacity). Knowledge management research must take into account the very fundamental congruence of the knowledge collaborating partners. Successful collaboration requires both articulation and digestion in light of the core knowledge taxonomy of the collaborating partners: (1) that knowledge is conveyed to recipients in a format that is relevant to them and enables them to comprehend it. And (2) that knowledge is interpreted by the recipients in light of the knowledge source's set of intellectual virtues and her corresponding aim of knowledge combination. Thus, organizations in meta-integration of knowledge in open innovation need to first frame their input in congruence with their partner organization's aims and capacities: the message framing in knowledge dissemination is the key to a successful knowledge collaboration. Second, in absorbing external knowledge, organizations need to tune in with the partner organization's frame of reference and intellectual virtue set: adaptive attentiveness in knowledge absorption is essential in a successful knowledge collaboration.

2.6 Conclusion

Considering the prominent role of knowledge in shaping the competitive advantage of organizations, this chapter illustrated a distinct correspondence of knowledge types and organizational types. The Aristotelian knowledge taxonomy of episteme, techne, and phronesis is shown to possess internal and external consistency in mapping the knowledge types which shape diverse institutions of the economy and their multifaceted networks contained by the Triple Helix model: episteme at the university, techne at the industry, and phronesis at the government. Specialized institutions comb into and integrate specific Aristotelian knowledge types. Organizations that collaborate through open innovation strategies, are advised to sketch their strategy in light of the core competence arising from their institution's primarily specialized knowledge type.

In open innovation networks, each organization further diversifies by incorporating secondary and tertiary knowledge types in its integration portfolio. A university may develop technologies and/or a firm may conduct research. Organizations can further gain a competitive edge by diversifying into a unique portfolio of knowledge integration encompassing a novel proportion of episteme, techne, and phronesis.

To achieve the highest level of knowledge integration, organizations collaborate to integrate all three specialized knowledge types in diverse fields. Each organization on this path can team-up with other organizations from different institutions which integrate different knowledge type and/or different proportion of knowledge types to attain the aims of an open innovation. In doing so, special attention needs to be paid to knowledge absorption and dissemination processes to be in congruence with the partner organization's institution and knowledge portfolio.

Chapter 3:

Interdependent Drivers of Inter-organizational Knowledge Collaboration[9]

Abstract. This paper seeks to model the drivers of the Inter-organizational Knowledge Collaboration (IKC). The Motivation, Opportunity and Ability (MOA) framework is previously used as the drivers of the knowledge collaboration at an individual level. Theoretically, the MOA are intercorrelated explanatory variables. Building on the consensus regarding the need for and benefits of the IKC, this study transposes the MOA framework to the organizational level to provide tools for measuring the combined effects of these interrelated drivers. The value of this study lies in addressing the methodological issues (multicollinearity) and theoretical requirements (intercorrelated MOA) at once. Additive, complementary, bottleneck, or a combination of these functional forms of the MOA have already been hypothesized and tested at individual level with varying model quality. Knowing how motivation, opportunity, and ability of an organization drive its knowledge collaboration (i.e. the functional form of the MOA) shapes the knowledge/technology transfer strategy and innovation system policy. The interdependent functional form for the MOA is hypothesized by this paper and is tested for its quality. Survey data of 475 organizations in the European Union (EU) Framework Program 7 (FP7)-Energy consortia have been collected and investigated with the help of Ordinary Least

[9] A paper version of this chapter (co-authored by V.E. Scholten and C.P. van Beers) is submitted to the Journal of Technology Transfer.

Squares (OLS) linear regression and Structural Equation Modeling (SEM) to test all aforementioned functional forms. The bottleneck model (i.e. Constraining Factor Model, CFM) of the MOA—the status quo in this field of research—due to multicollinearity is found not to be applicable in modelling inter-organizational knowledge collaboration. SEM could model the MOA's impact on the IKC as an interdependent set and confirmed the applicability of the MOA at an organizational level. These imply that when an organization aims at crossing its boundaries to transfer knowledge/technology, interdependent impact of the MOA needs to be accounted for. The MOA drive the IKC as a whole and at once rather than isolated independent drivers.

3.1 Introduction

Knowledge enhances the efficiency and effectiveness of organizational operations. Many organizations have become increasingly dependent on knowledge-based resources for gaining sustained competitive advantage (Choi et al. 2008; Grant 2002). To attain and retain a competitive edge, organizations strive to create new knowledge and/or put knowledge into practice. Due to high cost and uncertainty involved in research and development R&D, creating in-house knowledge or utilizing existing knowledge is not always possible (Caiazza et al. 2015; Slaughter and Leslie 1997). In order to acquire resources that cannot be developed internally - due to economic and/or technological constraints - organizations collaborate with external parties (Huang and Yu 2011; Powell et al. 1996). The process of collaboration, rather than the decision to engage in and/or the output product/process of such process, in this paper is investigated. What are the drivers of inter-organizational knowledge collaboration process? How can organizations amplify the extent of their current knowledge collaborations?

The IKC has been examined and discussed in several fields of research, including: strategy, with a resource-based-view focus (e.g., Dyer and Singh 1998; Hamel 1991); learning and innovation, emphasizing the knowledge creation outcome of collaboration (e.g., Barajas et al. 2012; Kale et al. 2002; Larsson et al. 1998; Powell et al. 1996); networks, studying the structure of a web of collaborations (e.g., Burt 2009; Di Cagno et al. 2014; Dyer 1996; Nahapiet and Ghoshal 1998; Powell et al. 1996); and knowledge collaboration partner(ship) management (Burnett et al. 1997; Morandi 2013). The objectives of these past investigations have been mostly towards demonstrating that through the IKC organizations are able to improve performance levels. Although the consequences of the IKC are carefully analyzed and measured (e.g. Aristei et al. 2015), the drivers of the IKC process are studied less. More recent studies, addressing the input side of the IKC process, focus on categorization of roles that foster knowledge collaboration (e.g., Cricelli and Grimaldi 2010; Venkitachalam and Bosua 2014) rather than the drivers. Without an empirically supported account for the drivers of the IKC, the variations in IKC cannot be explained and managed. Unlike studies that use inter-organizational knowledge collaboration as an independent variable to explain innovation or performance (e.g., Lee et al. 2012; Wilfredo Bohorquez Lopez and Esteves 2013), in the present empirical study the extent of the IKC is the dependent variable. Note that instead of predicting the decision to engage in an IKC, this study aims at an explanation of the variation in the extent of already initiated IKCs. In other words, given the strategic decision to initiate a collaboration, here the drivers of the IKC process are empirically examined.

Variations in the extent of inter-organizational knowledge collaboration process can be traced back to the individual and/or the organizational level drivers. A meta-analysis by Witherspoon et al. (2013, p.250) summarized the drivers of intra-organizational individual level knowledge collaboration to be “intentions and attitudes”, “rewards”, and “organizational culture”. Two other sets of variables are known to affect knowledge collaboration behavior: capabilities (e.g. generative, absorptive, and disseminative capacities) and opportunities (external contextual variables, such as available time, assisting or inhibiting knowledge collaboration) (Argote et al. 2003). A notable example, i.e. Narteh (2008), worked on drivers of knowledge collaboration – on an inter-organizational level – with a focus on the role of capabilities. Argote et al. (2003, p.575) assert that: “Just as successful individual performance depends on an individual's ability, motivation, and opportunities to perform, successful knowledge management also depends on ability, motivation, and opportunity.” The Motivation, Opportunity, and Ability (MOA) framework[10] in this study is conceptually examined for its efficacy to be transposed as the drivers of inter-organizational knowledge collaboration at an organizational-level. Empirical part of this study puts this transposition from the individual to the organizational level into test.

Historically the three components of MOA are found to be inherently hard to disentangle (Blumberg and Pringle 1982). This is mainly due to the intercorrelations between these components. The extent of motivation is corre-

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[10] The MOA framework originates from the work performance literature (Blumberg and Pringle 1982; Boudreau et al. 2003) and is already used in modelling individual-level intra-organizational knowledge collaboration (Argote et al. 2003; Kelloway and Barling 2000; Siemsen et al. 2008).

lated with the extent of the ability and opportunity. The same holds for the extent of ability which correlates with the extent of the opportunity[11]. This intercorrelation of supposedly independent (i.e. orthogonal) explanatory variables introduces a methodological challenge. The methods used in intra-organizational studies (e.g. Siemsen et al. 2008) to reflect on the effects of the MOA recognize these correlations, yet utilize Ordinary-Least-Squares (OLS) regression analysis. Methodologically, the explanatory components of an OLS regression model are required to be orthogonal with negligible intercorrelation (up to 5 in Variance Inflation Factor, VIF, measure). Theoretically, the MOA model of knowledge collaboration expects intercorrelations of its conceptual components. This fundamental methodology-theory requirements' tension will be addressed in the present study.

Moreover, the manner (i.e. functional form) with which the MOA together drive the IKC shape the knowledge/technology transfer strategy of an organization and the innovation system as a whole. One possible functional form for the combined effects of the MOA components is the additive function. In this form the MOA act in isolation and excess of one of the components compensates the lack of the other(s). The matching strategy to this form can be searching for the strongest of the MOA and disregard the other factors. The second possible functional form for the combined effects (i.e. in isolation and in relation to each other) of the MOA components complementarity. Argote et al. (2003, p.575) illustrating the complementarities of the MOA framework noted that: "Ability and extra effort are even more valuable when coupled with opportunity." Complementarity can take two forms. The first form is moderate complementarity in which the magnitude of the effect of one variable depends on the magnitude of other comple-

[11] This dynamic can be illustrated through self-actualization (Maslow 1950) mechanisms also on organizational level: an able collaborator is expected to be more motivated to collaborate to actualize its potential. And being motivated to collaborate, a collaborator is also expected to develop required ability to attain its desire (i.e. attaining the organizational goals). Likewise, if there is ample opportunity to collaborate, for example when one has excess time to spend, the motivation to collaborate will ultimately increase. The same stands for more opportunity associating with higher ability, when due to an opportunity one develops ability to harness benefits of such opportunity.

mentary variables. As illustrated by Argote et al. (2003), with moderate complementarity, ability's positive effect on behavior is intensified by the amount of opportunities. The ability of a performer has more effect with more opportunities. The matching strategy to this form can be searching for the synergies. The third possible form is extreme complementarity in which one variable has an effect only in the presence of the other complementary variables. In that case motivation, for instance, has an effect only if an ability is present. For example, a great deal of motivation and ample opportunity can drive no behavior in the absence of ability. Or, if one is not motivated to perform, it does not matter how able one is and how much opportunity is available, behavior is expected not to be performed. The matching strategy to this form can be searching for the bottlenecks and disregarding the other factors. A combination of these three forms is also examined in the past. An alternative functional form, proposed by this paper, is the interdependent form by which all the MOA factors are tied together so that the excess/shortage of one factor increases/decreases the extent of the other two factors. The matching strategy to this form can be addressing and investing in all the MOA factors as an interdependent set.

This study examines the following research questions: 1) Is the MOA framework suitable at organizational level to model IKC variation? 2) Are MOA components distinct or correlated[12] with each other and if so, how to deal with multicollinearity while utilizing intercorrelated explanatory variables? 3) Which functional form of the MOA better explains the IKC variation?

To this end, four OLS models specifying forms of complementarity and one simultaneous regression via Structural Equation Modeling (SEM[13]) are compared. Three steps are taken accordingly to examine: a) whether the MOA as drivers of the IKC are transposable for an analysis at the organizational

[12] As an empirical examination of the theoretical expectations.

[13] Zapata Cantú et al. (2009) utilized SEM to capture organizational learning variation. The scope of their study regarded human factors and did not investigate MOA's intercorrelations or complementarity. However, their methodological approach guided the method choice of the present study.

level; b) whether the MOA applied at the organizational level are intercorrelated and if so, how to address multicollinearity? c) Which functional form can capture the impacts that the MOA have on the IKC and on each other. The dependent variable, IKC, was captured through a survey administered to the key staff of participating organizations of consortia in the FP7-Energy. The key staff are fully in charge of the project management and operations of each participating organizations, thus, representing their organization. The survey accordingly collected the key staff responses with regard to the organizational level variables. For instance, the IKC was constructed reflectively (c.f. formatively) by three organizational-level questions addressed to the key staff: (1) Following a discussion on a complicated issue, how involved was your organization in any subsequent interactions?, (2) To what extent has your organization developed new ideas or skills because of the collaboration?, and (3) Throughout this consortium project, to what extent your organization learned to exchange skills, know-how, or technologies?

The paper is structured as follows: in section two, the conceptual model of the MOA framework is described and its pertinence for transposition to an organizational level is elaborated. This section also outlines the MOA modeling requirements. In the third section, the data source and the computational method of the conceptual variables are described. This section also reports the results of the data reliability and validity tests. The fourth section statistically tests the quality of various functional forms and discusses the implications. Section five concludes.

3.2 Theoretical Background

Knowledge collaboration is a behavior that its extent can be affected by individual or organizational level variables. Studying individual-level drivers, although fruitful in proving a micro-level understanding, may introduce level-of-analysis mismatch specially when the organizational level variables' impacts prevail. For instance, a particular individual employed by two organizations, e.g. a for-profit R&D lab and a public research institute, with particular individual-level characteristics, is expected to collaborate differently in accordance with the organizational-level variables; e.g. organizational type.

Moreover, the management of individual level factors aiming at shaping the mezzo (organization's) or macro level (innovation system's) performance seems impractical since: (a) given that an optimal solution is found, a top-down approach to align individual level factors of all involved staff (hundreds of thousands of individuals in FP7 for instance) to that optimal solution will not be effective, and (b) given the turn-over of involved individuals in the IKC, investments in individual level IKC management are inferior in efficiency to the investments aiming at organizations, consortia, or the innovation system. Here, facilitating innovation system's performance through the IKC management at an organizational level is argued to act as a guideline for organizations who in turn manage individual level factors.

Thus, to better understand the IKC, an organizational-level theory of behavior is also needed. One approach is to transpose the individual level theories of behavior and empirically test their efficacy in explaining the organizational level behavior. There are three generic theories relevant to understanding the behavior of individuals: the theory of reasoned action, TRA, and its modified version the theory of planned behavior, TPB (Ajzen and Fishbein 1970), the Cognitive-Affective Processing System, CAPS (Mischel and Shoda 1995), and the Motivation, Opportunity, and Ability theoretical framework, MOA (Blumberg and Pringle 1982). The TRA, TPB, and the CAPS models examine psychological mechanisms that shape one's behavior such as attitudes, beliefs, subjective norms, perceived controls, affective responses, emotions, feelings, and the affects accompanying physiological reactions. Transposing these theories are not aimed at since organizations' affective responses, emotions, feelings or physiological reactions are tricky to define and challenging to involve in the study of organizational-level behavior. These individual-level constructs are mainly suiting the intra-organizational individual-level context of modeling behavior. On the contrary, the MOA theoretical framework constitutes a set of broad and distinct categories of variables (Argote et al. 2003; Kelloway and Barling 2000; Siemsen et al. 2008) that possess organizational-level analogous conception which can potentially be transposed to model the IKC behavior. The following subsections conceptually transposes the MOA framework to an organizational level. The empirical part of this chapter puts the quality of this transposition into test.

MOA Framework

Before being utilized in the knowledge management literature, two distinct fields of study are known to be the origin of the MOA framework: (1) the work performance field in management science (Blumberg and Pringle 1982; Boudreau et al. 2003), and (2) the message elaboration likelihood field in consumer research (Petty and Cacioppo 1996, 1986; Batra and Ray 1986).

In the field of work performance, based on Maier's Psychology in Industry (1946) and its follow-up by Vroom (1964) various elements impacting individual-level work performance have been discussed, including attitudes, fatigue, and motivation. Individual performance was believed to be a multiplicative function of ability and motivation (Cummings and Schwab 1973; Maier 1946; Vroom 1964). A multiplicative function accounts for the interaction effect between motivation and ability. The interaction effect pertains, via the moderate complementarity condition, that the extent of ability gauges the effect of motivation on performance. The multiplicative models were not successful in capturing the variance in the work performance of individuals as the behavioral dependent variable. Following Peters and O'Connor (1980), in 1982 Blumberg and Pringle posited that (p.560): "Existing theory fails to provide strong and consistent prediction of individual job performance [...] [due to] neglect of an important dimension of performance – the opportunity to perform – and the interaction of opportunity with known correlates of performance [the authors, i.e. willingness (motivation) and capacity (ability)]".

In the field of social psychology, the conceptual origin of highlighting motivation, ability, and opportunity can be traced back to the development of the Elaboration Likelihood Model (ELM). ELM discusses drivers to the strategies people use to process information and respond to advertisements (Petty and Cacioppo 1986, 1996). Petty and Cacioppo (1986) acknowledge the contribution of Heider's (1958) preceding concepts of "trying" (motivation) and "can" (ability) in the foundation of the ELM. Four years after

Blumberg and Pringle (1982), Batra and Ray (1986) accounted for environmental factors (i.e. opportunity) interacting with motivation and ability to explain message elaboration likelihood. Clark et al. (2005) employed the MOA framework on an organizational level in the study of marketing performance.

To summarize, three broad categories of constructs are theoretically expected to serve as drivers to explain the behavior of individuals: motivation, opportunity, and ability. Motivation is the willingness to conduct behavior (in this context, the IKC behavior). Ability represents the skills, capabilities, and capacities related to the behavior. Opportunity embodies all the environmental and/or contextual mechanisms that externally enable or impede behavior.

Specifically in the field of knowledge management following Maclnnis and Jaworski (1989) several researchers (e.g. Argote et al. 2003; Siemsen et al. 2008) applied the MOA framework to explain intra-organizational individual-level knowledge collaboration behavior. The knowledge management literature posits that the dispositional factors, i.e. ability and motivation, positively affect the transfer of knowledge in collaborations (Baldwin and Ford 1988). Situational factors, i.e. opportunity, also positively affect the transfer of knowledge (Argote et al. 2003; Siemsen et al. 2008).

In inter-organizational consortia, organizations are represented by a key staff who takes full responsibility of the organization's performance. Independent of the origin and the outcome of the strategic choice of engaging in an IKC, the key staff manages the collaboration as a project manager to arrive at the set targets of an organization. In this context, the MOA can be transposed to organizational level. The organizational motivation can take the forms of incentive, encouragement, and/or a formal promotion. Note that in the transposition of motivation from individual level towards organizational level, motivation is condensed to solely incorporate extrinsic motivation. The varying levels of motivation (i.e. incentives, encouragements, and promotions) are applicable to all individuals in an organization, i.e. are invariant at an individual level. Thus, these forms of motivation can be seen and captured at organizational level. Given the strategic choice of engagement, the extent of motivation provided to the key staff and her team from each organization represents the organizational level motivation to perform the inter-organizational knowledge collaboration process.

Similarly, to transpose the available time of an individual to an organizational level – to proxy the availability of opportunity – the unoccupied time/effort of an organization can be assessed. The excess expenditure of time and effort by the organizational operational team (led by the key staff) compared to the contracted time and effort signals the available opportunity to an organization. When the operational team spends more time and effort than what the organization has committed to (in the contract) it can be expected that the organization has more opportunity in conducting the inter-organizational knowledge collaboration behavior.

Finally, the ability of an organization in collaborating with external parties is shared between all the organizational members and is equally available to all of them. However, such organizational level ability encompassing organizational capabilities, specialized capabilities, and success in execution of organizational plans varies between different organizations and can potentially drive different extents of inter-organizational knowledge collaboration.

To summarize, an organization which compared to its counterpart provides more motivation to its staff, has more available opportunity, and shows higher ability is expected to exhibit a more extensive IKC behavior. In this paper, the MOA framework is empirically tested to verify whether it can be used to capture the IKC variance when applied at an organizational-level. To this end, the following hypothesis has been formulated:

> *H1: The framework constructs motivation, opportunity and ability are expected each to affect IKC positively.*

Interdependency and Functional Form of the MOA

The three components of the MOA framework are hard to disentangle (Blumberg and Pringle 1982). Several mechanisms are proposed to show that the MOA either directly impact each other, or have a shared cause making them co-vary.

As an example of direct impact mechanisms, higher ability can induce higher motivation. Put in the IKC context, an able collaborator is expected to be more motivated to collaborate via self-actualization forces (Maslow 1950). And being motivated to collaborate, a collaborator is also expected to develop the required ability (i.e. generative, absorptive, disseminative, and adaptive/reflective capacities; see Parent et al. 2007). Likewise, if there is ample opportunity to collaborate, for example when there is time availability, the motivation to collaborate will ultimately increase. The same is valid if due to an available opportunity one develops the relevant ability to harness the benefits of such opportunity. Note that here the self-actualization mechanism is applied at an organizational level.

Indirect mechanisms can be the result of an underlying factor affecting all the MOA components. When a factor acts as the common cause, for example the extent of network relationships, its rise increases all components and its fall decreases them conjointly. The MOA components consequently can vary together due to a common cause (Argote et al. 2003, p.575). Siemsen et al. (2008, p.429) also stated that: "we conceptualize them [i.e. the MOA, the authors] as correlated." This leads to the following hypotheses:

> *H2.1 The Motivation component is positively correlated with the Opportunity component.*
>
> *H2.2 The Motivation component is positively correlated with the Ability component.*
>
> *H2.3 The Opportunity component is positively correlated with the Ability component.*

Below, several model specifications as well as estimation methodologies are examined in order to investigate the singular and joint impact of intercorrelated motivation, opportunity and ability on the IKC.

Model Specifications

To understand the IKC, it is necessary to know the effects of its drivers when each acts separately, also how their effects combine when acting jointly. The question of model specification is to investigate the explanatory variables' combined effect. The MOA components determining the IKC can potentially have any singular form (e.g. quadratic, logarithmic, exponential, etc.) and combinational form (e.g. complementary, supplementary, bottleneck, etc.). The functional form of applying the MOA framework is not standardized and different researchers apply different formulations in their model specification. Although the precise functional form is basically far from reach, anticipated formulations can be systematically compared so that the fittest[14] functional form can be identified. The status quo functional forms (guided by Siemsen et al. 2008) and an alternative formulation are explained below.

The simplest form is the additive scheme. This form is a linear combination of effects and is taken as the baseline for functional form comparisons. In the linear additive form, the MOA components separately impact knowledge collaboration and the overall impact is the sum of singular impacts. Here, the MOA complementarity is not addressed.

$$IKC = a_0 + a_1 M + a_2 O + a_3 A + a_4 Controls + \varepsilon \qquad (1)$$

In (1), the IKC is modeled as a linear function of sum of the isolated impacts of Motivation (M) Opportunity (O) and Ability (A) together with an intercept, a set of control variables, and an error term. An assumption of the linear modeling is that the explanatory variables are independent from each other. This assumption might not hold for the interrelated MOA components. In (1), the lack/shortage of one of the drivers can be compensated by the excess of the other factor(s). Enhancing one of the MOA factors will suffice for the enhancement of the IKC.

