Department of Civil and Structural Engineering

Collaborative risk management in complex construction projects

Liisa Lehtiranta

Aalto University

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Collaborative risk management in complex construction projects

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Abstract

Construction project success depends on efficient and effective risk management (RM) and collaborative working. Standard RM frameworks are currently focused on single-firm organizations, whereas in practice, construction project RM involves multiple organizations. Therefore, the adaptation of RM frameworks frequently requires stretching the standard RM framework to embrace a multi-organizational perspective. However, there is a lack of guidance and established structures for operating risk management as a collaborative process among several participating organizations. Multi-organizational RM processes are mainly overlooked in prior literature, standards, and frameworks.

The dissertation applies a constructive research approach, i.e., it focuses on an identified pragmatic project business problem, develops a (potentially) functional solution, i.e., constructs, assesses the construct's functionality and practice and demonstrates its theoretical connections. The research is divided into six studies (Articles I-VI), which include their individual goals, data, and methods. The methodology represents a mixed methods approach where both qualitative and quantitative studies are used as a complementary combination.

The purpose of the dissertation is to develop a systematic framework for multi-organizational RM (MORM) in construction management (CM) projects. The framework is founded on utilizing and supporting collaborative working among project participant organizations. The development of the framework is based on the adaptation of the single-organizational standard project RM process (PMBOK) and informed by complexity thinking, which recommends integration, communication, and flexibility.

The MORM framework provides guidance on the roles and activities of CM project owners, design group, project consultants, and contractors throughout the project lifecycle. Therefore, this research provides a rare explication of parallel multi-organizational RM processes. The framework is theoretically justified, empirically grounded, and partly tested in practice.

The practical contribution of the MORM framework is to enable construction project owners and managers to initiate their RM collaboration and involve focal participants more easily and efficiently. The framework supports managing emerging risks and taking flexible stance on risk responsibilities, which are a key to RM success in dynamic project environments. The theoretical contribution of the research is related to the application of complexity thinking and the reflections of the results to complex project management research.

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Keywords risk management, collaboration, complexity, construction project, project organization, multi-organization, construction management

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Tiivistelmä

Projektinjohtohankkeiden onnistuminen perustuu toimivaan yhteistyöhön ja riskienhallintaan. Käytännössä rakennusprojektin tehokas riskienhallinta vaatii usean osallistujaorganisaation yhteistyötä.Siitä huolimatta riskienhallinnan prosessimallit ja standardit on yleisesti tarkoitettu vain yksittäisen organisaation käyttöön ja sovellukset usean organisaation käyttöön luodaan tapauskohtaisesti. Prosesseja, joissa usean yrityksen välistä yhteistyötä hyödynnetään projektinaikaisen riskienhallinnan hyväksi ei ole käsitelty laajasti tutkimuksessakaan. Riskien-hallinnan tehokkaampi käyttöönotto ja läpivienti projektinjohtohankkeissa edellyttää käytännön-läheistä tutkimusta vaatimuksista ja mahdollisuuksista sekä systemaattista perusmallia, jonka pohjalta projektikohtaiset sovellukset rakennetaan.

Tässä tutkimuksessa sovelletaan konstruktiivista tutkimusotetta: kehitetään konstruktio käytännön projektityöstä löydetyn ongelman ratkaisemiseksi, arvioidaan konstruktion toimivuutta ja osoitetaan sen teoreettiset yhteydet. Tutkimus koostuu kuudesta osasta (Artikkelit I-VI), joilla on kullakin omat tavoitteensa, tutkimusaineistonsa ja metodinsa. Tutkimusmetodiikassa on yhdistelty toisiaan täydentäviä kvalitatiivisia ja kvantitatiivisia menetelmiä moninäkökulmaisen lopputuloksen saavuttamiseksi.

Tutkimuksen tarkoituksena on kehittää systemaattinen prosessimalli (MORM-malli, multi-organizational risk management framework) usean organisaation yhteistyönä suoritettavaan riskienhallintaan projektinjohtohankkeissa. Malli perustuu projektiosapuolten välisen yhteistyön hyödyntämiseen ja tukemiseen. Mallin kehittämisessä on hyödynnetty projektien riskienhal-linnan standardiprosessimallin lisäksi kompleksisuusajattelua, joka ohjaa keskittymään organisaatioiden integrointiin, kommunikaation ja joustavuuteen. MORM-malli määrittelee projektinjohtohankkeen tilaajan, projektikonsultin, suunnittelijoiden ja (pää)urakoitsijan roolit ja tehtävän hankkeen riskienhallinnassa. Malli on osittain käytännössä testattu.

Projektinjohtohankkeiden tilaajat ja projektikonsultit voivat hyödyntää MORM-mallia yhteistyöperusteisten riskienhallintaprosessien entistä laajempaan ja tehokkaampaan käynnistämiseen. Mallissa kuvatut prosessit tukevat ennalta aktiivisen riskienhallinnan lisäksi projektin aikana ilmaantuvien riskien hallintaa sekä joustavia riskienhallintavastuita, jotka ovat onnistumisen edellytyksiä dynaamisessa projektiympäristössä. Tutkimuksen teoreettinen anti liittyy kompleksisuusajattelun käytännönsovellukseen, jotka ovat tutkimuskirjallisuudessa harvinaisia.

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Foreword

When you Think of Things, you find sometimes that a Thing which seemed very Thingish inside you is quite different when it gets out into the open and has other people looking at it.
Winnie the Pooh, The House at Pooh Corner

Here is the Thing now, and it is time to thank the ones who have had an influence on my Thinking. First, I am grateful to Professor Emeritus Juhani Kiiras for inviting me to be a part of the academic world. That proved to be a most enjoyable and motivating step to take. Pekka Huovinen, Dr Lauri Palojärvi and Tuomo Göös were excellent mentors, colleagues and co-authors from the beginning.

Juha-Matti Junnonen, I have valued your supportive approach and would like to thank you for your guidance, work as a co-author, input on our numerous publications and support with the thesis manuscript. Dr Sami Kärnä, I have greatly enjoyed your contributions as my thesis instructor, mentor, co-author, travel companion and business planner. Professor Arto Saari, I would like to thank you for your support during the final stages of the thesis. To my colleagues at the BES research group, you made my infrequent visits to the office worthwhile and provided indispensable peer support. I would also like to thank all the other co-authors—Päivi Julin, Laura Pekuri, Adriana Sanchez, Dr Matti Kruus, Professor Keith Hampson, Professor Russell Kenley and Tuula Råman—for sharing the work, frustrations and rewards.

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Lastly (but firstly), I would like to thank my parents for providing me with the foundation, values and sense that led me to this point. The presence and support of family and "old" friends is paramount, no matter which Thing I'm working on. Much has changed during these five years, but you always remained by my side. To my more recent friends through the IPMA Young Crew network, you have been an inspirational distraction from research.

Simo, I would like to thank you for cheering me up during the tedious end parts of the project and I trust you will be there to co-grow the lessons into someThing meaningful.

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Finnish Construction Quality Association (RALA) provided access to the data that was used as the basis for articles III and IV.

The interviews for articles II, IV and V were carried out with helpful participants from Pöyry Finland, Ruokakesko Sweco PM, A-Insinöörit, Senaatti-kiinteistöt, ISS Proko, Länsimetro, SRV, LPR-Arkkitehdit, Innovarch, Granlund, CJN Arkkitehtitoimisto, Ylimäki & Tinkanen, Inlook Sisustus, Rautaruukki, Colliers Finland, and Kalliorakennus Yhtiöt.

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Table of Contents

List of publications

This dissertation of Doctor of Science in Technology comprises the following six scientific publications. The articles are referred to with numerals (I-VI) hereinafter.

Article I: Lehtiranta, Liisa (2014) Risk perceptions and approaches in multi-organizations: a research review 2000-2012. International Journal of Project Management, Vol. 32, No. 4, 640-653.

Article II: Lehtiranta, Liisa (2011) Relational risk management in construction projects: Modeling the complexity. Leadership and Management in Engineering, Vol. 11, No. 2, pp. 141-154.

Article III: Lehtiranta, Liisa; Kärnä, Sami; Junnonen, Juha-Matti (2011) Satisfaction with collaboration: a comparison of three construction delivery methods. In Haugbølle, K., Gottlieb S. C., Kähkönen, K. E., Klakegg, O. J., Lindahl, G. A., Widén K. (eds.) The proceedings of the 6th Nordic Conference on Construction Economics and Organisation – Shaping the Construction/Society Nexus Volume 1: Clients and Users, pp. 341-352.

Article IV: Lehtiranta, Liisa; Kärnä, Sami; Junnonen, Juha-Matti; Julin, Päivi (2012) The role of multi-firm satisfaction in construction project success. Construction Management and Economics, Vol. 30, No. 6, pp. 463-475.

Article V: Lehtiranta, Liisa (2013) Collaborative risk management processes: a constructive case study. Engineering Project Organization Journal, Vol 3, No. 4, pp. 198-212.

Article VI: Lehtiranta, Liisa; Junnonen, Juha-Matti (2014) Stretching risk management standards: Multi-organizational perspectives. Built Environment Project and Asset Management, Vol. 4, No. 2, pp. 128-145.

Author's contribution to the publications

The contribution of the author of this dissertation to the appended research publications I-VI is outlined below.

Article I: The author is the sole contributor to the article.

Article II: The author is the sole contributor to the article.

Article III: The author is responsible for developing the research design, writing the main parts of the article and conducting the quantitative assessment. The second and third author have contributed to parts of the literature review and provided constructive comments. The second author arranged the access to data.

Article IV: The author is responsible for developing the research design, writing the main parts of the article and participating in the quantitative analysis. The second and third author have contributed to parts of the literature review and provided constructive comments. The second author arranged the access to data. The fourth author conducted the quantitative analysis.

Article V: The author is the sole contributor to the article.

Article VI: The author is responsible for developing the research design, carrying out the research and writing the article. The second author has developed the article by providing constructive comments.

Main concepts and abbreviations

DBB = Design-Bid-Built: A construction project delivery model where the design and construction phases follow each other with minimal overlapping. Design and construction works are procured competitively in different stages of the project. Herein referred to as the traditional project delivery model.

D&B = Design and build: A construction project delivery model where the project owner procures the design and construction works from a single contractor who is responsible for both the design and implementation.

CM project = Construction management project: A construction project that is delivered with one of the CM delivery models: CM service, CM consultancy, or CM contracting. CM is a construction project delivery model in which a professional, consultant-like construction manager leads the project management tasks in close collaboration with the owner, designers, and contractors (Kiiras et al. 2002). Typically, in CM projects the construction work is split into several (sometimes hundreds) of trade contracts. The design, procurement, and construction phases are concurrently aligned, which allows starting the construction and procurement with unfinished designs.

CM consultancy: A construction project delivery model where a project consultant company leads the project management tasks in close collaboration with the owner, designers, and contractors. Responsibilities include coordinating the concurrent design and construction works and managing the procurement of trade contracts. All trade contracts are made in the owner's name. Known as Agency CM in the US and Construction Management (CM) in the UK.

CM contracting: A construction project delivery model where a project consultant company manages the project in close collaboration with the owner, designers, and contractors. Responsibilities include main contractor obligations, design management, and the procurement of trade contracts. All trade contracts are made in the project consultant's name but under the consent of the project owner. Involves, typically, a target price and bonuses and sanctions for deviations. Known as CM@Risk in the US and Management Contracting (MC) in the UK.

CM service: A construction project delivery model where a project consultant company leads the project management tasks in close collaboration with the owner, designers, and contractors. In addition to the responsibilities in the CM consultancy variant, CM service includes the project consultant being responsible for main contractor liabilities. Known as CM@Risk in the US and Management Contracting (MC) in the UK.

CM service provider: The company liable for the CM responsibilities in any of the CM project delivery models.

Collaborative risk management = collaborative RM: An RM process that is based on and supports collaborative working in construction project multi-organizations.

Collaborative working: Joint working of project stakeholders to effectively and efficiently accomplish project goals (applying Xue et al. 2010).

Collaborative relationship: Herein, the term collaborative relationship covers the variety of relationships the CM project participants may have with each other, i.e., contractual relationships where the obligations and tasks of the parties towards each other are defined with a contract (e.g., typically between the owner and the main contractor), management relationships where one party is responsible for coordinating the work of the other (e.g., typically between the project consultant and the design group), and other collaborative relationships where the contributions of the parties need to be synchronized without an explicit documentation (e.g., typically between the contractors and the design group).

Multi-organization: A project organization consisting of separate, fragmented, but interdependent, companies who share pre-defined goals and schedules (Walker, 2007) and need to coordinate collaborative work.

Multi-organizational: Involving a multi-organization working collaboratively.

Multi-organizational RM: An RM process that is focused on integration and communication within the collaborative relationships in construction project multi-organizations.

Multi-organizational RM model (MORM): The main result of this research. An RM process model that describes the responsibilities and tasks of four multi-organizational participants in Cm projects: the owner, the project consultant, the main contractor, and the design group.

Risk: The effect of uncertainty on objectives (International Organization for Standardization ISO, 2009).

RM = risk management: Coordinated activities to direct and control an organization with regard to risk (International Organization for Standardization ISO, 2009)

TMO = temporary multi-organization: Herein same as *multi-organization*. The term 'temporary' highlights the project-based nature of the organizational setting.

1 Introduction

Project risk management (RM) is a significant determinant of project success (Chapman and Ward, 2003; Cherns and Bryant, 1984) and a key project management competence area (Project Management Institute, 2000). In large-scale construction, project delivery is based on several companies' coordinated, collaborative work, which means that several risks are shared. Therefore, most project-specific risks, such as constructability, change orders, and conflicts in documents need to be managed by a joint effort of the project participants (Rahman and Kumaraswamy, 2002). Multi-organizational collaboration is critically needed to mitigate complex risks with significant lifecycle impacts, such as trade-offs between occupational health and safety risks in the construction phase versus the operation phase (Lingard et al. 2013), because these risks are often not identifiable or manageable by a single organization.

The potential for improving construction project success is embedded on improving the efficiency and quality of collaborative working (e.g., Kruus, 2008, Keinänen, 2009, Latham, 1994, Cicmil and Hodgson, 2006, Forgues and Koskela, 2009). The key to successful management of construction projects is to organize the contributors so that their skills are used at the right time and in an effective manner (Walker, 2007). In dynamic and complex project deliveries, this requirement implies well-organized use of collective knowledge and coordinated responses. A considerable potential of multi-organizational projects is frequently left unutilized when RM processes are run only within single-organizational boundaries.

However, most standard RM frameworks are traditionally designed for a single-organizational context and a relatively stable project environment and are therefore inadequate for complex construction projects. Project RM processes are outlined by standards such as the PMBOK practice standard for project risk management (Project Management Institute, 2009) and the APM body of knowledge (Association for Project Management, 2006). Successful application of the standards requires adapting the principles and processes to the needs of the project organization and project environment. Instead of a single organization, the project team typically consists of a multi-organization, i.e., an amalgam of fragmented, but interdependent, companies who share pre-defined goals and schedules throughout a project (Walker, 2007). A multi-organization needs to coordinate their project management, including RM. Furthermore, complex project environments make it impossible or impractical to foresee all risks in advance, which implies that the project organization needs to be prepared for uncertainty and flexibility (Olsson, 2006).

The necessary pre-conditions for successful multi-organizational RM approaches are prescribed in literature as equitable risk allocation in contracts (e.g., Jin, 2011; Bing et al. 2005), flexible and relational contracting conditions (e.g., Osipova and Eriksson, 2011; Rahman and Kumaraswamy, 2002), and pain/gain sharing (e.g., Rahman and Kumaraswamy, 2002; Love et al. 2011). The actual multi-

organizational adaptation of RM processes is not elaborated in standards, guiding frameworks, or research. The literature is especially thin regarding RM applications that cover both contractual and non-contractual relationships in the project delivery organization. The shortage of systematic presentation and established, repeatable collaborative applications in project RM can have a significant influence on whether the adaptation is efficient and systematic.

This research was motivated by the challenges identified in large Finnish construction management (CM) projects. In practice, the inadequacies of single-organizational RM frameworks need to be complemented on a case-by-case basis with multi-organizational practices and techniques. There is a need to map the already existing multi-organizational processes and develop a systematic model to support repeatability and efficiency.

A foundational, practical RM process and several risk management tools were introduced as a result of a University-industry joint research project (Kiiras et al. 2011) and the related RM requirements have been published as a national standard (Rakennustieto, 2012). The dissertation research aims to deepen the knowledge about collaborative relationships and give a systematic presentation of recommendable RM processes that utilize and support collaborative work in multi-organizational CM projects.

2 Research scope

2.1 Objectives and research questions

This dissertation discusses multi-organizational collaboration in the RM processes of complex construction projects. The premises for developing collaborative RM processes are outlined and several practices to facilitate collaborative RM in a construction multi-organization are identified and evaluated. Constructive research is meant to convert observations into organizational and/or process changes, with the aim of developing both practice and theory. The overall objective of this dissertation is:

> *To provide a systematic process model for multi-organizational risk management (RM) in construction management projects.*

To meet the objective of this dissertation, the following research questions were formulated (Table 1):

Table 1 Research questions

RQ1	What are the challenges and opportunities of collaborative RM with potential for pragmatic and academic contribution?
RQ2	What is the role of collaborative working in construction projects?
RQ3	Which practices, processes, and roles support multi-organizational RM?

RQ1 is designed to analyse the current research and practice in order to reveal the opportunities for academic and practical contribution related to collaborative RM. Articles I and II are designed to answer RQ 1 by investigating two perspectives: examining multi-organizational risk perspectives and risk management approaches as the basis for RM framework design (Article I) and justifying a suitable theory base, which fits organizational research in complex construction projects (Article II). The resulting pre-understanding helps in the following steps of the research.

