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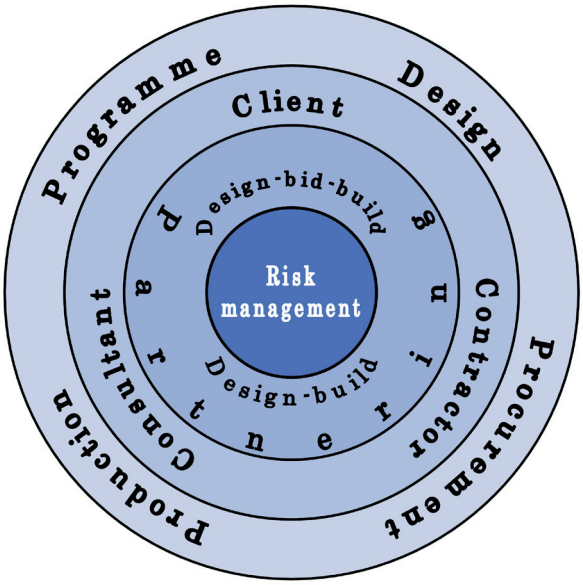
LICENTIATE THESIS

Risk management in construction projects:

a comparative study of the different procurement options in Sweden



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Doubt is not a pleasant condition,
but certainty is absurd.

Voltaire

Preface

This thesis is a result of my PhD studies during 2006-2008 in the Construction Management Research Group at the Division for Architecture and Infrastructure at Luleå University of Technology. The financial support of the Development Fund of the Swedish Construction Industry (SBUF) is gratefully acknowledged. I would like to thank our industrial partner, NCC Sweden, for its engagement in the project.

Many people have contributed to this work. First of all, I would like to express my gratitude to my scientific advisors Professor Jan Borgbrant and Adjunct Professor Lennart Apleberger. Jan, thank you for your continuous belief in me from our first meeting in Lund in October 2005, for the opportunity to join your research group and for all guidance and support you gave me during these years. Lennart, thank you for your commitment to the project, your valuable advice and the positive attitude you had every time we met. I would also like to thank Professor Brian Atkin, a programme director of the research school Competitive Building. Brian, I appreciate very much the knowledge you shared with me, the time you spent on proofreading my papers and our work together.

My colleague Per Erik Eriksson, thank you for your comments on my study and help in writing proposals for further research. I really look forward to our work together!

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The contributions of all questionnaire survey respondents and interview participants are gratefully acknowledged. To answer so many questions about risk management was not an easy task!

My dear colleagues, Anders Wennström, Annelie Karlsson, Azam Forsberg, Jan Jonsson, Jutta Schade, Kajsa Simu, Kristina Laurell-Stenlund, Stefan Sandesten, Håkan Norberg and Thomas Oloffson, thank you for the friendly and comfortable atmosphere we have in our group and many unforgettable memories from both inside and outside the University. Eva, thank you for helping me with the administrative stuff.

Finally, I would like to thank my closest people. Many thanks go to my parents and relatives in Saint Petersburg for their love and support. Evgeny, without you this work would never have been possible. You taught me a lot about researchers' life. Thank you! All my friends in Russia, Sweden and all over the world are acknowledged just for the reason they exist.

Luleå, April 2008

Ekaterina Osipova

Abstract

Risks have a significant impact on a construction project's performance in terms of cost, time and quality. As the size and complexity of the projects have increased, an ability to manage risks throughout the construction process has become a central element preventing unwanted consequences. How risks are shared between the project actors is to a large extent governed by the procurement option and the content of the related contract documents. Therefore, selecting an appropriate project procurement option is a key issue for project actors.

The overall aim of this research is to increase the understanding of risk management in the different procurement options: design-bid-build contracts, design-build contracts and collaborative form of partnering. Deeper understanding is expected to contribute to a more effective risk management and, therefore, a better project output and better value for both clients and contractors. The study involves nine construction projects recently performed in Sweden and comprises a questionnaire survey and a series of interviews with clients, contractors and consultants involved in these construction projects.

The findings of this work show a lack of an iterative approach to risk management, which is a weakness in current procurement practices. This aspect must be addressed if the risk management process is to serve projects and, thus, their clients. The absence of systematic risk management is especially noted in the programme phase, where it arguably has the greatest potential impact. The production phase is where most interest and activity are to be found. As a matter of practice, the communication of risks between the actors simply does not work to the extent that it must if projects are to be delivered with certainty, irrespective of the form of procurement.

A clear connection between the procurement option and risk management in construction projects has been found. Traditional design-bid-build contracts do not create opportunities for open discussion of project risks and joint risk management. Design-build projects offer cooperative work by the architects and contractors in early phases and, therefore, more thorough risk management. Partnering helps to establish cooperative relationships because the actors work together throughout the project and each actor participates in joint risk management. A number of drivers of and obstacles to effective risk management have been explored in the study. Every actor's involvement in dialogue, effective communication and information exchange, open attitudes and trustful relationship are the factors that support open discussion of project risks and, therefore, contribute to successful risk management.

Based on the findings, a number of recommendations facilitating more effective risk management have been developed for the industry practitioners.

Keywords: Risk management, Risk allocation, Construction project, Construction contract, Design-bid-build, Design-build, Partnering

Summary in Swedish

Riskhantering i ett byggprojekt har stor inverkan på tid, kostnad och kvalitet på utfallet. I och med ökad storlek och komplexitet på byggprojekten har förmågan att hantera risker således blivit en central faktor för att förebygga oönskade konsekvenser i projekten. På vilket sätt olika risker fördelas mellan aktörerna i byggprocessen påverkas av hur projektet är upphandlat. Valet av lämplig entreprenad- och samverkansform är därför viktigt för att stödja riskhantering i ett byggprojekt.

Det övergripande syftet med den här studien är att öka förståelsen av riskhanteringen inom de olika entreprenadformerna generalentreprenad, totaltentreprenad och projekt med samverkansformen partnering. Fördjupade kunskaper om riskhantering förväntas bidra till bättre slutresultat för både beställare och entreprenör. Studien omfattar nio byggprojekt som nyligen genomförts i Sverige. Datainsamlingen har skett via både intervjuer och enkäter till beställarna, entreprenörer och konsulter som deltagit i projekten.

Resultaten visar att nuvarande genomförandeformer saknar en fungerande process för riskhantering. Det är viktigt att aktörerna i större utsträckning fokuserar mer på processen för att riskhanteringen skall bidra till projektet. Frånvaron av systematisk riskhantering var speciellt tydlig i det tidiga skedet av byggprocessen, programfasen, där en systematisk hantering av risker dock ger det bästa utfallet. I produktionsfasen var intresset och användningen av en systematisk riskhantering större. Resultatet av studien visar att kommunikationen av risker mellan aktörerna inte fungerar i den utsträckning den borde, oavsett vilken genomförandeform som användes, för att projektsäkerheten skulle säkerställas.