The second model specification is the complementarity between the MOA components. Complementarity can take two forms: a) moderate complementarity in which the magnitude of the effect of one variable depends on the magnitude of other complementary variables, and b) extreme complementarity in which a variable has an effect only if another variable is present at all.

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[14] Model-to-data or data-to model fit based on the choice of the methodology.

In case of moderate complementarity, the impact of, for instance, ability on knowledge collaboration depends on the extent of the available opportunity. Moderate complementarity is mathematically expressed by a multiplicative function:

$$IKC = a_0 + a_1M + a_2O + a_3A + a_4M \times O + a_5M \times A + a_6O \times A + a_7M \times O \times A + a_8Controls + \varepsilon \quad (2)$$

However, as argued by Siemsen et al. (2008, pp.429-430), although the MOA components are theorized as complementary, empirical evidence supporting the complementarity is scarce:

> *Classic work-performance theories hypothesize moderate complementarity among the MOA variables [...] action is a multiplicative function of motivation, opportunity, and ability (Maier, 1955, Vroom, 1964 and Blumberg and Pringle, 1982) [...] Whereas the multiplicative model has been subjected to empirical scrutiny (see Cummings and Schwab, 1973 for a review), there is scant empirical evidence that the multiplicative terms explain significantly more variance than the linear terms alone (Campbell and Pritchard, 1976 and Terborg, 1977).*

The linear model of the MOA is known to do as good as the multiplicative model (Campbell and Pritchard 1976; Cummings and Schwab 1973; Terborg 1977). To address complementarity in other forms, alternative models are proposed in the literature. The extreme complementarity condition on ability and opportunity maintains that for the behavior to be commenced, a motivated agent needs to have both ability and opportunity at once. Extreme complementarity has an all-or-nothing formulation in which knowledge collaboration encompasses an inseparable set of motives, capabilities, and opportunities which jointly affect the extent of the knowledge collaboration. For example, illustrated by Cummings and Schwab (1973), the presence of high motivation and ample opportunity in the absence of ability is not expected to result in an extensive IKC. The same holds in cases that either motivation or opportunity is missing. Absence or lack of one component of the MOA, with an extreme complementarity condition, can be expressed by a Constraining Factor Model (CFM). In CFM, the lowest of all three factors acts as a bottleneck to express the impact of lack of one component. As bottlenecks in (3), θ_i is 1 if 'i' is the minimum of the MOA; θ_i is 0 otherwise.

$$IKC = a_0 + a_1M + a_2O + a_3A + \theta_O\,(a_4 + a_5M + a_6O + a_7A) + \theta_A(a_8 + a_9M + a_{10}O + a_{11}A) + a_{12}Controls + \varepsilon \quad (3)$$

The combined model in (4) is considered to account for both extreme (CFM) and moderate (multiplicative) complementarities.

$$IKC = a_0 + a_1M + a_2O + a_3A + \theta_O\,(a_4 + a_5M + a_6O + a_7A) + \theta_A(a_8 + a_9M + a_{10}O + a_{11}A) + a_{12}M \times O + a_{13}M \times A + a_{14}O \times A + a_{15}M \times O \times A + a_{16}Controls + \varepsilon \quad (4)$$

(1), (2), (3), and their combined model (4) assume the explanatory variables and their products to be independent of each other. The error terms (ε) are also assumed to be independent of all the explanatory variables. If these assumptions are not met, multicollinearity and endogeneity issues need to be addressed.

An alternative model—a Structural Equation Model (SEM) —is proposed to address these issues. SEM consists of a series of simultaneous regression equations that measure singular and joint impacts of the MOA constructs on the IKC simultaneously.

$$\eta\,(IKC) = \beta\eta + \Gamma\xi\,(M/O/A) + \zeta \quad (5.1)$$

$$IKC = \Lambda y\eta + \varepsilon \quad (5.2)$$

$$M/O/A = \Lambda x\xi + \delta \quad (5.3)$$

In the equations set (5.1) –(5.3), η is the latent endogenous variable; ξ is the latent exogenous variable; Γ is the regression coefficient relating ξ to η; ζ is the regression coefficient relating equation residuals to η's; Λy is the matrix of regression coefficients relating η's to manifest y variables; ε is the regression coefficient relating a measurement residual to a manifest y variable; Λx is the matrix of regression coefficients relating ξ's to X variables; and δ is the regression coefficient relating a measurement residual to a manifest X variable.

Parts of a Structural Equation Model (SEM) are linked to each other through a system of simultaneous regression equations. All equations in (5.1) – (5.3) are numerically solved simultaneously as one model. In SEM the combined effect is measured without fixating or ignoring the interplays of the explanatory constructs. SEM utilizes the variance/covariance matrix to account for relationships between exogenous, endogenous, observed, or latent variables. These relationships can either be unidirectional and causal (diagrammed by straight arrows) or bi-directional and covariance (diagrammed by curved arrows).

The main objective in using SEM is to determine whether an a priori model is valid rather than to find a suitable model (Gefen et al. 2000). It isolates the error term to neutralize the negative consequences of potential heteroskedasticity, autocorrelation, and/or endogeneity. Moreover, covariance of exogenous latent constructs measures the degree to which two variables correlate. The constructs in SEM not only are allowed to have covariance, but their covariance is also calculated alongside several other a priori defined simultaneous structural relationships (i.e. the MOA – IKC structural model). The covariance measures are calculated simultaneously in conjunction with other inter-construct relationships. Covariance in this specification binds the latent constructs as interdependent factors. Here, the excess/shortage of one factor increases/decreases the extent of the other two factors respectively.

Table 3.1 summarizes the models (1) – (5).

Table 3.1. Inter-organizational knowledge collaboration model specifications

	Model Specification	Notes
Linear (1)	$IKC = a_0 + a_1M + a_2O + a_3A + a_4Controls + \varepsilon$	-Total impact is the summation of the singular impacts. -Complementarity is not dealt with. -Orthogonality (independence) is assumed.
Multiplicative (2)	$IKC = a_0 + a_1M + a_2O + a_3A + a_4M\times O + a_5M\times A + a_6O\times A + a_7M\times O\times A + a_8Controls + \varepsilon$	-Total impact is the sum and the multiplication of the constructs. -Moderate Complementarity is taken into account by interaction terms. - Orthogonality (independence) is assumed.
CFM (3)	$IKC = a_0 + a_1M + a_2O + a_3A + \theta_O(a_4 + a_5M + a_6O + a_7A) + \theta_A(a_8 + a_9M + a_{10}O + a_{11}A) + a_{12}Controls + \varepsilon$	-Total impact depends on the construct that has the smallest magnitude. -Extreme Complementarity is taken into account by the bottleneck specification. - Orthogonality (independence) is assumed.
Combined (4)	$IKC = a_0 + a_1M + a_2O + a_3A + \theta_O(a_4 + a_5M + a_6O + a_7A) + \theta A(a_8 + a_9M + a_{10}O + a_{11}A) + a_{12}M\times O + a_{13}M\times A + a_{14}O\times A + a_{15}M\times O\times A + a_{16}Controls + \varepsilon$	-Moderate and Extreme Complementarities are taken into account by summation of singular impacts, the bottlenecks, and the interactions. - Orthogonality (independence) is assumed.
SEM (5)	$\eta\ (IKC) = \beta\eta + \Gamma\xi\ (M/O/A) + \zeta$ $IKC = \Lambda_y\eta + \varepsilon$ $M/O/A = \Lambda_x\xi + \delta$	-Interplay is taken into account by interdependence of the constructs. -Orthogonality (independence) is not assumed, instead, covariance between constructs are involved in the estimations.

IKC = Inter-organizational Knowledge Collaboration; M = Motivation; O = Opportunity; A = Ability; ai = OLS regression coefficients; e = Error term; CFM = Constraining Factor Model; θi = binary variable θi is one when the minimum of M, O, and A is 'i'; η = latent endogenous variable; ξ = latent exogenous variable; Γ= regression coefficient relating a ξ to an η; ζ=regression coefficient relating equation residuals to η's; Λy = matrix of regression coefficients relating η's to manifest Y variables; ε =regression coefficient relating a measurement residual to a manifest Y variable; Λx = matrix of regression coefficients relating ζ's to X variables; δ =regression coefficient relating a measurement residual to a manifest X.

3.3 Data and Method

Data

The data come from the Community Research and Development Information Service (CORDIS) website (available at http://cordis.europa.eu/). It provides detailed information on publicly funded projects in the European Commission's (EC) Framework Programs (FPs) on different themes. These programs fund research consortia of diverse organizations on topics such as Energy, Environment, Security, Health, etc. Each project consortium is a collection of inter-organizational knowledge collaborations.

The empirical research is conducted on the Seventh Framework Program (FP7) Energy theme. It consists of 367 consortia consisting of participating organizations (extracted from the CORDIS website at 12 March 2015). After refining the data with cloud computational Google Refine software, the number of unique organizations identified was 2,262 and their number of participations[15] was 3,910.

The target group for the survey consists of the key staff as these represent the organizations and are directly involved and held responsible in the projects. They also attend project meetings where inter-organizational knowledge collaboration takes place. The project websites, interim reports, and final reports of each project are used to extract contact information of key staff associated with each organization.

An online survey was sent to 2,050 key staff of the organizations that participate in the consortia. After two weeks, a reminder to the non-respondents was sent. The survey was initially filled out by 634 (31%) FP7-Energy participating organizations' key staff members from which 479 completed the questionnaire. Five of these were dropped due to input inconsistencies. As a

[15] Each organization as a 'participant' may have multiple 'participations' (i.e. consortia membership).

result, 474 responses were left for empirical analyses. The questionnaire items of the survey are listed in the Appendix.

In order to examine whether or not a response bias exists, the project data of all targeted respondents was taken into account. A t-test was used to test for differences between the respondents and a group of randomly selected non-respondents with the same group size regarding: 1) project duration, 2) project cost, and 3) the amount of EU funding. No overall significant differences at the 90% confidence interval between these criteria could be found[16].

By design, this research is based on a single-informant survey, which means that the variables are measured as self-reported items. In order to test whether this survey design can be expected to influence the variance, four statistical tests were performed to test Common Method Bias (CMB), i.e. Harman's single-factor, principal component analysis, constant latent CMB value in Confirmatory Factor Analysis (CFA), and constraint-free CFA. The results of all these tests suggested that common method variance is not confounding the interpretations of the results[17].

Method

The MOA framework consists of three explanatory variables, Motivation (M), Opportunity (O), and Ability (A). The dependent variable is the Inter-organizational Knowledge Collaboration (IKC). In order to extract these component from the questionnaire items, CFA (with maximum likelihood estimation method) is used. All questionnaire items are measured as a 7-point Likert scale (see Table 3.2).

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[16] The tests statistic values were $t(861) = 0.21$, $p=0.83$ (project durations); $t(872) = -1.58$, $p=0.12$ (project costs), $t(872) = -1.35$, $p=0.18$ (amounts of EU funding).

[17] The constrained single factor did not account for the majority of the variance (33%<50%). Freeing the single-factor constraint, 11 items (items on Table 3.2 excluding the controls) loaded on more than one factor. Four factors emerged using the varimax rotation in the principal component analysis corresponding to the first four factors.

Table 3.2. Operationalization

Construct	Items	Remarks
Inter-organizational Knowledge Collaboration (IKC)	I1-Extent of involvement in discussions I2-Development of new ideas/skills due to collaboration I3-Extent of learning to exchange ideas/skills	Davenport and Prusak (1998) Muthusamy and White (2005)
Motivation (M)	M1-Availability of incentives to work on ideas M2-Existence of encouragement to keep trying M3-Formal promotion of knowledge collaboration	Song and Parry (1993)
Opportunity (O)	O1 - Extent of additional (to contracted) spent time O2 - Extent of additional (to contracted) spent effort	Having available capacity to spend extra time/effort
Ability (A)	A1 - Extent of general organizational capability A2 - Extent of specialized organizational capability A3 - Extent of success at execution of organizational plans	Jarvenpaa, Knoll and Leidner (1998) Muthusamy and White (2005)
Controls	zdistance-Travel time between the organizations zIT- Extent of available IT systems zduration-Collaborative project's duration	-Using usual media of transport -Relevant to knowledge collaboration -In months

The CFA model is shown in Figure 3.1. It consists of four exogenous co-varying latent variables (IKC, Motivation, Opportunity, and Ability, diagrammed by eclipses) each of which being measured by endogenous observed variables (questionnaire items, diagrammed by rectangles) with their error terms as unobserved latent variables (diagrammed by circles). Causal paths from the latent constructs load on the observed measurement items (i.e. indicators)[18]. This construction is *reflective* which implies that measuring some co-varying manifestations of a conceptual construct results in the measurement of that construct. The CFA can be considered appropriate for the present research as latent constructs of CFA are conceptually correlated with each other. Moreover, in CFA each measurement item loads on one and only one construct. This expression fits the MOA theoretical framework which needs correlated yet distinct conceptual constructs. Each construct's indicator variable set, i.e., measurement items, were adopted from the empirical literature of knowledge management. Reliability and validity of this model specification is tested below. All coefficients are reported with standardized variance to be comparable.

Widely accepted model-to-data fit indices for CFA are: chi squared per degrees of freedom ($\chi 2/df$), Root Mean Square Error of Approximation (RMSEA) and its corresponding p of Close Fit – p-value of one-sided test of the null hypothesis that the RMSEA equals 0.05 – (pclose), Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR). CFA confirmed the measurement model by meeting all these fit criteria with conservative cutoff points: $\chi 2/df$ below 3 (1.696, the lower the better), RMSEA below 0.05 (0.038, the lower the better) with insignificant pclose at 0.05 level (0.882, the higher the better), CFI and TLI above 0.95 (0.988 and 0.983 respectively, the higher the better), and SRMR below 0.08 (0.032, the lower the better).

[18] The standardized path coefficient is the value of that factor loading.

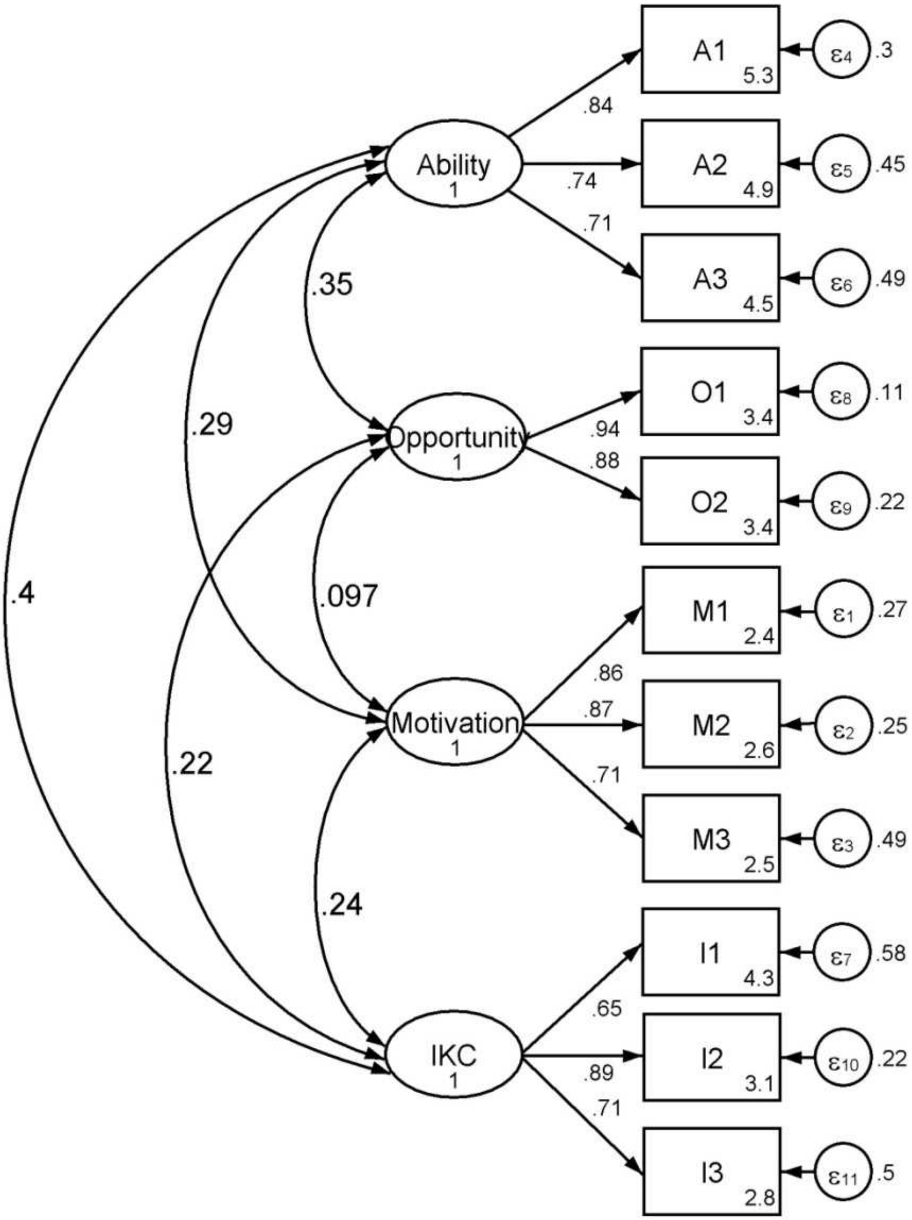

Figure 3.1. CFA model

The Reliability, Convergent and Discriminant Validity test results and inter-correlations of the factors are presented in Table 3.3. The reliability of the factors were measured by their Cronbach's α. Reliability of the factors was established by greater than 0.75 cutoff point in Cronbach's α measure (see Table 3.3). Moreover, the reflective factors' convergent validity needed to be established. Convergent validity derives from high loading (shown on straight arrows in Figure 3.1) compared to the relevant covariance (i.e. curved arrows) error term and is assessed using the AVE (Average Variance Extracted) with a cutoff point of 0.5. This posits that the error terms are less than 50% of the extracted variance. Convergent validity was established by extracting more than 0.5 for all items of all factors by the AVE measure.

With regard to distinctness of the explanatory constructs the SEM method relies on the discriminant validity test (Farrell and Rudd, 2009). This test assures that each construct is conceptually representing an autonomous meaning and is distinct from the other constructs. Discriminant validity is tested by comparing the squared root of the AVE with the corresponding correlations between the independent variables (Fornell and Larcker, 1981). This assures that each construct does not share more variance between its indicators/measures than it does with other constructs. To establish discriminant validity, the diagonal cells of Table 3.3 (squared root of AVE) should not be smaller than the off-diagonal intercorrelations of the constructs on the crossing row and column. Discriminant validity was established by smaller intercorrelations between the latent factors than the squared root of their AVE on all rows and columns. Supported by the evidence of discriminant validity, all the four main conceptual factors (IKC, Motivation, Opportunity, and Ability) are distinct measures and can be used to model the variation in the extent of IKC.

All trilateral MOA correlations are also positive and significant. Motivation is significantly correlated with opportunity and ability. Opportunity and ability are also significantly correlated. MOA are intercorrelated (i.e. non-orthogonal) explanatory variables.

Table 3.3. Constructs' Reliability, Convergent and Discriminant Validity

Component	Cronbach's α	AVE	IKC	Motivation	Opportunity	Ability
IKC	0.785	0.571	**0.755** [a]	0.280***	0.253***	0.466***
Motivation	0.852	0.666		**0.816**	0.11***	0.334***
Opportunity	0.910	0.835			**0.914**	0.399***
Ability	0.802	0.585				**0.765**

* $p \leq .10$ ** $p \leq .05$ *** $p \leq .01$

[a] Diagonal cells in **Bold** are squared root of AVE

Pair-wise correlations between the MOA factors and IKC are shown in Table 3.3. The dependent variable IKC is significantly correlated with the three explanatory factors Motivation, Opportunity, and Ability. This signals an empirical support for the utilization of the MOA theoretical framework as an organizational-level behavioral model.

Control Variables

A set of four control variables were considered to specify the models. The first one is geographical distance, which is measured as the travel time between the collaborating organizations. Geographical distance, hampering the ease of access was considered to negatively impact the extent of the IKC. In other words, a longer geographical distance is expected to reduce the extent of the IKC (Drivas and Economidou 2014; Lindelöf and Löfsten 2004). The second control variable is the extent of available Information Technology (IT) relevant to knowledge collaboration. IT relevant to knowledge collaboration are expected to facilitate the IKC, thus, a positive impact for the extent of IT is expected (Youtie et al. 2008). The duration of the collaborative project is used as the third control variable. This is defined as the timeframe of the projects. Collaborating organizations in longer projects face more challenging coordination, hence, a negative impact on the IKC is expected (Okamuro and Nishimura 2013). All control variables were standardized as z-scores (i.e. mean of zero and variance of 1). The coefficients of control variables' z-scores are reported in Table 3.4 and Figure 3.2.

3.4 Empirical Results and Discussion

In Table 3.4 the empirical results of the models (1) - (5) are reported. Columns (2) - (5) in Table 3.4 reveal the OLS estimates of the models specified in section 2.

The OLS estimates of Model 1 (M_1) in Table 3.4 shows that this model is statistically significant. Motivation component in this model have a significant positive impact ($\beta_M = 0.124$, $p < 0.01$) on the extent of IKC. Opportunity and Ability components also have a significant positive impact ($\beta_O = 0.087$, $p < 0.05$ and $\beta_A = 0.360$, $p < 0.01$, respectively) on the extent of IKC. The higher each of the motivation, opportunity and ability, the higher the extent of the IKC. Hypothesis H_1 is cannot be rejected.

Model 2 (M_2) addresses moderate complementarity by including multiplicative terms. The comparison between the M_1 and M_2 suggests that the linear model is doing as good as the multiplicative one. Models' power, F, reduced from 28.75 (in M_1) to 17.76 (in M_2). R^2 did not change ($p = 0.310$), as well, the error level Root MSE remained the same (Root MSE = 0.532). Parsimony of M_2 ($AIC_{M2} = 757.783$) was slightly worse than that of M_1 ($AIC_{M1} = 754.671$). The measure of multicollinearity is also better in M_1 (Max $VIF_{M1} = 1.38$) compared to M_2 (Max $VIF_{M2} = 1.47$). These correspond with Cummings and Schwab (1973) who argue that the fit of the multiplicative model is not significantly better than the fit of a linear model. Moreover, the multiplicative model (M_2) does not demonstrate the existence of moderate complementarity since none of the interaction terms are significant. This result is in line with a meta-study of Van Eerde and Thierry (1996).