RQ 2 aims to reveal perspectives of the strengths, weaknesses, and importance of collaborative working in Finnish construction projects. This knowledge is needed as a pre-understanding for collaborative RM development. Articles III and IV handle collaborative working in construction from two perspectives: the strengths and weaknesses of project participants' collaborative working relationships (Article III) and the significance of collaborative working for project success (Article IV).

RQ 3 focuses on identifying, developing, and systematizing practices, processes and roles as the basis for a multi-organizational RM framework. Articles V and VI are designed to answer RQ 3. Article V suggests and analyses three (sub-)constructs that function as parts of a multi-organizational RM process. Article VI identifies and analyses further practices and aims to form a systematic RM framework that utilizes and supports the collaborative working between the construction project owners, design group, project consultants, and main contractors.

These research questions represent the thematic topics of the research. The six interrelated articles are designed to provide understanding by relating their individual perspectives to the themes (Table 2).

Table 2 a Overview of the research papers I-III

Article # and title	Publication	RQ1 What are the challenges and opportunities of collaborative RM with potential for pragmatic and academic contribution?	RQ2 What is the role of collaborative working in construction projects?	RQ3 Which practices, processes, and roles support multi-organizational RM?
I Risk perceptions and approaches in multi-organizations: a research review 2000-2012	International Journal of Project Management	Perspective: Risk perceptions and risk management approaches		
II Relational risk management in construction projects: modeling the complexity	Leadership and Management in Engineering	Perspective: Suitable theory base		
III Satisfaction with collaboration: A comparison of three construction delivery methods	6th Nordic Conference on Construction Economics and Organisation		Perspective: Satisfaction with collaboration	

Table 3 b Overview of the research papers IV-VI

Article # and title	Publication	RQ1 What are the challenges and opportunities of collaborative RM with potential for pragmatic and academic contribution?	RQ2 What is the role of collaborative working in construction projects?	RQ3 Which practices, processes, and roles support multi-organizational RM?
IV The Role of Multi-Firm Satisfaction in Construction Project Success	Construction Management and Economics		Perspective: Significance of collaborative working and performance feedback	
V Collaborative Risk Management Processes: A Constructive Case Study	Engineering Project Organisation Journal			Perspective: Testing three sub-constructs
VI Stretching Risk Management Standards: Multi-Organizational Perspectives	Built Environment Project and Asset Management			Perspective: Creating the holistic and dynamic construct

2.2 Scope of risks

There are two main schools of thought on the definition of risks. Traditionally, risk is defined as the chance or likelihood of events with negative consequences, such as injury or loss (e.g., Frame, 2003; Jablonowski, 2006). This view is deeply rooted in project management practice. The broader view of risk as encompassing both negative and positive consequences for defined objectives is seen to be more fruitful in business contexts. For example, Lichtenberg (2000) defines this dual risk as a possible event that would have a negative or positive impact and Jaafari (2001) as "the exposure to loss/gain, or the probability of occurrence of loss/gain multiplied by its respective magnitude." The International Organization for Standardization ISO (2009) defines risk as the effect of uncertainty on objectives,

where uncertainty represents the possibility for both negative and positive deviations from goals.

The dual-component definition of risk has been applied in this research whenever possible. However, the interviews with practitioners focused on their personal perceptions of risks, which were mostly on the single-component threat-side. The resultant collaborative RM model is designed to cover the management of both threats and opportunities, but the value of this ability depends on the perceptions of the operating project organization.

Multi-organizational projects encounter risks that are related to their internal and external project environment. The internal (i.e., relational) risks are related to the project organization's ability to work together effectively (Das and Teng, 1999). They represent the prominence of the project organization itself as a potential source for risks or opportunities. The external risks (or technical risks, as suggested by Das and Teng, 1999) involve all other events that the project organization will encounter. There are technical risks, related to the project delivery, that the project organization can actively manage, such as communication networks, fitness between designs, and construction work quality. Furthermore, there are external risks that the project organization cannot influence but can prepare for, such as economy and market conditions, weather conditions, and political movements. These uncertainty environments have been outlined in Figure 1. The multi-organizational RM model should be seen as a tool for interaction between the project organization and the uncertainty environments.

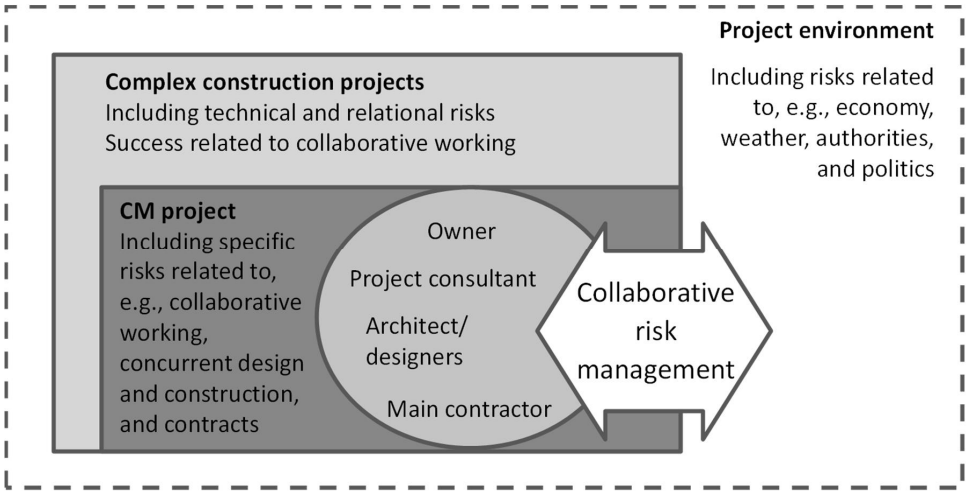

Figure 1 Positioning of the main concepts

2.3 Scope of the suggested multi-organizational RM model

RM covers the coordinated activities to direct and control an organization with regard to risk (International Organization for Standardization ISO, 2009).

Systematic, multi-organizational RM mobilizes all focal parties' expertise for risk identification and response. These parties include the owner, CM service provider, designers, and contractors. Furthermore, the systematic process model will cover the project delivery lifecycle from project planning to the end of the project.

Applying Xue et al.'s (2010) definition, collaborative working on project RM (i.e., collaborative RM) means "joint working of project stakeholders to effectively and efficiently accomplish" RM. However, there are various definitions of stakeholders, encompassing both delivery project team members (multi-organization) and external stakeholders such as authorities, occupants, neighbours etc. The development of the collaborative, multi-organizational RM model was aimed to encompass all such project participants that would have prominent knowledge from the RM perspective and would benefit from the collaborative management concept. Dorsey (1997) specifies the owner, architect(s), and contractor(s) as the main participants of construction project delivery. These roles suit well for capturing the main functions of internal stakeholders in a collaborative RM model. However, in Finnish construction projects there is an additional role: that of project consultant who works as the representative of the owner. In CM projects, the division of roles and responsibilities between project consultants and main contractors depends on the specific contract form, as discussed in Section 1.4. The multi-organizational RM model specifies the RM related roles, responsibilities, and activities of the owner, project consultant, designers, and main contractors.

2.4 Scope of articles

The research articles cover various perspectives to and cross-sections of complex project organizations and multi-organizational RM.

Article I is positioned to cover risk perceptions and RM approaches in any kind of multi-organizational context based on previous research. However, most of the results of the literature review are related to construction project context. The second largest share of the results refers to software development project contexts.

Article II focuses on RM in complex CM project organizations. It analyses the contextual complexity of CM project organizations and the conditions they set for risk perceptions and risk management. The analysis is based on empirics.

Articles III and IV again focus on construction project organizations and analyse the related conditions for collaborative working. From the perspective of this dissertation, the knowledge derived is perceived to support the significance of multi-organizational management structures and point out some of the current strong and weak links within the organizational relationships.

Article V and VI deal with multi-organizational RM processes in CM case projects.

2.5 Construction management projects as a research context

The case studies related to this dissertation are set in large Finnish construction management (CM) projects. The collaborative requirements, roles, and contractual models of these Finnish CM projects have also guided the development of the collaborative RM model. Therefore, Finnish CM projects are within the immediate scope of applicability of the results.

The RM challenges in Finnish CM projects are likely similar to those of other large construction projects, especially those based on high levels of collaboration, such as in the case of partnerships and alliances. In such contexts, collaborative working is seen as a significant enabler of performance improvement and success. Therefore, researchers and practitioners can consider applying the research results into other types of collaboration-based, complex construction projects.

CM projects involve high organizational and technical complexity. CM is a delivery model in which a professional, consultant-like construction manager leads the project management tasks in close collaboration with the owner, designers, and contractors (Kiiras et al. 2002). Each of the three main variants of CM contracts, i.e., CM service, CM contracting, and CM consultancy, involve a slightly different division of contractual responsibilities and reward sharing. In the US, the two first-mentioned are known as CM@Risk and the third as Agency CM. In the UK, the terms are Management Contracting (MC) and Construction Management (CM), respectively. CM consultancy with and without site management may be regarded as separate variations. Unlike in the US and the UK, main contract with multiple assigned prime contracts is not regarded as one of the CM delivery models in Finland.

Typically, in all CM projects the construction work is split into several (sometimes hundreds) of trade contracts. The design, procurement, and construction phases are concurrently aligned, which allows starting the construction and procurement with unfinished designs. The traditional design-bid-build (DBB) construction project delivery model presents the design and construction phases as following each other without overlapping. Breaking the consecutive implementation of design and construction into concurrent implementation will favour shorter overall schedules (see e.g. Kiiras et al. 2002, CMAA, 2003) compared to DBB delivery. Consequently, concurrent delivery creates a need for increased coordination and collaboration during the project. The schedule-impact of the consecutive DBB project delivery vs. the concurrent CM delivery model is compared in Figure 2.

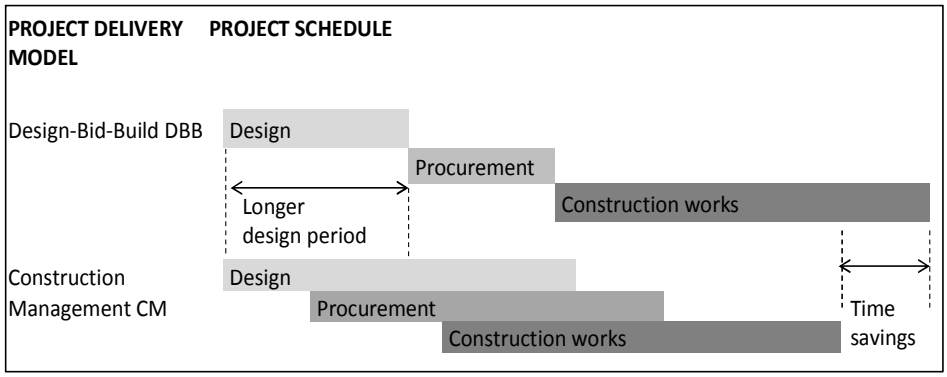

Figure 2 The influence of the CM contract on the project schedule (adapted from Kiiras et al. 2002)

Furthermore, the project owner continues to be the decision-making authority for design changes and trade contracts throughout the project. In CM projects, the owner, together with the project consultant, decides on each trade contract. That is, the owner has an opportunity (and a requirement) to simultaneously decide on the quality, price, and supplier of each construction item during the project execution phase. The CM service provider is responsible for actively proposing alternative solutions and reports of the project cost, schedule and risk status.

The delivery model's aims are to lengthen design times and shorten overall delivery times to enable the owner to make price-quality decisions throughout the project and improve construction performance by unifying the goals of the involved parties. However, these features increase the susceptibility to risk related to financial, commercial, scheduling, quality, and safety goals.

As a context, CM projects provide more collaborative relationships and thus a greater need for collaborative project management methods compared to DBB. Thus, successful delivery requires flexibility to complement project management approaches by bridging the gaps between contractual borders with advanced interdisciplinary management structures. The interfaces for authority, influence, and knowledge sharing are not adequately described by contractual relationships and traditional responsibilities, as illustrated in Figure 3. The procurement-based, collaboration-intensive, and risk-bearing features of CM provide support for adopting previously unexploited RM practices in the case project.

The requirement for collaboration, which is embedded in the CM project contract, lends considerable potential for project success, but it also entrenches risks related to trust and commitment, key personnel, communication, and sharing the financial risk (Dorsey, 1997). Special risk sources in multi-organizational construction projects, particularly in CM projects, stem from the broad collaboration between the participants, incomplete designs when contracts are made, and concurrent implementation (Keinänen, 2009).

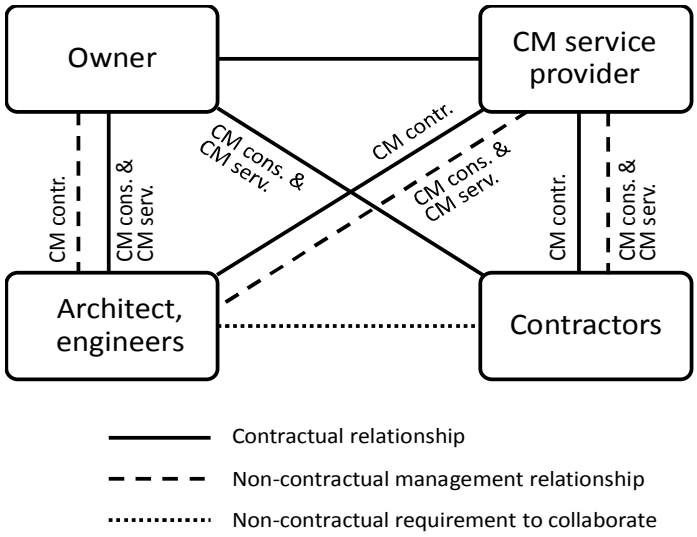

Figure 3 Contractual and non-contractual collaborative relationships in CM project organizations

Compared to DBB, CM projects offer more potential and risks related to multi-organizational collaboration. The problems may be partly tracked back to the main contractor's dual role as the consultant and the implementer of the project in CM projects. Traditionally, ethics has been over-emphasized when combating the collaborative risks in construction (Haltenhoff, 1999).

All large construction projects require risk management, and two common practices of CM projects increase their requirements for collaborative risk management among the management team; i) the concurrent implementation of design, procurement, and construction, and ii) the owners' decisive power over each trade contract throughout the project. Therefore, a systematic RM practice should be a natural part of the project life-cycle across delivery organizations, guiding the related contractual arrangements, participant selection strategies and collaborative work. The same properties that give rise to the CM project delivery model's characteristic risk sources, such as wide collaborative work, may be turned into opportunities for risk response.

In summary, from the perspective of developing an RM framework, three properties of CM projects need to addressed: a) the requirements for collaborative working inherent in the scope, aims, and contractual structures of a CM project, b) the multi-organizational nature of the CM project team, c) the complexity of the project, which is based on the dynamics of the project goals, environment, and organization.

3 Theoretical foundation

The theoretical foundation of this dissertation is based on the aim of understanding the needs and potential of construction project risk management from the perspective of multi-organizational complexity. Therefore, two bodies of knowledge are studied.

First, the contextual understanding is captured from literature that describes the characteristics of multi-organizational complexity (Section 3.1). The complexity-related characteristics of multi-organizational project deliveries are discussed and the concept of temporary multi-organizations (TMO) is introduced. This perspective is selected as determining the scope because a TMO a) involves the whole project delivery team but no additional stakeholders, which is the same group that could actively participate in the project RM process, b) focuses on the project delivery time-frame, which is the same time that the project RM framework could be active and c) enables relatively balanced analysis from the perspective of several participating organizations (not only the owner, for example).

Second, understanding of the management domain is gained by studying literature on project RM. Two types of project RM processes are introduced: so-called traditional processes and complexity-based processes (Section 3.2). The two main process types can be seen as complementary perspectives that provide understanding to support RM model development. In this dissertation, both of these process types are addressed when developing a suitable approach for multi-organizational RM.

Article I gives a more comprehensive presentation of literature on multi-organizational risk perceptions and approaches.

3.1 Complex project organizations

The construction industry is based on a growing number of companies with a narrowing focus of differentiation. The participant firms are interdependent on each other within the project but independent outside the project. Organizational (or social) complexity is identified as the dominant type of complexity in large construction projects (Hertogh and Westerveld, 2010; Lehtiranta, 2011; Pryke and Smyth, 2006).

Construction project organizations can be referred to as temporary organizations (Walker, 2007) or, indeed, temporary multi-organizations (Cherns and Bryant, 1984; Lizaralde et al. 2011). The *multi*-organizational nature of TMOs relates to the interconnectedness of multi-disciplinary work, in which the participants pursue at least partly-shared goals (Walker, 2007; Cherns and Bryant, 1984), whereas temporality refers to the purpose of accomplishing predetermined tasks in a scheduled time frame (Packendorff, 1995). A multi-organizational coalition does

not usually have a common history or a defined future together outside of the present project.

The management challenges in multi-organizational projects are due to the lack of prior collaboration or a clear structure of hierarchical authority (Janowicz-Panjaitan et al. 2009), differing or contradictory objectives and practices (Lehtiranta, 2011), and conflicts in the relationship between the project organization and the participants' parent organizations (Kenis et al. 2009). Each company has its own management policies, processes, and tools, which must be fitted together in a multi-organizational structure. The temporary nature of these projects creates challenges for learning and for the replication of learned matters.

RM in construction multi-organization depends on the alignment or conflicts within several individual, single-organizational, and multi-organizational relationships, as illustrated in Figure 4. While working toward shared project goals, multi-organizational participants need to look after their own interests, which include, for example, increasing productivity, improving service, maintaining existing clients, and attracting new business (Walker, 2007). For example, an individual project participant's perception of risk and participation in RM is influenced by viewpoints of the single-disciplinary project team, in the project multi-organization as well as in the line organization.