Vidare visar studien på ett tydligt samband mellan genomförandeformen och riskhanteringen. Generalentreprenadformen skapar inte rätt förutsättningar för en öppen diskussion om projektrisker och gemensam riskhantering. Totalentreprenaden ger en större möjlighet till diskussion av projektrisker mellan konsulter och entreprenörer i ett tidigt skede av byggprocessen. Samverkansformen partnering stöder en tidig samverkan mellan aktörerna och medför att alla aktörer deltar tidigt i riskhanteringen. Studien visar också på att det finns en del drivkrafter och hinder för en effektiv riskhantering.

Rapporten avslutas med ett antal rekommendationer till aktörerna i byggprocessen för en mer effektiv riskhantering.

Nyckelord: riskhantering, riskfördelning, byggprojekt, entreprenadform, utförandeentreprenad, totalentreprenad, partnering

List of appended papers

1. Osipova, E. & Apleberger, L. (2007). Risk management in different forms of contract and collaboration – case of Sweden. Proceedings of CIB World Building Congress "Construction for Development", Cape Town, South Africa.

2. Osipova, E. (2007). Risk management in the different phases of a construction project – a study of actors' involvement. Proceedings of 4th Nordic Conference on Construction Economics and Organisation, Luleå, Sweden.

3. Osipova, E. (2008). The impact of procurement options on risk management in Swedish construction projects. Research report, Luleå University of Technology, Sweden[1].

4. Osipova, E. & Atkin, B. (2008). From project-oriented to process-oriented risk management in construction. Proceedings of CIB International Conference on Building Education and Research "Building Resilience", Heritance Kandalama, Sri Lanka.

[1] The research report is an extended version of the peer-reviewed conference paper: Osipova, E. (2007) The impact of contractual and collaboration forms on risk management in Swedish construction projects. *Second International Conference World of Construction Project Management*. Delft, the Netherlands.

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Glossary

Client – a part that carries out or assigns others to carry out construction, demolition or land work (PBL 1987).

Contract – a mutually binding agreement that obligates the seller to provide the specified product and obligates the buyer to pay for it (PMI 2000).

Contractor – a performing organisation whose employees are most directly involved in doing the work on the project (PMI 2000).

Design-bid-build – a traditional procurement option where the client contracts separately with a designer and a constructor (Ling and Kerch 2004).

Design-build – a procurement option where the contractor is responsible for construction and the full design (Harris et al. 2006).

Effective risk management - doing the right things in a way to ensure that the project is risk efficient and project objectives are achieved (Chapman and Ward 2003).

Opportunity – a source of upside risk (Chapman and Ward 2002).

Partnering – a structured management approach to facilitate teamworking across contractual boundaries (Smith et al. 2006).

Project – a unique process, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including the constrains of time, cost and resources (IEC 2001).

Project life cycle – a collection of generally sequential project phases whose name and number are determined by the control needs of the organisation or organisations involved in the project (PMI 2000).

Project phases - parts of the project that are marked by completion of one or more deliverables (PMI 2000).

Project risk – an uncertain event or condition that, if occurs, has a positive or a negative effect on a project objective (PMI 2000).

Risk – an implication of significant uncertainty, which may be upside and downside (Chapman and Ward 2002).

Risk management – a systematic process of identifying, analysing and responding to project risks (PMI 2000).

Risk identification – a process of determining which risks might affect the project and documenting their characteristics (PMI 2000).

Risk assessment – a process of assessing the impact and likelihood of identified risks (PMI 2000).

Risk response – a process of selection and implementation of measures to modify risk (IEC 2001).

Uncertainty – a lack of certainty, involving variability and ambiguity (Chapman and Ward 2002).

Abbreviations

AB (Allmänna bestämmelser) – General Conditions of Contract for Building, Civil Engineering and Installation Work

ABT (Allmänna bestämmelser för totalentreprenader) - General Conditions of Contract for Building, Civil Engineering and Installation Work performed on a package deal basis

BKK (Byggandets Kontraktskommitté) – Building Contracts Committee

DBB – design-bid-build

DB – design-build

IEC – International Electrotechnical Commission

JRM – Joint risk management

LOU (Lagen om offentlig upphandling) – the Public Procurement Act

PBL (Plan- och bygglag) – the Swedish Planning and Building Act

PMI – Project Management Institute

PMBOK – Project Management Body of Knowledge

RC – Relational contracting

RM – Risk management

SBI (Sveriges Byggindustrier) – the Swedish Construction Federation

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1 Introduction

This chapter sets the background to the research area and discusses the problems the study deals with. The aim, objectives and research questions are presented and delimitations are described. Finally, the structure of the thesis is outlined.

1.1 Background and problem description

The construction industry is one of the largest segments in the Swedish economy. It provides jobs for almost 11 percent of all employees and construction investments contribute eight percent to the country's GDP in 2006 (SBI 2007). As the quality of the buildings and infrastructure has a direct impact on the level of people's life, a well-functioning construction industry is an important factor for the development of society. In recent years, the Swedish construction industry has been criticized for increasing costs, low productivity, quality problems and project delays. Two governmental reports (SOU 2000, 2002) address the problems that the industry experiences and highlight the need for change to improve the current situation. Among other things, the reports point to the lack of means of control in the construction process. In particular, the risk management process is argued to play an important role in project management and, therefore, has to be further developed in order to achieve further efficiency improvement in the industry.

Any construction process can be divided into four main phases: programme, design, procurement and production. In the programme phase the client has an idea about the project and analyses conditions for its execution. During the design phase the architects and engineers produce design and construction drawings according to the client's requirements. Depending on the procurement option, the design phase follows either the programme phase or the procurement phase. In the procurement phase the client chooses the contractor and the parties sign the contract. Finally, the contractor executes the job in the production phase. Traditionally, a construction process is sequential; many actors are involved only in some project phases and focus on their own part of work rather than on the whole project. The Construction Cost Delegation (SOU 2000) highlights that an ability to manage the whole process and thus all actors in the value chain is a foundation for change and improvement in the construction industry.

As the size and complexity of projects have increased, an ability to manage risks throughout the construction process has become a central element preventing unwanted consequences (Maytorena et al. 2007). Different project risks have to be allocated to the project's actors on the basis of who has the best qualifications for dealing with a specific risk (SOU 2000). However, in many projects there is an attempt by actors to try to avoid risks as far as possible and let somebody else in the value chain deal with them. There are many examples of construction projects where occurred risks have led to significant deviations in the project

performance in terms of time, cost and quality. According to a report that investigates more than 3000 quality problems, the cost for poor quality can amount to 20% of the total cost (Josephson and Larsson 2001). Moreover, about 70% of all problems can be identified at the early stages and, therefore, poor quality cost can be decreased by more than 60%. The Construction Commission (SOU 2002) confirms these findings and says that savings up to 150 000 Swedish kronor (approx. 17 000 euros) per new apartment are possible when quality problems can be avoided.