Table 3.4. Results of OLS and SEM regressions

	OLS				SEM
	M_1:Linear	**M_2:Multiplicative**	**M_3:CFM**	**M_4:Combined**	**M_5: Interdependent**
	β (S.E.†)	**β** (S.E.)	**β** (S.E.)	**β** (S.E.)	**β** (S.E.)
zDistance	**-0.073*** (0.025)	**-0.069*** (0.025)	**-0.078**** (0.024)	**-0.082**** (0.025)	**-0.081*** (0.046)
zDuration	**-0.082**** (0.025)	**-0.080**** (0.025)	**-0.088**** (0.025)	**-0.087**** (0.025)	**-0.093**** (0.046)
zIT	**0.155***** (0.026)	**0.160***** (0.026)	**0.167***** (0.026)	**0.166***** (0.026)	**0.200***** (0.048)
Motivation	**0.124***** (0.023)	**0.112**** (0.024)	0.107 (0.048)	0.033 (0.054)	**0.115**** (0.053)
Opportunity	**0.087**** (0.026)	**0.077*** (0.027)	-0.044 (0.051)	0.086 (0.082)	**0.101*** (0.053)
Ability	**0.360***** (0.045)	**0.344***** (0.046)	**0.476***** (0.089)	**0.554***** (0.116)	**0.299***** (0.058)
M*O		0.058 (0.022)		0.104 (0.041)	
M*A		-0.051 (0.036)		0.042 (0.051)	
O*A		-0.031 (0.031)		**-0.144**** (0.044)	
M*O*A		0.047 (0.020)		0.033 (0.022)	
Θ_O			-0.054 (0.100)	-0.031 (0.101)	
Θ_O*M			0.062 (0.077)	**0.143*** (0.102)	
Θ_O*O			0.127* (0.079)	0.025 (0.119)	
Θ_O*A			**-0.186**** (0.122)	**-0.308***** (0.171)	
Θ_A			**-0.223**** (0.127)	-0.159 (0.137)	
Θ_A*M			**0.246***** (0.100)	**0.259***** (0.101)	
Θ_A*O			0.056 (0.095)	-0.071 (0.135)	
Θ_A*A			**-0.191**** (0.149)	**-0.231**** (0.179)	
					‡**Cov_{MO}** **0.101**** (0.051)
					Cov_{MA} **0.290***** (0.051)
					Cov_{OA} **0.353***** (0.048)
N	474	474	474	474	472

Table 3.4. Results of OLS and SEM regressions (*Continued*)

	OLS				SEM	
	M_1:Linear	M_2:Multiplicative	M_3:CFM	M_4:Combined	M_5: Interdependent	
F	28.75***	17.76***	14.21***	11.45***	-	
R^2	0.270	0.277	0.302	0.312	0.205	
adjusted R^2	0.260	0.262	0.281	0.285	-	
R^2 change		0.007	0.033	0.009	**SEM's fit statistics**	
[p > F]		[0.310]	[0.007]	[0.188]		
					chi^2 (68)	127.739***
					CFI	0.974
					TLI	0.967
					SRMR	0.057
Root MSE	0.532	0.532	0.525	0.524	**RMSEA [Pclose]**	0.043 [0.831]
AIC	754.671	757.783	748.987	750.595	17865.271	
Max VIF	1.38	1.47	5.97	12.08	-	

Dependent variable: extent of the inter-organizational knowledge collaboration.
All coefficients (except Covariance) are standardized by size and reported as βs.
†S.E. is standard error.
‡Cov_{XY} is covariance of X and Y.
* p ≤ .10 ** p ≤ .05 *** p ≤ .01

In both the constraining factor model, model M_3, and the combined model M_4 the factors Motivation and Opportunity do not exhibit significant coefficients despite the significant coefficients in the linear model M_1, and the multiplicative model M_2. The insignificant result can be attributed to strong multicollinearity between the factors as witnessed by a high (more than 5) VIF-measure (Max $VIF_{M3} = 5.97$, Max $VIF_{M4} = 12.08$). Multicollinearity leads to coefficient estimates that are unstable in sign, and difficult to interpret. In M_3 the Opportunity construct switches sign from positive to negative. As well, interpreting the results, e.g. Ability as the bottleneck, is difficult: when θ_A is 1, the coefficient of Ability construct is 0.476-0.191 or 0.285 which is smaller than the coefficient of Ability when Motivation or Opportunity are the bottlenecks ($\beta_A = 0.476$ or $\beta_A = 0.290$ respectively). This implies that when the Ability is the bottleneck, increasing Ability has less impact than when the Ability is not the bottleneck. This result cannot be interpreted given the definition of a bottleneck.

Moreover, two fundamental factors, Motivation and Opportunity, are downplayed by an artificially higher coefficient for the third factor: Ability. A higher coefficient as compared to the linear model is also reported for Motivation in an intra-organizational setting (Siemsen et al., 2008) together with downplayed impacts of Opportunity and Ability as compared to the linear model. Hence, the constraining factor and combined models are not likely to explain the variance in the IKC appropriately. The functional form of the CFM can be seen as the source of multicollinearity in that when $\theta_i = 1$, the factors M, O, and A are estimated as duplicates: for instance $\theta_A = 1$ (thus $\theta_O = 0$), then

$$IKC = a_0 + a_1 M + a_2 O + a_3 A + a_8 + a_9 M + a_{10} O + a_{11} A + a_{12} Controls + \varepsilon \quad (6)$$

There is not a significant change ($p = 0.188$) in F and in the R^2 of the combined model M_4 compared to M_3. To summarize, linear and multiplicative models are the only two out of the four tested OLS models that meet the multicollinearity criteria within which the linear specification is more powerful and more parsimonious than the multiplicative specification. But the linear form does not address the complementarity of the MOA components. Neither moderate nor extreme complementarities are taken into account.

The explanatory variables in the OLS models are assumed to be orthogonal. This assumption is violated given the significant positive correlation of the explanatory variables.

Structural Equation Modelling (SEM)

To address H1, H2.1, H2.2, and H2.3 in one model, the impacts of MOA factors on each other (i.e. interdependence) and on the dependent variable IKC are calculated simultaneously. Does this functional form of the model well represent the variation of the IKC data? SEM fit the data by meeting conservative cutoff pints of $\chi 2/df$ below 3 (1.879), RMSEA below 0.05 (0.043) and insignificant pclose at 0.05 level (0.831), CFI and TLI above 0.95 (0.974 and 0.967 respectively), and SRMR below 0.08 (0.057). AIC was 17865.271. These results reveal that the MOA factors are the interrelated antecedents of the IKC. H1, H2.1, H2.2, and H2.3 cannot be rejected simultaneously.

Covariance between the factors (reported on the last three rows of coefficients of M5 in Table 3.4 are a measure of interplay between the MOA components. As shown in Figure 3.2, the curved arrows' value and p-value suggest that higher ability corresponds with higher motivation [$Cov_{MA} = 0.290$, $p < 0.01$) and higher opportunity [$Cov_{OA}=0.353$, $p < 0.01$]. To a lesser degree, higher motivation corresponds with higher opportunity [$Cov_{MO} = 0.101$, $p < 0.05$]. MOA are interdependent determinants, i.e. the excess/shortage of one factor increases/decreases the extent of the other two factors.

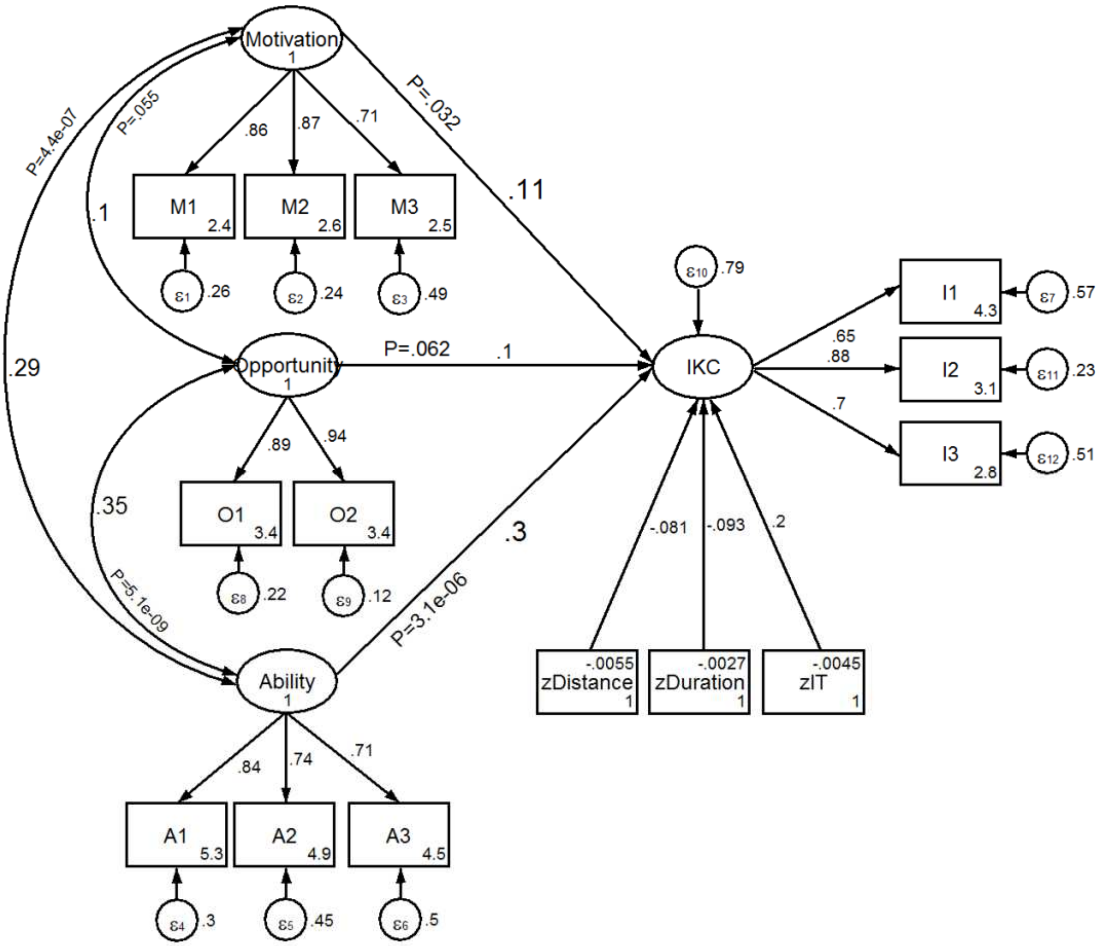

Figure 3.2. Structural model

Standardized (to variance) coefficients of the interrelated impact from the MOA factors together with the control variables on the extent of the IKC are presented in Figure 3.2. Coefficients of each questionnaire item, reflectively measuring each factor, are reported on causal straight arrows from latent factors to observed measurement items. Error terms of all latent and observed variables are isolated as exogenous latent variables. This is an improvement to the OLS models with regard to endogeneity issue. Ability's latent factor exhibits the highest impact on the IKC compared to Motivation or Opportunity. These impacts are also reported on the straight causal arrows in Figure 3.2. The curved arrows in Figure 3.2 represent the covariance of the MOA exogenous latent factors, reported with their p-values. Exogenous observed control variables' effects on the IKC are reported on each corresponding straight arrow. Conform to all a priori expectations, the set of control variables shows that the longer the distance between the two collaborators, the less the extent of their inter-organizational knowledge collaboration ($\beta_{zDistance} = -0.081$, $p < 0.10$). Long-distance knowledge collaboration relationships exhibit less extensive collaborations. The longer the duration of the collaborative project, the less the extent of knowledge collaboration ($\beta_{zDuration} = -0.093$, $p < 0.05$). The extent of availability of IT to support the knowledge collaboration process positively affects the extent of the IKC ($\beta_{zIT} = 0.200$, $p < 0.01$). These effects are consistent in all model specifications.

To establish the invariance of the factors and relationships, the data was divided into two groups of collaborations. One group included collaborations with partners from Southern or Eastern Europe and the other group included collaborations with partners from North or West of Europe. A Wald test reveals insignificant p-values and therefore fails to reject the null hypothesis of invariance between those two groups at 95% confidence interval. This result further supports the quality of the model design and specification.

3.5 Conclusion

The aim of this study was the specification of a model for the Inter-organizational Knowledge Collaboration (IKC) taking into account the intercorrelation between the MOA factors. The results showed that the MOA framework is applicable at an organizational level model. Also, the MOA factors are interrelated constructs. Drivers of the IKC thus can be condensed to be the three interrelated, yet distinct categories of motivations, opportunities, and abilities. The Constraining Factor Model (CFM) expressing the MOA framework with bottleneck in explaining the variance of the IKC reveals high levels of multicollinearity. Multicollinearity in the CFM results in coefficients that are hard to interpret. Likewise, the combined model, incorporating moderate and extreme complementarities, exhibited multicollinearity in the model of the MOA impacting the IKC. A multiplicative model does not provide more variance-explanation than a linear model and none of the interaction terms proves significant. This suggests that the linear model is as good as the multiplicative one. The linear model disregards any interrelationship between the MOA factors. Applying the SEM methodology leads to an improvement over the OLS methodology when dealing with intercorrelated explanatory variables acting jointly. Furthermore, SEM deals with heteroskedasticity, autocorrelation, and/or endogeneity problems by isolating the error terms. This enhances the modeling quality as compared to linear, constraining factor, multiplicative, or combined forms of the MOA expressions. The simultaneous regression method inherent in SEM facilitates the modelling of interrelated explanatory components. The covariance structure of latent exogenous explanatory variables provides an estimation of that interplay and SEM involves that covariance in the estimation of each causal path coefficient. The MOA were found to be the interdependent drivers of the IKC in that the excess/shortage of one factor increases/decreases the extent of the other two factors. Interdependent nature of the MOA joint impact means both synergy and dragging. The MOA framework not only provides a systemic approach in identifying the relevant factors, measuring their impact, and strategically defining the points of improvement, but also provides a method to reflect on the synergistic (or otherwise dragging) effects of those interdependent factors. Thus, the MOA as drivers of the IKC need to be addressed and invested in as an interdependent set. This functional form of the MOA representation helps in the provision of a better systemic understanding. As a result, managerial actions can be designed to leverage the MOA not only in parts but as a whole. There are two sets of managerial implications to these results:

First, the salient role of the Ability in inter-organizational setting of knowledge collaboration implies that the collage of diverse organizational cultures, vocabularies, tools, and routines which are shaping the IKC, necessitates higher levels of Ability to cope with these emerging challenges on an organizational level. Overall, for a better IKC, investments in the organizational capabilities, including specialized technical capabilities, generative, absorptive, disseminative, adaptive and responsive capacities exert the highest impact.

Second, the extent of inter-organizational knowledge collaboration is interdependently determined by the provided Motivation and available Opportunity. Underinvestment in motivation and opportunity have negative implications for organizations' knowledge collaboration directly, and indirectly by decreasing the Ability. Facing critical decision points in allocating their limited resources, organizations may be tempted to underinvest in motivation and opportunity. Underinvestment in motivation and opportunity going hand in hand with unnecessary overinvestment in ability development, advised by models displaying multicollinearity, drains organizational knowledge resources as well as financial resources ineffectively and inefficiently which may result in inter-organizational knowledge collaboration failure.

The focus of this study was on EU level FP funding: national programs may experience different dynamics, and would also be worth studying. The focus was on funded projects in FP7, the rejected or not-applied projects were excluded. This may explain challenges in establishing extreme complementarity: although minimums could act as bottlenecks in CFM, none of the observations completely lacked motivation, opportunity, or ability due to the sample-selection of funded projects. Future work can address these concerns by surveying a priori rejected or a posteriori collapsed inter-organizational knowledge collaboration projects.

Chapter 4:

Organizational Types' Impact on Knowledge Collaboration[19]

Abstract. Organizations collaborate with external actors in order to acquire knowledge resources they cannot develop internally for economic and/or technical reasons. Mode 2 and Triple Helix models have examined the role of different organizational types in collaborative creation and knowledge use. This chapter is an empirical investigation on whether universities differ from business-oriented or industrial organizational types with regard to the extent of their knowledge collaborations. Using SEM methodology, it demonstrates the role of universities in knowledge collaboration through a survey of 472 organizations in the 7th Framework Programme for Research and Technological Development of the European Commission, Energy theme (FP7-Energy). In line with the Triple Helix model, universities are found to exhibit more extensive knowledge collaboration than businesses. Also between-university collaborations are found to be more extensive knowledge collaboration relationship types than between-business relationships. The findings imply that : (1) Publically funded consortia should be aware that universities are more conducive and hence more effective in inter-organizational knowledge collaboration networks than other organizational types, particularly compared to for-profit business organizations. Universities should be included in these consortia. (2) Business organizations that do not have an extensive relationship with universities need to reconsider their partner portfolio and extend the

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[19] A paper version of this chapter (co-authored by V.E. Scholten and C.P. van Beers) is under review at the Journal of the Knowledge Economy

knowledge collaboration of their network by connecting to more universities. (3) Policymakers should not only involve academic organizations but also include groups of more than one university per consortium to enable between-university knowledge collaboration to boost collaborative knowledge exploration and exploitation of the consortia.

4.1 Introduction

In the last two decades, the output performance of organizations has increasingly been dominated by the production factor knowledge. Due to the increasing complexity of technology and markets, organizations cannot develop all required knowledge internally and therefore aim to collaborate with external actors. In particular, knowledge collaboration between universities and industry has received considerable attention. Since the 1990s, the mainstream understanding of knowledge collaboration has shifted from a linear process (frequently termed as 'Mode 1' or ivory tower) towards an iterative inter-organizational collaboration process. Researchers such as Gibbons et al. (1994) and Leydesdorff and Etzkowitz (1998) have proposed two knowledge collaboration models that explain the role of different organizational types in the collaborative production and utilization of knowledge. These are the Mode 2 and Triple Helix models respectively.

In Mode 2, knowledge production focuses solely on applicability. It is context-driven and problem focused. The university plays a subordinate role in innovation systems compared to business firms, and are hence said to be on the 'demise' path. Gibbons et al. (1994) contested the ivory tower knowledge production for linear innovation processes and concluded that production of new knowledge takes place outside the loci and disciplines of universities. In the Triple Helix model[20] (THm) (Leydesdorff and Etzkowitz 1998), knowledge production focuses on the simultaneous interaction of theoretical, practical, and legislative knowledge of several organizational types. The university in THm plays the role of a 'salient' actor that is central in innovation systems.

These opposing views call for evidence to further identify the role of universities in knowledge development through collaboration. Should universities be allocated more or fewer collaboration opportunities? Should collaboration consortia involving more universities be valued more or valued less? This chapter explores the differences of the two models and empirically

[20] Other research extended this model to four and five helices (Carayannis and Campbell 2011; Carayannis *et al*. 2012).

investigates their relevance to identify the role of universities in the context of the European Framework Programmes.

The role of universities in knowledge production and innovation systems (Edquist 2010) has been studied in the context of public-private research partnerships (Stiglitz and Wallsten 1999), agents of national economic competitiveness (Greenaway and Haynes 2000), patenting and licensing agents (Nelson 2001), and entrepreneurial academe (Mavi 2014) and led to different views on the relevance of universities in knowledge production and utilization. These different views are mainly based on conceptual debates rather than empirical investigations. They impose profound political implications (see e.g. Carayannis and Campbell 2011; Schoonmaker and Carayannis 2013) on the role of universities in knowledge collaboration networks. "Generally, scientists are oriented towards the reputation-based reward system of open science, while industry scientists face the commercial imperative to produce exploitable results" (Perkman and Walsh, 2007 p.273). Consequently, the authors called for further empirical research on whether knowledge collaboration is affected by organizational types. Furthermore, considerable research has been conducted on knowledge collaboration in business alliances, B&B, (Hagedoorn et al. 2000) and in university-industry alliances, U&B, (Florida and Cohen 1999). However, little attention has focused on university and university (U&U) knowledge collaboration relationships. This can be attributed to the financial and strategic aspects of these types of inter-organizational relationships. U&B and B&B relationships are perceived as more financially substantive compared to U&U relationships. U&B and B&B knowledge collaborations are also perceived to be strategically more critical than U&U relationships, due to the possible unintended spillover of strategic knowledge (e.g. trade secrets) to competitors. Examples of U&U collaboration include co-authorship, co-patenting, academic mobility, collaborative teaching (e.g. transnational student exchange programs), and transnational support for innovation and technology transfer (e.g. international incubation). U&U collaboration also occurs in development programs by national, regional or supranational authorities (Stiglitz and Wallsten 1999), for example, the Framework Programmes (FPs) for Research and Technological Development of the European Union (Caloghirou et al. 2001). Although there is ample literature on organizational learning and knowledge management, the nature of knowledge collaboration behavior between universities remains mostly unexplored and poorly understood (Bock et al. 2005; Milne 2007).

We argue that various organizational level factors have an effect on knowledge collaboration and that these depend on organizational type, e.g. university, industry and government. Therefore, organizational type may explain variations in the extent of inter-organizational knowledge collaboration. Our main research question is: Do universities differ from business-oriented[21] organizational types in the extent of their knowledge collaboration? We measure the extent of knowledge collaboration by its manifestations: (1) extent of involvement in group discussions; (2) extent of development of new ideas/skills due to collaboration; (3) extent of learning to exchange ideas/skills (adopted from Davenport and Prusak 1998 and Muthusamy and White 2005). he empirical examination of the two competing models assists evidence-based decision making by all organizational types: universities and businesses in partner selection, consortia in formation decisions, and governmental organizations in the resource allocation and division of labor. We aim to answer the research question at two levels:

(1) At an organizational level, do universities have more extensive knowledge collaboration than business organizations?

(2) At an inter-organizational level, does a University and University relationship type have more extensive inter-organizational knowledge collaboration than a Business and Business relationship type?

The next section describes the theoretical framework of inter-organizational knowledge collaboration. We examine the differences in organizational logic of a university versus a business-oriented organization and formulate our hypotheses. In the third section, we describe our method, data source, and operationalization. Section four reports the empirical results. The fifth section concludes.

[21] In this chapter 'business-oriented' and 'industrial' are treated as interchangeable terms and refer for profit making firms.

4.2 Knowledge Collaboration

Terminology and Rationale

Knowledge sharing between personnel is a key dimension of learning organizations and can contribute to organizational learning and innovation (Brown and Duguid 2001; Cohen and Levinthal 1990; Goh 1998). Previous research suggests a positive relationship between intra-organizational knowledge sharing and organizational performance (e.g. Harlow 2008; Srholec 2014). Furthermore, knowledge exploration and exploitation can also take place at the overlap of many different kinds of organizations (e.g. businesses, universities, research institutes, and governments) giving knowledge-based activities an inter-organizational dimension. To make inter-organizational knowledge collaboration possible, concepts of knowledge transfer (i.e. from sender to receiver), knowledge exchange (i.e. from sender to receiver and reciprocated), and knowledge sharing (from sender to multiple receivers) need to be combined into knowledge collaboration.