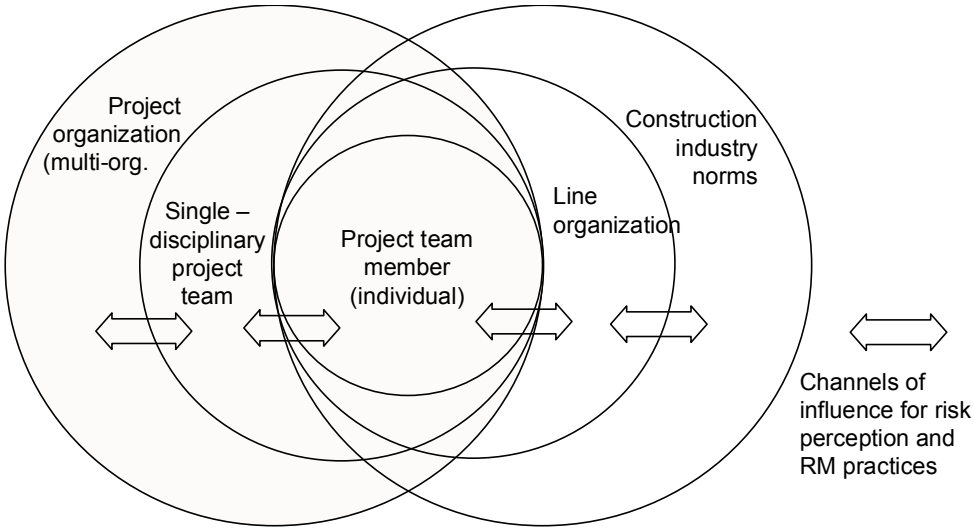

Figure 4 The structure of RM related interactions and influences in a construction multi-organization structure (Adapted and amended from Lehtiranta, 2011). With permission from ASCE.

Most traditional project management structures and methods are designed for fairly stable environments; consequently, pressure is set for change in organizational structures (Walker, 2007) as well as for practical construction project management methods. The challenges and opportunities related to multi-

organizational project delivery may be managed by understanding the roles and complexities of project owners, actor networks, and end-users, including formal and informal structures of the multi-organization (Lehtiranta, 2011; Lizarralde et al. 2011).

Several researchers (Cicmil and Hodgson, 2006; Cooke-Davies et al. 2007; Bredillet, 2010) have suggested meeting project complexity with complexity-based approaches to construction PM theory and practice. Complexity theory is a lens which provides an approach that enables exploring research objects, such as organizations and projects, as "complex, adaptive systems which have non-linear causal relationships, self-organizing attributes, and emergent properties"(McMillan, 2004) and in which the risks and their management are inherent in the interrelatedness among stakeholders, tasks, and conditions. Complexity thinking deals with the conceptual themes of self-organization, discontinuous developments, uncertainty, and unpredictability (van Eijnatten, 2004a).

Primarily, the complexity-based approach guides the researcher (or practitioner) to address integration, knowledge sharing and communication within the project multi-organization. The productivity of multi-organizational project delivery can only be increased through improved collaboration (Latham, 1994). Multi-organizations provide opportunities to flexibly mobilize resources to accomplish complex and unique tasks (Söderlund et al. 2008), to engage in creativity, innovation (Swan, 2002) and knowledge creation (Sydow et al. 2004), and to utilize collaborative working structures and collective expertise to optimize project and mutual learning (Bakker et al. 2010; Fong, 2005). These views are adopted in this study.

Literature offers few examples of complexity-based management approaches that guide practical applications. For example, Shenhar and Dvir (2007) provide a model for selecting the scope of a suitable project management approach based on the assessment of project complexity, novelty, technology, and pace. The level of bureaucracy and formality of project management depends on the results of the assessment. Hertogh and Westerveld (2010) suggest that success in the management of large (complex) infrastructure construction project can be supported with five "extraordinary" solutions: a cooperation-based stakeholder system, project champions, competent team members, capability of finding new management solutions, and utilizing windows of opportunity. In conclusion, the complexity-based approaches aim to identify the dimensions of project complexity and fit management approaches to it. In best cases, complexity is used for the best of the project.

3.2 Project risk management

Project risk is defined as the "effect of uncertainty on objectives," and project RM is defined as the "coordinated activities to direct and control an organization with regard to risk" (International Organization for Standardization ISO, 2009). Project RM is regarded as a significant determinant of project success, and a formal,

systematic procedure is often seen as desirable (Institution of Civil Engineers, 2005; Chapman and Ward, 2003; Project Management Institute, 2000).

"Risk management can be applied to an entire organization, at its many areas and levels, at any time, as well as to specific functions, projects, and activities" (ISO 31000:2009 - Risk management: Principles and guidelines, 2009). Risk management principles do not depend on the scope of risks, and guidelines may be presented on a general level to fit "managing any form of risk in a systematic, transparent, and credible manner, and within any scope or context (ISO 31000:2009 - Risk management: Principles and guidelines, 2009).

Therefore, practical applications of project RM vary greatly. Two general types of RM processes are presented here. The traditional processes (3.2.1) refer to the systematic RM frameworks that are well documented in literature. They are mainly threat-based and focused on single-organizational applications. The complexity-based processes (3.2.2) can be seen to reflect additional elements of multi-organizational integration and communication. The division between these types of RM processes is not exclusive, and in reality an RM framework can involve elements of both types.

3.2.1 Traditional project RM processes

Risk management, traditionally, is a systematic set of managerial practices and methods that are applied to minimize the negative consequences of a risk. A broader view of risk as encompassing both negative and positive consequences for defined objectives is proposed to be more fruitful in business contexts. Lifson and Scheifer (1982), see risk as a possibility that the expectations posited towards an action are not met. For example, Lichtenberg (2000) defines this dual risk as a possible event that would have a negative or positive impact.

Risk management has been applied in construction since 1980's (Palojärvi, 2009). Concepts of project RM have evolved as natural extensions of firm and business RM (Artto et al. 2000), thus being traditionally focused on single-firm contexts. Formal project RM applications are based on standards, such as the PMBOK practice standards for project RM (Project Management Institute, 2009) and the APM body of knowledge (Association for Project Management, 2006). Practical applications are further supported by standard-like RM frameworks, such as the construction project risk management process by Flanagan and Norman (1993) and the risk analysis and management for project (RAMP) processes by the Institution of Civil Engineers (Institution of Civil Engineers, 2005). The Project Management Institute (2009) defines the formal RM process as "conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Chapman and Ward (2004) argue that whereas formal RM processes do not suit all projects, the decision of not applying a formal process must be based on the understanding of such process contents, costs, and benefits. In practice, formal procedures are complemented with or replaced by informal ones.

From the perspective of TMOs, the main inadequacies of traditional RM processes relate to their focus on a single-organizational context. This means that they look at

risks and suggest processes for one of the multi-organizational participants only. Typically, other participants are then seen as parts of the risk to be managed and not parts of the solution, i.e., active participants to the RM process. This approach leads to focusing on risk allocation, instead of risk sharing, and suggests means for the owner to control, motivate, and persuade contractors to act towards the owner's goals. This is done through bilateral contracts and financial incentives. CM project contracts frequently include target and ceiling schedules and budgets. Ironically, such incentives may result in a misalignment of collaborative and quality goals if the implementing party is under pressure (Haltenhoff, 1999).

Traditional RM processes provide a useful, systematic structure and principles for project RM. However, TMOs need more complexity-based processes to complement their approaches.

3.2.2 Complexity-based approaches to project RM

In a multi-organizational context, no individual party can exclusively run effective RM. Therefore, in multi-organizational projects, the single-organization-focused standards must be adapted for use by the different companies, following and complementing the principles addressed in the standards. For instance, optimal RM in CM projects requires the sharing of information between the owner, architect, designers, and contractors throughout the project delivery lifecycle. RM frameworks can be founded collaboratively and through team work to support information sharing and response coordination (Rahman and Kumaraswamy, 2005).

McMillan (2008) and Shenhar and Dvir (2007) explain how the various dimensions of complexity, i.e., the scope, dynamics, and pacing of the project, environment, and stakeholders, among others, provide the basis for complexity-based management approaches. A paradigmatic change from deterministic to complex systems approaches would fit the dynamic environments and organizational structures of contemporary construction projects as both a research and management approach (Cicmil and Hodgson, 2006; Cooke-Davies et al. 2007; Bredillet, 2010). The implication of complexity theory for PM practice relates to the variability of project goals and success criteria, unpredictability of future events, and complex multi-organizational interaction (Cicmil et al. 2009). The complexity approach suggests responding to challenges with dynamic, wide-perspective structures and techniques (Shenhar and Dvir, 2007; Cicmil and Marshall, 2005), integrating the system components to work effectively (Walker, 2007) and managing by coordination, communication and control (Baccarini, 2006; Walker, 2007).

In the case of RM, these features of complexity are visible, for example, as the emergence of unpredictable risks and as the challenges of mobilizing the identification and response within the multi-organizational team. The complexity and dynamism of construction organizations, processes, and environments make it impossible, or at least extremely impractical, to forecast and arrange a response for every imaginable risk at the beginning of a project. In the context of RM, communicative and trustful links among the members of the multi-organization

are required (Pryke and Smyth, 2006; Lehtiranta, 2011). Cicmil et al. (2009) suggest socializing rather than delegating project control.

Conceptualizing the construction process as a complex, open system directs the focus to integrating the system components to make them work effectively and ensuring adequate connections for communication between them (Walker, 2007). Advanced responses to the organizational problem in contemporary construction projects require actively attending to informal organizational structures as well as formal ones (Walker,, 2007; Lizarralde et al. 2011). Frequent emergence of unanticipated risks requires adaptable and flexible organizational structures and management responsibilities. RM is not only a process or methodology but also connected to the organization's preparedness of responding to risks as they arise (Bannerman, 2008).

Rahman and Kumaraswamy (2002) have found a trend toward more collaborative and teamwork-based RM in the construction industry. Risk management concepts are deemed collaborative if they require participation of more than one organization in a TMO. This can be seen to reflect the suggestion of integration that is related to the complexity approach. Collaborative risk management demands both managing the efficiency of the collaboration and facilitating project risk management as a collaborative effort. It is likely to be most efficient through the aims of soft models, i.e., managerial actions that are targeted towards meeting or exceeding the collaborative benefits. The means for collaborative risk management may be practical, contractual, and motivational, and have other similar attributes as well. Different experience-based forms of utilizing expert knowledge, such as brain-storming, have long been the preferred method for risk identification and response planning (Akintoye and MacLeod, 1997). A common nominator for collaborative RM concepts is the utilization and sharing of collective knowledge for the best of the project.

Some RM processes are explicitly prescribed to multi-organizational contexts and reflect the complexity approach. They are typically related to projects in which the delivery models include specific requirements and incentives for collaborative RM (Osipova and Eriksson, 2011). For example, partnership- and alliance-related RM concepts (Bresnen and Marshall, 2000; Chan et al. 2004) aim to direct focus from risk allocation to integration, i.e., from procurement, to shared concern for risks. Some processes, however, are quite independent from the delivery model. Lichtenberg (2000) recommends involving a multidisciplinary team in risk identification, analysis and response, and Rahman and Kumaraswamy (2005) propose joint risk management to be founded in collaboration and as a team to support information sharing and response coordination. Kiiras et al. (2011) present a question procedure to make it easier for a multi-organizational expert team to identify the project risks by focusing on the special features of the targeted project. Pryke and Smyth (2010) see people as the source and driver of value in a construction project. Their relationship approach to construction project management is the basis for Loosemore's (2006) relationship approach to construction project risk management that involves integrating all focal stakeholders into the RM process.

In sum, practical applications of project RM in TMOs should complement the standards and general RM frameworks with processes and tools that address multi-organizational complexity so that it becomes advantageous for risk identification, assessment, and response. Traditional RM frameworks should be complemented by adaptable practices that are based on integration and communication. Therefore, both traditional RM processes and complexity-based concepts can be used to inform the development of a multi-organizational RM framework.

4 Methodology

4.1 The constructive research approach

The constructive research approach aims to solve practical problems while producing an academically acceptable theoretical contribution. The dual aim of constructive research is strived for by combining existing theories to real world problems (Figure 5). Ideally, the real-world management problem is solved by implementing a novel construct which has practical relevance and makes a theoretical contribution (Lukka, 2000). The constructs can be, e.g., rigorously justified tools, techniques, processes, and organizations. With its pragmatism, constructive research may significantly narrow the gap between academia and industry, which is important when working together with companies and with on-going projects.

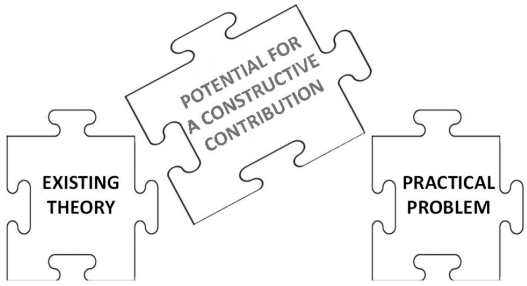

Figure 5 Potential for research contribution with the constructive research approach

In its inherent assumptions, the constructive research approach leans on pragmatism (Lukka, 2000) for the core idea that the meaning of knowledge is determined by its practical consequences (Hammersley, 2004). PM research, in general, can be seen as pragmatic design science which aims at developing PM skills and techniques or, in a broader sense, making human-made artefacts or methods work more effectively (Dewey, 1984). Analogously, constructive research is interested in problem resolutions, which could have an impact on the current state of affairs, i.e., that knowledge should have instrumental value. In addition, the idea that the practical feasibility of a construct should be determined by a practical test comes down to pragmatist notions.

The constructive research approach may be regarded as a form of case/field research parallel to ethnographic research, grounded theory, illustrative case research, theory testing case research, and action research (Lukka, 2000).

Constructive research is distinct from action research. First, constructive research always focuses on the construct as an outcome, whereas action research may have other goals. Second, the researchers' interaction with practice and practitioners, although common in constructive research, is obligatory only in action research.

Kasanen et al. (1993) present the constructive research approach as a type of applied study that aims to produce new knowledge as a normative application. That is, the results of constructive research should express how one should act in a current situation to achieve a desired state. There is, thus, an assumption about the causality of things: when an action to fix a problematic situation is proposed, there is an assumption that the action will cause some anticipated effects. Without that assumption, presenting these types of technical norms would be illogical. It is this normative character and the pursuit of change in reality that differentiate constructive research from other case/field research types and especially from other less empirical and more basic types of research.

It should be noted, however, that although solving a practical problem is at the center of all constructive research, not all problem-solving activities should be called constructive research. Kasanen et al. (1993) introduce four elements that should always be included in constructive research. These are displayed in Figure 6. To fulfil the requirements of a dual audience, constructive research should be evaluated based on both practical and theoretical contributions.

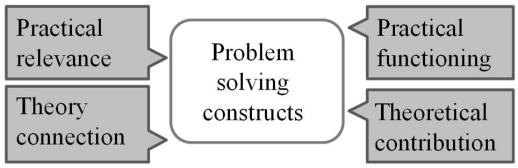

Figure 6 Elements of constructive research (adapted from Kasanen et al. 1993)

A distinction should be made between the validity of constructive research and the validity of the construct, both of which feature in constructive research. Construct validity is commonly connected to the functionality of the construct, i.e., its ability to solve the organizational problem that it was designed for (Lukka, 2000; Oyegoke, 2011). A pilot case study is the preferred means to test and improve a construct (Oyegoke, 2011). While there is no universal process of validating constructs, Kasanen et al. (1993) propose a three-level market-based validation, which can be seen appropriate for PM research. The weak market test is based on the willingness (not demonstrated action) of a manager to apply the construct. The semi-strong market test is based on the rate of adoption of the construct as demonstrated by companies. The strong market test aims to analyze whether the business units applying the constructs systematically produce better results than those without (Kasanen et al. 1993).

However, constructive research involving a failed construct does not need to be invalid research. The constructive piece of research as a whole can be validated if, and only if, a) the construction exists and b) variations in the functionality of the construction causally produce variations in the testing outcomes (Pekuri, 2013 following Borsboom et al. 2004). Whereas the existence of an applied construct is easy to show, the second condition is more challenging in the case of a single pilot case project. Projects are unavoidably complex one-off endeavours where parallel tests or detached causal relationships are not feasible. However, the extremes of possible causal relationships can be outlined and the researcher may evaluate and justify the construct application's success between these extremes. Lukka (2000) suggests applying the following general evaluation criteria of field research to constructive research: relevance of research topic, theoretical connections, clear research design, credible study, theoretical contribution, and clear and economic reporting.

4.2 Research process

Constructive research should be seen as a research approach that provides a pragmatic goal-oriented umbrella for tailor-made research designs. Therefore it has the potential to correspond well on complex (multi-)organizational contexts, which require the researcher to immerse, from different viewpoints, in the characteristics, challenges and opportunities in the collaborative relationships. Understanding and intervening in a complex situation can be supported with methodological pluralism (Dainty, 2008). Pluralistic approaches that incorporate both quantitative and qualitative research techniques, methods, approaches, concepts, or language into a single study are referred to as mixed methods research (Johnson and Onwuegbuzie, 2004). The results of mixed method research are said to outperform the results of mono-method research in advancing knowledge (Johnson and Onwuegbuzie, 2004).

The herein selected constructive research approach applies a mixed methods research design that allows pluralistic inquiries and a degree of triangulation within one study. In this way, the variety of methods adds their own unique value to the research, making it stronger than it otherwise would be. The provided pragmatic and theoretical perspectives to complex PM problems are suggested to offer both practically relevant and scientifically rigorous research results (Figure 7).

The core process applies the steps of constructive research, as presented by Kasanen et al. (1993) and Lukka (2000). A mix of six different research methods were used on different steps of the research project to provide understanding on the related research questions, as explained in Figure 8.