The construction of the tunnels through the Halland ridge (Hallandsås) is a very well-known example of a project that has gone wrong. The project was started in 1992 and terminated in 1997 due to the occurred environmental risks. Following several investigations, the project was recommenced in 2003. The work continues and the project is planned to be completed in 2012. One of the reports of the government-appointed Hallandsås Committee, which reviews the methods and decisions of the Swedish Rail Administration during the project implementation, focuses on risk management application in the project (Hallandsås Committee 2002). The report states that some significant risks have not been adequately managed and that the risk management model has not been followed systematically in the project. Another example is a new construction of apartments in Hammarby Sjöstad. Before the project was completed it had suffered from significant moisture problems. The commission investigating the case pointed to poor analysis of moisture risks and suggested that risk analysis has to be performed during the whole construction process (SOU 2002).

How risks are shared among the actors in a construction project is to a large extent governed by the choice of procurement option and the content of the related contract documents. As different procurement options imply different ranges of responsibilities and liabilities in the project, selecting an appropriate project procurement option is a key issue for project actors. Today the majority of Swedish contracts are based on the standardized conditions of contract, AB and ABT, which have been developed and issued by the Building Contracts Committee (BKK 2004, 2006). These documents assign responsibilities and liabilities of each contracting party regarding job performance, organisation, timeframes, guarantees, errors, payment and insurance. Two traditional procurement options that are mostly used in Sweden are design-bid-build (DBB) contracts and design-build (DB) contracts. In DBB contracts the client is responsible for the design and the contractor for the execution. In DB contracts the contractor is responsible for both design and production. However, it has been argued that traditional contractual arrangements do not support effective collaboration in construction projects (Kadefors 2004). Thus, a question of particular interest for the actors in the Swedish construction industry is the way in which project management needs to be further developed, based more on openness, trust and collaboration rather than on sharp contract formulations. Positive experiences of collaborative form of partnering in the USA, UK, Norway and Denmark have resulted in partnering concepts being adopted in Sweden. Common goals, continuous improvement, structures for problem solving and effective collaboration form the concept of partnering. The three largest construction companies in

Sweden, Skanska, NCC and Peab, actively work with partnering projects and report positive results.

To conclude, this section set the background and summarised those problems in the study area that form a basis for this research. The main area of the study is risk management in construction projects adopting different procurement options. To the best of the author's knowledge, relatively little attention has been paid in the Swedish research community to understanding the joint role of clients, contractors and consultants in the risk management process. An extensive literature review (Tang et al. 2007) shows that the international studies have also been focused on the perspective of one group of project actors. The review of all project actors is limited. Therefore, this research discusses risk management from the joint perspective of clients, contractors and consultants, and reviews their roles in risk management during the project life cycle.

1.2 Aim, objectives and research questions

The overall aim of this research is to increase the understanding of risk management in the different procurement options in Sweden. Deeper understanding is expected to contribute to the more effective risk management process and, therefore, a better project output and better value for both clients and contractors.

The objectives of the study are statements that translate the strategic aim into coherent, operational statements and concern how the study will be implemented (Fellows and Liu 2003). There are two objectives of this study:

1. To analyse how risks are shared and managed in various procurement options.
2. To develop recommendations, which contribute to more effective risk management in construction projects.

On the basis of the aim and the objectives three research questions have been formulated.

1. In what ways and to what extent are the actors involved in risk management through the different phases of the construction project?
2. What impact does the chosen procurement option have on risk management?
3. What are the main factors that contribute to more effective risk management in the construction projects?

1.3 Delimitations

"As much as you might want to, you cannot study everyone everywhere doing everything" (Miles and Huberman 1994). The research focuses on three main groups of actors on the supply side of the project, i.e. clients, contractors and consultants. Those are shown in Figure 1 inside the red circle. Clients' relationships with project stakeholders on the demand side, i.e. end-users, funding bodies and authorities, are excluded from the study. Subcontractors are not included in the study. Project procurement options are limited to those that are mostly used in Sweden: design-bid-build, design-build, and partnering.

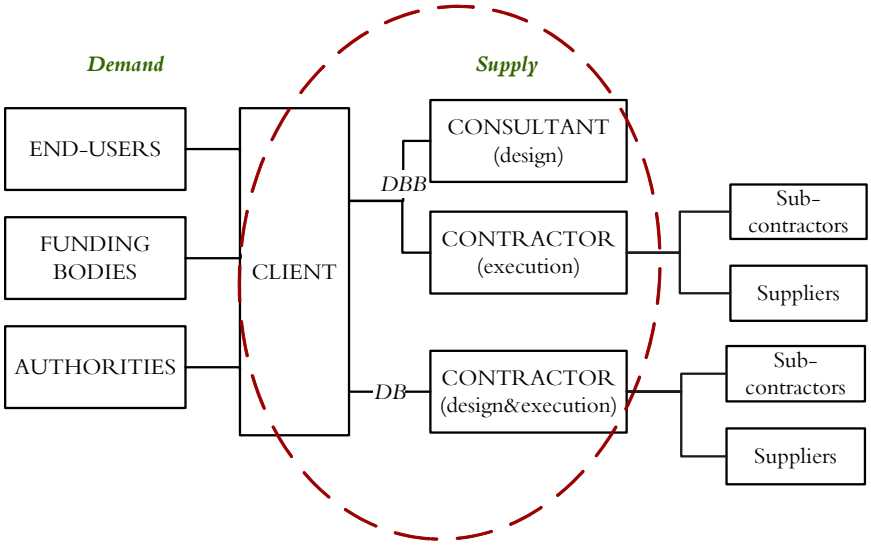

Figure 1. Delimitations of the study.

1.4 Outline of the thesis

This thesis consists of five chapters, two appendices and four appended papers. Chapter 1 is an introduction to the research and includes four sections that present the background and problem description; aim, objectives and research questions; delimitations; and the structure of the thesis. In Chapter 2 the research methodology is discussed. Six sections of Chapter 2 describe the research design, the role of the reference group, methods for literature search, data collection and data analysis, and discuss trustworthiness of the research. Chapter 3 discusses the theoretical framework for the study and the previous research in the area. In Chapter 4 the summary of the results is presented. Chapter 5 finalises the thesis and consists

of three sections that discuss answers to the research questions, present recommendations to the practitioners and directions for further research.

Appendix 1 contains a questionnaire template. Interview questions are listed in Appendix 2.

Three conference papers and one research report are included in the thesis. Each paper deals with a specific research question and adopts different research methods (Table 1). Paper 1 presents the state-of-the-art analysis in the area of various procurement options and risk management. Paper 2 focuses on the actors' roles in risk management in the different phases of the project and utilises data from the questionnaire survey. In Paper 3 the impact of the different procurement options on risk management is discussed, based on the questionnaire and interview data. Paper 4 investigates the factors that contribute to the more effective risk management process and utilises the results of the interviews with the project actors.

Table 1. Paper overview.