Inter-organizational knowledge collaboration networks are defined as formally established arrangements spanning different organizations aimed at pooling knowledge resources for new knowledge exploration and/or exploitation (Alter and Hage 1993; Freeman 1991; Powell and Grodal 2005). Alliances with other organizations are often recommended to acquire new knowledge, skills, and expertise to enhance the performance of organizations (Hamel 1991). Knowledge collaboration is considered to reduce the costs of attaining knowledge through risk sharing. It also reduces the cost of recognizing and solving problems, i.e. exploration (Sher and Lee 2004), and increases the knowledge utilization capacity of organizations. “Knowledge facilitates the use of other knowledge” (Powell et al. 1996, p.120). Existing, i.e. already explored, knowledge can potentially be utilized in new areas via inter-organizational knowledge collaboration, i.e. exploitation. The more heads and hands involved, the more knowledge exploration and exploitation capacity.

Theoretical Background

Florida and Cohen (1999) argue that a key role for universities in the knowledge economy is to be a 'collector of talent'. Universities educate, develop, and produce talent and consequently contribute to the quality of knowledge infrastructure in a country or a region. In a knowledge-based economy, universities constitute a key element of the national or regional innovation system, not only as a human capital provider/developer, but also as a seed-bed of new firms (Etzkowitz et al. 2000). However, Gibbons et al. (1994, p.76) assert that: "the tradition of university-based research is threatened by the encroachment of industry and profit-making mentality and values."

Variations in the extent of the knowledge collaboration based on organizational type can be used to reflect on the role of the universities in inter-organizational collaborations. However, heterogeneity in the extent of knowledge collaboration can also be attributed to variations in knowledge collaboration antecedents such as motivation, opportunity, and ability (MOA) (Argote et al. 2003). The MOA framework, originally developed at the individual level, is also known to be effective in explaining behavior at the organizational level (Clark et al. 2005). We use the MOA framework to disentangle the output variation due to organizational type and/or the MOA factors. By extracting the MOA impact, we can estimate the exact effects of organizational types. The MOA framework and its transposition to an organizational level is discussed in Chapter 3 of this dissertation.

Differences of university and business relationships: knowledge, a public or a private good

Inter-organizational knowledge collaboration is more challenging than intra-organizational collaborations especially when the collaborating organizations pursue different and often opposing organizational rules and agendas. A number of factors can shed some light on this statement.

Knowledge is essentially a public good. This is a shared resource from which every group member can benefit regardless of their contribution to its provision. No-one can be prevented from benefiting from knowledge once it has been provided; i.e. non-exclusivity. Moreover, the availability of knowledge resources does not diminish with usage (Olson 1965). Knowledge can be used simultaneously by many without diminishing its availability to any of the users, and it will not become depleted by usage (Foray 2004) i.e. non-rivalry. Adding established knowledge of one field/domain to a new field/domain enriches the existing knowledge base of both fields/domains, i.e. cumulativeness. Combining and re-utilizing knowledge in new contexts adds value to the original knowledge resource through validation and extension of its application scope. New knowledge solves problems of the recipient field/domain by extending its knowledge base. To conclude, knowledge is a non-excludable, non-rival, and cumulative resource that generates increasing returns through its systematic exploration and exploitation.

Some organizational types prefer knowledge to be privatized as 'proprietary knowledge' to be able to reap its benefits. Others publicize knowledge to gain the acknowledgement for both 'serving the public' and 'priority of discovery'. "What makes a knowledge-worker a 'technologist' rather than a 'scientist', in this usage, is not the particular cognitive skills or the content of his or her expertise [...] what matters is the socio-economic rule structures under which the research takes place." (Partha and David 1994, p.495) Depending on the socio-economic rules of organizations, knowledge can either be circulated as a public good or alternatively safeguarded as a private good.

Universities have institutional rules to spread knowledge as a part of their public mission (Partha and David 1994; Stern 2004). The university system is rooted in Mertonian norms of science (Merton 1973). Universities perform based on collegiate reputation-based institutional rules. For the academic system to work, publication or presentation of knowledge is crucial to trigger reputation building via disseminating as much knowledge as possible and to gain the priority of discovery. Mertonian 'communality' asserts complete and free disclosure (see Partha and David 1994 for detailed dynamics of knowledge sharing of scientists and technologists).

Hypotheses

The Mode 2 outlines the end of the universities' monopoly in knowledge exploration. The conclusion of Mode 2 model follows as: "universities, in particular, will comprise only a part, perhaps only a small part, of the knowledge producing sector." (Gibbons et al. 1994, p.85). Although the linear innovation models (taking an ivory tower monopolistic role for universities) are correctly dismissed in Mode 2, the resultant conclusion does not directly follow from the premises of wider knowledge exploration loci and disciplines. Universities may still comprise the crucial organizational type in inter-organizational knowledge collaborations and may still play a salient role in knowledge production. Indeed, universities in THm are viewed as important actors in the networks of knowledge-based activities (Cooke et al. 2004; Etzkowitz 1998). The THm pictures universities as 'entrepreneurial' or 'generative' institutions (Etzkowitz and Zhou 2006; Gunasekara 2006). As scientific knowledge is important for innovation and new business development (Mansfield and Lee 1996), universities have a more prominent role as actors in regional and national economic development. Accordingly, exploitation of university-generated knowledge has a stronger role in government policies (Lambert 2003). Universities have a direct role in society by commercializing research results, i.e. 'entrepreneurial science' and 'third mission' (Etzkowitz 1998; Martin 2003). Considering the extent of 'engagement in discussions', 'development of ideas or skills', and 'learning due to collaboration' as manifestations of the extent of inter-organizational knowledge collaboration, we propose the following hypothesis:

> *Hypothesis 1: Universities collaborate more extensively in inter-organizational knowledge networks than business organizational types.*

In business organizations, sharing valuable knowledge and admitting to require knowledge may be perceived as risky (Borgatti and Cross 2003). From an economic perspective, the cost to individuals may be in the effort and time spent in sharing knowledge. However, by sharing knowledge, businesses may help advance competitors at the cost of diminishing their own chances. Firms hesitate to enhance their rivals' knowledge base as long as this knowledge hoarding is not costly to their own knowledge base. Their primary concern is the appropriation of knowledge for creating a sustained competitive position which contributes to shareholder value. Openness to external actors is only used as a strategic mechanism to gain advantage (Chesbrough 2006). The business-oriented knowledge creating entities (e.g. commercial R&D) aim at extracting rent from their available knowledge and keep their knowledge as a proprietary commodity.

While universities aim to make knowledge as public as possible, businesses aim to keep their knowledge as private as possible. The two worlds of university and business have clear boundaries on their institutional rules and agendas that govern knowledge. These boundaries are the main obstacle to inter-organizational knowledge collaboration (Partha and David 1994). Universities make knowledge 'leaky' so that they become acknowledged as pioneering discoverers, whereas businesses make knowledge 'sticky' so that they can control a resource that is not available to their competitors (Brown and Duguid 2001). These leads to hypothesis 2.

> *Hypothesis 2: Knowledge collaboration between universities (U&U relationships) is more extensive than knowledge collaboration between businesses (B& B relationships)*

Controlling the Confounding Effects

In the empirical part of this study, we use a multivariate regression analysis that relates inter-organizational knowledge collaboration to the organizational types, the MOA framework, and a number of control variables. First, we explain the context of the knowledge collaborations used in this study.

Inter-organizational knowledge collaborations in this study take place in the project consortia in the European Union 7th Framework Programme for Research and Technological Development Energy theme (FP7-Energy). FP7-Energy constitutes project consortia each comprising numerous types of organizations: universities, businesses, research institutes, and administrative organizations. The main project variables include: the duration of the collaborative project, the geographical distance between the collaborators, and the availability of Information Technology (IT) to the members of the project consortium.

In project-based inter-organizational knowledge collaborations, the allocated work-load of the project is assumed to be proportional to the project's duration. A longer project means that more tasks need to be coordinated and performed, which might distract the collaborators from focusing on an extensive collaboration. Longer projects are also less likely to give the collaborators a sense of urgency that shorter projects do. Project duration is expected to negatively affect the extent of knowledge collaboration.

Geographical proximity and colocation are beneficial because such proximity increases the likelihood of communication between actors (Zahn 1991) and facilitates knowledge spillovers (e.g. Almeida and Kogut 1999; Malmberg and Maskell 2002). Geographical proximity entails that working close to the potential source of knowledge increases the probability and the extent of learning from that source. Borgatti and Cross (2003) have shown that the likelihood of having effective and efficient knowledge flows decreases as distance increases. Empirical studies on university spillovers have found that knowledge spillovers from universities are localized and contribute to higher rates of corporate patents or innovations in geographically bound areas (e.g.; Anselin et al. 1997; Feldman and Florida 1994; Fischer and Varga 2003; Van Der Panne and Kleinknecht 2005). Knowledge spillovers are "confined largely to the region in which the research takes place" (Hewitt-Dundas 2013, p.94). Geographical proximity is expected to positively affect the extent of knowledge collaboration.

Utilizing Information Technology (IT) systems in knowledge collaborations can support organizations. IT removes communication barriers and offers access to even geographically distant collaborators. The availability of IT is expected to positively affect the extent of knowledge collaboration.

4.3 Method

Approaches and Operationalization

The MOA framework posits that MOA components are interrelated and distinct concepts. We apply a Structural Equation Modelling (SEM) with *reflective*[22] measurements to match the theoretical framework's interrelated explanatory variables. SEM is useful for disentangling the effects of the theoretical constructs and/or confounding variables from the effects of the organizational/relationship types, which all contribute to variations in the extent of the knowledge collaboration.

Table 4.1 shows the operationalization of the constructs that are used in the empirical analysis. The list includes the dependent variable (i.e. knowledge collaboration, KC), a set of control variables (i.e. project duration, geographical distance, and IT availability), the MOA theoretical framework concepts (i.e. motivation, opportunity, and ability), and two sets of dummy variables (i.e. organizational type and inter-organizational relationship type).

We adapted the dependent variable KC to the inter-organizational context using Davenport and Prusak (1998) and Muthusamy and White (2005). We adopted the control variables from Gertler and Levitte (2005), Sher and Lee (2004), and Zaheer and McEvily (1999). The operationalization of the three MOA constructs is guided by Jarvenpaa et al. (1998), Muthusamy and White (2005), and Song and Parry (1993). The questionnaire items are listed in the Appendix.

[22] As opposed to *formative* measurements.

Table 4.1. Operationalization

Construct	Items
KC (dependent variable)	KC1-Extent of involvement in group discussions KC2-Development of new ideas/skills due to collaboration KC3-Extent of learning to exchange ideas/skills
Controls	zDuration-Collaborative project's duration zDistance-Geographical distance between the collaborators zIT-Extent of available IT systems relevant to knowledge collaboration
Motivation	M1-Availability of incentives to work on ideas M2-Existence of encouragement to keep trying M3-Formal promotion of knowledge collaboration
Opportunity	O1-Extent of additional (to contracted) spent time O2-Extent of additional (to contracted) spent effort
Ability	A1-Extent of organizational capability A2-Extent of specialized capability A3-Extent of success at execution of organizational plans
Organizational type	-Dummy variables for Business (B), University(U), Research institute(R), and Administrative (A)
Inter-organizational relationship Type	- Dummy variables for Business and Business (B&B), University and University (U&U), Research Institute and Research Institute (R&R), Administrative and Administrative (A&A), and six inter-type relationships: B&R, U&B, U&R, A&B, A&U, and A&R.

Dummy Variable Approach

Organizational/inter-organizational relationship types are included as exogenous observed dummy variables. Dummy variables are useful for modeling variables that are not conventionally measured on a numerical scale such as organizational type and inter-organizational relationship type. Including all categories of a variable in a regression equation introduces singularity in the moment matrix. The moment matrix singularity is due to the perfect linear multiple correlation among the categories[23] . Constraining the constant to zero or omitting one category in regression equations as a baseline are two alternative solutions to this issue (Suits 1957). Both solutions yield identical results (Suits 1957). In this research, we omit one category. However, the outcome of tests of comparative effects are dependent on the choices made about which group or groups are omitted and used as the baseline (Hayes and Preacher 2014). Therefore, we investigate three models with three different baselines for each hypothesis, to provide a more complete picture.

4.4 Data

Empirical inter-organizational knowledge collaboration studies often use quantitative datasets on patents, licensing, and co-authoring (e.g. Acs et al. 2002; Anselin et al. 1997; Coenen et al. 2004; Fischer and Varga 2003; Jaffe et al. 1992). Clearly, patent data excludes forms of collaboration that do not result in patents or types of innovation for which patents are not important. Although patents are a relevant measure of application-oriented collaboration, not all of such collaborations lead to a patent (Acs et al. 2002). The same holds for co-authorship and licensing. Transfer-based interactions between universities and industry (i.e. use of codified knowledge of research papers, patents or prototypes) play a moderate role, providing a need for studying 'bench-level' interactions in inter-organizational knowledge

[23] For instance, an organization which is not a business, a university, nor a research institute is determinatively an administrative organization according to this chapter's all-inclusive categorization of organization types.

collaboration networks (Perkmann and Walsh 2007). Studies on knowledge collaboration between universities mainly focus on co-authorship and citation counts of scientific papers or patents. This chapter complements these studies by investigating the university's roles from an application-oriented bench-level perspective (Godin and Gingras 2000, p.277).

An example of the 'bench-level' knowledge collaboration of diverse organizational types is the Framework Programmes for Research and Technological Development (FPs). FPs are an example of global inter-organizational knowledge collaboration that deal with the grand challenges of the society. More than €112 billion was spent on FP1 to FP7 until 2013 and an estimated additional €80 billion will be spent under the Horizon 2020 scheme. The Community Research and Development Information Service (CORDIS) website (available at http://cordis.europa.eu) provides detailed information on publically funded projects under the FPs. CORDIS dataset is relevant to this research since FPs represent collaborations of several organizational types and diverse inter-organizational knowledge collaboration relationships, and allows us to investigate these 'bench-level' knowledge collaborations. Moreover, providing a cross-border set of observations enhances the generalizability. Also, a homogeneous institutional norms of FPs across all project consortia, exerted by the EC and peer researchers, facilitate the interpretations of empirical results by avoiding the impact of outliers. We use the inter-organizational knowledge collaborations in FP7 Energy as a random sub-sample.

Details of the data source and the measurement model are provided in the subsection 3.3.

4.5 Results and Discussion

The measurement model by which the MOA constructs and the IKC dependent variable are measured (constructed) is identical to the Confirmatory Factor Analysis (CFA model) as reported in subsection 3.3 on pages 51-56. To establish the constructs as a valid and reliable set of variables, several tests are executed. Meeting the conservative model-to-data fit indices and exhibiting positive results for the reliability and validity tests indicate the appropriateness of utilizing the MOA independent variables and the IKC dependent variable in a structural model. The structural model consists of the latent constructs tested by the CFA and the variables of interest, i.e. organizational and inter-organizational types, as well as the control variables.

Table 4.2 lists data related to organizational and inter-organizational relationship types. Associations, government organizations, and not-for-profit organizations were pooled together and labeled as Administrative (A). Business organizations (B) are the most frequent organizational type in this FP7-Energy survey. Administrative organizations are the least frequent. Therefore, collaborative relationships involving administrative organizations are also the least frequent relationship types. Business and research institute (B&R), university and research institute (U&R), plus business and business (B&B) relationships were the top three most frequent relationship types[24].

[24] Sideridis *et al.* (2014), investigating the appropriate sample size of SEM methodology, found 50 to be a satisfying sample size for a four-latent construct model. Our sample of 472 respondents complies with those sample size considerations.

Table 4.2. Organizational and inter-organizational relationship types

Organizational type *(Respondent)*	Frequency	Percent	Inter-organizational Relationship	Frequency	Percent
Business (B)	175	37.08	**B&B**	65	13.77
University (U)	111	23.52	**U&U**	46	9.75
Research Institute (R)	132	27.97	**R&R**	57	12.08
Administrative (A)	54	11.44	**A&A**	13	2.75
			B&R	108	22.88
(Singled-out Partner)			**U&B**	59	12.50
Business (B)	144	30.51	**U&R**	73	15.47
University (U)	132	27.97	**A&B**	22	4.66
Research Institute (R)	173	36.65	**A&U**	18	3.81
Administrative (A)	23	4.87	**A&R**	11	2.33

Table 4.3 shows the descriptive statistics. KC and MOA constructs are centered, i.e. data points are linearly shifted to a mean of zero. Additionally, control variables (starting with ‘z’ in Tables 4.5 and 4.6) are standardized as z-scores, i.e. have zero mean and unit variance. The average duration of energy projects of FP7 was 929.5 days (i.e. ~31 months), with 29 days as standard error. The average travel time between the respondents and their paired partner organization was about four and half hour, with less than six minutes as standard error. The average extent of availability of IT systems was 2.8, with .07 standard error.

In Table 4.4, the MOA constructs and the dependent variable KC have different means in each category of organizational type. Except for Motivation, the mean differences are significant (F-test in ANOVA). This justifies the inclusion of MOA to explain the KC variation. Thus, to estimate the exact impact of organizational type on KC, we disentangled the KC variations due to MOA.

We estimated the impact of organizational type on the extent of knowledge collaboration using Dummy variables. The baseline for comparison by a dummy variable can be any of the major organizational types. The coefficients of the other organizational types in each model are a measure of the impact of those types compared to the baseline. We assigned three organizational types, i.e. business, university, and research institutes, as the baselines in three models. As administrative organizations constitute the smallest group in the observations, they were are not taken as the baseline. We applied the same dummy variable approach to measure the comparative impact of the remaining nine relationship types with B&B, U&U, and R&R as baselines in three models.

Table 4.3. Descriptive statistics

		N	Cronbach's α	AVE	Mean	Std. Error
Constructs:	**KC**	472	.78	.57	.0026	.0286
	Motivation	472	.85	.67	.0012	.0528
	Opportunity	472	.91	.83	.0017	.0471
	Ability	472	.80	.59	.0010	.0296
Unstandardized Controls:	**Duration** (days)	472			928.7542	28.9955
	Distance (7-point Likert scale 0-6)	472			2.8369[a]	.0615
	IT Availability (7-point Likert scale 0-6)	472			2.8242	.0722

[a] Corresponding to 4 hours and 32 minutes travel using respondents' usual media of transport

Table 4.4. Constructs' Means as per Organizational Type

	Business Mean (Std. Error)	**University** Mean (Std. Error)	**Research Institute** Mean (Std. Error)	**Administrative** Mean (Std. Error)	**ANOVA** F p-value
KC	-0.15 (0.05)	0.21 (0.06)	0.05 (0.05)	-0.06 (0.08)	**8.32*****
Motivation	-0.04 (0.08)	0.06 (0.13)	0.07 (0.09)	-0.12 (0.16)	0.50 $^{0.69}$
Opportunity	-0.17 (0.08)	0.10 (0.10)	0.14 (0.08)	-0.03 (0.13)	**2.84****
Ability	-0.13 (0.05)	0.14 (0.06)	0.13 (0.05)	-0.18 (0.09)	**7.37*****

* $p \leq .10$ ** $p \leq .05$ *** $p \leq .01$

Table 4.5 and Figure 4.1 (corresponding to university as the baseline: $Model_2$ in Table 4.5) report the results of comparative organizational types differences in three models: Business, University, and Research Institute, respectively in $Model_1$, $Model_2$, and $Model_3$. βs are the standardized regression coefficients which measure whether each organizational type exhibits more or less KC compared to the baseline. For example, a significant negative β for Business (β = -0.26, $p<0.01$) when University is the baseline (Model2) means that businesses exhibit significantly 26% less KC than universities.

$Model_1$ portrays 23% more KC for universities (β = 0.23, $p<0.01$) compared to businesses (i.e. the baseline). Based on the negative coefficients for business, research institute, and administrative organizational types in $Model_2$, and the significantly positive coefficient of University compared to Business in $Model_1$, we can conclude that universities collaborate more extensively compared to the other organizational types. Hypothesis 1 cannot be rejected. THm propositions hold while there is no evidence for the assertions of the Mode 2 model.

Moreover, the MOA components have a significant positive impact on KC in all models. As expected, the more motivation, opportunity, and ability of an organization, the higher the extent of knowledge collaboration. The control variables, project duration, geographical distance, and IT systems relevant to knowledge collaboration all significantly influence the extent of knowledge collaboration. As expected, project duration and geographical distance have a negative impact, whereas IT has a positive role in facilitating KC. The SEM structural model fits the data by meeting conservative cut-off points (as of CFA fit criteria) on all fit indices. These indices are reported in the last row of the Table 4.5.