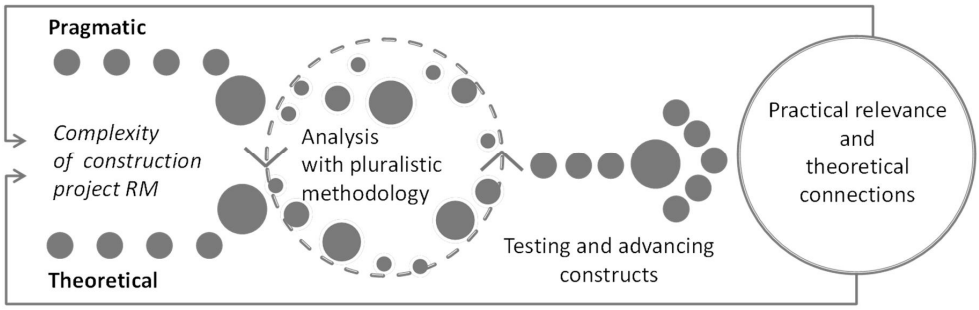

Figure 7 Pluralistic research methodology as the "engine" for analysing complex PM problems

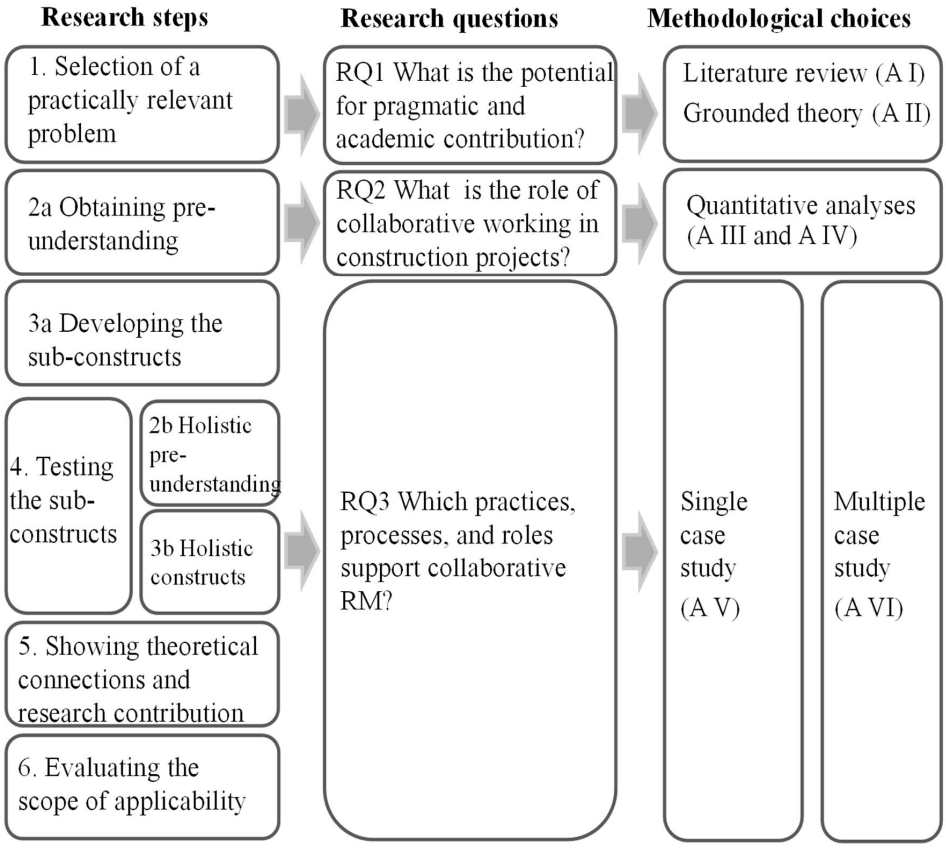

Figure 8 Methodological choices related to research steps and questions

Research steps

1 Selecting a practically relevant problem with research potential

Constructive research should always begin by finding a practically relevant research problem (Kasanen et al. 1993). Common ways of coming across these kinds of problems is by identifying a problem of a company or by identifying a practically relevant research gap from the literature (Labro and Tuomela, 2003). Constructive research problems can generally be based on anecdotal evidence, practical experience, or theoretical work (Oyegoke, 2011). A suitable research problem should offer opportunities for both practical and theoretical contribution.

The selected research theme, multi-organizational RM process, was identified as a potential area of development in earlier research (Kiiras et al. 2012), and acknowledged as such by the participants of the case projects. A multi-organizational process model would contribute to the practice of setting up RM processes in CM projects. Furthermore, single-organizational RM has been widely dealt with in prior research, but studies on multi-organizational RM are rare. This provides potential for theoretical contribution and contrasts with existing theoretical work.

Two studies (Articles I and II) were conducted to deepen the understanding of the focal industry context, to define specific research problems, and to have insight of a suitable theory base for further research. Article I presents a literature review on the trends and gaps of multi-organizational RM research, and Article II focuses on a grounded-theory approach of relational risk management.

2 Obtaining pre-understanding of the topic

The research process proceeds by obtaining a comprehensive understanding about the problem situation. The pre-study, which is usually based on the literature, should provide the researcher with a thorough understanding of the research problem, its context (Oyegoke, 2011), and the relevant theories that may be used to contribute in constructing the solution Kasanen et al. 1993). Naturally the researcher's prior education and work experience will have an influence on the pre-understanding.

In this doctoral research, pre-understanding was obtained through two quantitative analyses that explore the role of collaborative working in construction projects (reported in Articles III and IV).

3 Developing the sub-constructs

Constructs are suggested solutions to the selected research problem. The innovation phase is creative and heuristic by nature, but it may not be randomly imaginative. It needs to be firmly grounded to the actual problem and the knowledge gathered through the pre-understanding phases. Still, very few methodological means can be named to aid the innovation process (Lukka, 2000) or the means are case-specific. The innovation process is dependent on the innovators, which indispensably leaves a certain 'innovative leap' between the evidence and the results.

The constructs related to this dissertation were developed and partly tested in two case study approaches. First, a set of constructs (sub-constructs from the perspective of the dissertation) were co-created and tested with the participants of a constructive research case project (Article V). In this manner, the construct development process becomes a consultative iteration between the researcher and the practitioners to ensure the constructs' suitability for practice. Furthermore, a multiple case study was carried out to identify and analyse a larger number of projects (Article VI). As a result of the multiple case study, a multi-organizational RM process (holistic construct from the perspective of the dissertation) is presented.

4 Testing and evaluating the constructs

The testing and evaluating of the constructs was conducted as a part of the two case study approaches (Articles V and VI).

5 Theoretical connections

Theoretical connections of the constructs were discussed as a part of the two case study approaches (Articles V and VI).

6 Scope of applicability

The scope of applicability of the constructs was assessed as a part of the two case study approaches (Articles V and VI).

Logics of reasoning

The two basic logics of reasoning are deductive and inductive logic. Deductive logic aims to apply general theories to a particular situation, whereas inductive logic proceeds from a particular situation to statements about the results' general applicability. The constructive research approach applies both reasoning logics in a cyclical manner (Figure 9). The early stages of the constructive research process resemble deductive logic: from the vast amount of knowledge gained through pre-studies, a single construct is designed and then tested in the situation where the problem was initially identified. In the later stages, where the results' theoretical and practical contributions as well as their wider applicability are considered, the reasoning more closely follows inductive logic.

As a whole, constructive research can be regarded as following the abductive logic of reasoning, which involves a cyclical alternation between the inductive and deductive processes. This approach does not produce results that are as certain as those in purely deductive studies or as probable as those in inductive studies in general, but they are nonetheless plausible (Shank 2008).

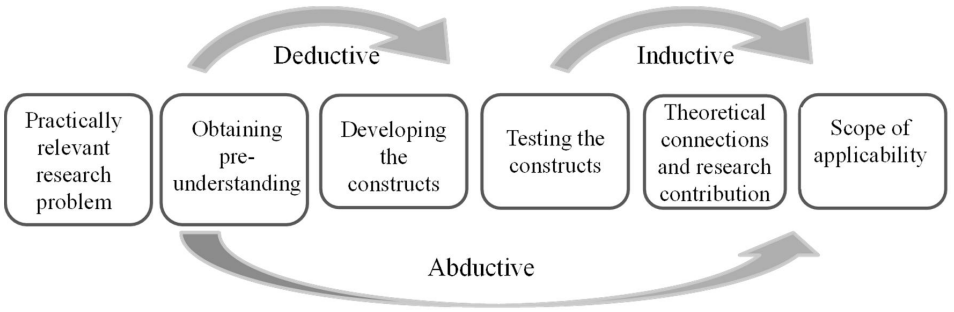

Figure 9 The main cycles of reasoning logic in the constructive research process

4.3 Data and analysis

4.3.1 Systematic literature review (Article I)

Literature reviews provide readers with syntheses and analyses of research in particular subject areas (Cooper, 1998). The review process aims to present a systematic and replicable approach for identifying and analyzing multi-organizational RM research. The process roughly follows the guiding principles introduced by Huovinen (2006) and advanced by Lehtiranta and Huovinen (2010) to outline the essential steps of a systematic literature review.

1. Objectives: The core concepts in this research (i.e., risk perception and approach) are divided into analyzable units through research questions. The research questions are chosen to represent important academic debates or potentially under-researched topics based on earlier research, as discussed in Sections 2 and 3. Two research concerns are intended as the basis for observations on risk perception: 1) the preferred view on risk as threat, opportunity, and/or uncertainty, and 2) the nature of addressed risks as anticipated or unanticipated risks or unrealistic assumptions. Two additional research items are targeted for analyzing the RM approaches: 3) the role of TMO as the source of risks and/or resource for RM and 4) the allocation of risk responsibilities within TMO.

2. Scope: The eligible papers represent the multi-organizational nature of work activity as either a risk itself or a resource for RM. The thirteen-year period from 2000 to 2012 was deemed adequate for capturing a wide variety of research to describe the dominant trends and gaps in our knowledge.

3. Publication channels: The two leading project-focused journals, *International Journal of Project Management* (IJPM) and *Project Management Journal* (PMJ), were selected to capture the international trends in generic project management research as the only project management-focused journals listed in the 2011 JCR Social Sciences Edition. Two industry focuses, i.e., construction and software

development, were found the most researched (and, thus, the potentially most fruitful) contexts for multi-organizational RM based on publications in generic journals. Therefore, the review was complemented by including two journals from the two allied fields, i.e., the *Journal of Construction Engineering and Management* (JCEM) and *IEEE Transactions on Software Engineering (TSE),* which were the only journals with suitable scopes in the 2011 JCR Sciences Edition. The literature search covered the 3993 papers that were published between the years 2000 and 2012 in the four selected journals.

4. Inclusion and exclusion of references: To allow variance in terminology, the literature search could not be based on search words. Therefore, all papers within the scope of the review were browsed. Articles were included if they described TMO as a source of risk and/or specified a multi-organizational response to risks. This process therefore included papers that implied the intended focus but did not specify "risk," "opportunity," or "uncertainty" in their titles. RM in multi-organizational projects was identified as the topic in 215 articles. Of these articles, 105 papers specified TMO as a source of risk, a means for RM, or both and were eligible for the review.

Examples of excluded paper include those addressing risk and/or RM related to end-product qualities with no explicit connection to the management of multi-organizational project delivery and those describing a specific step of an RM process but not connecting it to multi-organizational risks or multi-organizational RM solutions. Additionally, research studies on TMOs' interactions with their environments (i.e., with individuals and organizations who are not in a direct role, employed or employer, with the project) were excluded from this study.

The distribution of the selected papers vis-à-vis publication channels and publication years is illustrated in Figure 10.

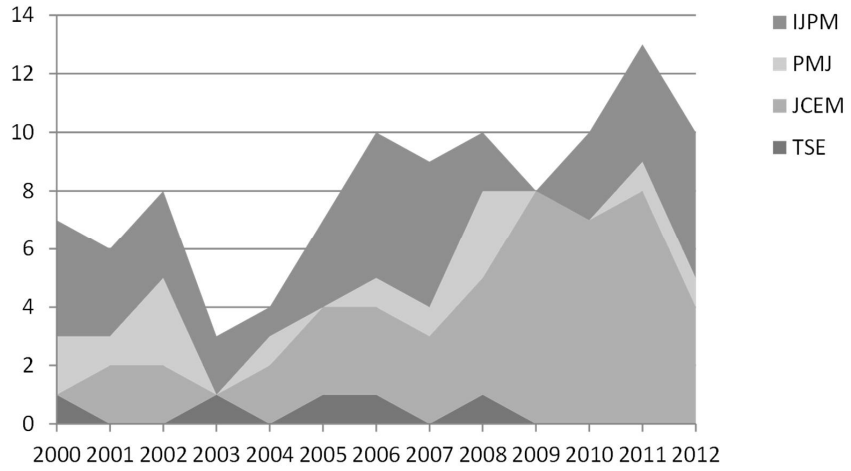

Figure 10 Annual publications of research on multi-organizational RM in the four selected journals

5. Coding, exposure, and analysis of the conceptual data: A structured Excel database was utilized to classify each reference according to the four research questions. Typically, the author's risk perception was revealed in the abstract and/or introduction. The author's stance on RM process activities was normally found within the abstract and the conclusions. If not, other sections of the paper were reviewed, such as the literature review and discussion. The construction project context dominated 74 (70%) of the papers, whereas 20 papers (19%) were based on IT or software projects, and 11 (11%) were based on other industries or on project contexts in general.

6. Validity: The review was performed by a single reviewer following steps 3-5 of the described process and following the principles of selectivity and neutrality (Hart, 1998; Cooper, 1998). A single reviewer process can be seen as upholding consistency, and the replicable process description allows for posterior review.
7. Reporting: The reporting was pre-planned based on the four research questions and related analyses.

8. Conclusions for researchers: Research literature reviews are a means to justify courses of action, such as strategic plans, grant proposals, or topics of dissertations (Fink, 2009). Therefore, the analyses and conclusions are intended to provide readers with suggestions for the advancement of focal conceptual knowledge by addressing significant research gaps.

9. Conclusions for practitioners: Although the main messages from this review are primarily of academic interest, the conclusions should aid multi-organizational project managers in developing better awareness of their RM practices from the perspective of practical challenges and opportunities in multi-organizational projects.

10. Limitations: A review should provide a systematic, explicit, comprehensive, and reproducible explication (Fink, 2009), which is herein respected by documenting the review process and result tables. However, the identification of eligible papers was limited by the reviewer's ability to make connections to multi-organizational contexts. In certain cases, the line between an RM topic and another project management topic was thin or non-existent. Further, it was difficult to identify "unanticipated" risks if a paper did not underline the suggested method's suitability for them. The research method led to the exclusion of at least one group of papers that may have contributed to multi-organizational RM: papers that did not explicitly specify a multi-organizational source of risk or means for RM but were nevertheless applicable for such a context. The scope of the review intends to be descriptive rather than exhaustive. The presentation of software development research seems scant for forming a complete picture of the current RM methodologies because a number of advancements are reported at top conferences instead of journals. It may, however, provide an idea of processes in the close past or, indeed, the lack of them.

4.3.2 *Grounded theory (Article II)*

The study aims to provide background information on the context of complex multi-organizational project RM. An interpretative, qualitative research approach was selected to enable exploring the potential embedded in the social processes within the construction project organization. The validity and value of such research is grounded not in objective observations, but in rigorous, context-dependent interpretation of "what practitioners say about practice" (Lousberg and Wamelink, 2009).

The selection of grounded theory was based on the ambiguity of the theoretical knowledge base behind the emerging collaboration-based (multi-organizational) paradigm of project management. On one hand, the traditional PM paradigm handles collaborative issues through contractual relationships and structured responsibilities. On the other hand, the complexity paradigm focuses on organizational dynamics, communication, and integration. Systematic RM frameworks are frequently based on traditional thinking. There was a need to understand how reality was reflected in relation to these alternative theory bases.

Grounded theory was created by Glazer and Strauss (1967) as an inductive methodology for the "discovery of theory from data". The grounded-theory approach enables the researcher to creatively but systematically tie the empirical findings to the emerging conceptualization (Corbin and Strauss, 2008). Originally, the methodology was used in highly participative, longitudinal studies in the healthcare sector on topics where no prior theory base existed. There are several, often confusing, approaches to grounded-theory studies, which vary from the original longitudinal, purely empiric forms presented by Glaser and Strauss (1967) to shorter 'hybrid' forms between empirics and prior theory (such as Martin and Turner, 1986). These hybrid forms support the use of grounded theory in situations where prior theory exists but is too general or ambiguous to offer adequate guidance. They describe a cyclical comparison between data and literature, whereas the original form incorporated only the cycles between data collection and forming of emerging theory.

Grounded theory has gained an established position in social and management studies (among other disciplines), but few construction-related applications exist. Loosemore (1999) and Phua and Rowlinson (2004) provided grounded-theory applications that strove toward questioning and advancing the theoretical foundation behind recognized construction-related topics that already had suggested pragmatic solutions. Close to the context of this study, Martin and Turner (1986) discuss grounded theory as a methodological tool for incorporating organizational complexities and facilitating understanding and identification of desirable improvements within the organization. They explain, relevantly to the aims of this study, that the emerging understanding "enables the researcher to ask questions about the similarities and differences between this theory and other more general theories in the field, especially with respect to goodness of fit and scope of coverage."

The grounded-theory approach used in the present study aims at comparing the empiric representation of CM project participants' RM perceptions with two

potential theory bases. A focal aim is to review existing theory bases on project management to identify their theoretical lenses and observe which base would give the most realistic view of the interview data, i.e., CM project participants' own words and contextual observations.