Paper	Title	Authors	RQ	Methods	Publication status
1	Risk management in different forms of contract and collaboration – case of Sweden	E. Osipova & L. Apleberger	2	Literature review	Proceedings of CIB World Building Congress "Construction for Development". Cape Town, South Africa, 2007
2	Risk management in the different phases of a construction project – a study of actors' involvement	E. Osipova	1	Questionnaire survey	Proceedings of 4th Nordic Conference on Construction Economics and Organisation. Luleå, Sweden, 2007
3	The impact of procurement options on risk management in Swedish construction projects	E. Osipova	2	Questionnaire survey and interviews	Research report, Luleå University of Technology, Sweden, 2008.
4	From project-oriented to process-oriented risk management in construction	E. Osipova & B. Atkin	3	Interviews	Proceedings of CIB International Conference on Building Education and Research "Building Resilience". Kandalama, Sri Lanka, 2008.

2 Research methodology

In this chapter the research methodology is presented. The chapter is divided into six main sections that describe the research design, the role of the reference group, methods for literature search, data collection and data analysis, and discuss trustworthiness of the research.

2.1 Research design

Research design is about turning research questions into the research project (Robson 2002). It means that in order to answer research questions, the appropriate strategies, methods and techniques should be chosen. Yin (1994) proposes that the types of research questions determine the most suitable strategy. The research questions in this study focus mainly on "what" questions. To answer this type of question, a survey strategy is suggested (Yin 1994). Fellows and Liu (2003) describe several types of research, e.g. instrumental, descriptive, exploratory, explanatory and interpretive. The research presented in this thesis is of a descriptive type. Descriptive research aims at identifying and recording a phenomenon, process or system and may be conducted using surveys (Fellows and Liu 2003). Thus, as both references suggest, survey technique was chosen for data collection.

The work on the project was divided into two main parts as illustrated in Figure 2.

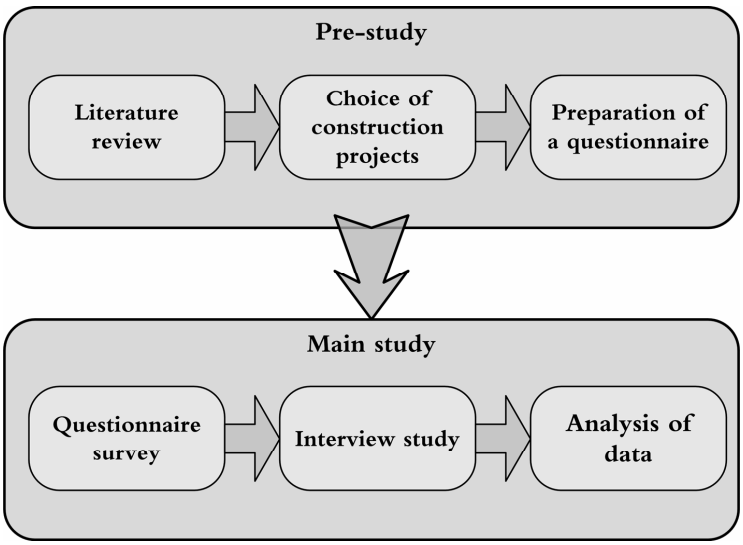

Figure 2. Research design.

1. Pre-study aimed at defining the theoretical basis, formulating more clearly the research questions and consisted of three steps:

- Literature review including an inventory of existing research and theory formation in the relevant areas. The purpose was to obtain a theoretical basis for further work and clarify in greater detail the research questions and delimitations.
- Selecting a number of construction projects to be included in the main study. At this stage the reference group connected to the project helped to find the projects (see Section 2.3).
- Preparation of a questionnaire survey, using the results of the literature review.

2. Main study involving nine recently finished construction projects, both those that had "gone wrong" and those that had been implemented as intended. The main study aimed at finding out how the risk management process worked in the projects and consisted of three main stages:

- A questionnaire survey. The purpose was to get a picture of the risk management process from the different actors' perspectives. The involvement of the actors in the project phases, their roles in the risk management process in particular and their influence on risk management were analysed.
- Interviews with the project participants aimed at a deeper analysis of the risk management process and finding connections between the chosen procurement option and risk management in the projects.
- Analysis of the gathered data and presentation of the results.

2.2 Literature review

Project risk management is a fairly broad subject. In the very beginning of the study the main authors of textbooks in the field of risk management in construction were identified. The books were reviewed in order to get a general understanding of the research area. The next step was a search for articles in the databases provided by Luleå University Library, e.g. Ebsco, Elsevier Science Direct, Compendex, ByggDok etc. The search was made by using the following keywords: risk management, risk management & construction, construction contracts, procurement, design-build, design-bid-build, partnering, and uncertainty. To receive information about new articles in the area the number of e-mail search alerts was created. EndNote 9 software was used for sorting, keeping, and working with the references.

2.3 Reference group

Fellows and Liu (2003) differentiate two main types of research, pure and applied. This research is more of the applied type than of the pure type because it aims at solving a practical problem – increasing the efficiency of risk management in construction projects. In order to give a researcher an insight to the current practice, a reference group was set up. The group consists of five persons from the construction industry and two scientific advisors from Luleå University of Technology. The industry participants represented two client organisations, two contractor firms, and the Swedish Construction Federation. The aim of the reference group was twofold. Firstly, the group contributed to valuable discussions of the problem area and the expected results of the study. Secondly, it assisted the researcher in the choice of study projects and in organising workshops for the survey respondents. The meetings with the reference group were organised twice a year. In total four meeting were held during the two years of the research project.

2.4 Data collection

2.4.1 Choice and description of the projects

In order to help the author to find the projects to study, each industrial member of the reference group was asked to choose two recently finished construction projects within their own organisation. This method of project choice has both strengths and weaknesses. On the one hand, the researcher does not have to spend time contacting a lot of organisations and trying to find those who want to participate. Moreover, people share information more easily when they are aware of the research project and its aim. On the other hand, the number of projects is limited and the researcher does not influence the choice process. In order to obtain an accurate picture, the following requirements were formulated:

- the projects are located in large and small cities;
- they use different forms of contract and collaboration, i.e. design-bid-build contracts, design-build contracts and partnering;
- the types of the projects are building and civil engineering;
- the projects are medium-sized (between 5 and 100 MSEK).

As a result nine construction projects were chosen (Table 2). A detailed description of the projects follows the table. The characteristics of the projects implementation are based on the assessments[2] of projects participants, not of the researcher.

[2] Four alternatives were available for assessment of project implementation: very bad, fairly bad, fairly good, very good. For assessment of an effect of identified and unforeseen risks on the project cost the following alternatives were available: very small, fairly small, fairly large, very large.

Table 2. Characteristics of construction projects included in the study.