Table 4.5. Results of SEM regressions of organizational types

		Model$_1$ β (S.E.)	**Model$_2$** β (S.E.)	**Model$_3$** β (S.E.)
Controls:	**zDuration**	**-0.10**** (0.05)	**-0.10**** (0.05)	**-0.10**** (0.05)
	zDistance	**-0.10**** (0.05)	**-0.10**** (0.05)	**-0.10**** (0.05)
	zIT	**0.22***** (0.05)	**0.22***** (0.05)	**0.22***** (0.05)
Theoretical Framework:	**Motivation**	**0.12**** (0.05)	**0.12**** (0.05)	**0.12**** (0.05)
	Opportunity	**0.10*** (0.05)	**0.10*** (0.05)	**0.10*** (0.05)
	Ability	**0.27***** (0.06)	**0.27***** (0.06)	**0.27***** (0.06)
Organizational Type:	**Business**	*Baseline*	**-0.26***** (0.06)	-0.09 (0.06)
	University	**0.23***** (0.05)	*Baseline*	**0.15***** (0.05)
	Research Ins.	0.09 (0.05)	**-0.16***** (0.06)	*Baseline*
	Administrative	0.06 (0.05)	**-0.11**** (0.05)	0.00 (0.05)
	SRMR	0.057	0.060	0.059

Dependent variable: extent of the knowledge collaboration.
βs are standardized coefficients. (S.E.) is standard error.
***N*= 472**
Model fit indices:
Log likelihood = -9493.997; **χ^2/df** = 1.88; **RMSEA [p close]** = 0.043 [0.875];
CFI = 0.964; **TLI** = 0.955
* p ≤ .10 ** p ≤ .05 *** p ≤ .01

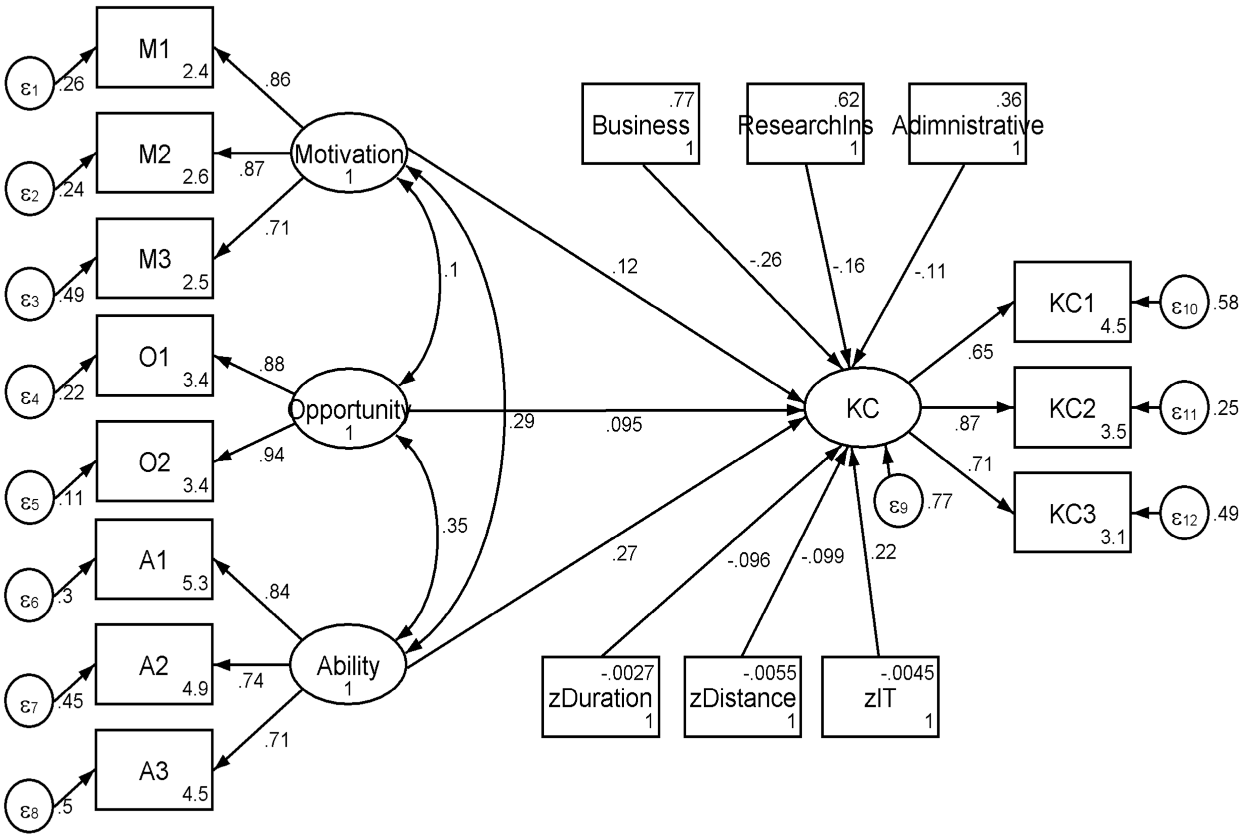

Figure 4.1. Structural Model

Figure 4.1 shows $Model_2$ in Table 4.5 with some extra information. Latent constructs KC, Motivation, Opportunity, and Ability are presented by eclipses. Means of observed endogenous variables (measurement items) are shown at the bottom right corner of each rectangle. By reflective measurement, the latent variables load on measurement items. The loadings are presented by unidirectional straight arrows. Covariance of interrelated explanatory variables are shown in curved bidirectional arrows. Causal influence of the theoretical framework constructs, control variables, and dummy variables of interest are shown in straight directional arrows towards the latent endogenous variable KC. All errors of variance of endogenous variables are isolated as latent exogenous variables in circles.

Table 4.6 reports the results of SEM analysis with a dummy variable approach for different inter-organizational relationship types. Depicted by significant positive coefficients of $Model_4$ in Table 4.6, the B&B relationship shows a significantly less extensive knowledge collaboration compared to U&U ($\beta = 0.23$, $p<0.01$), R&R ($\beta = 0.11$, $p<0.10$), and U&R ($\beta = 0.14$, $p<0.05$) relationship types. Depicted by significant negative coefficients of $Model_5$ in Table 4.6, the U&U relationship shows a significantly more extensive knowledge collaboration compared to B&B ($\beta = -0.26$, $p<0.01$), R&R ($\beta = -0.14$, $p<0.05$), A&A ($\beta = -0.16$, $p<0.01$), B&R ($\beta = -0.28$, $p<0.01$), U&B ($\beta = -0.18$, $p<0.01$), U&R ($\beta = -0.14$, $p<0.05$), and A&B ($\beta = -0.10$, $p<0.10$) relationship types. Taking into account the theoretical constructs and contextual confounding variables simultaneously, the U&U inter-organizational relationship type shows a significantly more extensive knowledge collaboration compared to the B&B relationship type. Contrary to the claims of the Mode 2 model, all evidence is in line with the propositions of the Triple Helix model in inter-organizational knowledge collaborations. Hypothesis 2 cannot be rejected.

The impacts of motivation, opportunity, ability, project duration, geographical distance, and the availability of IT systems kept their significance and sign in all six models. Based on all models, conform to our expectations, we can conclude that the higher the MOA, the higher the KC. The longer the duration of a project, the less the extent of the knowledge collaboration, which can be attributed to coordination issues in longer projects. This can also be caused by the lack of a sense of urgency in longer projects. Geographical distance between the collaborators has a significant negative impact on the extent of the knowledge collaboration. The availability of the IT systems has a significant positive impact on the extent of the knowledge collaboration. Fit indices of $Model_4$ – $Model_6$ can be found in the last row of Table 4.6.

Table 4.6. Results of SEM regressions of inter-organizational relationship types

		Model$_4$ β (S.E.)	**Model$_5$** β (S.E.)	**Model$_6$** β (S.E.)
Controls:	**zProject Duration**	**-0.09**** (0.05)	**-0. 09**** (0.05)	**-0. 09**** (0.05)
	zDistance	**-0.10**** (0.05)	**-0.10**** (0.05)	**-0.10**** (0.05)
	zIT Availability	**0.20***** (0.05)	**0.20***** (0.05)	**0.20***** (0.05)
Theoretical Framework:	**Motivation**	**0.12**** (0.05)	**0.12**** (0.05)	**0.12**** (0.05)
	Opportunity	**0. 09*** (0.05)	**0. 09*** (0.05)	**0. 09*** (0.05)
	Ability	**0.27***** (0.06)	**0.27***** (0.06)	**0.27***** (0.06)
Relationship Type:	**B&B**	*Baseline*	**-0.26***** (0.07)	**-0.12*** (0.06)
	U&U	**0.23***** (0.06)	*Baseline*	**0.13**** (0.06)
	R&R	**0.11*** (0.06)	**-0.14**** (0.06)	*Baseline*
	A&A	-0.03 (0.05)	**-0.16***** (0.05)	**-0.09*** (0.05)
	B&R	0.04 (0.07)	**-0.28***** (0.07)	-0.11 (0.07)
	U&B	0.07 (0.06)	**-0.18***** (0.06)	-0.04 (0.06)
	U&R	**0.14**** (0.06)	**-0.14**** (0.07)	0.01 (0.06)
	A&B	0.06 (0.05)	**-0.10*** (0.05)	-0.01 (0.05)
	A&U	0.07 (0.05)	-0.07 (0.05)	0.01 (0.05)
	A&R	0.08 (0.05)	-0.03 (0.05)	0.03 (0.05)
SRMR		0.045	0.046	0.046

Dependent variable: extent of the knowledge collaboration.
βs are standardized coefficients. (S.E.) is standard error.
***N*= 472**
Model fit indices:
Log likelihood = -8863.2597; χ^2/**df** = 1.51; **RMSEA [p close]** = 0.033 [1.000];
CFI = 0.966; **TLI** = 0.960
* p ≤ .10 ** p ≤ .05 *** p ≤ .01

Limitations and Implications

The focus of this paper was on EU level FP funding. National programs or non-EU funding schemes may have different dynamics, and would also be worth studying. FP projects are funded after being peer-reviewed in accordance with a common review protocol, thus all projects showed above-standard performance. Since rejected proposals and not-applied proposals are omitted by this selection method, the input data might exhibit pre-selection sample-bias. Consequently, the implications of the results specially hold for above-standard performing organizations. For generalization, future work could address these concerns by including a priori rejected or a posteriori failed inter-organizational knowledge collaboration project. Moreover, universities and businesses were categorized uniformly. A more comprehensive categorization of e.g. technical/non-technical university or public/private business may enhance the level of detail.

The findings nevertheless conform to the Horizon 2020 context and imply that universities' salient role can be strengthened in order to facilitate inter-organizational knowledge collaboration networks. More specifically, publically funded consortia can be composed taking into account that universities are more conducive and hence more effective in inter-organizational knowledge collaboration networks than other organizational types, specifically compared to for-profit business organizations. Replacing universities with businesses in a consortium is likely to reduce the extent of knowledge collaboration in the consortium.

We need to take into account the fact that business organizations are not conducive to inter-organizational knowledge collaboration. These organizations benefit from keeping knowledge private and proprietary. We cannot expect businesses to broadcast knowledge to their rivals. Business organizations that do not have an extensive relationship with universities need to reconsider their partner portfolio and extend the knowledge collaboration of their network by connecting to more universities. Stereotyping university knowledge as 'knowledge in books' can change to a recognition of academic knowledge as a 'practical' potential source of sustained competitive advantage.

Universities have the main responsibility and power in shaping regional economic capability and competitiveness in the knowledge-based economy. Academia can become aware of this power and use it to conduct and extend inter-organizational knowledge collaborations. Stereotyping academics who collaborate with businesses as turncoats can change to a recognition of business-oriented collaboration as a source of insight for theory development and/or the validation of research results as well as an accomplishment of the public mission.

Administrative structures, specifically the European Commission, can use these findings in their perspective on diverse organizational types in inter-organizational knowledge collaboration for resource allocation and division of labor. Administrative structures might instill the findings of this research in their new policies on the structure of the to-be-funded consortia, for instance, in Horizon 2020. The message to the policymakers is to involve academic organizations in groups of more than one per consortia to enable between-university knowledge collaboration.

Finally, collaborating organizations can address the need for shorter, more easily manageable projects powered by direct contacts by decreasing the distance between their sites/partners and by providing collaboration-related IT systems to their operational team.

4.6 Conclusion

By studying the collaborative knowledge exploration and exploitation in inter-organizational knowledge networks of FP7-Energy, we empirically examined the impact of organizational type on the extent of inter-organizational knowledge collaboration at the organizational and at the inter-organizational level. Empirical evidence depicted the central role of universities in innovation systems by studying bench-level knowledge interactions rather than examining scientific papers or patent count/citations. The results provide empirical support for the predictions of the Triple Helix model (Leydesdorff and Etzkowitz 1998) and show no evidence for the claims of the Mode 2 model (Gibbons et al. 1994). At the organizational level, our findings show that universities are the organizational type with the most extensive knowledge collaboration with regard to the extent of their involvement in group discussions, in the development of new ideas/skills, and in extent of learning to exchange ideas/skills (as manifestations in a reflective construction).

At an inter-organizational relationship level, our results show that a U&U knowledge collaboration relationship is the most extensive compared to other major relationship types. B&B relationships are less extensive than U&U. In this paper, being open or closed to external organizations is ascribed to the stance of an organization with regard to the public or private dimension of knowledge: whether an organization aims to 'safeguard' its knowledge and keep it proprietary and private, or aims to publically 'disseminate' as much knowledge as possible. The differing extents of inter-organizational knowledge collaborations can be attributed to the different and often opposing organizational agendas of businesses and universities. These findings are most relevant for resource allocation of publically funded projects (e.g. Horizon 2020) in which underinvestment in and exclusion of the role of the universities can likely negatively impact the extent of inter-organizational knowledge collaboration. Policymakers might not only involve academic organizations, but also include groups of more than one university per consortium to enable between-university knowledge collaboration and to boost collaborative knowledge exploration and exploitation of the consortia.

Chapter 5:

Knowledge Collaboration Proximity Dimensions: Substitution of Effects[25]

Abstract. This chapter empirically investigates the impact of geographical, network, and social proximity as well as the substitution of their effects to explain the extent of inter-organizational knowledge collaboration. Using survey data and network data of the Seventh Framework Program (FP7) Energy theme, econometric results reveal that the effect of social proximity is a substitute for the effects of network and geographical proximity. For innovation strategy and policy, these results imply that an ideal setup for inter-organizational knowledge collaboration is a consortium of organizations that *in order*: (1) have close inter-organizational social relationships, (2) are geographically closely located, and (3) are at the periphery of an inter-organizational knowledge collaboration network.

[25] A paper version of this chapter (co-authored by V.E. Scholten and C.P. van Beers) is submitted to the Regional Studies journal.

5.1 Introduction

In the study of geographical agglomeration effects, inter-organizational knowledge collaboration (IKC) is often used to explain regional structures of firm-level economic activity (e.g., Malmberg & Maskell, 2002, 2006). While some contend that knowledge interactions[26] take place more easily over shorter distances (Gertler & Levitte, 2005), others argue that longer distance interactions are more beneficial (Balland, Suire, & Vicente, 2013; Bathelt, Malmberg, & Maskell, 2004; Huber, 2012).

Distant knowledge partners are expected to be gainful as more likely providers of novel substance for knowledge interaction, whereas physically proximate sources of knowledge are more likely to provide duplicated pieces of knowledge (Breschi & Lissoni, 2001). At the same time, knowledge collaboration with distant partners is more challenging and costly compared to proximate collaboration partners due to accessibility problems. This implies that distant knowledge collaborators are likely to provide novel knowledge but are more difficult to access, while proximate knowledge collaborators provide less novel substance, despite having more opportunities and means to send and receive knowledge. The present chapter examines this trade-off between novelty and accessibility benefits of knowledge collaboration vis-à-vis geographical proximity as well as network and social dimensions of proximity. The aim is to look at the singular and the joint effects of geographical, network, and social proximity dimensions to reveal a possible substitution of effects.

Different dimensions of proximity either enable or hamper knowledge collaborations. The results of theoretical and empirical analyses looking into proximity and collaboration suggest that geographical, organizational, institutional, cognitive and social proximity drive collaborations in various combinations and ways (e.g. Boschma 2005; Broekel and Boschma 2012). Knoben and Oerlemans (2006) examined: which dimensions of proximity are relevant in inter-organizational collaboration (IOC) and how are they defined? They stated that 'disentangling effects of the different types of

[26] intended as in the case of collaboration or unintended as in the case of spillover.

proximity on IOC can provide very valuable information' (2006, p. 86). Boschma (2005, p. 72) also contributed conceptually and called for empirical analyses to 'isolate and identify individually the effects of each dimension of proximity' to find out 'in what way the different dimensions of proximity are related to each other', since 'the impact of geographical proximity can only be assessed in empirical studies when controlling for the other dimensions of proximity, because they may act as powerful *substitutes*.'(emphasis added)

Substitution relationship is between two variables: either due to a negative moderation or by masking. In moderation the value of one independent variable modifies the effect of another. In masking, the explained variance by one variable (i.e. its effect) reduces the variance explanation of another.

Negative moderation happens, for instance, if the effect of geographical proximity, on a knowledge collaboration, is reduced for higher values of social proximity. In this case the social proximity value is substituting (i.e. negatively regulating) the *effect* of geographical proximity.

Masking happens, for instance, if the *effect* of geographical proximity on a knowledge collaboration (i.e. explained variance) becomes negligible when the *effect* of social proximity is taken into account. In this second case the social proximity effect is substituting (i.e. masking) the effect of geographical proximity. In masking, an initially non-zero and significant effect becomes close-to-zero and insignificant after including another explanatory variable. The loss of magnitude and significance in masking is due to the loss of degrees of freedom for estimating the error that does not compensate the reduction in the sum of squares of the error.

This chapter empirically investigates the substitution of effects (i.e. masking) of geographical, network, and social dimensions of proximity in the explanation of the extent of inter-organizational knowledge collaboration.

We mapped, measured, and merged project data of the European Union Seventh Framework Programme of Research and Development Energy theme (FP7-Energy) with the survey data of 457 FP7-Energy participants. The context of the data narrows down the dimensions under investigation to geographical, network, and social proximities.

The present study contributes by examining the substitution of effect of different dimensions of proximity by estimating the simultaneous impact of proximity dimensions using Structural Equation Modelling (SEM). This chapter is organized as follows: The next section provides an overview of the literature on the dimensions of proximity and the organizational level antecedents of inter-organizational knowledge collaboration. We also formulate our hypotheses in this section. Section 3 outlines our methods, and Section 4 reports and discusses the data collection and the results of the empirical analyses. Section 5 presents the conclusions.

5.2 Theory and Hypotheses

Boschma (2005) proposes the following five dimensions for proximity: cognitive, organizational, social, institutional, and geographical and outlines their co-existence and possible impacts on each other. Knoben and Oerlemans (2006) add two dimensions to this list, namely cultural and technological dimensions. They condense these seven dimensions into three, i.e., organizational, technological, and geographical, to reduce overlap. They also address the importance of the level of analysis in each dimension: general and dyadic. For example, geographical proximity can entail general agglomeration or dyadic physical distance depending on the level of analysis.

However, in these review papers, organizational and social proximities can conceal another dimension, i.e., network proximity. Network proximity is essentially different from the rules and routines (i.e. discussed in organizational proximity), and from the kinship and friendship (i.e. addressed in social/personal proximity). The effects of network proximity are frequently understudied in the literature of geographical proximity[27].

[27] Network proximity, notably studied by Rice and Aydin (1991), investigates attitudes in social information processing.

Geographical Proximity

Geographical proximity entails that working close to the potential source of knowledge increases the probability and the extent of learning from that source. Geographical proximity is known to facilitate knowledge spillovers (Almeida & Kogut, 1999; Jaffe, Trajtenberg, & Henderson, 1993; Malmberg & Maskell, 2002). However, there are three opposing views on the impact of geographical distance on knowledge collaboration. The first view advocates the Death of Distance. Hence, the impact of geographical distance on knowledge collaboration has diminished to zero (Howells, 2002). The second view suggests an inhibiting impact and argues that non-proximate collaborators have less face-to-face contact, suffer from inefficiencies of time-zone mismatch, and generally have poorer access and hence possess less collaborative capacity[28]. The third view advocates a facilitative impact of geographical distance on knowledge collaboration by emphasizing that distant knowledge collaborators are likely to provide novel knowledge. We elaborate these views below.

Echoing Marshall's (1920) three mechanisms of labor market pooling, input sharing, and knowledge spillovers, some researchers (e.g., Cairncross, 2001) advocated the Death of Distance by arguing that the transportation and IT revolutions of the 20th century had eroded the effects of distance. Labor, goods, and knowledge can easily and cheaply move around the globe, and geographical distance has lost its relevance in determining collaborative and innovative capacities. However, Cairncross (2001, p. 5) holds: 'The death of distance loosens the grip of geography. It does not destroy it.' More recent studies show that this grip of geography is not even loosened. Maggioni and Uberti (2009, p.718) studying four phenomena of Internet hyperlinks, EPO co-patent applications, the mobility of Erasmus students, and European research networks conclude that: 'far from the claim of the "death of distance", geographical distance is relevant for determining the structure of inter-regional knowledge flows.' They argue that the collocated synchro-

[28] Torre and Rallet (2005) advocate the sufficiency of 'temporary geographical proximity' for inter-organizational knowledge collaboration which is made possible, easy, and cheap by transportation revolutions.

nous interactions are superior to distant interactions in the co-creation of knowledge, and that IT cannot fully cover the shortcomings, at least not the currently available IT. Olson and Olson (2003) also show that IT barely supports advantages of collocated synchronous interactions, if any at all.

On the access side, geographic proximity and colocation are beneficial because proximity increases the likelihood of communication between actors (Borgatti & Cross, 2003; Zahn, 1991) and facilitates knowledge interactions (e.g., Almeida & Kogut, 1999; Jaffe et al., 1993; Malmberg & Maskell, 2002) through access advantages over distant collaborators. Levels of cooperation can be increased by simply providing subjects with an occasion to see one another (Frey & Bohnet, 1996; Orbell & Dawes, 1991). The main finding of empirical studies on university spillovers is also that knowledge spillovers from universities are localized and contribute to higher rates of corporate patents or innovations in geographically bound areas (e.g., Anselin, Varga, & Acs, 1997; Feldman & Florida, 1994; Jaffe, 1989; Van Der Panne & Kleinknecht, 2005). Knowledge spillovers are ‘confined largely to the region in which the research takes place’ (Hewitt-Dundas, 2013, p. 94). Borgatti and Cross (2003) also showed that effective and efficient knowledge collaboration likely decreases as distance increases.

On the novelty side, long-distance knowledge collaboration can be beneficial (Glaeser, Kallal, Scheinkman, & Shleifer, 1991). Innovativeness arises from high-quality and non-redundant knowledge. In a geographically dispersed meta-network, the eyes and ears of members are in different parts of the meta-network, and therefore they have access to a greater variety of task-related information, which can open up new possibilities for knowledge collaboration (Monge, Rothman, Eisenberg, Miller, & Kirste, 1985). Work group members in distant locations are also likely to have different social networks outside of the group because members run into different persons in hallways, see different people at meetings, and communicate socially with different folks (Conrath, 1973). Thus, the likelihood of redundancy of knowledge in geographically distant settings is lower compared to this likelihood in local settings (Davenport, 2005; McEvily & Zaheer, 1999; Zaheer & Bell, 2005).

It can be argued that access benefits of proximate collaborators and novelty benefits of distant collaborators have produced these mixed results in the literature. Without taking into account other dimensions of proximity to correct for accessibility-novelty variations, the effect of geographical proximity cannot be evaluated. Boschma (2005, p. 72) asserts ‘the impact of geographical proximity can only be assessed in empirical studies when controlling for the other dimensions of proximity.’ Two geographically distant collaborators might possess novel knowledge but certainly have difficulty of access. Two geographically proximate collaborators similarly might possess duplicated knowledge but certainly benefit from ease of access. Solely looking at geographical proximity, accessibility gains are expected to outweigh novelty losses. This leads to the following hypothesis:

> *Hypothesis 1: Geographical proximity has a positive effect on the extent of inter-organizational knowledge collaboration.*

Network Proximity

In a network defined by past and present collaborations, partners who are close in a network are likely to be more similar in knowledge content to each other and are therefore less likely to provide novel knowledge. Redundancies of knowledge held by structurally proximate actors decrease the novelty of their knowledge interactions. Having worked with a set of partners in other projects or having shared contacts with those partners leaves little room for new, novel, and insightful knowledge collaboration. This fits well in the structural holes argument (Ahuja, 2000; Burt, 1992; Fleming, King, & Juda, 2007) suggesting that nodes at the dense core of a network are saturated with redundant knowledge, while nodes around structural holes at the periphery can benefit from the possession/reception of novel and strategic knowledge.