The participants were selected from two representative medium-sized CM projects, which had been subject to significant changes in either project scope or delivery organization. The seven interviewees represented parties who had the possibility of or responsibility for influencing decisions concerning project design, schedule, technical implementation, schedule, or organization. Participants 1, 2, and 3 were project consultants, Participant 4 was an electrical designer, Participant 5 was an architect, Participant 6 was a CM service provider (site manager), and Participant 7 was a CM service provider (project manager). On reaching project goals, the participants described the influence of the other parties by referring to their experience from current and previous projects. All participants had more than 10 years of experience, and they were encouraged to give detailed, narrative accounts on each evolving theme about the challenges and opportunities in relational RM.

The interviews were conducted in two phases to allow cyclical development of the conceptual framework on relational RM. These cycles are described in more detail in Article II. The analysis constructs three fundamental themes: one theme that represents the conditions where relational risk is low (collaborative competence) and two themes that describe the processes that shape relational risk in project organization (learning and incentivizing).

The relevant results with regard to this dissertation relate to the comparison of the empirical data and two theoretical lenses to project management. This final step of the research process was conducted by analysing the three themes that emerged from the research interviews through both traditional and complexity thinking lenses. Examples of empirical evidence are included in the analysis to identify the more realistic theoretical base.

4.3.3 Descriptive quantitative analysis (Article III)

The study aims to analyse the collaborative relationships in construction projects from the perspective of participants' satisfaction with collaborative working. The results are intended to provide useful background data on the strengths and weaknesses of collaborative relationships, which should be addressed when developing a collaboration-based RM system.

Data for this study were gathered from a project feedback system, ProPal, which comprises ca 2300 entries, in which project owners evaluate the participants of the project delivery team and the participants evaluate one another's operations relating to their projects in Finland. Based on a recent doctoral research (Kärnä, 2009), the system was developed, piloted and launched with the central aim of improving customer orientation and quality in the construction industry. The ProPal tool is now widely recognized and utilized within the Finnish construction industry. It is operated by the Finnish Construction Quality Association (RALA),

which jointly represents owners, contractors, and consultants. The system has a Web-based interface to facilitate its use.

ProPal was primarily developed from construction-related companies' perspective to yield versatile information on the strengths and weaknesses within projects' collaborative relationships and work practices, which lessons the project owner's and participants may turn into operational enhancements. All focal parties, for instance the owner, the consultant, the main contractor and the architect are invited to assess each other's operations by filling one of 15 standard questionnaires per each evaluated party. The owner, too, will evaluate all the participants. Thus the result will present a more profound review of the projects than any one-directional feedback system could.

For researchers, the system offers a unique and cost-efficient means for data collection. The evaluation reports from hundreds of projects are readily available and easily convertible into Excel form for analysis. The cumulated results of all projects are limitedly accessible for research and industry evaluation and may, for example, be used to highlight the areas needing improvement in the whole branch of industry and gives opportunities for setting the benchmarks of customer satisfaction. The multifaceted view on project operations and the participants "peer reviews" unfold a rewarding opportunity to study collaborative relationships.

Figure 11 illustrates feedback flows between the parties in the system. Each arrow represents the direction of the feedback and one questionnaire. All feedback flows between the parties are bidirectional, except for the owner, as their operations are not assessed here. Subsidiary contractors and sub-contractors are not included in the analysis because they were not directly connected to the owner.

In the feedback system, the questions are formed as statements and connected to a 5-point Likert scale, where answer (1) describes the operations very inaccurately and (5) very accurately. No opinion (N/A) could also be chosen as an answer. Feedback providers can specify their answers in the open comment field. The questionnaire is answered electronically using an Internet form which displays the project and company being evaluated. The basis for the questions is derived from the various tasks in construction and from the requirements of a construction project. The feedback questions concentrate on the matters each party considers important, and, on the other hand, those which each party is able to assess. The tasks and requirements of various parties in construction were grouped into fields which are similar to each other, although the contents of the questions are determined by the role and task of the actor. The evaluation areas common to all parties were project management, cooperation, staff, and accomplishing goals.

The sample includes altogether 1617 evaluation reports. The data was arranged by feedback flow (giver-receiver) and by delivery model. 407 (25%) are project owners, 478 (30%) consultants, 203 (12%) designers, and 529 (33%) contractors. Evaluations completed in DBB projects numbered 677 (42%), in D&B projects 528 (33%), and in CM projects 412 (25%).

The resulting data was utilized mainly to describe the general levels of satisfaction and outline the major differences between delivery models. To further support the descriptive analysis, a simple statistical test was conducted with the T-Test Excel tool (two-sample, assuming unequal variances). To test and estimate the difference between evaluation sample population means, the results within each feedback flow were matched in pairs so that each delivery model sub-sample was tested against both of the other alternatives. For instance, the DBB evaluations were tested against both D&B and CM evaluations within each feedback flow. The statistical significance of the difference between each pair-wise test was determined by the resulting p-value, i.e., risk level.

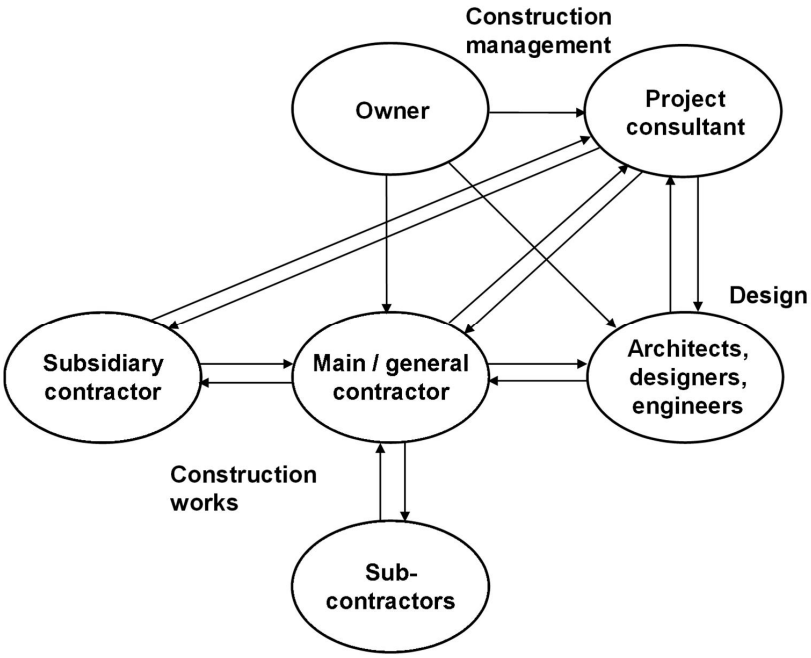

Figure 11 Feedback flows in the evaluation system

4.3.4 Statistical quantitative analysis (Article IV)

The study aims to identify (i.e., establish or refute) the relationship between inter-organizational performance evaluations and project success. The study was designed to test the proposition that dependencies can be found between the project participants' satisfaction with each other's performance and the owner's perception of project success. The dependencies identified are interpreted to indicate discipline-specific success factors. From the perspective of this dissertation, the dependencies denote relationships and factors that are significant for project success, and thus, for developing collaborative RM practices.

The fairly large sample size targeted and the attempted degree of generalizability directed the choice of the quantitative research method. The selected correlation

analysis, Pearson's correlation, is frequently used to measure quality factors, for example, in psychology studies. Because project satisfaction and success cannot be transformed directly into numerical data, survey answers are used to measure the attributes. Correlation itself does not reveal the causality of the variables, but it does measure the expected and linear relationship because there is no foreknowledge to presume any other, higher-level connection.

The data were retrieved from the ProPal feedback system, as described in Section 2.4.3. The included sample consists of 580 evaluation reports, representing 214 construction projects. The sample of projects is heterogeneous in terms of value, length, delivery model and type of construction. The unit of analysis used is the evaluation report, i.e., the individual feedback from one participant to another. The feedback flows between the participants are bidirectional, but the accumulated data quantities are asymmetric. Owner-related feedback flows represent exceptions to the mutuality of assessment, as the feedback system does not support the evaluation of owner's operations

The feedback question sets, i.e., the performance factors to be evaluated, are designed individually for each feedback flow. The question content is based on the various tasks in a construction project and the requirements they set for a construction project. The evaluated factors are formed as statements and based on a five-point Likert scale where the value (1) describes low satisfaction and (5) describes high satisfaction.

The owner's view was assumed as the determinant of overall project success and measured in terms of the owner's satisfaction with project goals related to budget, schedule, service, environment and safety, collaborative working, and product quality. This approach is somewhat different from that of earlier studies on construction project success (Chua et al. 1999; Phua, 2004) that determined success more objectively in terms of budget, schedule and quality. The client satisfaction focus on success, when measured against goal achievement, will give a balanced view, thereby allowing for changes and complexities occurring throughout the project.

A test factor representing Project Success was created as the dependent variable. Project Success conglomerates the owners' evaluations of factors within the category of accomplishing project goals, which was separated from the other owner-evaluated categories. The accomplishing project goals category can be found on each feedback flow, that is, the owners' evaluation of the project consultants, contractors and designers. The performance factors contributing to the Project Success variable consist of financial, schedule, product quality, environmental and safety, collaborative working, and service quality goals. The dependent variable was formed when evaluated project accomplishment factors were found in at least one out of three feedback flows.

As the variables approximately follow the normal distribution, correlations are calculated using Pearson's correlation coefficient. Statistical analysis was performed using the R-project software environment for statistical computing. Pearson's correlation coefficients were calculated for the eligible feedback entries that featured an attachable Project Success variable. The method is suitable for

judging the strength and direction of a linear relationship between two quantitative variables, assuming normal distributions (Keller and Warrack, 2000).

Lower general levels are predictable when comparing evaluation variables within the horizontal relationships with Project Success. Conclusions should not be drawn directly from correlation results. Spurious correlation may arise when the connection between two variables is coincidental (Aldrich, 1995). As the pairs of variables are not equal quantities, the correlations cannot be valued with equal accuracy. The number of usable variables within pairs defines the critical rates for significant correlation; hence, the significance test used to test for correlations is the t-test. This is why small numbers of pairs require higher p-values to be accepted, whereas large numbers of pairs have lower limits. A t-test was applied to test the reliability of the correlation coefficients because of a concern about the unequal quantities of available data and the level of variation within feedback flows. The t-test accepts the correlation as significant if the 0-hypothesis of insignificant difference from zero can be abandoned ($p < 0.05$). Accepted values are marked with the symbol / in the tables. The significantly correlating factors are herein called success factors.

4.3.5 Single-case study (Article V)

The study aims to suggest and test three solutions for multi-organizational risk identification and management. The research design of the single-case study follows the principles of constructive research, as presented by Kasanen et al. (1993) and Lukka (2000) and summarized in Sections 4.1 and 4.2.

The research motivation of the study is the same as the one in the overall dissertation, i.e., the need to improve collaborative RM in complex construction projects. Understanding of the problem and context was acquired through a comprehensive review of international RM literature, with a specific focus on collaborative solutions (as reported in Article I). The constructs result from the suggestions of researchers based on the pre-understanding phase, the target project's specific needs and the preferences and amendments of the project organization's key individuals in the application phase. In this manner, the innovation process becomes an iterative consultation between the researcher and the practitioners to ensure the constructs' practical suitability. All the constructs seek to address issues related to sharing and developing RM knowledge and committing participants to coordinated responses.

The practical conclusions about the constructs are based on pre-set hypotheses, which serve as a basis to anticipate and evaluate the influence of the constructs in the case project. The theoretical conclusions about the constructs reflect on their ability to demonstrate aspects of the complexity approach to collaborative RM.

The case study was set in a shopping center construction project that was delivered as CM service. The scope of the project involved a 60 000 m^2 building and a construction time of 23 months (11/2010-9/2012). The project was successful in terms of schedule, budget, quality, and client satisfaction. The project owner was a

large, professional, private, stock-listed retail sector company. The CM service provider was selected based on the key individual's experience and demonstrated potential for the project. The CM service provider's only contractual relationship was with the owner. All design and construction contracts were made between the owner and the vendors, in keeping with traditional design-bid-build contracts. The CM was responsible for tender processes and site management. Neither the owner nor the CM service provider was familiar with the CM service delivery model. All applied constructs were new in the current form for all participating companies, including the owner and the CM service provider.

The researcher was involved as a change agent in developing the three RM processes. This task included creating the project RM plan in collaboration with the PM team, observing the workshop related to construct 1 (RM workshop), giving an informative session about the principles of construct 2 (contractor integration), and collecting the feedback and running the workshop related to construct 3 (performance feedback). Other observations are based on 20 formal theme interviews, informal discussions on construction site and meetings, participant observation, performance feedback analysis, and project document development and reviews between November 2010 and October 2012. The interviewees were selected to thoroughly reflect the key participants in large construction projects. The participants include 4 owner representatives, 7 CM service provider's representatives, 2 architects, 4 engineers, 1 sub-contractor, and 2 user representatives. The participants had between 7 and 32 years of experience with construction projects. Sixteen of the theme interviews were conducted during the period of April to May 2011, and 4 were conducted in October 2012. Other discussions and observations were scattered throughout the project.

In the early stages of the research project, the interviews aimed to identify focal development needs in the project organization performance, especially in the applied RM processes. Towards the end of the project, the interviews and discussions were focused on evaluating the constructs and future development needs for multi-organizational RM. In practice, the interview structure was tailored to suit each occasion, based on the interviewee's role and the researcher's prior knowledge about the project. The majority of the interviews (16) were tape-recorded and transcribed. The remainder of the interviews, discussions, and observations were captured by research notes.

4.3.6 Multiple case study (Article VI)

The case study approach allows capturing rich information and retaining a holistic and meaningful picture of complex contexts (Barrett and Sutrisna, 2009). The three case studies of large-scale construction projects undertaken by professional public and private clients representing both building and infrastructure construction are summarized in Table 3.

The selected projects involve multi-organizational approaches to RM and employ professionals interested in developing multi-organizational RM. The case projects are unusually large, unique and/or time-pressured public or private construction projects, where the owner needs or wants to be involved throughout the project.

In the absence of exhaustive RM process maps, information needed to be retrieved from project participants. Interviewing enables both identification of complex links between practices that are assigned varying names and functions depending on the interviewed individual and dealing with future development needs, without being limited to the researchers' prior knowledge; this would not have been possible with a survey method.

Table 4 The case projects

	Description	Delivery model	Schedule	Data
Case 1	Music center 38 000 m2 ca. 170 M€	CM contracting Owner-client: Public, professional government property manager	Design 2001-2011 (incl. interruptions) Construction works 2006-8/2011 Interviews made 4-5/2011	6 Interviewees · 2 Owner representatives · 2 PM consultants · 1 Architect · 1 CM service provider (main contractor role)
Case 2	Shopping center 60 000 m2, over 80 commercial tenants	CM service Owner-client: Private professional large, stock-listed retail sector company	Design 2008-2011 (with a break) Construction works 11/2010-9/2012 Interviews made 3/2011-10/2012	20 Interviewees · 4 Owner representatives · 7 CM service provider representatives (main contractor role) · 2 Architects · 4 Engineers · 1 Contractor (trade contractor role) · 2 User representatives
Case 3	Metro line extension 14 km, 8 stations ca. 714 M€ (target)	CM consultancy Developer-client: Public professional company established for the project purpose	Design 2007-2014 Construction works 2009-2015 (target) Interviews made 6-10/2012	9 Interviewees · 1 Owner representative · 4 CM service provider representatives (PM consultant role) · 2 Architects · 1 Contractor (main contractor role) · 1 External RM expert

A total of 35 semi-structured theme interviews were conducted between March 2011 and October 2012. Case 1 is represented by 6 interviews, case 2 by 20 interviews, and case 3 by 9 interviews. The interviewees were targeted to represent a holistic overview of the key participants of large construction projects: 7 owner representatives, 2 PM consultants, 12 construction managers/CMs (who are PM

consultants or main contractors, depending on the CM project delivery model type), 5 architects (who represent the design group), 4 designers/engineers, 2 contractors, 2 user representatives and 1 external RM expert.

The selected complexity-based approach guided the interviews to focus specifically on themes related to integration within RM processes: 1) the interviewee's role in multi-organizational RM, 2) multi-organizational relationships that are covered and those that are not covered by RM processes, and 3) the desirable future of multi-organizational RM. In practice, the interview structure was tailored to suit each occasion based on the interviewee's role and the researcher's prior knowledge about the project. The majority of the interviews (27) were tape-recorded and transcribed. The rest of the interviews were captured in research diaries. The analysis included manually identifying comments related to each theme and making syntheses based on them.

5 Results

This chapter summarizes the key results of the research papers from the perspective of the dissertation. Section 5.1 summarizes the results of Articles I and II and aims to answer RQ1. Section 5.2 summarizes the results of Articles III and IV and aims to answer RQ2. Section 5.3 summarizes the results of Articles V and VI and aims to answer RQ3.

5.1 Challenges and opportunities of collaborative RM

The contribution of Articles I and II is related to describing the nature of management of complex construction projects and research on them. The results of Articles I and II aim to answer research question 1: What are the challenges and opportunities of collaborative RM that have potential for pragmatic and academic contribution?

5.1.1 Risk perceptions and approaches in multi-organizations (Article I)

The results indicate that studies regarding how risks are perceived and managed in TMOs cover a wide range but do not correspond to the knowledge of state-of-art RM principles in a balanced way. The relevant results related to advancing multi-organizational RM research are presented below and discussed in more detail in the article.

Opportunities for opportunities

The uncertainty view of risk, i.e., including both threats and opportunities as part of risk definition and RM, has not been widely adopted in multi-organizational RM research thus far. Only a few reviewed theoretical contributions address both threats and opportunities (i.e., uncertainty), and no advice is given for practical uncertainty management in multi-organizational contexts. This shortfall contradicts the state-of-art recommendation and represents a potentially serious drawback for TMO success. This leads to the conclusion that multi-organizational RM research is not prepared to seize opportunities as part of project RM.