Nr.	Location	Type of the project	Procurement option	Contract sum (MSEK)
1	Norrbotten	Building	Design-build	41
2	Norrbotten	Building	Design-bid-build	18
3	Norrbotten	Civil Engineering	Design-build	53
4	Norrbotten	Civil Engineering	Design-bid-build	20
5	Norrbotten	Civil Engineering	Design-bid-build	5
6	Stockholm	Building	Design-build	81
7	Stockholm	Building	Design-build	48
8	Stockholm	Civil Engineering	Design-bid-build	95
9	Stockholm	Building	Design-bid-build/Partnering	15

Project 1 comprised the construction of a new house for meetings at the university campus in the northern part of Sweden. The project was executed during 15 months between 2003 and 2004. The contract sum was 41.1 MSEK and the final cost was 43.5 MSEK. Design-build, with a lump sum payment mechanism, was the chosen form of procurement. The project implementation was very good in terms of time and fairly good in terms of quality. In terms of budget, the project was very good for the client and fairly bad for the contractor. The identified risks occurred in the project, but their effect on the project cost was fairly small. The unforeseen risks during the project execution led to a fairly large increase in project cost.

Project 2 comprised the rebuilding, refurbishment and additional construction of university premises, located in the northern part of Sweden. The project was undertaken between 2004 and 2005 and took 10 months to complete. The contract sum was 17.9 MSEK and the final cost of the project was 19.6 MSEK. A lump sum payment mechanism was chosen and a design-bid-build contract was signed between the client and the contractor. The technical characteristics of the final product were evaluated as very good and the time constraints for project execution were kept. However, the poor quality of the design documents increased the contractor's costs significantly. Thus, in terms of budget, the project was very good for the client and fairly bad for the contractor. Identified risks occurred in the project and had a fairly large effect on the project cost; even so, the consequences of unforeseen risks were fairly small.

Project 3 comprised the construction of infrastructure in the north of Sweden. The project was executed during 13 months in 2006 and 2007. The contract sum was 53 MSEK and remained unchanged during the project. Design-build procurement option, with a lump sum payment mechanism, was chosen. The project execution in terms of function, time and cost

was fairly good. Both identified and unforeseen risks occurred in the project and had a fairly small effect on the project cost.

Project 4 comprised the construction of a road in the north of Sweden and was performed during 14 months between 2005 and 2006. The contract sum was 19.7 MSEK and the final cost was 24.5 MSEK. The contractor was procured on a design-bid-build basis, with a lump sum payment mechanism. The project implementation was fairly good in terms of cost and function and very good in terms of time. Both identified and unforeseen risks occurred in the project and had a fairly large effect on the contractor's cost.

Project 5 comprised the construction of a road in the north of Sweden and took 10 months between 2005 and 2006 to complete. The contract sum was 4.9 MSEK and the final cost was 4.7 MSEK. The design-bid-build form of procurement with a lump sum payment mechanism was chosen. The project execution was fairly good in terms of function and cost and fairly bad in terms of time. An insufficient geotechnical survey led to identified risks occurring in the project, but their effect on the project cost was fairly small. No unforeseen risks occurred.

Project 6 comprised the construction of a residential building in Stockholm. The project was executed between 2005 and 2006 and took 17 months. The contract sum was 81 MSEK and the final cost was 84 MSEK. The procurement option was design-build, with a lump sum payment mechanism. The quality of the final product was evaluated as very good, the time constraints were kept at a fairly good level. In terms of cost, the client evaluated the project execution as very good while the contractor's evaluation was fairly bad. Both identified and unforeseen risks occurred in the project, but had a fairly small effect on the project cost.

Project 7 comprised the reconstruction of a residential building in Stockholm and was executed during 12 months between 2004 and 2005. The contract sum was 47.7 MSEK and remained unchanged during the project. Design-build procurement, with a lump sum payment mechanism, was chosen. The project implementation was very good in terms of time and function, very good in terms of cost for the client and fairly good for the contractor. Neither identified nor unforeseen risks occurred during the project execution.

Project 8 comprised the reconstruction of infrastructure facilities in Stockholm. The building period was three years between 2004 and 2007. A design-bid-build contract with a lump sum payment mechanism was chosen for the project. The contract amount was 95 MSEK. In terms of cost, the project implementation was very good for the contractor and very bad for the client. Unforeseen risks caused significant delays and high costs for the client. The quality of the final product was fairly good. The identified risks occurred and had a fairly large impact on project cost.

Project 9 comprised the reconstruction of a residential building, located in Stockholm. The reconstruction was executed in 2005 and took 6 months. The project was implemented as a form of partnering on the basis of a design-bid-build contract with a cost reimbursable payment mechanism. The contract sum was 15 MSEK. The project implementation in terms of function was very good, and fairly good in terms of cost and time. Together, the client and the contractor succeeded in decreasing the project costs. Both identified and unforeseen risks occurred in the project, but had a fairly small effect on the total project cost.

2.4.2 Questionnaire survey

Survey is a suitable method of data collection for descriptive purposes (Robson 2002). As one of the study's objectives was to analyse how risk management worked in the projects, a questionnaire survey was chosen as one of the methods of data collection.

Atkin (2006) lists seven main steps in performing a questionnaire survey:

1) *Determine the general purpose and specific requirements.* The purpose of the questionnaire survey was to obtain the points of view of different actors on the issues of project risk management.

2) *Develop the kinds of questions and sub-questions that need to be asked.* When developing the survey, questions were formulated so that they could help to answer the research questions. A draft questionnaire was developed consisting of five sections. The first section contained general questions about the respondent. In the second section, the aspects of the risk management process through the different phases of the project were covered. The third section investigated relationships between the actors in the project. The fourth section focused on software management systems, which the company uses in the risk management process. The fifth section was a concluding one for miscellaneous comments regarding the risk management process in the project.

3) *Construct the questionnaire.* To construct a questionnaire that would be easy for respondents to answer is a difficult process. The potential respondents wanted to have the questionnaire in electronic form, fill it in and send back by e-mail. On the other hand, the researcher has to ensure that there will not be any problems with software and lost data due to the respondents' unfamiliarity with advanced computer tools. Thus the questionnaire was constructed in MS Excel and consisted of three sheets. The first one was a covering letter with information about the research project, questionnaire disposition, general instructions and how the answers would be used. The second sheet was the questionnaire. The last sheet provided the basic technical instructions on how to fill in information, save and return the questionnaire.

4) *Determine the population and sample to be selected.* The survey sample comprised clients, contractors and consultants. Within each group those persons who worked with risk management in a particular project were identified. The following categories, representing the main actors in the construction project were defined:

    - From the client's side:
        - Representative signing the contract;
        - Project manager.
    - From the contractor's side:
        - Representative signing the contract;
        - Site manager;
        - Estimator.
    - Consultants (design manager or architect)

5) *Pilot the questionnaire.* In order to test the questionnaire a workshop was arranged to which all potential respondents were invited. During the workshop the aim of the study and the structure of the questionnaire were presented. The respondents were given the opportunity to fill in the questionnaire and discuss possible changes or re-formulations. In total, about 50% of the potential respondents participated in the workshop.

6) *Finalise the questionnaire, making any necessary adjustments.* After the meeting with the respondents the questionnaire was adjusted. Some questions were excluded, some reformulated and completed.