Although network proximity also entails easier access, the access benefits are argued to be outweighed by extreme novelty loss. First, the presence of a shared contact does not necessarily provide access benefit. The shared contact might be strategically hesitant to connect an organization directly to their contacts. However, the knowledge flowing throughout the network directly or indirectly reaches all network members, and more uniformly at the core. The smaller the network path distance, the more uniform the knowledge bases. Second, having worked with an organization in the past might equally enable or inhibit future collaboration based on positive or negative past experiences. However, repetitive collaborations leave little room for novel knowledge. Singularly looking at the network proximity effects on IKC, novelty losses are expected to be more than accessibility gains. This leads to the following hypothesis:

> *Hypothesis 2: Network proximity has a negative effect on the extent of inter-organizational knowledge collaboration.*

Social Proximity

In the study of the innovation networks, social proximity is central to describe the network's evolution i.e., which linkages are more likely to be formed. To estimate the likelihood of collaboration between two organizations, we need to consider how structurally proximate the members of the two organizations are, and to reflect on the extent of their social relationship (Grabher, 2002). In this perspective, the formation of a collaboration is contingent. For example, Boschma and Frenken (2010) reflecting on social relationships, state that 'Such relationships carry information about *potential partners* and thereby increase the *probability* of organizations *to engage* in innovation networks.' (emphases added, p.122-3)

Studying the extent of an existing collaboration requires a different perspective on social relationships and thus on social proximity. In a network of organizations that are already in collaboration, the linkages are not contingent. Instead, the extent to which those linkages are fruitful is contingent to nodal, dyadic, or network level variations. In a network sketched by inter-organizational collaborations on a consortium basis, two already collaborating organizations are neighboring nodes. By having a geodesic distance of 1, these two hypothetical network proximate organizations might or might not have members who maintain close social relationships. Such contingent social relationships may potentially determine the extent of such actualized collaboration. Thus, looking at the invariant network, geodesic distance of those hypothetical organizations does not reveal their social proximity. Indeed, in the social network of friendship/kinship of individuals, network proximity corresponds with the social proximity revealing the social relationships. Social proximity in the study of collaboration output (instead of the likelihood of collaboration) of organizations is related to the extent to which some members of an organization maintain close social relationships with some members of the partnering organization.

Social relationships between members of partnering organizations positively impact the extent of knowledge collaboration in at least two distinct ways. First, they reduce the likelihood of conflict by increasing trust. '[T]he perceived risk of conflict is also lower as social proximity adds to trust among organizations.' (Boschma & Frenken, 2010, p.123) '[S]ocial relations not only co-ordinate transactions but are also vehicles that enable the exchange of knowledge because of mutual trust.' (Knoben & Oerlemans, 2006, p.78) Second, they increase the likelihood of knowledge spillover through informal channels. 'Social proximity also plays a role in informal knowledge exchange between employees affiliated to different organizations.' (Boschma & Frenken, 2010, p.123)

On the access side, social proximity at the organizational level provides access benefits that are far beyond the contractual or authority-based provisions. Additionally, social distance between partner organizations may lead to misunderstanding and/or knowledge hoarding, limiting the extent of inter-organizational knowledge collaboration. When organizations in a knowledge collaboration are socially distant, i.e., their members lack close social relationships, conflicting behaviors, misunderstandings, and interaction inefficiencies can be expected. Social distance of organizations involved in knowledge collaboration can lead to all kinds of impediments, interruptions, and hindrances that cannot be avoided by contractual means, yet can potentially screen all devised plans and tools aimed at supporting an inter-organizational knowledge collaboration. Socially proximate organizations are better equipped to tap into the resources embedded in their relationship than socially distant actors.

On the novelty side, the close social relationship of the members of two collaboration partners regards their type of bonding which understandably does not interfere with the substance of their knowledge collaboration or their knowledge bases. Thus, social proximity is not expected to pose any novelty loss. This leads to the following hypothesis:

> *Hypothesis 3: Social proximity has a positive effect on the extent of inter-organizational knowledge collaboration.*

Motivation Opportunity Ability Framework

We adopt the motivation, opportunity, and ability (MOA) theoretical framework (Argote, McEvily, & Reagans, 2003; Blumberg & Pringle, 1982; Maclnnis & Jaworski, 1989) to account for the effects of the organizational level antecedents of knowledge collaboration. Given these organizational level variations, we include three measures of proximity together with some possible contextual confounding variables as controls in order to examine their impact on the extent of knowledge collaboration. By using the MOA framework, we can correct for the variation in IKC due to different levels of antecedents in different organizations. By extracting the effects of the MOA components, we can refine some observed organization related variations in IKC and can exclusively examine the effects of the proximity dimensions. The MOA framework is discussed in detail in Chapter 3.

5.3 Methods

Measuring Network Proximity

Network proximity is revealed at three levels: (a) dyadic, (b) general nodal, and (c) general network. Structural equivalence and geodesic distance are two examples of dyadic network proximity. Structural equivalence measures the similarity between two nodes. Geodesic distance measures the shortest path (number of edges) between two nodes of interest. Closeness-centrality and eccentricity are two examples of general nodal level. Closeness-centrality is the sum of the length of the shortest paths between the node and all other nodes in a network. The more central a node is, the closer it is to all the other nodes[29] and the more it can absorb knowledge from all other nodes or alternatively disseminate a node's knowledge to the whole network. Eccentricity is the maximum distance of a node to all other nodes . Average path distance and network diameter are examples of general network level measures of proximity. Average path length, as a measure of overall network connectivity, is the average number of steps (edges) on the shortest paths for all possible dyads.

We can measure the similarity of the connections of two nodes and study the structural equivalence at a dyadic level. A structural equivalence measure for network proximity, as suggested by Rice and Aydin (1991), focuses on the similarity of the structure of the relationship between two nodes. Two structurally equivalent nodes, despite the similarity in the patterns of their relationships, might actually lack an easily accessible (if any at all) route of connection for knowledge collaboration while path-distance-based measures objectively take the length of such a connecting route into account as a measure of ease of access: a dyadic route in geodesic distance, a one to all route in closeness-centrality, and an all to all route in average path length. Therefore path-distance-based measures are the most appropriate to use in the present study[30].

Geodesic distance is useful in studying the network formation and evolution, and is uniformly 1 for partners that are already in collaboration. Average path length studies are useful in comparing, for example, the knowledge networks of Europe and the US, or publically funded and privately funded knowledge networks. In this chapter, we measure network proximity by closeness-centrality, since the network of collaborations is already in place.

[29] In a disconnected graph, all vertices are defined to have infinite eccentricity.

[30] Geodesic path distance was not applicable considering the fact that all partner organizations in a consortium are directly linked to each other, thus, having an invariant geodesic distance of 1.

5.4 Data, Results, and Discussions

The empirical research in this study focuses on the Seventh Framework Program (FP7) Energy theme. The data source and the relevant quality tests are described in subsection 3.3.

Operationalization of Variables

Table 5.1 reports the operationalization of the variables, the constructs, and their sources in the literature. It includes the dependent variable (i.e., inter-organizational knowledge collaboration, IKC), the independent variables (i.e., geographical, network, and social proximities), the MOA constructs (i.e., motivation, opportunity, and ability), and a set of control variables (i.e., organizational size, number of past FP participations, IT availability, and project duration). We measured the dependent variable, IKC, and the MOA constructs on a 7-point Likert scale from 0 to 6 (not at all, very little, a little, somewhat, much, very much, and extremely). The questionnaire items are listed in the Appendix.

Proximity Measures

Only a few empirical studies exist on the joint effects of geographical and non-geographical dimensions of proximity on the extent of inter-organizational knowledge collaborations that are already in place (See Grabher, 2002 for the study of the network formation). A notable example, Broekel and Boschma (2012), consider cognitive (technological), organizational (dichotomous public/private), social (dichotomous a shared past employment), and geographical (physical distance) dimensions to explain the formation and innovative performance of inter-firm collaborations.

However, in FP7-Energy, participating organizations have already formed a network of collaborations. This means we need to consider the contextual boundaries of the network, which shape the choice of the proximity measures. In FP7-Energy, we observe a uniform cognitive and technological proximity Organizations, that already have submitted their proposal, are expected to have adequate cognitive proximity with little variation due to deliberate partner selection. The peer-reviewed and accepted proposals are also expected to possess adequate technological proximity with little variation due to proven partner compatibility.

Table 5.1. Operationalization

Construct	Items	Source in literature
IKC	I1-Extent of involvement in discussions	Davenport and Prusak (1998)
(dependent variable)	I2-Development of new ideas/skills due to collaboration	Muthusamy and White (2005)
	I3-Extent of learning to exchange ideas/skills	
Motivation	M1-Availability of incentives to work on ideas	Song and Parry (1993)
	M2-Existence of encouragement to keep trying	
	M3-Formal promotion of knowledge collaboration	
Opportunity	O1-Extent of additional (to contracted) spent time	
	O2-Extent of additional (to contracted) spent effort	
Ability	A1-Extent of organizational capability	Jarvenpaa, Knoll, and Leidner (1998)
	A2-Extent of specialized capability	Muthusamy and White (2005)
	A3-Extent of success at execution of organizational plans	
Geographical Proximity	zGP- Travel time between the two organizations	
Network Proximity	zNP-Closeness-centrality measure	Sabidussi, 1966
Social Proximity	zSP-Extent to which a close social relationship is maintained with some members of the partner organization	
Controls	zSize-Organizational size (number of employees)	Gertler and Levitte (2005)
	zFP-Number of past FP participation	Zaheer and McEvily (1999)
	zIT-Extent of available IT systems	Sher and Lee (2004)
	zDuration-Collaborative project's duration	

Moreover, the rules of the game are the same, with no variation for the participating organizations in all consortia, and are imposed top-down by the European Commission via guidelines and procedures. That means that institutional proximity is invariant at the organizational level since the European Commission is their sole governing body.

Thus, there is no variation in the cognitive, technological, or institutional proximity dimensions, which therefore cannot be used in the empirical analysis. The focus is on three proximity dimensions: travel-time (dyadic geographical proximity), closeness-centrality (general nodal level network proximity), and the extent of maintaining close social relationships with some members of the partner organization (dyadic social proximity).

We measure geographical proximity by travel time on a 7-point Likert scale from 0 to 6 (<30 minutes, 30-60 minutes, 1-3 hours, 4-6 hours, 7-9 hours, 9-11 hours, and >11 hours). Travel time provides a better measure of efforts to overcome distance than absolute geographical distance in kilometers/miles due to the varying connectivity of different routes and ease of access to transportation media. Travel time takes those variations into account and better represents the accessibility aspect of geographical proximity. We measured network proximity by closeness centrality, which models the knowledge collaboration of nodes based on the inverse of their network distance from all other nodes. Network proximity here corresponds to having a smaller sum of path lengths to all other nodes of a network. The more closeness central a node is, the shorter its total distance is to all other nodes. Hence such a node is located at the core of the network. The less closeness centrality a node is, the more the node is located at the periphery. We measured network proximity by linking the FP7-Energy participating organizations on a consortium basis. Given that some organizations (participants) had more than one participation (two or more consortia membership under FP7-Energy), we illustrated a network of organizations' partnerships (i.e., edges) and calculated the closeness centrality of its nodes (i.e., organizations) as a standardized to size measure. Social proximity is measured by unifying the organizational, cultural, and social dimensions, following Knoben and Oerlemans (2006). We measured the perceived level of maintaining close social relationship with some members of the partner organization on a 7-point Likert scale from 0 to 6 (not at all, very little, a little, somewhat, much, very much, and extremely).

Control Variables

Four control variables are used in the empirical analysis. The size of the organization is measured as the number of employees on a 12-point Likert scale (from <5 to >10,000 employees). In general larger organizations possess more resources and more specific knowledge resources to enhance their knowledge collaboration. Strong financial resources hand in hand with an extensive knowledge base are the main advantages of larger organizations regarding IKC. Capital advantages provide more opportunities to engage in a knowledge co-creation and/or co-utilization process, while an extensive knowledge base feeds substance into these processes. Organizational size is expected to positively affect the extent of knowledge collaboration. Organizational size is also expected to covary with the Ability construct.

We measured the number of past participations in FP projects as count data. Past participations are expected to result in more hands-on experience which further develops learning-by-doing. Organizations with previous participation in FP consortia are expected to have a more extensive inter-organizational knowledge collaboration. Past participation in FP projects is expected to positively affect the extent of knowledge collaboration. Past participation in FP projects is also expected to covary with the Ability construct.

We measured the extent of available Information Technology tools relevant to knowledge collaboration on a 7-point Liker scale (not at all, very little, a little, somewhat, much, very much, and extremely). IT reduces communication barriers between organizations and broadens access to geographically distant collaborators, which leads to a direct positive impact on inter-organizational knowledge collaboration and an indirect impact by enhancing ability. The extent of available IT is expected to positively affect the extent of knowledge collaboration. The extent of available IT is also expected to covary with the Ability construct.

We measured project duration as the number of days of each project. Lengthy projects can get out of hand and drain energy of the collaborators as more efforts have to be made to manage coordination tasks. Project duration is expected to negatively affect the extent of knowledge collaboration. All control variables were standardized as z-scores prior to the structural modelling.

Descriptives

The descriptive statistics of the independent and control variables in the structural model are provided in Table 5.2. Table 5.3 shows that the bilateral correlation coefficients of the three proximity measures are close to zero and insignificant. Hence, we cannot find a direct inter-relationship between these three dimensions. This implies that an organization's network proximity does not correspond to its geographical or social proximities. Geographical and social proximities are also found to be independent of each other.

As expected, the three control variables, organizational size, the number of past FP participations, and the extent of available IT correlate positively and significantly with the Ability construct (see Table 5.3).

Table 5.2. Descriptive Statistics of independent and control variables

		N	**Mean**	**Std. Dev.**
Proximity Measures	**Geographical Proximity (GP: raw 0-6 Likert)**	474	3.158†	1.337
	Network Proximity (NP)	460	0.406	0.070
	Social Proximity (SP: raw 0-6 Likert)	474	3.158	1.591
Controls (raw)	**Size (1-12 Likert for <5 to >10,000)**	474	6.977	3.146
	Past FP (number)	474	3.177	3.072
	Available IT (0-6 Likert)	473	2.831	1.570
	Duration (in days)	474	929.488	630.611

†Corresponding to 4 hours and 19 minutes travel using usual media of transport

Table 5.3. Correlations between the independent and control variables

Correlations between the independent variables		**GP**	**NP**	**SP**
Proximity Measures	**Geographical Proximity (GP: raw 0-6 Likert)**	-		
	Network Proximity (NP)	0.013 [p=0.784]	-	
	Social Proximity (SP: raw 0-6 Likert)	0.060 [p=0.194]	-0.066 [p=0.156]	-

Correlations between the control variables and Ability		**Ability**
Controls (standardized)	**zSize**	0.132***
	zPast FP	0.185***
	zIT	0.253***
	zDuration	0.054 [p=0.243]

* $p \leq 0.10$ ** $p \leq 0.05$ *** $p \leq 0.01$

Structural Model

To model the effects of the three proximity dimensions on the IKC, we propose the structural model[31] illustrated in Figure 5.1. The structural model shows that the IKC latent construct is reflected by its three indicators (I1- I3 from the Confirmatory Factor Analysis, CFA) and is affected by three latent MOA constructs (motivation, opportunity, and ability), three proximity measures (zGP, zNP, and zSP), and four control variables (zSize, zFP, zIT, and zDuration). The error terms are clustered around four organizational types (Business, University, Research Institute, and Government) to adjust for IKC variation of different organizational types. It is expected that, for instance, universities share similar IKC trends, but that these vary when other organizational types are examined (see Chapter 4). Thus, the error terms in estimating IKC can be clustered around organizational type. To estimate the exact effects of the three proximity dimensions, the MOA variation and the confounding contextual variations are controlled for. Then, zGP, zNP, and zSP are assigned to affect IKC separately and jointly in five models. These causal paths are shown in gray in Figure 5.1.

Substitution of effects in a simultaneous structural model can be detected by scanning the changes in these causal paths based on the presence/absence of an effect acting as a substitute (mask). For example, in the structural model in Figure 5.1 the effect (i.e. coefficient and its significance level) of zGP on the IKC in the absence of zNP and zSP effects can be compared to that effect in the presence of zNP and/or zSP effects. In case such impact shrinks in magnitude/significance, it can be interpested that in the explanation of the variations in the IKC, the effects of zNP and/or zSP substitute the effect of zGP.

Results of the Structural model

Table 5.4 reports the SEM regression results of five models to show the separate and the joint effects of the three dimensions of proximity on IKC. Model_1 models the singular effect of geographical proximity. As expected,

[31] the corresponding measurement model is detailed in the subsection 3.3.

geographical proximity between collaborators had a positive impact (β_{zGP} = 0.087, $p<0.05$) on IKC. Hypothesis 1 cannot be rejected if we consider the singular effect of this dimension. This result suggests that access benefits outweigh the costs of novelty losses experienced by geographically proximate collaborators. All three MOA constructs showed a significant positive effect ($\beta_M = 0.137$, $p<0.01$; $\beta_O = 0.096$, $p<0.01$; $\beta_A = 0.268$, $p<0.01$) on IKC. The signs, sizes, and significance levels of these determinants of organizational level variations of IKC are robust throughout the five models. The MOA framework refines IKC variation and the remainder variation is specially related to the proximity dimensions. The control variables show signs in line with a priori expectations. Organizational size positively affects IKC, however, insignificantly ($p = 0.236$) in $Model_1$. Past FP experience (β_{zFP} = 0.158, $p<0.01$) and the extent of IT availability ($\beta_{zIT} = 0.178$, $p<0.01$) show significant positive effects. As expected, project duration shows a negative significant impact ($\beta_{zDuration} = -0.098$, $p<0.05$) on IKC. All covariance paths in the five models in Table 5.4 (except zSize covariance with Ability in $Model_2$, $Model_4$, and $Model_5$) are positive and significant as expected. To check the model-to-data goodness of fit, several fit indices are reported. Standardized Root Mean Square Residual (SRMR) is the fit index of a structural model which is the same for the clustered and not clustered error terms. To enable fit statistics beyond SRMR, we estimated those five models without clustering. $Model_1$ – $Model_5$ fitted the data considering the conservative cut-off points depicted earlier for CFA in all the indices.

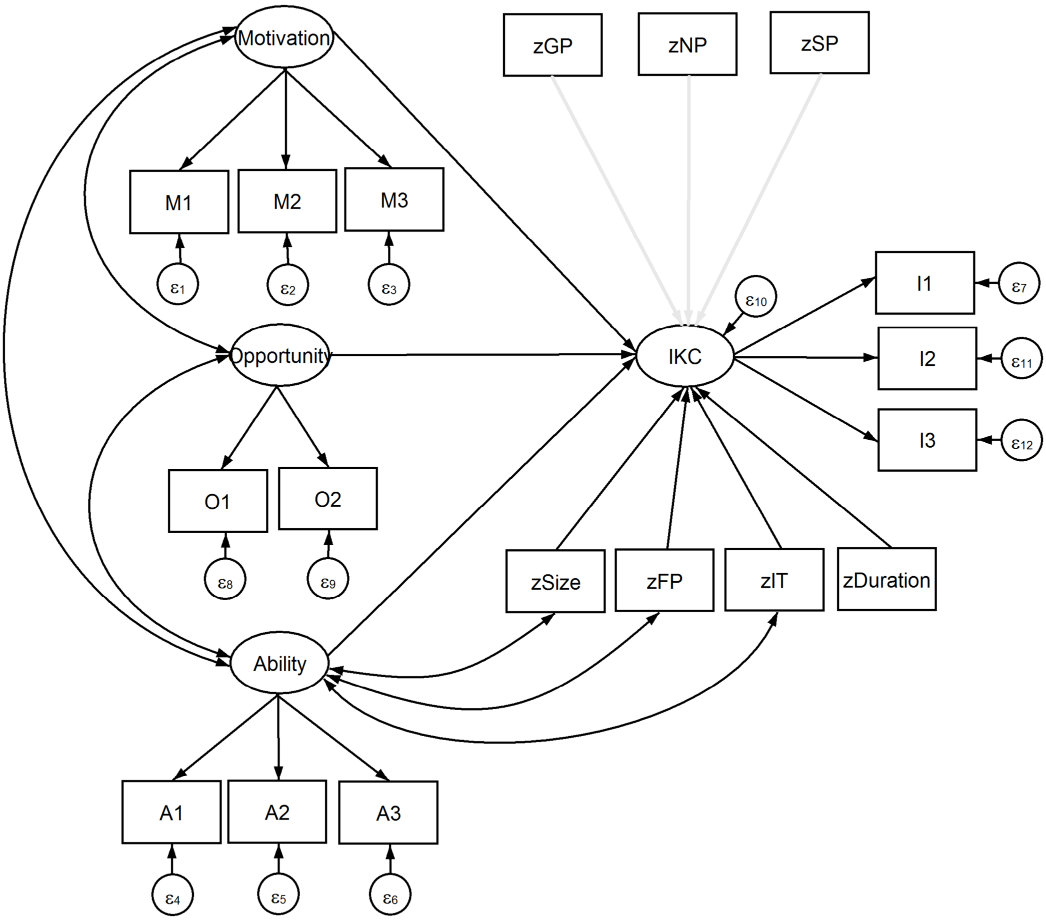

Figure 5.1. Structural model

Table 5.4. Results of SEM regressions

	Model$_1$ β (S.E.)	**Model$_2$** β (S.E.)	**Model$_3$** β (S.E.)	**Model$_4$** β (S.E.)	**Model$_5$** β (S.E.)
Motivation	**0.137***** (0.052)	**0.111**** (0.059)	**0.178***** (0.041)	**0.141**** (0.056)	**0.178***** (0.043)
Opportunity	**0.096***** (0.024)	**0.095***** (0.025)	**0.038***** (0.016)	**0.093***** (0.022)	**0.037***** (0.013)
Ability	**0.268***** (0.067)	**0.269***** (0.065)	**0.203***** (0.063)	**0.277***** (0.067)	**0.213***** (0.065)
Geo Proximity (zGP)	**0.087**** (0.041)	-	-	**0.088**** (0.038)	**0.057*** (0.033)
Network Proximity (zNP)	-	**-0.067***** (0.016)	-	**-0.068**** (0.019)	-0.028 (0.019)
Social Proximity (zSP)	-	-	**0.353***** (0.020)		**0.343***** (0.018)
zSize	0.051 (0.043)	**0.079**** (0.038)	**0.073*** (0.038)	**0.078**** (0.036)	**0.084***** (0.029)
zFP	**0.158***** (0.049)	**0.177***** (0.050)	**0.124***** (0.040)	**0.172***** (0.052)	**0.128***** (0.041)
zIT	**0.178***** (0.052)	**0.168***** (0.049)	**0.145***** (0.055)	**0.177***** (0.052)	**0.152***** (0.056)
zDuration	**-0.098**** (0.053)	**-0.100**** (0.044)	**-0.108***** (0.033)	**-0.097**** (0.041)	**-0.106***** (0.032)
Cov(Motivation~Opportunity)	**0.099**** (0.043)	**0.100**** (0.044)	**0.100**** (0.044)	**0.100**** (0.044)	**0.100**** (0.045)
Cov(Motivation~Ability)	**0.282***** (0.017)	**0.280***** (0.018)	**0.281***** (0.017)	**0.283***** (0.018)	**0.284***** (0.019)
Cov(Opportunity~Ability)	**0.326***** (0.013)	**0.333***** (0.015)	**0.338***** (0.013)	**0.334***** (0.015)	**0.347***** (0.015)
Cov(zSize~Ability)	**0.135***** (0.047)	0.067 (0.051)	**0.137***** (0.052)	0.067 (0.051)	0.065 (0.051)
Cov(zFP~Ability)	**0.208***** (0.017)	**0.171***** (0.009)	**0.169***** (0.017)	**0.174***** (0.009)	**0.134***** (0.006)
Cov(zIT~Ability)	**0.173**** (0.073)	**0.177**** (0.071)	**0.158**** (0.071)	**0.166**** (0.072)	**0.136**** (0.069)
N	457	457	457	457	457

Table 5.4. Results of SEM regressions (*Continued*)

	$Model_1$	**$Model_2$**	**$Model_3$**	**$Model_4$**	**$Model_5$**
SRMR	0.047	0.052	0.062	0.051	0.063
Log likelihood	-9905.322	-9874.269	-9878.671	-10518.584	-11134.333
			Model-to-Data Fit Statistics (without clustering)		
chi^2 /df	1.831	2.059	2.236	1.970	2.266
RMSEA [Pclose]	0.043 [0.871]	0.048 [0.605]	0.052 [0.356]	0.046 [0.737]	0.053 [0.301]
CFI	0.969	0.961	0.956	0.960	0.945
TLI	0.960	0.950	0.943	0.949	0.930

Dependent variable: extent of the inter-organizational knowledge collaboration.
βs are standardized coefficients. (S.E.) is standard error.
Standard errors are clustered around 4 organizational types: Business, University, Research Institute, and Government
* $p \leq 0.10$ ** $p \leq 0.05$ *** $p \leq 0.01$

$Model_2$ estimates the singular effect of the network proximity. As expected, network proximity has a significant negative effect (β_{zNP} = -0.067, p<0.01) on IKC. The singular effect of network proximity supports the novelty argument. Knowledge collaborators that are close to the core of the network lack novelty hence exhibit less extensive knowledge collaboration. This suggests that access benefits through network proximity are outweighed by the costs of novelty loss. Hypothesis 2 cannot be rejected. The control variables, zSize (β_{zSize} = 0.079, p<0.05), zFP (β_{zFP} = 0.177, p<0.01), and zIT (β_{zIT} = 0.168, p<0.01) show a significant positive effect, which is in line with our expectations. As expected, project duration has a significant negative effect ($\beta_{zDuration}$ = -0.100, p<0.05) on IKC in $Model_2$.