Investigating efficient strategies to promote opportunities as the complementary side of multi-organizational project, RM may improve the project probabilities for success, perhaps occasionally beyond expectations. In the context of TMOs, such opportunities may arise from the same premises as the traditionally tracked threats such as multiple stakeholders, communication, and cost-quality optimization. Seizing opportunities cannot be a mechanistic task in TMO. Opportunities are mostly developed from complex types of uncertainties that require the participants to develop a holistic view of the project before it becomes possible to identify and realize opportunities (Olsson, 2007). In addition to a holistic view, Olsson (2007) lists two major factors that are needed for managing opportunities: organizational

support and interest and the ability to understand how other organizations affect the project's objectives. Fruitful approaches to seizing opportunities involve integration and commitment within a team (Pavlak, 2004) and structuring through conversation (Olsson, 2007; Pavlak, 2004). These features are not usually supported by traditional RM approaches or in traditional RM research.

Being proactive, reactive, and aware

The premises of proactive RM treat the identification of risks as a prerequisite for properly managing such risks (Royer, 2000). This view focusing on anticipated risks was found to be substantially dominant within multi-organizational RM research. Kutsch and Hall (2010) claim that "project risk management with its assumptions of 'hyper rationality' excludes many aspects of managerial behaviour."

Large, complex, and long-term projects are characterized by high uncertainty, which leads to unanticipated risks. Based on the review, multi-organizational RM research also frequently omits aspects of internal and external uncertainty that lead to unexpected risks and unrealistic assumptions. Proper management of unanticipated risks is not based on proactivity but on reactivity. An organization should complement its RM approaches with a disciplined reactive component, that is based on multi-disciplinary collaboration (Pavlak, 2004). Olsson (2006) and Jorgensen (2005) suggest flexibility as an approach for an organization's need to adapt to unexpected changes and uncertainty in the business environment.

A third RM approach is needed to address unrealistic assumptions. To better address its position in relation to these inherent risks, the multi-organization must be aware, questioning, and open about them. Royer (2000) suggests documenting and addressing project assumptions in the same manner as risks. In the construction industry, the basic approaches to "managing" unrealistic assumptions include reliability buffering (Park and Pena-Mora, 2004) and float allocation (Al-Gahtani, 2009). In the software industry, solutions are provided for addressing, questioning, and improving assumptions (Jorgensen, 2005; Damian and Chisan, 2006).

Outside-in and inside-out perspectives on the role of the TMO

The review identified a variety of perspectives on the role of multi-organizational collaboration as a risk itself and a resource for RM. These perspectives can be divided into two main categories: the "outside-in" perspective and the "inside-out" perspective.

Generally, TMO assumes an outside-in perspective, looking at its structure and relationships themselves as having potential for risks. Busby and Zhang (2008) state that the internal risks related to the organizational decisions and structures are, in fact, more prominent than the external ones because they determine the stance and preparedness for external risks. From the client's perspective, treating collaboration as a risk source involves, among other issues, predicting and preparing for contractor default (Al-Sobiei, 2005), participating in the requirement setting and change process (Fu et al. 2012), and investing in dispute resolution (Menassa et al. 2010). The supplier-side interests are focused on, for example, risk

analyses of bid pricing (Laryea and Hughes, 2011) and customer involvement and communication issues (Holzmann and Spiegler, 2011).

The inside-out perspective addresses the multi-organizational collaboration as a resource for RM. For example, De Bakker et al. (2012) explain the use of RM communication efforts to influence IT project success, and Aleshin (2001) looks at joint ventures as one way of managing risks in the Russian construction market.

There is frequent overlapping of the dual role of TMO. Studies addressing collaboration as both risk and solution were featured in two-thirds of the papers. Especially in the construction context, the dual role is frequently addressed as part of procurement practices and contract considerations. However, the dual role of TMOs as both a source of risk and opportunity and as a powerful and versatile resource for risk and opportunity management has not been addressed to its full potential in many recent studies. Both identified means for "collaborative" RM (i.e., contractor selection and contractual risk allocation) can be regarded as passive solutions for RM because they are usually based on one-off decisions and focus on transferring risk to a specific party.

Solutions that involve both or several parties in the problem-solving, decision-making, and response-handling processes could be seen as active solutions. For example, Rahman and Kumaraswamy (2005) demonstrate how integrated teams can be used as a means for RM, and Chapman (2001) introduces a system for utilizing multi-disciplinary capital for risk analysis. To address the remaining shortfall, researchers could engage in investigating and developing active, collaborative solutions that combine the inside-out and outside-in perspectives. An inside-out- and outside-in-looking multi-organization would be in a better position for timely and efficient risk responses, which would ultimately benefit each participant's business. Cross-functional teams and group analysis sessions are perceived to have a strong impact on achieving benefits for RM from requirements engineering (Damian and Chisan, 2006). Conversely, the lack of joint RM mechanisms was found to be the most important barrier to efficient RM (Tang et al. 2007).

Allocated and shared RM responsibilities

In construction contexts, almost equal numbers of studies address the client/owner-side risk responsibility and the vendor/contractor-side responsibility. Of these papers, roughly half feature contexts in which the responsibility for bearing the risk or undertaking RM was shared between two or more participants. Designers' or project consultants' RM responsibilities are seldom handled in research.

Risk responsibilities are typically determined when a multi-organization is created during the procurement process. The factors determining the preconditions for (un)successful collaborative risk management include selecting the project delivery model (Mostafavi and Karamouz, 2010), contractual risk allocation (Ng and Loosemore, 2007), planning for contracting (e.g., Al-Sobiei et al. 2005) and selecting the best value contractor or team (Kashiwagi, 2010).

Procurement strategies may be used to transfer risk responsibilities from the owner to the vendor and to commit the vendor to the RM process (Kashiwagi, 2010). Joint ventures (Shen et al. 2001), partnering arrangements (Tang et al. 2006; Osipova and Eriksson, 2011) and joint risk responses (Pavlak, 2004) improve the efficiency of involving multiple parties in RM.

Further research and development should identify solutions to address the role of multi-organizational collaboration and outline each participant organization's role as part of the project (risk) management. The risk responsibilities should be based on who is in the position to manage them. However, in a multi-organization, the best position may not be stable. It is suggested that the multi-organization is in the best position to share responsibility for the risks that are common to its participants.

5.1.2 Complexity thinking as a lens for analyzing and developing multi-organizational management approaches (Article II)

Article I describes the challenges that multi-organizations face in relational risk management. From the perspective of this dissertation, the contribution of the paper relates to justifying complexity thinking as a suitable theoretical framework for analyzing and developing multi-organizational management concepts, such as collaborative RM. The article scope is related to relational RM, which is described as "a multifaceted management problem that substantially influences the project's success".

The first relevant finding relates to justifying the use of complexity thinking as the lens for analyzing multi-organizational management problems. The traditional RM frameworks, as well as the disintegrative approaches to complexity, properly address only the formal side of risk identification and response, whereas the informal side, such as addressing and managing dynamism-based risks vis-à-vis individual mixes of conditions, stakeholders, and tasks, is better covered by complexity thinking. Table 4 summarizes some of the differences between traditional and complexity thinking in relation to the three fundamental themes of relational RM.

Complexity thinking should be regarded not as a self-standing theory but rather as a lens for seeing reality in a certain way (van Eijnatten, 2004). Complexity thinking does not offer direct advice on project management but guides building approaches that integrate organizational parts, goals, and management structures.

Table 5 Comparing the fit of traditional PM paradigm and complexity thinking to empirics

Relational risk theme	Traditional PM thinking lens (e.g. Project Management Institute, 2008)	Complexity thinking lens (e.g. Edwards, 2005; Cicmil and Marshall 2005)	Empirical evidence (research interviews)
Conditions of collaborative competence	Collaborative working is characterized though contractual relationship and task-specific responsibilities. Sequential planning, organizing, and control form collaborative competence.	"Nested systems, such as organizations, are more adequately represented as complex strata of holons rather than as networks of individual parts" (Edwards, 2007). Formal and informal communication and power relations shape the functionality of an organization.	Contractual or other formal relationships do not set the boundaries for interaction and influence. Individuals' (rather than companies') attitudes and competences determine the success of collaborative working.
Learning	Organization and individuals have stable competences, skills and knowledge. Information on goals and interests is transmitted through formal channels such as contracts, meetings, and 'lessons learned' sessions.	"Organizational dynamics can be concerned with change that occurs in a continuous, translational fashion as well as in a discontinuous, transformative fashion" (Cicmil and Marshall, 2005).	The traditional view on learning guides managerial thinking; mostly, learning is reactive. Informally, people develop procedures beyond formal ones for coping with changes and uncertainty during project.
Incentivizing	Sub-organizations are contracted to perform the work. Financial incentives are used to motivate performance.	Uncertainty and complexity shape individuals' relationships with each other and their motivation towards the project goals.	Individual's motivation is of extrinsic and intrinsic origin, which often contradict. Similarly, contradictions appear on different organizational levels, such as individual and the project organization.

Selected conclusions of the article have relevance for developing a collaborative RM framework:

- Most risks originate within the project organization and stakeholder network, not from the technical implementation of the project. A flexible, multilevel management approach is preferable to a rigid and simplistic or single-organizational one in construction project organizations.
- Complexity thinking appears to be more fruitful than traditional approaches to project management in understanding implicit, informal, and ambiguous management problems. Therefore, complexity thinking can be regarded as a suitable theory base informing the development of multi-organizational RM. Future research on the implicit or informal areas of project management, such as relational RM, should benefit from research approaches and models informed by complexity thinking.
- Practical improvements to the multi-organizational RM process based on complexity thinking include: a) creating a flexible managerial framework enabling the organization not just to cope but also to thrive in the face of uncertainty, change, and complexity, b) considering financial incentives to support teamwork, c) strengthening the link between designers and site workers (excluding site management), d) supporting face-to-face communication.

5.2 The role of collaborative working in construction projects

The contribution of Articles III and IV is related to analyzing the strengths and weaknesses of collaborative relationships in construction projects. The results of Articles III and IV aim to answer research question 2: What is the role of collaborative working in construction projects?

5.2.1 Satisfaction with collaborative working in construction projects (Article III)

The choice of delivery model determines the requirements, expectations, and preconditions for the project organization's collaborative relationships. The aim of this research was to explore the differences in the levels of satisfaction with collaboration. For this, three alternative delivery models were used in Finland; DBB, CM, and D&B. The data includes over 1600 bidirectional evaluations from the Finnish project feedback tool ProPal. The overall satisfaction with the collaboration between the participants ranges from good to excellent (between 3.71 and 4.76 on a 1-5 scale), as summarized in Figure 12. The satisfaction with collaboration was, as expected, lowest in DBB in many relationships. The owners' and the designers' satisfaction with consultants and contractors also was the lowest in DBB. The consultants were less satisfied with contractors in DBB than in D&B. In general, the worst satisfaction levels were found in the relationships with the designers.

Contractors, on the contrary to the common belief, performed well. From the owners and designers in DBB projects, consultants received evaluations ranging from mostly very good to some of the lowest in the data. Both consultants and contractors get best scores in the delivery model where they have the major role for project success, i.e., in CM and D&B, respectively.

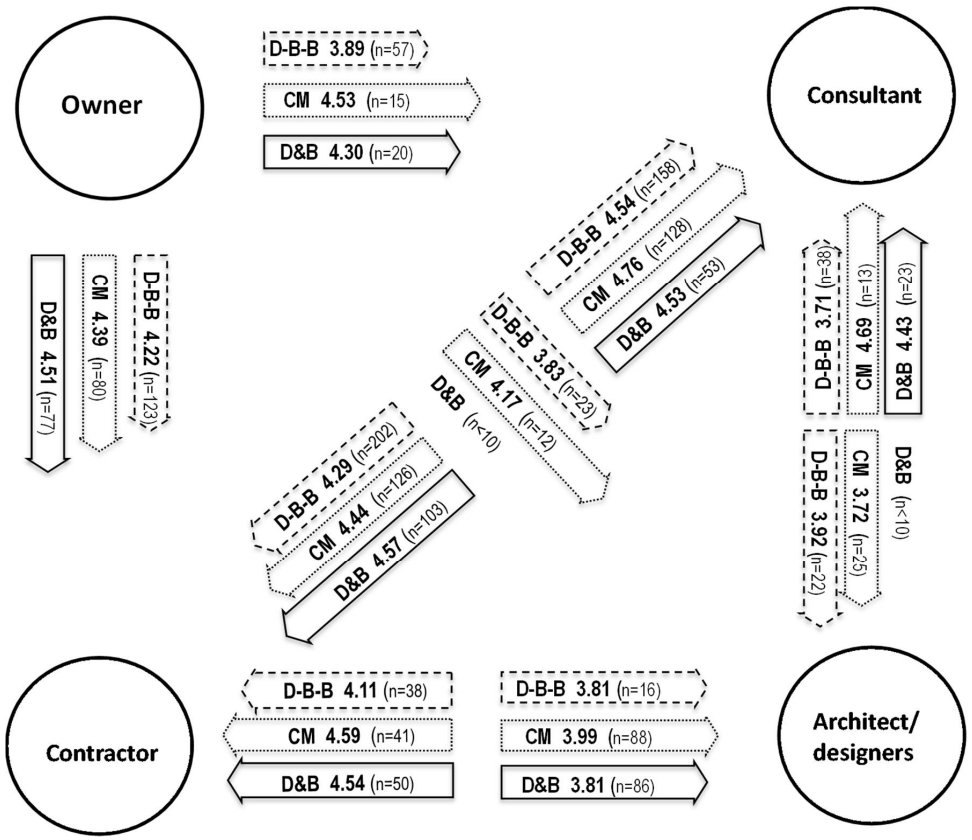

Figure 12 The levels of satisfaction in the bidirectional evaluation in three different delivery models. The arrows point from the feedback giver towards the receiver. The figures refer to the mean value of the evaluations given in each category.

Selected implications of the study results can be used to guide developing collaborative RM:

- The multi-directional performance feedback tool (ProPal) provides useful data for analyzing the collaborative relationships.
- The results suggest that in Finland the contractors' collaborative relationships work better than expected but the designer's role in the collaborative project organization should be more prominently acknowledged and developed.

- As the lowest scoring relationships in the project organization, the designers' collaborative relationships have the highest potential for overall project performance improvement. The owners' collaboration with consultants in DBB projects is another potential development area.

5.2.2 The role of multi-firm satisfaction in construction project success (Article IV)

Connections have been identified earlier between multi-firm team satisfaction and performance (Leung et al. 2004) and between multi-firm team satisfaction and client satisfaction (Nzekwe-Excel et al. 2010). This study establishes the relationship between project success and project participants' evaluations of each other. The results show that correlations can be found between certain project participants' satisfaction with each other's performance and the owner's perception of project success. Therefore, the results support the proposition that satisfaction within both owner-related and non-owner-related relationships is reflected on success. More specifically, satisfaction with performance factors within the relationships between the owner and any other participant (i.e., the contractor, designer or project consultant), within the relationship between project consultants and designers and within the relationship between project consultants and contractors were reflected in the owner's perception of project success. The statistical presentation of the dependencies is given in the article.

Selected implications of the study results can be used to guide developing collaborative RM:

- Because multi-organizational performance evaluations reflect on project success, the importance of measuring, monitoring and improving service quality within the horizontal as well as owner-related relationships can be re-established based on this study.

- The present results provide advice for selecting the most prominent relationships and performance factors as the basis for engaging appropriate measurement and management mechanisms.

- The designers' relationships seem to have the most prominent development potential. For example, the designers' ability to maintain adequate information flows with the owner and assume a systematic project management approach correlates with successful project delivery. Although project management is not the traditional responsibility of the design profession in Finland, modern project delivery models and practices accentuate the need for efficient coordination and communication on all levels and across disciplines.

5.3 Complexity-based collaborative RM practices

The contribution of Articles V and VI is related to creating and evaluating constructs for collaborative RM. The results of Articles V and VI aim to answer research question 3: Which practices, processes, and roles support collaborative RM? Article V suggests and analyses three individual sub-constructs, and Article VI aims to provide a holistic construct (management framework) for collaborative RM.

5.3.1 Evaluating complexity-based collaborative RM sub-constructs (Article V)

A constructive case study approach is applied to propose, test, and analyze three practices (constructs) for multi-organizational risk identification and response in a Finnish shopping center construction project. The complexity approach to project management guides basing management processes on integration and communication within the multi-organizations. Therefore, the constructs aim to utilize and support collective knowledge and collaborative working. The constructs include 1) a risk workshop, 2) a process for involving the contractors in RM, and 3) a process of utilizing performance feedback for RM. The following is a summary of the description, observations, and conclusions on the constructs based on the case study. A more detailed analysis is presented in Article V.

Construct 1: Risk workshop

Construct 1 is a focus group application for project-specific risk identification and response planning, further referred to as the risk workshop. This research project followed the risk workshop application that was set up by the project owner around the time the construction works began (November 2010). An effective time for the risk workshop is during the early phases of the project when the key project participants are selected but works have not begun. Depending on the project, it may be useful to have one workshop in the beginning of the project and another or several others once more key participants have been selected.

The aims of the risk workshop were to share information on the project's focal success factors and special management processes and to increase the levels of risk knowledge, communication, motivation, and opportunity. The workshop was thereby meant to trigger thoughtful, risk-based project planning. Approximately 50 people from 7 organizations representing the owner, the CM service provider, the designers, the tenant agent, and the researchers participated. The role of the moderator, which is stressed by Krueger and Casey (2009), was shared by the owner, who presented the project's goals and main concerns, and "an outsider", i.e., a researcher, who explained the threats and opportunities inherent to the CM delivery model. Furthermore, the workshop aimed to ensure that all key participants know their roles in the project and its RM process.