7) *Conduct the survey.* Totally 54 questionnaires were sent out by e-mail (Table 3). 43 respondents or 80% replied to the survey. Of those 43 replies 36 were fully completed questionnaires and seven persons explained the reasons for non-participation. Therefore, 36 usable questionnaires formed the response rate of 67%. Amongst persons who attended our workshop the response rate was 100%. This shows that those who were aware of the research project's objectives were more interested in taking part in the study.

Table 3. Questionnaire distribution and respondents profile.

	Client	**Contractor**	**Consultant**	**Total**
Number of questionnaires sent	18	30	6	54
Number of usable responses received	14	18	4	36
Response rate (%)	78	60	67	67
Average age (years)	50	50	48	-

	Client	Contractor	Consultant	Total
Average experience in construction industry (years)	24	28	24	-
Education (number of respondents)				
University	9	5	2	16
Upper secondary school	5	12	2	19
Vocational training	0	1	0	1

2.4.3 Interviews

Interviews are usually used as a complementary method of data collection for deeper investigation of underlying motives. They are suitable when a study focuses on a particular phenomenon and its meaning to the interview participants (Robson 2002). Based on the compiled results of the questionnaire survey, 20 interviews across nine projects were conducted. The objective of the interviews was to make a deeper analysis of the risk management process in the projects. Since it was impossible to interview all survey respondents within the time constraints, the number of interviewees was limited to the two or three persons responsible for risk management in each project. From the client side, it was a project manager, from the contractor side a site manager and from the consultant side an architect or design manager.

There are three main interview techniques: fully structured, semi-structured and unstructured interviews (Robson 2002). The main difference between the techniques is the degree of freedom the interviewer and interviewee have. Fully structured interviews are characterised be predetermined questions that follow in a specific order and do not change during the interview. Semi-structured interviews follow predetermined questions but their order can be changed, irrelevant questions can be skipped and new questions included. Using unstructured technique, the interviewer lets the interviewee talk quite freely within a general area of interest. In this study semi-structured technique was used.

Each interview took approximately one and a half hours and consisted of three main parts. First, the main definitions in the research area were discussed. Since the study deals with the terms risk, risk management, risk identification, risk assessment, risk response etc., it is important to understand the perception of these terms by the respondents. Next, the results of the questionnaire survey were presented and discussed. In particular, the interviewees were asked to comment on the majority of survey questions, try to find motivation for the answers and find solutions to the improvements. Finally, some time was given to the concluding remarks. As the researcher had no previous experience of the interview techniques, about 50% of the interviews were conducted with the help of scientific advisors.

All interviews were taped in order to get a permanent record. Taping also provided an opportunity to concentrate on the interview instead of taking notes.

2.5 Data analysis

When the completed questionnaires had been collected by e-mail, the data was entered into the Statistical Package for Social Science (SPSS). All questions and sub-questions were converted into variables. Each answer alternative was coded using value labels. In total, 122 variables were entered and used for the analysis. Fellows and Liu (2003) differentiate three main forms of content analysis – qualitative, quantitative and structural. Despite a set of quantitative data, a sample of 36 responses was not enough for a deep statistical analysis. Thus, simple SPSS tools such as descriptive statistics and custom tables were used. With their help frequencies, means, distributions and rankings were obtained. In order to illustrate statistical data, graphs were constructed in Microsoft Excel. The analysis of questionnaire data formed a basis for the interviews.

Interview is an example of qualitative data and the aim of the analysis is to determine the meaning of data (Fellows and Liu 2003). No particular analytic technique was used to process the data. Instead, the researcher tried to find patterns, and understand the respondents' perceptions, opinions, and views of the study area. All interviews were audio-taped and transcribed. It is important to mention here that transcribing is a very time-consuming task. As a large part of the interview was structured, many questions followed the same order in each interview. This method gave a quite straight structure of answers and eased the processes of transcription and analysis. The data analysis was made in two steps. First, interviews were grouped by the project name and answers within each project were analysed. Then, the analysis was made from the perspective of the different project actors. The most interesting and illustrative quotations were selected from the interviews and used in the presentation of results.

2.6 Trustworthiness of the research

In establishing trustworthiness of the research, three concepts are usually taken into account – validity, reliability and generalizability (Robson 2002). Validity is concerned with the accuracy of the results. Reliability refers to obtaining the same results when repeating exactly the same study and following the same procedures. Generalizability is about applying research results to other situations or populations.

Triangulation is a widely used strategy to facilitate validity of the research. Triangulation involves use of multiple sources (data triangulation), methods (methodological triangulation), investigators (observer triangulation) and theories (theory triangulation) (Robson 2002). In

this research three types of triangulation were used. Data triangulation was achieved by using several sources of data, i.e. different groups of project actors. Use of two different methods, questionnaire survey and interviews, resulted in methodological triangulation. It is often argued that bias might be created when respondents answer the questionnaire survey. This bias may be the result of misunderstanding and misinterpretations or a desire to look better by answering "correctly". Therefore, the methodological triangulation by using an alternative method (interviews) was extremely important for this study. Observer triangulation was obtained by involving scientific advisors in the interview process and cooperating with other researchers in writing the papers.

To form a thesis as a compilation of papers has some disadvantages. As the work on the thesis progresses, the researcher obtains new knowledge and may find some inaccuracy in the previously reported results. In this research two terminological problems arose. In papers 1 and 2 the term "performance-based contract" was used, while later on the term "design-bid-build contract" proved to be more accurate for describing this form of contract. Another term "form of contract and collaboration", used in Papers 1 and 2, was replaced by "procurement option" because the latter is more widely recognised in the research community.

In order to ensure reliability, all the steps of the research process were documented. The database, containing all reference literature was created using EndNote software. The completed questionnaires were printed out and sorted by the project name. All interviews were audio-typed and transcribed.

The limited sample resulted in a generalizability problem. For example, only four consultants were involved in the questionnaire survey and two in the interviews. This made it difficult to generalize the findings about the whole category. Another example is a single partnering project. Although the study of this project resulted in some interesting findings, it is impossible to generalise for all partnering projects.

3 Theoretical framework

This chapter presents the main theoretical framework for the research. The nature of construction projects is discussed and the concepts of project risk and risk management process are explored. An overview of the various procurement options, i.e. design-bid-build, design-build, and collaborative form of partnering is given. Finally, the theories of joint risk management and relational contracting that have a significant influence on the effectiveness of project risk management are described.

3.1 Construction projects

As this research deals with risk management in the construction project context, it is reasonable to start with a discussion of the nature of projects.

According to Turner (1992), a project is an endeavour in which human, material and financial resources are organised in a novel way; to undertake a unique scope of work of given specification, within constraints of cost and time, so as to achieve unitary, beneficial change, through the delivery of quantified and qualitative objectives.

The definition suggests three key targets of the project, i.e. time, cost and quality, which are to be in focus when undertaking the project. It also highlights the importance of efficient organisation of available resources in order to achieve a good final result.