$Model_3$ estimates the social proximity of the collaborators. Conform to expectations, social proximity has a significant positive impact (β_{zSP} = 0.353, p<0.01) on IKC. Hypothesis 3 cannot be rejected. Having a close social relationship enhances accessibility and positively and significantly improves the extent of IKC. As expected, the MOA constructs, control variables, and covariance paths all show significant effects on the extent of IKC.

$Model_4$ estimates the joint impact of network and geographical proximities. Examining proximity in two dimensions of geography and network reveal similar results to the singular effects. The geographical and network proximity effects do not substitute for each other's effects. Geographically proximate collaborators, controlled for their novelty by network proximity, have significantly more extensive knowledge collaboration (β_{zGP} = 0.088, p<0.05) than geographically distant counterparts. Controlling for the access benefits of geographical proximity, the novelty loss of network proximity (β_{zNP} = -0.068, p<0.01) is apparent. $Model_4$ is a manifestation of accessibility-novelty trade-off. Geographical proximity, representing accessibility, has a positive effect on IKC with comparable impact size (standardized β coefficients) to the absolute value of the negative impact of the network proximity, a representation of the novelty dimension.

$Model_5$ includes the social proximity dimension in $Model_4$. The joint impact of the three dimensions of proximity reveals that the effects of network and geographical proximities are substituted by the effect of social proximity. The negative effect of network proximity shrinks to less than half and becomes insignificant (β_{zNP} = -0.028, p=0.139) when the effects of social proximity are simultaneously accounted for. This change is not a result of multicollinearity as: a) the bilateral correlations of dimensions of proximity (Table 5.3) are close to zero and insignificant, b) all models $Model_1$ – $Model_5$ fit the data with conservative cut-off points with negligible fluctuations, and c) no change of sign is witnessed for any variable. Therefore, it is likely that socially proximate collaborators exhibit significantly more extensive knowledge collaboration regardless of the closeness centrality in their network. The positive impact of geographical proximity shows a sharp decline in the magnitude in $Model_5$ (β_{zGP} = 0.057, $p<0.10$). This sharp decline signals that given a close social relationship among members of the partnering organizations, geographical proximity/distance is rendered ineffective. This is in line with the assertions of Boschma (2005) for substitution of effects. In $Model_5$, social proximity effect acts as a powerful substitute for the effects of network and geographical dimensions of proximity.

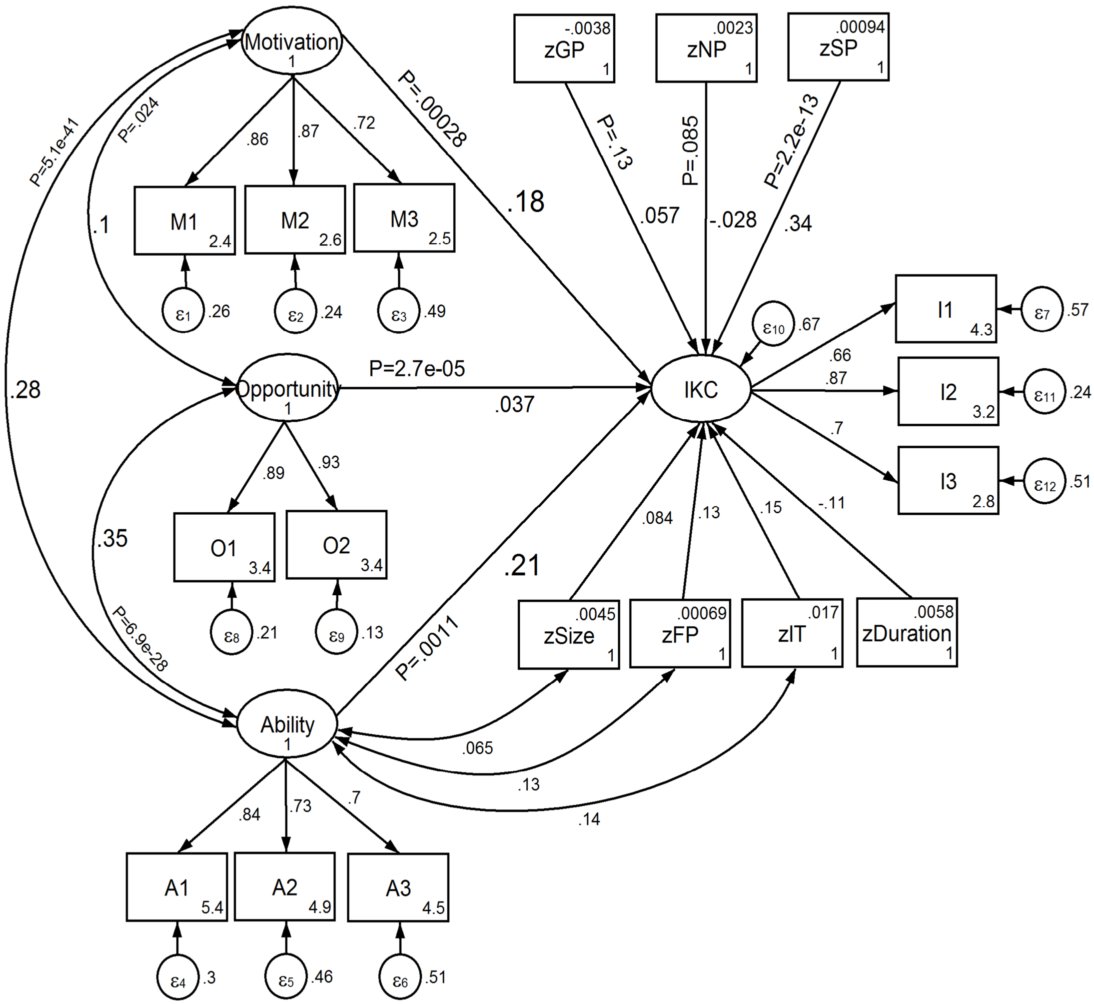

Figure 5.2. Structural Model ($Model_5$ in Table 5.4)

5.5 Conclusion and Future Research

This chapter suggests two aspects along which proximity and the multifaceted impacts of its diverse dimensions can better be understood: accessibility and novelty. The empirical findings reveal that proximity is indeed a multidimensional concept. Geographical proximity has a significant positive effect on IKC, providing an advantage for organizations which collaborate with shorter travel times. This effect suggests that accessibility benefits of geographically proximate organizations outweigh the costs of reduced novelty. Opposite, network proximity studied through closeness centrality, has a significant negative effect on IKC. This effect is interpreted as loss of novelty at the core of a network while holding an advantageous stance for organizations collaborating at the periphery (i.e., low closeness centrality). Social proximity, studied by the extent of maintaining close social relationships with some members of the partner organization, has a significant positive effect on IKC. The impact of social proximity is almost three times greater than the impact of geographical or network proximity (in absolute terms). This effect suggests that accessibility benefits of socially proximate organizations outweigh the costs of less novelty. Accessibility benefits of socially proximate collaborators are linked to trust mechanisms as well as to informal channels for knowledge interaction.

Dimensions of proximity simultaneously exert their impact together. For example, the singular impact of geographical proximity is greater than the joint impact of geographical proximity and social proximity. Moreover, the effect of proximity in a dimension can substitute the positive/negative effect of the other proximity dimensions. The empirical results reveal that social proximity effect substitutes the negative effects of the excess of network proximities. When members of the partner organizations are socially proximate, lack of novelty due to network proximity does not exert its negative impact on an inter-organizational knowledge collaboration.

Social proximity effect also substitutes for the positive effects of the geographical proximity, though not as drastically as the substitution of the network proximity effect. An ideal setup for an extensive inter-organizational knowledge collaboration is a consortium of organizations that are geographically closely located with little travel time and time zone difference, are situated at the periphery of an inter-organizational collaboration network, and most importantly promote and sustain a close social relationship among their members.

The focus of this chapter was on EU level FP funding: national programs or non-EU funding schemes may experience different dynamics, and their differences (including their network level variations) would also be worth studying. The FP projects are funded after being peer-reviewed according to a common standard review protocol, thus all observations showed technological proximity of the partners and above-standard performance. Similarly, through the process of deliberate consortium formation, partner organizations are expected to be uniform regarding their cognitive proximity. Consequently, the implications of the results specially hold for above-standard performing organizations. For a wider generalization, future work could address these concerns by surveying a priori rejected or a posteriori collapsed inter-organizational knowledge collaboration project to be able to shed light on a wider set of proximity dimensions.

Nevertheless, this study provides a fresh insight on the characteristics of a fruitful inter-organizational knowledge collaboration in relation to three dimensions of proximity. Considering the context, the results hold specifically for H2020 consortia. Rules and procedures, as well as participants and countries in FP7 are similar to those of H2020. Therefore, the results and implications of this study are strategically important not only for the participating organizations in consortium formation and/or inter-partner relationship management, but also for the policymakers and proposal reviewers to better adjust and appraise the conditions of an extensive inter-organizational knowledge collaboration.

Chapter 6:

Concluding Remarks

Innovation through inter-organizational knowledge collaboration can be enhanced by managing several organizational and inter-organizational factors. Regarding the research questions raised in Chapter 1 and in light of the research findings, this chapter outlines the implications of the preceding chapters' results for the innovation strategy of organizations and innovation system policy. The focus was around four aspects to understand and enhance inter-organizational knowledge collaboration: investigating correspondence of knowledge type and organizational type in knowledge integration; examining organizational-level determinants of knowledge collaboration and their interplay; inspecting the role of universities in knowledge collaboration networks; and studying the singular and joint effects of proximity dimensions, probing for the substitution of effects.

In section 6.1, a summary of the investigations and their results are presented along with their implications for the innovation strategy of organizations and innovation system policy. This chapter closes with limitations of this research and possibilities for future research.

6.1 Summary of the Findings, Implications, and Reflection

To examine '*Which knowledge types are processed by which organizational types?*' Chapter 2 conceptually examined three knowledge types: episteme, techne, and phronesis. Three institutional types of organizations were identified: universities, businesses, and governments. Considering organizations of each institution as knowledge integrating machines, it was argued that the knowledge type - subjected to integration - should correspond with the institutional type. Allowing for episteme, techne, and phronesis as knowledge types, and universities, businesses, and government organizations as the institutional types, a correspondence of knowledge and institution types was outlined through the institutional specialization of knowledge integration.

Furthermore, through organizational diversification, it was observed that diverse organizations belonging to each institution type may venture outside their institution's core knowledge typology and integrate other types of knowledge. Techne, the specialization of businesses, would for instance be integrated by a university as in a technical university and/or an academic technological spin-out. Likewise, episteme, the specialization of universities, would be integrated by a business as in a scientific corporate R&D lab.

Discussing knowledge meta-integration by synthesizing specialized institutional knowledge integration and organizational knowledge integration diversification, the rationale for inter-organizational knowledge collaboration was put forward: diversification through integration of all specialized knowledge types. Coalescing diverse types of specialized knowledge provides a basis for innovation, since novel combinations arise from such blending, as well, cross-fertilization becomes possible by linking problems and solutions of otherwise isolated domains. Public-private knowledge collaborations, which lie at the heart of the innovation system, are clear examples of meta-integration of specialized knowledge types. The implications for the innovation strategy of organizations and innovation system policy are threefold:

(I) Strategic positioning of organization regarding knowledge type composition: Each organization, e.g. a university or a business, can contribute to the economy by engendering a unique proportion of three main knowledge types: episteme, techne, and phronesis. Diversification through integration of diverse knowledge types in novel proportions provides each organization with a competitive edge by which an inimitable value is created. Rather than an institution-based categorization of organizations for partner selection and/or funding allocation, the unique knowledge-type portfolio of organizations need to be assessed. There are indeed technology-based applied universities as well as science-oriented research firms.

(II) Elevating knowledge pieces by meta-integration: beyond intra-organizational knowledge integration, organizations collaborate with external partners to integrate their specialized knowledge type with that of other organizations. Each knowledge piece possesses a potential for value creation in other domains. Meta-integration is a process through which such potential is actualized and other aspects of the meaning of a knowledge piece are unveiled. Innovation system policy can carefully select the partnering organizations in order to maximize the meta-integration gains. By looking at the core knowledge-type portfolio of the prospective partnering organizations, duplication can be eliminated by giving more opportunity to complementary knowledge portfolios. As well, by reaching out to the 'close innovators', the private and public benefits of open innovation can be communicated so that more organizations contribute to and benefit from the meta-integration knowledge pool.

(III) Normative deliberation of actions' consequences ought not to be outsourced: Ethical bearings of actions need to be considered, deliberated, and anticipated by all actors. Specialization in phronesis does not exempt other economic actors from such normative deliberation. Responsible research and innovation, responsible business, and responsible governance take place by self-audit and self-regulation rather than following orders or recommendations from external parties. Organizations can involve normative deliberation in their innovation strategy, especially when collaborating with external parties. The innovation system policy can integrate checks and balances on the existence / quality of such deliberation by the consortium

members in the selection process and grant allocation. Rather than seeing activities such as corporate social responsibility and responsible research and innovation as a bonus or an additional activity, organizations and policy need to address normative deliberation as the base upon which all the other activities are built and appraised in every single organization.

To investigate *'Which organizational level variables determine the extent of inter-organizational knowledge collaboration?'* and *'How those determinants jointly influence the collaboration behavior?',* Chapter 3 examined the motivation, opportunity, and ability (MOA) framework at an organizational level to explain knowledge collaboration. Since MOA was proposed and tested on an individual level, special attention was paid to theoretically transpose MOA to an organizational level. A Structural Equation Modelling (SEM) methodology was utilized to empirically assess this transposition.

The MOA framework, resting on a set of broad yet distinct concepts, poses profound challenges for modelling and estimation. The challenges are mainly due to the inter-relatedness of the explanatory variables: motivation, opportunity, and ability are correlated. Past attempts to estimate MOA in behavioral studies faced multicollinearity issues. This dissertation's third chapter proposed and successfully tested the Structural Equation Modelling (SEM) technique using reflective measurements as a methodological solution to estimate the MOA framework with correlated explanatory variables. MOA were found to jointly impact inter-organizational knowledge collaboration with an interdependent functional form. That is: higher motivation increases the extent of IKC directly, as well, it corresponds with increases in the levels of opportunity and ability, hence jointly increasing the extent of IKC. The same mechanism holds for the other two determinants of IKC. This interdependent mechanism encompasses that the excess/shortage of one factor increases/decreases the extent of the other two factors. These findings imply that:

(IV) Motivation, opportunity, and ability are interdependent factors: Strategizing on these drivers of knowledge collaboration as independent and isolated input factors is misleading. Organizations aiming at fostering inter-organizational knowledge collaboration need to attend these factors all at once to benefit from their joint effects rather than being harmed by focus-

ing on one or two factors. Consider the literature on the role of incentives which disregards the role of ability or opportunity and aim at shaping the innovation strategy and policy. Or consider the literature on absorptive capacity (as a component of ability) that does not concern motivation or opportunity: organization's collaboration capacity development, partner selection, and applicant appraisal need to all include motivation, opportunity, and ability interdependently. The innovative output of a knowledge collaboration is affected by the interdependent MOA of the involved organizations. Ideally, innovation system policy would evaluate the applications and allocate funding resources based on the consortium members' organizational level motivation, opportunity, and ability as an inseparable set of criteria. A shortage in either of these factors should not be treated as compensable by the other two factors.

To identify 'Ho*w organizational type impacts the extent of inter-organizational knowledge collaboration?'* the IKC variation based on organizational type was studied in Chapter 4. Distinction between the core knowledge types of diverse organizational types was sketched in Chapter 2. Chapter 4 performed an empirical comparison of the extent of IKC of generic organizational types: university, business, research institute, and government.

The role of universities, specifically, in the innovation system is highly debated. Among scholars and practitioners there are opposing views advocating a progressive or otherwise a regressive role for universities. The innovation strategy of organizations in partner selection and innovation system policy in resource allocation and the extent of inclusion is critically depending on the perceived / actual extent of knowledge collaboration of different organizational types. Such perceptions are not always pointing at one direction: the Mode 2 model of innovation, for instance, sees universities as regressive actors of the innovation system and predicts their role to demise. Public policy, following the Mode 2 viewpoint, has to slash research funding and downplay the role of universities in shaping innovation strategy and policy. A trend that many researchers in many countries are dealing with after the 2008 crisis and consecutive austerity measures. Alternatively, the Triple Helix model sees universities as progressive actors of the innovation system and stresses their salient role. Public policy, following the Triple Helix viewpoint, has to increase research funding and provide more room for universities to play their role. In this view, universities' involvement in innovation is a way out of the crisis and is seen as a powerful engine for economic growth. The empirical study in Chapter 4 aims at examining the actual extent of the knowledge collaboration of different organizational types to shape the perceptions of the organizational leaders and the policy makers by empirical evidence.

Chapter 4 of this dissertation examines the actual extent of knowledge collaboration of different organizational types by performing a systematic comparison at two levels: organizational and inter-organizational.

Universities were found to have a more extensive knowledge collaboration than businesses, research institutes, and governmental organizations. Between universities relationships (i.e. dyadic level) were found to conduce more extensive knowledge collaboration than relationships between businesses, between research institutes, and between governmental organizations among others. These findings imply that:

(V) Universities are the salient actors of the innovation system: The innovation strategy of organizations, e.g. in partner selection, and innovation policy, e.g. in resource allocation and division of labor, ought to understand and utilize universities to their full capacity. Undermining the universities' role and downplaying their contribution in the knowledge economy is likely to end in a suboptimal innovation system. Beyond their singular salient role, the inter-university linkages are also of high importance to the innovation system's performance. Broadening the share of universities and inter-university linkages in the innovation system is expected to result in a more fertile knowledge collaboration for all organizational types. Replacing universities with industrial organizations in collaborative projects, as the core recommendation of the Mode 2 model (and its derivatives), is likely to be a recipe for sustained stagnation rather than a prescription for economic growth.

Chapter 5 investigated the concept of proximity in inter-organizational knowledge collaboration to find out *'How geographical, network, and social* *dimensions of proximity impact the extent of inter-organizational knowledge collaboration?'* This investigation included: the study of the multiple dimensions of proximity, the exploration of accessibility/novelty aspects of proximity, and the analysis of the joint effect of dimensions of proximity in search for the substitution of effects.

Geographical, network, and social proximity were found relevant and applicable considering the context of the research. Geographical proximity was found to increase the accessibility benefits more than decreasing the novelty as a cost. Network proximity was found to decrease the novelty as a cost more than increasing the accessibility benefits. Social proximity was found to increase the accessibility benefits without posing a significant novelty cost. Consequently, a significant positive effect was found for the singular effects of geographical and social proximity. Network proximity, expectedly, showed a negative significant impact on the extent of IKC.

The joint effect of the proximity dimensions was estimated by a set of simultaneous equations. Social proximity's effect was found to be a powerful substitute for the network proximity effect. Social proximity's effect furthermore partially substituted the effects of geographical proximity. These findings point at the importance of analyzing and managing proximity dimensions as a whole rather than as separate parts. These findings imply that:

(VI) Social proximity of organizations is of immense importance to the knowledge collaboration's success: Social proximity, i.e. having a close social relationship between the members of the two partnering organizations, is a paramount asset for the collaborating organizations. Other proximity dimensions in an inter-organizational knowledge collaboration are rendered ineffective in the absence of social proximity. Investing in the social proximity can substitute the costs of lack or excess of other dimensions of proximity. These 'effect substitution mechanisms' can assist innovation system policy through selective allocation of resources, for instance by appraising proximity dimensions of applicants a priori, and/or manipulation of the proximity dimensions a posteriori, for instance by investing in the social proximity of already collaborating organizations by allocating more time and budget for social events. At the end of the day, it is the individuals involved from

each organization that actualize the inter-organizational knowledge collaboration. Bringing them closer to one another has an immense impact on the higher-level operation of interest: inter-organizational knowledge collaboration.