The risk identification and preliminary response planning was conducted in three predetermined sub-groups focusing on PM, design, and procurement and production. Krueger and Casey (2009) recommend a manageable size of a maximum of 12 participants per group. Each sub-group included participants from most of the participating organizations, and the individuals for each sub-group

were selected based on the expected relevance of the theme. The discussions were moderated by the sub-group leaders, according to a questioning procedure that was briefly explained to them. The sub-group leaders collected the results, i.e., lists of identified risks and their respective responses, and presented them in a collective wrap-up session.

The risk workshop was found to serve its purpose of addressing a wide variety of multi-organizational expert insights for collaborative risk identification and response planning. Further, the workshop construct has the potential to initiate collaborative RM more efficiently if participants are selected and more carefully briefed and if the overall project RM process is explained clearly as part of the workshop.

Construct 2: Contractor risk integration

Construct 2 has been designed to respond to the common concern about contractor performance and involvement in the owner's RM process during the project. The construct involves a procurement and project planning process that integrates contractors into the project RM process. The purpose of the construct is to trigger the contractors' risk awareness and self-management by sharing project-specific risk information in the procurement phase and by asking them to develop contract-specific risk identification and response planning documents.

The contractor integration process was deemed to promote better risk awareness and communication in the applied limited form. To leverage the full potential of the construct, it could be further advanced in Finnish CM projects towards its original role in best value procurement.

Construct 3: Performance feedback

Construct 3 is a methodology for identifying strengths and weaknesses in collaborative relationships by collecting and responding to multi-directional performance feedback from participants. The construct has two main purposes. First, it is meant to serve as a structured quality risk identification system that utilizes the project participants' observations. Second, it functions as a development (learning) system, the participants receiving useful feedback on their own performance from the perspectives of others.

The feedback construct was applied in two rounds: once when the construction works had been on-going for approximately 6 months (April-May 2011) and again at the end of the project (October 2012). The collection of feedback was based on a commercial performance feedback system called ProPal, which allows project participant companies to evaluate each other's operations on a scale from 1 to 5, where 1 is poor and 5 is excellent. The factors being evaluated are grouped into four general areas of project performance: project management, collaboration, staff, and goal achievement. Bidirectional evaluations were carried out among the project owners, project consultants, main contractors, and designers. In the first round, interviews were used to support the analysis of the strengths and weaknesses of collaborative relationships. A workshop was held after the first round to disseminate the results and generate innovative development initiatives

based on the findings. The results of the second round were delivered as a summary report for the participants.

The multi-directional performance feedback was found to facilitate identification of the strengths and weaknesses of each participant's performance and to discover innovating initiatives for performance improvement. This result supports and further defines the findings of the quantitative study of Article IV, where the significance of collaborative working was established. In the future, the process could be better integrated with project delivery so that each key participant would be aware of feedback goals and committed to the implementation of the resulting improvements.

5.3.2 Advancing complexity-based collaborative RM (Article VI)

The study analyses how risks are managed in three multi-organizational construction case projects in order to identify and systematize useful processes. The practice of RM in large construction projects was analyzed from the perspectives of multi-organizational roles, RM activities, and future development needs.

The multi-organizational RM roles

The owners were more concerned than other participants about risks related to the investment, stakeholder network, collaboration, and politics. Some items of the owners' risk lists are not part of any other delivery team members' interests, such as taxation and tenant acquisition. However, several client responsibilities, including permits, user information management, and, in some cases, design management, influence decision making and the construction schedule, indicating that they are contractors' concerns as well. The fit for use required risk identification and management in collaboration with the architects, engineers, and contractors. The owners regard the construction phase as being a significant determinant of their goals. Generally, they are more concerned about the risks that relate to the multi-organizational collaboration itself rather than to technical solutions.

The main contractors regard their role in project RM mainly in terms of schedule and safety management. The schedule marks the baseline for expectations and the foundation for RM. The contractors' stance regarding risks is purely on the threat side; deviations from the already tight construction schedules and costs are rarely positive. Often the risks are connected to other parties, typically designers.

The PM consultants are in a role that aims to integrate the actions of the other parties. Therefore, the interviewed PM consultants raised risks related to both investment and site management. In RM processes, they are in the role of gathering and sharing risk information. The PM consultants' primary task is to supervise the performance according to the owner's goals. This may involve work on identifying and prioritizing the goals, too. On the other hand, the PM

consultants' success criteria are close to those of the contractors: construction schedule, time, and quality.

The architects' and other design and engineering professionals' role in the case projects' RM is that of the owners' advisor. These professionals are generally not an active part of any systematic RM procedure but participate when asked. The architects' involvement in the projects starts long before that of the PM consultants and contractors. Therefore, they regard their expertise as being most valuable in the early phases of the project. They perform tasks related to risk identification in the early phase of the project in collaboration with the owner, although the tasks are not necessarily labelled as being RM.

Multi-organizational integration for RM

The results indicate that in practice a significant share of the RM processes are based on multi-organizational collaboration: 16 of the identified RM practices include collaborative participation of 2 or more of the reviewed key participants. The majority, i.e., 15, of the identified processes are common to more than one case project in some form. Furthermore, the practices are matched against the process steps in standard RM (Project Management Institute, 2009), which enables observing differences in coverage.

The adaptations of the RM process to the multi-organization include collaborative processes, such as meeting procedures, workshops, and multi-directional performance feedback. Practical RM processes are focused on risk identification and response planning, whereas risk analysis is clearly an overlooked area of RM in practice. Risk analysis is addressed as an intuitive part of risk identification and response planning.

Needs for further development

All research participants were asked how they would like to see project RM develop in the future. Most wishes related to the systematic nature and clarity of multi-organizational RM procedures and roles. More specifically, development suggestions based on interviews and observations included:

- The multi-organizational RM procedure must include clearer responsibilities and more frequent or predictable updating practices.
- Some roles, such as those of the architect, designers and engineers, and (sub)contractors, are underutilized bearing in mind their current potential.
- The planning and communication of each role, especially the owners' role, should be conducted transparently.
- For the sake of thoroughness, multi-organizational RM practices should involve parties through smart procurement practices more systematically than in the past.
- RM collaboration should be extended to participants other than those working in the delivery organization—most importantly, end users and key authorities.

- Learning should be regarded as part of RM development. Therefore, the development of functional lessons learned, rather than the development of the unutilized data banks, would be crucial.

A framework for multi-organizational RM (MORM)

The project results imply that the project RM procedures have been adequate and successful. Therefore, the results provide useful material for contrasting against and complementing existing RM literature and standards in search of development opportunities. Although all the activities listed in the PMBOK risk management standard process were found within the case studies, the sequence and proportions of those activities do not conform to the standard. Four key differences stand out from the multi-organizational RM practices when compared to the process depicted in the PMBOK standard RM process:

- The 'generic' RM process described in the standards is, in reality, spread among the participants and several forums in the multi-organization. This implies that to adapt the standards (such as PMBOK by Project Management Institute, 2009) to the project organization (ISO 31000:2009), considerable work needs to be done in each project. Risks are handled from diverse perspectives, depending on the role of the participant, and there is usually no universal, systematic procedure for the collection of the risk data. Many of the interviewees sought more systematic procedures, but the system for collecting risk information would need to be able to differentiate between different levels of risk, according to the expertise and interest of each participant. However, these concerns are hardly discussed in literature, which implies a significant research gap.

- Multi-organizational RM processes will function efficiently only if all participants have a similar understanding of the risks and an incentive to participate in their handling. This understanding addresses the importance of the early phases of the participants' relationship and is related to procurement and incentive strategies. The multi-organizational project owner (or PM consultant) must also plan the process of selecting and committing the key participants for multi-organizational RM. The need for additional collaboration or partnering agreements was not identified by the participants. However, they did address the need for aligning contractual incentives by providing payment schemes that support accomplishing project objectives. To facilitate collaborative RM, it may be useful to apply the principles of relational contracting, as described by Lahdenperä (2009). For instance, Ling et al. (2006) and Osipova and Eriksson (2011) recommend more contractual incentives to align the goals and to create opportunities for increased participation. Several participants mentioned the willingness to be assessed by their ability to demonstrate RM competence in the tendering phase. This would improve integrating project key participants as part of multi-organizational RM. Furthermore, the

architects and designers/engineers are frequently left out of contractual incentives, i.e., profit sharing, although their role in RM is significant. The explanation of the owners' goals is sometimes described as a specific step of the RM process (e.g., Lichtenberg, 2000), and a good number of studies address RM considerations related to contractor selection (e.g., Kashiwagi, 2010). The importance of these RM considerations would be better appreciated if they were added as an explicit step in the multi-organizational RM process. Nowadays, this is rarely done.

- The activities involved in the identification and analysis of risk are in practice intertwined. Risk analysis in the case projects is often intuitive, and the main assessment is simply made between the qualitative categories, 'significant' and 'insignificant'. The finding aligns with Chapman and Ward (2004), who suggest that the "best practice in project RM is concerned with managing uncertainty that matters in an effective and efficient manner". The identified processes seem to be more based on heuristics and intuition than on calculative analytics, as described by Slovic et al. (2004). Forbes et al. (2008) point out that there are numerous tools to support risk analysis but they are hardly used. In this study, quantitative risk analysis appears to be practically relevant only in investment risk analysis and not during the construction project. However, most research on risk analysis focuses on analytic reasoning. These findings suggest that research should rather be concerned with understanding and supporting the mechanisms of assessing what type of uncertainty matters and how to identify and manage it. Alternatively, the finding can be taken as a challenge of identifying or innovating the quantitative techniques that would, in fact, fit into the project practice, resulting into less biased and more easily visualized risk information.

- The functionality of multi-organizational collaboration must serve as the foundational "tool" for multi-organizational RM. Several interviewees indicated that motivation for multi-organizational RM must be based on functional collaboration and that the same practices that are used to facilitate RM be used to improve conditions for collaboration. Therefore, the monitoring and controlling of collaborative performance should be an acknowledged part of the RM process. Relational contracting and the collaboration-based project delivery models give a good foundation for multi-organizational RM (Osipova and Eriksson, 2011; Bresnen and Marshall, 2000; Chan et al. 2004), but more specific processes need to be added to utilize and support collaboration for RM. For example, the multi-organizational project feedback system that was used in case project 2 may be utilized for collecting information on multi-organizational performance. The results enable the identification of risks for project performance as well as the development of ideas for improving the efficiency of collaborative work.

Suggested amendments to the RM standard process flow, based on the research results, are illustrated in Figure 13. The novel RM process is designed to better fit

the requirements of construction multi-organizations and is herein called Multi-Organizational Risk Management MORM. The MORM process is further detailed into several parallel processes occurring in the key participant organizations.

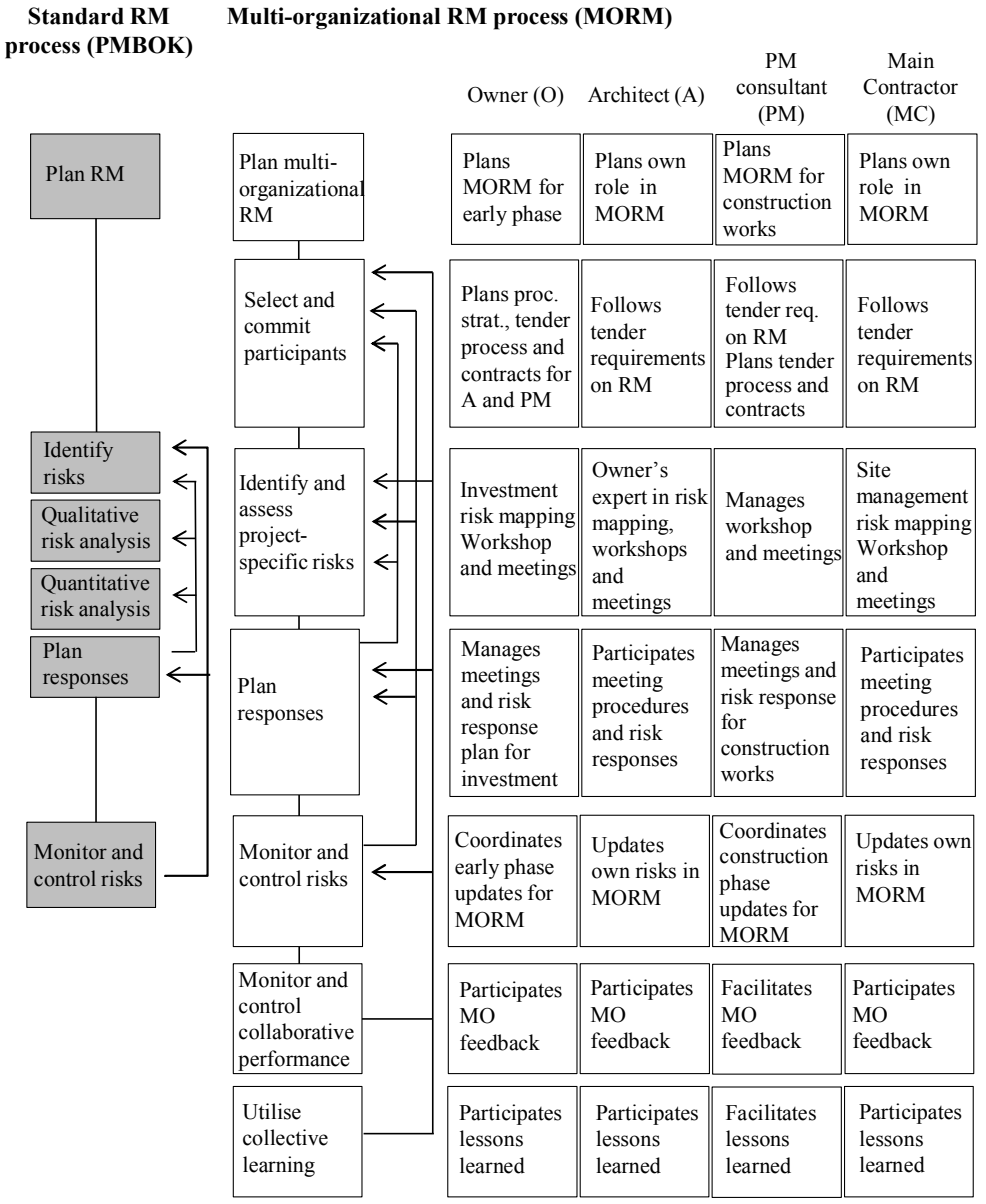

Figure 13 Complementary and parallel processes in multi-organizational RM (MORM) allocated to key project participants

5.4 Results summary

This section aims to capture the key results from the research articles from the perspective of potential development of a multi-organizational RM framework.

RQ1 What are the challenges and opportunities of collaborative RM that have potential for pragmatic and academic contribution?

- Research on multi-organizational RM is inadequately scoped for complex multi-organizational projects. Research gaps include systems that support addressing a wide scope of risks (incl. emerging risks and opportunities), utilizing collaborative expertise, and taking flexible approaches toward allocating and sharing of risk responsibilities. (Article I)
- Complexity thinking is a useful lens for analyzing and developing multi-organizational management structures. (Article II)

RQ2 What is the role of collaborative working in construction projects?

- The collaborative relationships within the design management team should be improved. Multi-directional performance feedback can be used to address the strengths and weaknesses of collaborative relationships. (Article III)
- Satisfaction within both owner-related and non-owner-related relationships is reflected on success and should be managed as a part of project RM framework. (Article IV)

RQ3 Which practices, processes, and roles support collaborative RM in practice?

- The suggested constructs (a risk workshop, contractor RM integration, and multi-directional performance feedback) usefully complement single-organization-focused RM approaches and can be regarded as useful processes for multi-organizational RM. (Article V)
- The results outline the RM processes in practice, presenting both overlooked and added steps compared to standards and identifying several parallel processes spread among the key participants. (Article VI)

6 Discussion

The constructive research approach aims to provide both theoretical and practical contributions. The main scientific contributions of the dissertation are the foundation and reflections on complexity-based management theory. Section 6.1 discusses the scientific contributions in more detail. The main practical implication of the dissertation is the resultant collaborative RM model, which enables CM project practitioners more efficiently to plan and initiate their multi-organizational RM processes. Section 6.2 discusses the practical implications in more detail. Section 6.3 addresses the critical enablers for using the MORM model as procurement and collaboration models as well as for professional training. Section 6.4 discusses the validity of constructive research that is connected to construct validity and research validity. Section 6.5 handles the reliability of the research, Section 6.6 the limitations and applicability and Section 6.7 suggestions for further research.

6.1 Theoretical contributions

Construction management theory is defined as the body of knowledge which currently is established and accepted to explain the most effective management of construction projects (Wing et al. 1998). The complexity of construction projects essentially limits the scope and possibilities of testing such theories (Love et al. 2002). Currently, traditional RM approaches (as explained in Section 3.2.1) represent the widest accepted body of knowledge on construction project RM. However, in practice they do not correspond well to the complexity of construction projects. This research aims to contribute to the theory of complex construction project RM by exploring and guiding RM processes within some of the multi-organizational collaborative relationships.

The research is grounded on and has implications for complexity theory on PM. Practical responses to project complexity need to address the relational and communicative nature of project planning, control, and organization, etc. (Cicmil et al. 2009). A successful complexity-based approach requires integration on several levels between multi-organizational participants, organizational levels, and management practices. The sub-constructs and the main construct provide useful examples of RM initiatives that reach beyond discipline-specific organizational boundaries and indicate a potential for integration between organizational levels and management practices.

The main result of this dissertation, i.e., the MORM framework, applies a traditional process model that is informed by complexity thinking. The complexity approach is visible in the analysis and interpretation of the project organization as the context of RM and in the recommended management approach. When the construction project is analyzed as a complex, open system, potential for integration can be found within the system parts (Walker, 2007). The MORM framework is developed to respond to the complexity of construction project RM by systematically increasing the opportunity for risk communication, response

innovation, and flexibility in the sharing of risk responsibility. This approach also assists in adapting to high levels of uncertainty, including the consequent dynamic changes in project goals and emerging unanticipated risks.