Flanagan and Norman (1993) emphasize two aspects of any construction project: the process, i.e. project phases, and the organisation, i.e. project actors. From the process perspective, any construction project comprises a number of sequential phases. Different authors suggest a different number of project phases (Chapman and Ward 2003, Flanagan and Norman 1993, Harris et al. 2006, PMI 2000, Smith et al. 2006). The simplest approach identifies two main phases – project development and project implementation. These two can be further detailed and developed into a larger number of phases, e.g. feasibility, design, procurement, construction, commissioning, and operation. The model adopted in this research comprises four phases - programme, design, procurement and production. The maintenance phase was excluded from the study because no risk management activities are to be found in this phase. In the programme phase the client has an idea about the project and analyses conditions for its execution. During the design phase the architects and engineers produce construction drawings according to the client's requirements. In the procurement phase the client appoints the contractor to carry out the project. Depending on the form of contract, the procurement phase follows either the programme phase (DB contracts) or the design phase (DBB contracts). Finally, the contractor executes the job in the production phase. Figure 3 overviews the different models presented in the literature and the model used in the thesis.

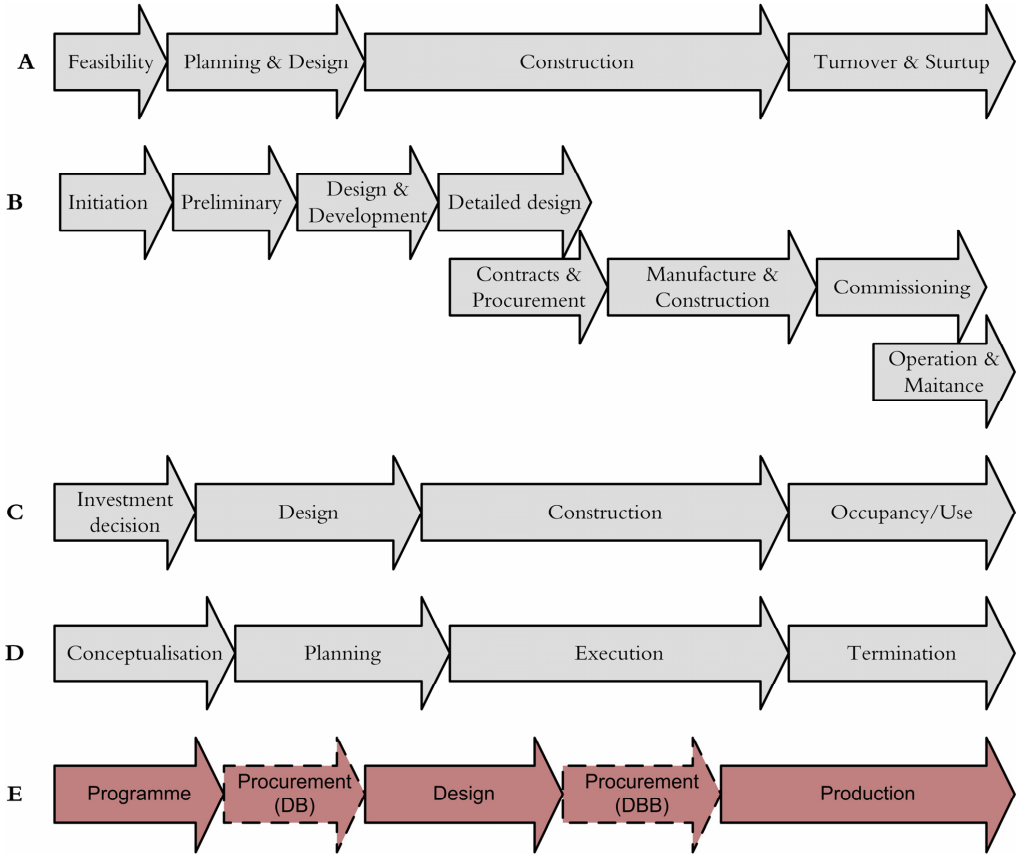

Figure 3. Construction project phases. Source: A (PMI 2000), B (Harris et al. 2006), C (Flanagan and Norman 1993), D (Chapman and Ward 2003). Model E is used in this thesis.

Another important aspect of the construction process is project organisation. Different participants are usually involved in a construction project. These are clients or owners, contractors, sub-contractors, manufacturers and suppliers, architects, engineers, consultants, local authorities, funding organisations etc. The more participants that are involved, the more complex the task of project management becomes. In this research three main groups of construction industry actors are in focus: clients, contractors and consultants. According to PBL (1987), a *client* is a party that carries out or assigns others to carry out construction, demolition or land work. There are two main groups of construction clients: public and private. Privately owned companies undertake the projects to make a profit. The public sector includes the central government and local authorities and undertakes the projects to provide a public service and/or benefit to the citizens. A *contractor* is an organisation that provides a service for the client, i.e. executes the construction works. The contractor organisations have different complexities and provide different ranges of services – from ground works to electrical installations and telecommunications. The role of *consultants* is to assist clients and contractors and provide architectural and engineering services.

Due to their dynamic nature, projects change continuously. Thus a great amount of risk and uncertainty is involved in construction activities (Chapman and Ward 2004). This uncertainty may have a significant impact on the project objectives and, therefore, has to be properly managed by the project actors during the whole project life cycle.

3.2 Project risk

The research literature offers different definitions of project risk (Baloi and Price 2003, Barber 2005, Chapman and Ward 2002, Flanagan and Norman 1993, IEC 2001, Jaafari 2001, PMI 2000, Smith et al. 2006). Several of these definitions have a common feature: they define risk in terms of uncertain events and their impact on a project's objectives. The international standard "Project risk management – Application guidelines" uses the terms probability and consequence and defines risk as a combination of the probability of an event occurring and its consequences for project objectives (IEC 2001). As this research discusses risks in the project context, a formal definition from "A Guide to the Project Management Body of Knowledge" is used (PMI 2000). There risk is defined as "an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives". Ward and Chapman (2003) discuss the concept of risk in greater detail and suggest using a more general concept of *uncertainty*. They argue that the term 'risk' is often associated with adversity and focus on threats, not opportunities. The questionnaire survey conducted by Akintoye and MacLeod (1997) strengthens the argument, showing that the majority of respondents perceive risk as a negative event.

According to Smith et al. (2006) all project risks can be divided into three main categories: known risks, known unknowns and unknown unknowns. The difference between the categories is the decreasing ability to predict or foresee the risks. Taking into account the probability of the occurrence and the consequence for project objectives, those events that have high probability and high impact are subject to risk management (Figure 4).

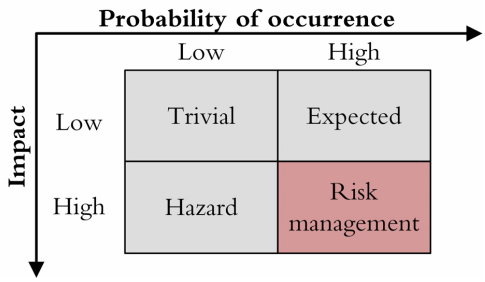

Figure 4. Classification of risk events (Smith et al. 2006).