6.2 Future Research

Limitations of the stand-alone studies are discussed in each respective chapter. To extend the studies, the following paths are recognized:

The assumption that all universities, ranging at their core from teaching, to, theoretical research, to applied research are behaving identically with regards to inter-organizational knowledge collaboration is not expected to hold at all times. The same also might not hold for a range of business organizations. A more granular approach in collecting specific and fine-grained organizational type categories will enhance our understanding of organizational roles in inter-organizational knowledge collaborations.

Future research can extend the scope of this dissertation in at least four aspects:

First, the innovation systems and thus the innovation programs of different regions provide complementary puzzle pieces for the understanding of inter-organizational knowledge collaboration. Studying the similarities and divergences of the Framework Programs (FPs), Small Business Innovation Research (SBIR), National Institutes of Health (NIH), Defense Advanced Research Projects Agency (DARPA) among others help to judge the generalizability of the results.

Second, studying not subsidized networks of inter-organizational knowledge collaborations also feeds into our understanding of IKC in general. The mechanisms at play and dynamics of collaboration are expected to be different between the subsidized and not subsidized networks. Apart from differences in the external financial incentives, the entry barriers, e.g. extensive administration vs. extensive multilateral contracting costs, are extremely different which may result in either different entry decisions, collaboration patterns and/or exit decisions.

Third, ended participation of some network members holds valuable information regarding the knowledge collaboration behavior. Research and practice can learn as much from the failures as from the success stories. Throughout the present research several instances of an ended participation was reported by the project coordinators and fellow participants. This information was not however systematically recorded and could not be utilized in empirical analysis of the inter-organizational knowledge collaboration behavior. The reasons behind ending a participation are manifold and complex. Such reasons can seem different to different actors. Hypothetically speaking the poor performance of a participant can result in ending the participation. Equally plausible is the poor performance of the project team. To include ended participations in the econometric modelling of knowledge collaboration behavior and the tools to collect such valuable and at the same time multifaceted and critical information need to be developed by the researcher.

Fourth, another approach to extend the scope of this research is to compare the organizations with drastic innovation strategy differences. Studying *Open Innovators*, who undergo knowledge collaboration inter-organizationally, and *Close Innovators*, who rely on their internal knowledge and solely purchase external knowledge, can extend our understanding of the knowledge collaboration process through the lens of contrasts which these two opposite worlds of strategy provide.

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Summary

Knowledge is regarded as the main source of competitive advantage for the economic actors at various levels: individuals, organizations, networks, regions and nations. Knowledge-based competitive advantages, contrary to the advantages based on land, labor, capital, and alike, are argued to better maintain the required causal ambiguity and withstand the inimitability condition of a sustained competitive advantage. Thus, knowledge-based economy constitutes the core of our understanding of the contemporary economic realm.

Looking into the knowledge sources available to the economic actors at various levels, three main categories of sources are observed: internal, external, and collaborative. For an organization, internal Research and Development (R&D) and employee's knowledge constitute internal knowledge sources. The rate of returns on the usually costly investments made on the internal knowledge resources is highly uncertain. Contracted (i.e. outsourced) research, licensing, and purchase of consultation constitute external knowledge sources. Knowledge valuation and knowledge purchase are complex and high risk, as well, they involve additional costs such as search cost and transaction cost. Due to high costs, complexity, and uncertainty involved in both internal and external knowledge acquisition processes, organizations attempt to collaborate with other organizations to co-create and/or to co-utilize knowledge resources. Knowledge collaboration is regarded as a strategy to spread the risks which inevitably spreads the returns. The strategic choice regarding such collaboration –outlining the costs and benefits- is discussed in the field of Open Innovation.

Besides, in practice (specifically in Europe), a gap has been identified between the creation and the utilization of knowledge. The European Paradox describes the mismatch between the excellent scientific knowledge input and the lagging innovation (i.e. marketable) output. Critics of this viewpoint mainly question the assumption of the European excellence in scien-

tific knowledge creation and disregard the existence of the European Paradox. Independent of being excellent or not, and with no regards to the breadth of the knowledge input-output gap in Europe, it cannot be denied that in Europe there are input knowledge pieces (scientific and/or technological) as potentials for innovation that are not actuated. To actualize these potentials, the European Commission, throughout the Framework Programmes (FPs), funds inter-organizational knowledge collaborations (IKCs) to co-create and to co-utilize knowledge resources aiming at open innovation between academic and industrial organizations.

The scope of this dissertation is to model the inter-organizational knowledge collaborations under the Seventh Framework Programme to arrive at an understanding of the factors involved, their singular and joint effects, and their implication for innovation strategy of organizations and innovation policy. It aims to answer the following main question: how to enhance inter-organizational knowledge collaboration? The enhancement comes by knowing the objects, the subjects, the drivers, and the contexts which jointly determine the extent of an inter-organizational knowledge collaboration. Thus, it aims to answer the following sub-questions: (a) which knowledge types are processed by which organizational types? (Chapter 2), (b) which organizational level variables determine the extent of inter-organizational knowledge collaboration? How those determinants jointly influence the collaboration behavior? (Chapter 3), (c) how organizational type impacts the extent of inter-organizational knowledge collaboration? (Chapter 4), (d) how geographical, network, and social dimensions of proximity impact the extent of inter-organizational knowledge collaboration? (Chapter 5), and (e) what do all these imply for innovation strategy of organizations and innovation system policy? (Chapter 6).

On this path the costs and benefits of open innovation (determining the strategic choice for collaboration) as well as the breadth of the input-output gap are outside the scope of this dissertation. Instead of asking whether or not the FPs are strategically attractive or whether or not FPs are relevant to the European innovation system's needs, this dissertation aims at answering: what factors are influencing the extent of inter-organizational knowledge collaborations? The goal here is to leverage the capacity of teams of organizations to collectively innovate rather than examining the costs and benefits of open innovation or the breadth of the knowledge-creation-knowledge-utilization gap in Europe.

Before focusing on the factors and hypothetical models, it is necessary to gain a perspective on the objects under investigation- i.e. knowledge- and the subjects- i.e. knowledge collaborating organizations. In chapter two, knowledge is mapped by the Aristotelian knowledge taxonomy and organization is framed as a knowledge integrating machine. An association is outlined between these objects and subjects. In brief, Aristotelian knowledge taxonomy is shown to correspond with the Triple Helix model. Here the inter-organizational knowledge collaboration is conceptually modelled as a meta-integration of the Aristotelian knowledge types by the Triple Helix actors: universities, businesses and governmental institutions. The implications regard partner selection and consortium composition.

The first empirical step is taken in chapter three to explain which organizational level variables determine the extent of an inter-organizational knowledge collaboration. This chapter also investigates how those determinants jointly influence the knowledge collaboration behavior. Organizational-level determinants are modelled to explain the variations in the extent of IKCs by transposing the Motivation, Opportunity, Ability (MOA) framework to an organizational level and testing its efficacy. An interdependent functional form is hypothesized (based on the theory) and empirically tested. The MOA framework with an interdependent functional form is shown to explain a substantial portion of the IKC variation. This implies that innovation strategy and policy should consider all the three components of the MOA framework interdependently. Focusing solely on the incentive structures or absorptive capacity, for instance, may be misleading and ineffective since the three drivers of knowledge collaboration act interdependently.

Chapter four models how organizational type (university, business, or government) impacts the extent of an IKC. The aim is to know whether a difference exists in the extent of IKC between the universities and other organizational types: including businesses, research institutes, and governmental organizations. Moreover, the inter-organizational relationship types (e.g.

between universities, between businesses, between university and industry, and alike) are systematically compared to provide an empirical perspective on the impact of consortium composition on the extent of IKC. Universities (and inter-university relationship types) are found as salient actors (and relationships) of the innovation system exhibiting the most extensive inter-organizational knowledge collaboration.

The last empirical step in this dissertation models the proximity (by geographical, network, and social dimensions) to explain how different dimensions of proximity impact the extent of an IKC. First, the singular impact of each dimension is hypothesized based on its contribution to the novelty and accessibility aspects. Then, the singular effects are empirically tested. Second, the possibility of substitution of the effect of one dimension by the effect of the other(s) is empirically tested. This empirical investigation of the substitution of effects informs both the innovation strategy and innovation system policy about optimal partner characteristics to improve the IKC processes. Social proximity dimension is found exerting the biggest impact (of the three investigated dimensions) on the extent of an IKC. The effect size of the social proximity factor substitutes the novelty costs of network proximate and the accessibility costs of geographically distant collaborators.

This dissertation discusses knowledge-based competitive advantage, organizational drivers of IKC, partner selection and consortium composition, and management of the proximity between the partnering organizations, providing the implications for innovation strategies and policies.

Samenvatting

Kennis wordt beschouwd als de voornaamste bron van concurrentievoordeel voor verschillende niveaus van economische actoren: individuen, organisaties, netwerken, regio's en landen. In tegenstelling tot concurrentievoordelen die gebaseerd zijn op grondbezit, arbeid, kapitaal en dergelijke, wordt doorgaans verondersteld dat op kennis gebaseerde concurrentievoordelen duurzamer zijn omdat zij minder imiteerbaar zijn. De kenniseconomie vormt zodoende de kern van ons begrip van het hedendaagse economische systeem.

Kijkend naar de kennisbronnen die de verschillende economische actoren tot hun beschikking hebben, vallen er drie hoofdcategorieën te onderscheiden: interne, externe en collaboratieve kennisbronnen. Voor een organisatie vormen de eigen afdeling Onderzoek & Ontwikkeling (O & O) en de kennis van de medewerkers de interne kennisbronnen. Het rendement van de doorgaans dure investeringen in deze interne kennisbronnen is uiterst onzeker. Contractonderzoek, octrooilicentieovereenkomsten of het inhuren van een adviesbureau vormen de externe kennisbronnen. Het bepalen van de waarde van kennis en de aanschaf ervan is een ingewikkelde en risicovolle aangelegenheid waar tevens extra kosten aan kleven, zoals zoekkosten en transactiekosten. Vanwege de hoge kosten, complexiteit en onzekerheid die komen kijken bij zowel interne als externe kennisverwervingsprocessen, proberen organisaties samen te werken met andere organisaties om zo kennisbronnen te co-creëren of samen te gebruiken. Kennissamenwerking wordt beschouwd als een strategie om risico's te verspreiden waardoor logischerwijs de opbrengsten zich ook verspreiden. Het vakgebied van Open Innovatie houdt zich bezig met de strategische keuzes rondom dit soort samenwerkingen, waarbij de kosten en baten ervan uiteengezet en tegen elkaar afgewogen worden.

Bovendien is in de praktijk (met name in Europa) een kloof vastgesteld tussen de creatie en het gebruik van kennis. De Europese Paradox beschrijft de wanverhouding tussen de uitstekende wetenschappelijke kennis en de achterblijvende verhandelbare innovatie. Critici van dit standpunt trekken met name de aanname van de Europese uitmuntendheid op het gebied van het creëren van wetenschappelijke kennis in twijfel en ontkennen het bestaan van de Europese Paradox. Desondanks kan niet worden ontkend dat er in Europa kennis is (wetenschappelijke en/of technologische) wiens innovatiepotentieel niet ten volle benut wordt. Om de ontwikkeling van dit potentieel te stimuleren, financiert de Europese Commissie door middel van de Kaderprogramma's (KP's) interorganisatorische kennissamenwerkingsverbanden (IK) om kennisbronnen te co-creëren en gebruiken, resulterend in open innovatie tussen academische en industriële organisaties.

Het doel van dit proefschrift is om door middel van het modelleren van interorganisatorische kennissamenwerking in het Zevende Kaderprogramma, inzicht te creëren in de betrokken factoren, hun enkelvoudige en gezamenlijke effecten en hun implicaties voor de innovatiestrategie van organisaties en innovatiebeleid. Het beoogt aldus antwoord te geven op de volgende hoofdvraag: hoe kan interorganisatorische samenwerking verbeterd worden? De verbetering is het gevolg van het beter begrijpen van de objecten, subjecten, determinanten en contexten die gezamenlijk de mate van een interorganisatorische kennissamenwerking bepalen. Aldus beoogt het de volgende deelvragen te beantwoorden: (a) welke kennissoorten worden verwerkt door welke organisatietypes? (Hoofdstuk 2), (b) welke organisatorische determinanten bepalen de mate van interorganisatorische kennissamenwerking? Hoe die determinanten gezamenlijk van invloed zijn op het samenwerkingsgedrag? (Hoofdstuk 3), (c) hoe het organisatietype de mate van interorganisatorische kennissamenwerking beïnvloedt? (Hoofdstuk 4), (d) hoe geografische, netwerk- en sociale nabijheid van invloed zijn op de mate van interorganisatorische kennissamenwerking? (Hoofdstuk 5), en (e) wat de implicaties hiervan zijn voor de innovatiestrategieën van organisaties en innovatiebeleid? (Hoofdstuk 6).

De kosten en baten van open innovatie (oftewel het bepalen van de strategische waarde van kennissamenwerking) en de omvang van de wanverhouding tussen wetenschappelijke kennis en innovatie vallen buiten het bestek van dit onderzoek. In plaats van te vragen of de KP's vanuit strategisch oogpunt aantrekkelijk zijn of niet, of dat de KP's voorzien in de behoeften van het Europese innovatiesysteem, beoogt dit proefschrift de volgende vraag te beantwoorden: welke factoren beïnvloeden de mate van interorganisatorische kennissamenwerking? In plaats van de kosten en baten van open innovatie of de wanverhouding tussen kenniscreatie en het benutten van deze kennis in Europa te onderzoeken, is het doel van dit onderzoek om de capaciteit van teams van organisaties om collectief te innoveren te vergroten.

Alvorens in te gaan op de determinanten en hypothetische modellen, is het van belang om een duidelijk beeld te krijgen van de onderzochte objecten - dat wil zeggen kennis - en de subjecten – oftewel de kennissamenwerkende organisaties. In hoofdstuk 2 wordt kennis nader in kaart gebracht aan de hand van de kennis taxonomie van Aristoteles en wordt een organisatie omschreven als een kennisintegrerende machine. Daarnaast wordt het verband tussen deze objecten en subjecten uiteengezet. Kort gezegd zal er aangetoond worden hoe de kennis taxonomie van Aristoteles overeenkomt met het Triple Helix-samenwerkingsmodel. Interorganisatorische kennissamenwerking wordt conceptueel gemodelleerd als een meta-integratie van Aristotelische kennistypen en de Triple Helix organisaties: universiteiten, bedrijven en overheidsinstellingen. De implicaties hebben betrekking op de selectie van samenwerkingspartners en de samenstelling van consortiums.

In hoofdstuk drie wordt de eerste empirische stap genomen om te verklaren welke organisatorische determinanten de mate van interorganisatorische kennissamenwerking bepalen. Tevens wordt in dit hoofdstuk onderzocht welke gezamenlijke invloed deze determinanten hebben op het kennissamenwerkingsgedrag. Organisatorische determinanten worden gemodelleerd om de variaties in de mate van IK te verklaren door het Motivation, Opportunity, Ability (MOA) raamwerk op organisatorisch niveau toe te passen en de effectiviteit ervan te testen. Op basis van de theorie is een interdependente functionele vorm verondersteld welke empirisch is getoetst. Het MOA-raamwerk met een interdependente functionele vorm blijkt een aanzienlijk deel van de variatie in IK te verklaren. Dit impliceert dat alle drie de componenten van het MOA-raamwerk en hun onderlinge samenhang overwogen moeten worden bij het bepalen van een innovatiestrategie en innovatiebeleid. De nadruk leggen op enerzijds stimulansen (Motivation) of anderzijds absorptiecapaciteit (Ability) kan bijvoorbeeld misleidend en ineffectief zijn, aangezien de drie determinanten van kennissamenwerking onderling afhankelijk zijn.

Hoofdstuk vier modelleert hoe organisatietype (universiteit, bedrijf, of overheid) de mate van IK beïnvloedt. Het doel hiervan is om te achterhalen of er een verschil bestaat in IK tussen universiteiten en andere organisatietypen: bedrijven, onderzoeksinstituten en overheidsinstellingen. Bovendien worden de interorganisatorische relatietypes (bijvoorbeeld tussen universiteiten, tussen bedrijven, tussen universiteit en industrie, en dergelijke) systematisch vergeleken om een empirisch perspectief op de impact van de samenstelling van het consortium op de mate van IK te geven. Universiteiten (en samenwerkingen tussen universiteiten) blijken de voornaamste bijdrage te leveren aan interorganisatorische kennissamenwerking.

De laatste empirische stap in dit proefschrift bestaat uit het modelleren van de invloed van geografische, netwerk en sociale nabijheid op de mate van IK. Ten eerste zijn er hypotheses opgesteld en getoetst aangaande de afzonderlijke invloed van iedere dimensie op de aspecten nieuwigheid en toegankelijkheid. Ten tweede is getoetst of substitutie van het effect van de ene dimensie door het effect van een andere dimensie mogelijk is. Dit empirisch onderzoek naar de substitutie van effecten informeert zowel de innovatiestrategieën van organisaties als innovatiebeleid over wat de optimale kenmerken van samenwerkingspartners zijn om zodoende de IK-processen te kunnen verbeteren. Van de drie onderzochte dimensies blijkt sociale nabijheid de grootste impact te hebben op de mate van IK. De effectgrootte van de sociale nabijheidsfactor substitueert de nieuwigheidskosten van in netwerk opzichten nabijgelegen samenwerkingspartners en de toegankelijkheidskosten van geografisch verre samenwerkingspartners.

Dit proefschrift bespreekt op kennis gebaseerde concurrentievoordelen, organisatorische determinanten van IK, selectie van samenwerkingspartners, en het beïnvloeden van de nabijheid tussen de samenwerkende organisaties, resulterend in implicaties voor de innovatiestrategieën van organisaties en innovatiebeleid.

Appendix

Variable Name	Questionnaire Item	Answer Choices
duration	How long was the project duration? (in months)	<6, 6-12, 13-18, 19-24, 25-30, 31-36, 37-42, 43-48, 49,54, 55-60, >60
IT	Relative to your current personal needs regarding inter/intra-organizational knowledge collaboration has your consortium invested in knowledge collaboration enabling hardware/software? (for example: corporate server, knowledge-interface, sharepoint, website, platform, etc.)	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
org_type	Which organizational type best describes your organization?	For-profit company or NGO (incl. consultancy), University, Research Institute, Association, Government (incl. ministry, municipality), Non-profit company or NGO, Other
org_size	Approximately, how many employees are working in your organization?	<5, 5-9, 10-19, 20-49, 50-99, 100-249, 250-499, 500-999, 1000-2499, 2500-4999, 5000-10000, >10000

past_FP	How many times have you participated in a Framework Programme consortium before this project?	0, 1, 2-3, 4-5, 6-7, 8-9, ≥10
motivation_1	In your organization how much incentives are provided to work on new ideas despite the uncertainty of their outcomes?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
motivation_2	In your organization how much encouragement exists to keep people trying when they fail while creating something new?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
motivation_3	In your organization how much formal promotion of knowledge generation, dissemination, and application exists?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
opportunity_1	The time that your organization spent relative to the allocated time in the consortium was:	Much less, --, -, Equal, +, ++, Much more
opportunity_2	The effort that your organization spent relative to the allocated effort in the consortium was:	Much less, --, -, Equal, +, ++, Much more
ability_1	How capable was your organization in performing its role in the project consortium?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
ability_2	How much specialized capabilities does your organization have that add value to this consortium?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
ability_3	Was your organization successful at the execution of its plans?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely

A partner organization is singled out for the below questions

partner_type	Which organizational type best describes this partner organization?	For-profit company or NGO (incl. consultancy), University, Research Institute, Association, Government (incl. ministry, municipality), Non-profit company or NGO, Other
south_east	Is this partner organization based in Eastern or Southern regions of Europe?	Yes, No
IKC_1	Following a discussion on a complicated issue, how involved was your organization with this partner organization in any subsequent interactions?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
IKC_2	Throughout this consortium project, has your organization learned to exchange skills, know-how, or technologies with this partner organization?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
IKC_3	Has your organization developed new ideas or skills because of the collaboration with this partner organization?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely
geographical proximity	The travel time between your organization and this partner organization, using usual media of transport, is approximately:	<30 minutes, 30-60 minutes, 1-3 hours, 4-6 hours, 7-9 hours, 9-11 hours, >11 hours
social proximity	Did you maintain close social relationships with some members of this partner organization?	Not at all, Very Little, A Little, Somewhat, Much, Very Much, Extremely

Curriculum Vitae

Ardalan Haghighi Talab was born in Tehran, Iran, 1983. He earned his MSc in Management of Technology in 2009 at the Faculty of Technology, Policy, and Management, Delft University of Technology, Delft, the Netherlands. He holds a BSc in Physics (2006) from the Faculty of Physics, Sharif University of technology (SUT), Tehran, Iran.

During his PhD study he participated in four major research projects. First, the INTERREG IVB NWE KARIM project. Second, the European Research Area, ERA-NET evaluation project. Third, the Science in Society, SiS evaluation project. Fourth, the European Foundations Award for Responsible Research and Innovation, EFARRI, funded by the King Baudouin Foundation. Furthermore, he was the teaching assistant for the MSc course Quantitative Research Methods; Faculty of Technology, Policy and Management, TU Delft from 2012 to 2015. Before his PhD candidacy, he worked as a quality control researcher, quality control statistician, sales manager, procurement manager, and business development manager.

Skills:

- Risk management (PECB certified)
- Web-scraping
- Network analysis
- Time-Series analysis
- Business intelligence
- Survival analysis
- SEM
- Multi-level analysis
- Bayesian statistics
- Data visualization
- Causal inference

Languages:

- Persian (native)
- English (fluent)
- Dutch (proficient user)
- Arabic (basic user)

Open innovation, knowledge co-creation, and research joint ventures, unified under the term 'inter-organizational knowledge collaboration', are discussed in various fields of innovation management to ultimately shape innovation strategy of the organizations and the innovation policy.

Several ongoing debates are crucial in the allocation of resources and division of labor with regards to the innovation system: industries vs. universities, who are the salient actors of the innovation system? Death of distance vs. geographical boundedness, does distance matter? Network cohesion vs. structural holes, where in the network is more fertile for innovation?

This book, discussing these debates, intends to direct the innovation strategy and policy.

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ISBN 978-94-028-0761-5
9 789402 807615