The sub-constructs are analysed from the perspective of complexity thinking. For example, the risk workshop (construct 1) or, indeed a series of workshops as a future enhancement, provides a systematic method to share and gather dispersed risk knowledge in multi-disciplinary teams, which is often recommended but not explained in research. The contractor integration (construct 2) helps to leverage the complexity of multi-organizational collaborative relationships by increasing risk communication and opportunities for case-by-case flexible approaches to emerging risks. The multi-directional performance feedback (construct 3) responds to the opportunity of utilizing multiple perspectives of project performance to the benefit of performance improvement and collaborative RM. As several of the new or strengthened links of risk communication are not based on contractual or supervisory relationships, the constructs can be seen as steps for addressing the informal organizational structures which Walker (2007) and Lizarralde et al. (2011) stress as essential to match the needs of complex multi-organizations.

6.2 Practical implications

The results provide evidence that the suggested collaborative RM processes in Article V can be validated as applicable, useful, and beneficial for bridging the gaps that have been identified within the scope of single-organization-focused RM standards and the needs of multi-organizational CM projects. The three sub-constructs formed the core of a useful multi-organizational RM framework. The MORM framework developed in Article VI (Figure 13 in Section 5.3.2) is intended to provide CM project managers and participants a holistic, multi-organizational RM process, which enables efficient set-up in future projects. Such guidance has been requested in the Finnish construction industry.

The developed and analyzed constructs aim to turn multi-organizational complexity into an advantage for risk identification, assessment, and response, providing substantial added value for multi-organizational projects. The constructs are designed to respond to the complexity of construction project risks by systematically increasing the opportunity for risk communication, response innovation, and flexible sharing of risk responsibility. This approach also assists in adapting to high levels of uncertainty, including the consequent dynamic changes in project goals and emerging unanticipated risks.

A successful complexity-based approach requires integration on several levels between multi-organizational participants, organizational levels, and management processes. The constructs provide useful examples of RM initiatives that reach beyond discipline-specific organizational boundaries and indicate a potential for integration between organizational levels and management processes.

RM is expected to be a growing priority area of development in construction companies, as the owners begin to require it in project plans and as the companies

increase their preparedness for efficient multi-organizational RM. The success of construction projects depends increasingly on the multidisciplinary team's participants' collaborative and coordinative competences and on the managers' competence to mobilize their team's expertise for the best of the project. In volatile construction projects, comprehensive processes enabling RM and (fast) learning as integrated parts of project management will play key roles.

The results of this dissertation provide complementary RM processes to stretch standard RM processes beyond discipline-specific organizational boundaries. It is suggested that the construct would help bridge the gaps that have been identified between the scope of single-organization-focused RM standards and the needs of multi-organizational projects. The developed and analyzed sub-constructs aim to turn multi-organizational complexity into an advantage in risk identification, assessment, and response, providing substantial added value for multi-organizational projects. The main construct, i.e., the systematic presentation of parallel RM processes in construction multi-organization guides construction project managers more efficiently, setting up the RM process for their multi-organizational projects. A multi-level process chart enables participants to understand their roles more easily than in case-by-case project RM plans. Because multi-organizations are the default delivery structures in several industries, including construction, this advancement would be potentially significant.

6.3 Enablers and obstacles for the use of MORM

Several management structures, incentives or levels of competence may enable or inhibit the use of the suggested MORM model. Although they are not tested in the current study, similar studies make it possible to understand their roles.

Risk responsibilities and the division of risk and reward are typically determined when a multi-organization is created during the procurement process. From the owner's perspective, a large part of the uncertainty is related to selecting a suitable project delivery model as the basis for risk allocation (Mostafavi and Karamouz, 2010), planning for contracting (e.g., Al-Sobiei et al. 2005) and selecting the best value contractor or team (Kashiwagi, 2010). At the same time, the prerequisites for each participant's motivation to contribute to RM are defined. Therefore, the tendering process and requirements influence the success of later risk management. Collaboration and meaningful contributions are naturally more likely when risk and reward are divided equally.

RM could be used as an integral part of forming a TMO. The tenderers' ability to identify risks related to their suggested work performance can be used as a selection criterion. Kashiwagi (2010) recommends a systematic process for transferring risk responsibilities from the owner to the vendor as the result of a risk-focused tendering process and risk management-based vendor selection. Several participants in this study mentioned their willingness to be assessed via their ability to demonstrate RM competence during the tendering phase. This would make it easier to integrate project key participants as part of multi-organizational RM.

Contracts document (at least a major part of) the division of risk responsibilities between project parties (Puddicombe, 2009). The terms of forming a multi-organization concern both parties. For instance, Ng and Loosemore (2007) analyzed a case of risk distribution and its consequences for both public and private parties. They found that an appropriate distribution of project risks between private and public sectors in the private provision of public infrastructure benefits the communities most. However, risks are often underestimated and misallocated for a party that is not in the best position to control them.

Although most contractual arrangements can be considered to involve risk sharing, the increased potential for involving multiple parties in RM will most likely be observed in joint ventures (Shen et al. 2001), partnering arrangements (Tang et al. 2006) and joint risk responses Pavlak (2004). The development of joint RM mechanisms would significantly improve multi-organizational RM because the risks are common to several participants (Tang et al. 2007). In the construction industry, this development is clearly ongoing. Management and incentives beyond traditional contracting have been utilized to improve collaborative RM. For example, Tang et al. (2006) and Osipova and Eriksson (2011) have found that partnering improves the efficiency of joint RM in construction projects.

The need for additional collaboration or partnering agreements was not identified by the participants in this study. However, they did address the need for aligning contractual incentives by providing payment schemes that support accomplishing project objectives. To facilitate collaborative RM, it may be useful to apply the principles of relational contracting, as described by Lahdenperä (2009). For instance, Ling et al. (2006) and Osipova and Eriksson (2011) recommend that parties use more contractual incentives to align their goals and create opportunities for increased participation.

Finally, adequate training is an integral part of the success of any management structure. The use of MORM requires that all focal participants (owner, construction manager, design group, and main contractor) understand its principles, have appropriate access to the related tools and documents, and are committed to systematic risk management.

6.4 Validity

A distinction should be made between the validity of constructive research and the validity of the construct, both of which feature in the constructive research approach.

Construct validity is commonly connected to the functionality of the construct, i.e., its ability to solve the organizational problem that it was designed for (Lukka, 2000; Oyegoke, 2011). A pilot case study is the preferred means to test and improve a construct (Oyegoke, 2011). While there is no universal process of validating constructs, Kasanen et al. (1993) propose a three-level market-based validation that suits PM research. The weak market test is based on the willingness (not demonstrated action) of a manager to apply the construct. The semi-strong market

test is based on the rate of adoption of the construct, as demonstrated by companies. The strong market test aims to analyze whether the business units applying the constructs systematically produce better results than those which don't apply them. (Kasanen et al. 1993)

In this dissertation, three of the practices were evaluated and further developed in a constructive case study (Article V), therefore a single pilot project version of the strong market test was carried out. The main construct is not tested in practice as a holistic process. Four experienced professionals with at least 20 years of experience in the construction industry familiarized themselves with the suggested constructs and deemed them applicable. Thus the main construct is verified with a weak market test.

The constructive piece of research as a whole can be validated if, and only if, a) the construction exists and b) variations in the functionality of the construction causally produce variations in the testing outcomes (Pekuri, 2013 following Borsboom et al. 2004). Whereas the existence of an applied construct is easy to show, the second condition is more challenging in the case of a single pilot case project. Projects are unavoidably complex one-off endeavours where parallel tests or detached causal relationships are not feasible. However, the extremes of possible causal relationships can be outlined, and the researcher may evaluate and justify the construct application's success between these extremes. Lukka (2000) suggests applying general evaluation criteria of field research to constructive research: i.e., relevant research topic, theoretical connections, clear and fruitful research design, credible study, theoretical contribution, and clear and economic reporting. This dissertation summary aims to give an account that enables the reader to evaluate the above qualities.

Methodological pluralism convenes as triangulation when qualitative studies are used to cross-check or validate quantitative results, or vice versa (Dainty, 2008). Herein, methodological pluralism has a somewhat similar role, although different methods have been used more in order to provide complementary viewpoints and support for emerging conceptions than in order to validate prior results. For example, the quantitative study presented in Article IV was used to investigate whether the importance of collaborative working that had been qualitatively identified in Article I would be visible in quantitative data. Further, both quantitative studies (Articles III and IV) provide hints about which collaborative relationships to focus on in further qualitative studies (Articles V and VI).

6.5 Reliability

Research reliability is based on consistency and repeatability (Lucko and Rojas, 2010). In practice, the constructive research approach does not aim at full repeatability but is based on a certain innovative leap that is dependent on the subjective assessment and creativity of the researcher. However, the sub-studies aim to make the basis of these assessments and creative dimensions clear, and they are explained in the Articles I-VI.

Only the quantitative studies (Articles III and IV) and, to some extent, the literature review (Article I) are practically replicable if same data are used. On the other hand, the quantitative studies' role in the final result of the dissertation is relatively small. Further, the results are dependent on the utilized data, and it is not evident, by any means, that the data available for this research represent average projects (or even if average projects would be the best sample to study).

As such, the case studies' repeatability is questionable based on the data consisting of a high level of subjective information. The interview results are a product of an encounter between the researcher and the (volunteered or assigned) participants. Both parties bring along their individual interpretations and conceptions, which may depend on their interests, prior knowledge, stage of project, quality of working environment etc. Therefore, the reader needs to base the assessment of the reliability of the case studies on reporting, which is often too limited in space to provide a full picture.

In the main case studies included in this research (Articles V and VI), the several interviews and researcher observations produced somewhat consistent results. Further, the reasoning between the interviews and the results did not require a high level of interpretation but merely stating which RM processes had been listed, whether these are functional, and which RM development needs to be identified. These features could be taken as a sign of plausibility of another observer coming to similar conclusions and suggesting a somewhat similar (not the same) RM model.

6.6 Limitations and applicability

There are several limitations to the individual sub-studies, i.e. Articles I-VI. In retrospect, the scope of Article II should have been designed to better support the later publications. For example, it could have focused on grounded-theory analysis of the several functions of multi-organizational RM processes. The small data samples in Article III limit statistical abstraction to normally distributed forms and therefore reduce the robustness of conclusions. However, Articles I-IV are contemplated as pre-studies from the viewpoint of the whole dissertation, and their contribution to the final results functions as background information along with other sources. Most relevantly, the limitation and applicability of the dissertation work is related to the limitations and applicability of the constructs, which are discussed in Articles V and VI.

It is not within the scope of this (or any other) case study to draw conclusions regarding particular causal relationships, prove any RM process' success, or to provide widely generalizable results. The findings of the empirical study, which form a significant basis for the development of the main construct, must be interpreted while being conscious of their context.

First, the cases represent unique, large-scale projects, which are run by professional owners. Therefore, the described practices may not be practical in smaller projects or in the case of one-off owners (non-professionals). On the other hand, both public and private projects were included, which was not found to be a

significant factor for the RM process. The multi-organizational RM roles under study are based on the typical roles in the Finnish construction industry. In particular, the roles of project consultants and architects may differ significantly between countries. For example, in the US and in the UK, these two roles are typically handled by a single architect firm.

Second, the case data sample is small but deep. The cases were purposefully selected to represent successful, prominent projects with a known interest in advanced collaborative RM approaches. Therefore, these cases do not attempt to represent any average current practices in the construction industry. However, because the findings are based on only three selected case projects, the scope of the research may have limited or biased the findings. The findings have not been validated on any forum other than that of the research participants. Therefore, it is feasible that more collaborative RM practices may be found in other projects, other countries, and other industries.

Third, the research covers several participants' perspectives, but proportionally, the owners' view is dominant. While this may be appropriate to convey the "foundational" goals of the project as meant by owners, it may limit the description of the multi-organizational process model. The project owners in this study were found to be active. They already were relatively advanced as risk managers in the early phase of the project, which is a significant pre-condition for successful RM. The owners may have been unusually motivated for RM, due to the high profile and media visibility of the case projects. In contrast to Osipova and Eriksson's (2011) findings, active owner involvement may be an exception rather than a rule. The inclusion of users and other stakeholders would be useful to improve the coverage of the multi-organizational RM process.

Fourth, the main construct is not tested as a whole. At this point, the suggested MORM model can be taken as a hypothesis of feasible and beneficial RM processes, which may be validated and further developed in future projects. However, part of the practices is tested in the constructive case study (Article V), and the rest of the framework consists of practices that are identified as useful multi-organizational RM processes based on the case studies (Article VI). With the accumulated experience of the participants and researchers, the constructive research approach aims to compensate for the limited number of pilot studies.

The applicability of the main construct is limited to the context it was designed for: large, Finnish CM projects. The type of the project is not relevant; it could be for example private building construction or public infrastructure construction project. Problems similar to those initiated in this study can be found within several organizations. Therefore, it is suggested that they can be applied to any large (i.e., complex) construction project where the participants wish to engage in multi-organizational RM. In small projects, the MORM model would be less applicable, because it would likely consume too much resources. Furthermore, constructs are always bound by the space and time in which they are developed (Pekuri, 2013). Therefore, the construct (or their re-developed versions) will be deemed useful only until conditions change to the extent that they no longer function, or until a better solution is developed.

The case project participants' openness to adopting new practices is likely to be above average, and thus the application of the constructs may encounter more resistance in average projects. The success of complexity-based project management approaches depends on the extent to which they are understood as integrative and communicative processes throughout the organization. Oyegoke (2011) explains that complex organizational processes and procedures interfere with the implementation of constructs and should be carefully planned for. Further, knowledge, skills, and competences that reflect rigid rather than complexity-based project management are significant restrictions to development (Cicmil et al. 2009). Training, communication of goals, and the commitment of participants are key to implementation success. Finally, complexity researchers stress that managers should take the advice, provided with care, by "fine-tuning and developing their own 'complexity' based approach which resonates with their own values, experience, and understanding of their local organizational environment" (Cicmil et al. 2009).

6.7 Recommendations for further research

In retrospect (after finishing the research work and publishing all of the articles), several comments have been made that cast doubt on the optimistic evaluation that all the case projects were completely successful. Most notably, critics have accused cases I and II of being over budget, and leaks were detected in the roof of the building related to case III. This somewhat contradicts the conclusions made in articles V and VI, which were based on (complete) project success. These retrospective evaluations may give reason to question the power and robustness of a risk management framework. The new information would likely not influence the results of the research work much, but it does emphasise the need for further research. Could different measures have been taken and incorporated within the RM framework that would have avoided the risk consequences?

All of the retrospective evaluations involved identified risks, and several measures have already been taken to avoid the types of problems encountered during these projects. Therefore, while the risk management framework likely enabled mitigation, it didn't help to completely avoid the consequences of risks. Since research work was not resumed after these pieces of information had been discovered, the root causes of the related risks are not clear (at least not to the researcher). Therefore, it is left for speculation whether some of the improvements suggested in the MORM model, such as increased involvement of the design group and contractors, could have helped to further avoid some of the encountered risk consequences.

Furthermore, this research did not include a case study on the evaluation of the complete MORM framework. A case study would be useful on one or several large Finnish CM projects which decide to apply the construct in practice. The retrospective information should be studied in more detail before designing the case study. The case study would provide evidence on the MORM framework's functionality, pre-conditions, and needs for development. In the case of one or a

few projects, the case study could be based on qualitative analysis, whereas a larger number of projects would enable complementary quantitative studies. Together the new knowledge and thereby further developed RM framework could enable the CM project industry to develop a standard framework for multi-organizational RM. For example, a certain risk theme, such as sustainability, could be selected as a starting point for a study that aims to draw conclusions regarding the effectiveness of multi-organizational RM.

The research also opens avenues for further research related to multi-organizational RM and practical applications of complexity thinking. Researchers and practitioners alike are encouraged to take advantage of the complexity approach to project RM and advance the standard frameworks toward the needs of interconnected multi-organizations. The advancement of RM research and standards would benefit from adopting the multi-organizational project structure as a starting point for RM process development, not only as a source of risk but also as an opportunity to be mobilized for effective RM. From a research perspective, theoretical bases addressing multi-organizational complexity are useful.

Future research may involve further improving complex construction projects' RM by extending the roles and activities in the multi-organizational RM model to other stakeholders, such as authorities and end users. The qualities and supportive needs of the integrative elements in complexity-based RM could be further studied, including the communicative features, power structures, and incentives in multi-organizational RM. Furthermore, the analysis of the constructs has indicated additional benefits of integration that could be studied further. Collaborative RM and inter-organizational learning and collaborative working were identified as interrelated concepts and goals. In addition to advancing RM approaches, the (sub)constructs were found to support learning and collaborative working itself. The relationships between multi-organizational RM, inter-organizational learning, and project and business success would make interesting research topics with clear connections to business benefits and productivity in the construction industry.

7 Conclusions

A multi-organizational RM framework MORM (Figure 13 in Section 5.3.2) was developed as the main result of this study. It is recommended to be adopted in Finnish CM projects and applied in other types of complex construction projects where multi-organizational RM is strived for. The MORM framework reflects the organizational complexity in CM projects. Unlike traditional single-organizational RM frameworks, the MORM framework covers the roles and activities of several project participants: project owners, PM consultants, design groups, and main contractors. Notably, not all useful channels for sharing RM knowledge exist only between contractual parties.

These suggested complementary RM processes stretch traditional, standard-based, single-organization focused RM processes beyond discipline-specific organizational boundaries. Therefore, the research contributes to bridging the gap between single-organizational RM standards and multi-organizational RM needs. These multi-organizational (especially non-contractual) RM processes have been overlooked in previous literature, standards, and frameworks.

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