3.3 Risk management process

Risk management is a systematic process of identifying, assessing and responding to project risk (PMI 2000). The overall goal of the risk management process is to maximise the opportunities and minimise the consequences of a risk event. A variety of risk management models with different numbers of stages can be found in the literature. The international standard "Project risk management – Application guidelines" (IEC 2001) offers a model with four steps: risk identification, risk assessment, risk treatment, and risk review and monitoring. PMBOK's model (PMI 2000) is similar but divides risk assessment into two processes of qualitative risk analysis and quantitative risk analysis. Baloi and Price (2003) include an additional step of risk communication. Chapman and Ward (2003) present the SHAMPU (Shape, Harness, and Manage Project Uncertainty) framework which involves nine stages: define the project, focus the project, identify the issues, structure the issues, clarify ownership, estimate variability, evaluate implication, harness the plans, and manage implementation. Del Cano and de la Cruz (2002) propose an integrated methodology for project risk management in large and complex construction projects. The model is divided into four process phases: initiation, balancing, maintenance and learning. Each phase consists of several stages, which, in turn, are divided into different activities. Despite the variety of models, risk identification, assessment and response form the core of project risk management. Therefore, a model consisting of these three stages is used in this study (Figure 5).

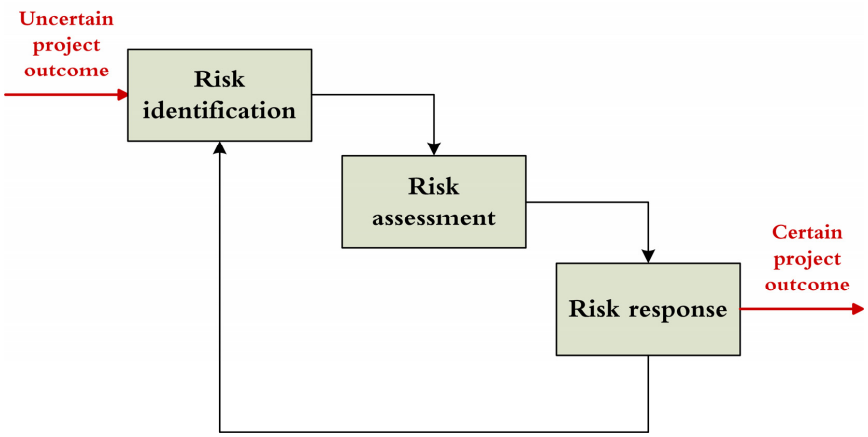

Figure 5. Risk management process adopted in the study.

Risk identification is the first step of the risk management process. It is aimed at determining potential risks, i.e. those that may affect the project. PMBOK (PMI 2000) suggests that as many project stakeholders as possible should participate in the risk identification process. There are a number of tools and techniques for identifying the project risks (IEC 2001).

These are brainstorming, expert opinion, structured interviews, questionnaires, checklists, historical data, previous experience, testing and modelling, evaluation of other projects. Empirical studies of risk management practice (Akintoye and MacLeod 1997, Lyons and Skitmore 2004, Uher and Toakley 1999) show that checklists and brainstorming are the most usable techniques in risk identification. They also highlight that risk identification often relies on individual judgments of the project participants. In this context, it is interesting to mention a recent study by Maytorena et al. (2007) that suggests that the role of experience in risk identification is less significant than is commonly assumed.

During the risk identification process the potential risks fall in the different groups. There are several approaches to classifying project risks and risk sources (Baloi and Price 2003, Jaafari 2001, Leung et al. 1998, Li et al. 2005, Mbachu and Vinasithamby 2005, Tah and Carr 2000, Zhi 1995). In general, the sources of risk in construction projects may be divided into three groups:

- Internal or controllable risks (e.g. design, construction, management and relationships);
- External or uncontrollable risks (e.g. financial, economic, political, legal and environmental);
- Force majeure risks.

Several studies contributed to knowledge by identifying unique, specific and country-related risks (Andi 2006, Ling and Hoi 2006, Zou et al. 2007)

During *risk assessment*, identified risks are evaluated and ranked. The goal is to prioritise risks for management. The research literature offers a large number of models that use both qualitative and quantitative methods for assessment of project risks. Tah and Carr (2000) develop a formal model for qualitative risk assessment based on fuzzy estimates of risk components. Baccarini and Archer (2001) describe a methodology for risk ranking of projects, which allows an effective and efficient allocation of the resources for the management of project risks. The JRAP (Judgemental risk analysis process) model proposed by Öztas and Ökmen (2005) is a pessimistic risk analysis methodology, which is effective in uncertain conditions within construction projects. Zeng et al. (2007) propose a risk assessment methodology based on fuzzy reasoning techniques and aimed at dealing with risks in complex projects. A fuzzy system is also used by Motawa et al. (2006) to evaluate the risk of change in construction projects. Poh and Tah (2006) have developed an integrated model that takes into account both duration and cost risks and can be used for modelling risk impacts that affect the project. Dikmen and Birgonul (2006) propose a methodology for both risk and opportunity assessment of international projects.

Empirical research on risk assessment practice investigates the use of the different risk assessment techniques in construction projects. A study by Baker et al. (1998) shows that the

construction companies in UK use both qualitative and quantitative techniques for assessing the project risks. Personal and corporate experience, and engineering judgement are the most successful qualitative techniques, while quantitative techniques include break-even analysis, expected monetary value and scenario analysis. Several authors report rather opposite results on the usage of quantitative techniques. The studies of risk management practice in the UK construction industry show that the practitioners rely mostly on professional judgment, intuition and experience (Akintoye and MacLeod 1997, Wood and Ellis 2003). A questionnaire survey conducted by Tang et al. (2003) shows that qualitative analysis is the most commonly used technique in the Chinese construction industry, while the use of quantitative methods is very low. The results of the study conducted by Simu (2006) show that the Swedish contractors mostly use professional experience and gut-feeling in risk assessment. Kähkönen (2007) argues that the quantitative methods used in risk management have advantages in comparison with the qualitative methods but their use is limited due to difficulties that practitioners face. He also discusses the elements that contribute to development of a workable solution for quantitative risk assessment.

The *risk response* process is directed at identifying a way of dealing with the identified and assessed project risks. There are four main risk response strategies: risk avoidance, risk reduction, risk transfer and risk retention (IEC 2001, PMI 2000, Smith et al. 2006). Risk avoidance deals with the risks by changing the project plan or finding methods to eliminate the risks. Risk reduction aims at reducing the probability and/or consequences of a risk event. Those risks that remain in the project after risk avoidance and reduction may be transferred to another party either inside or outside the project. Risk retention or acceptance indicates that the risk remains present in the project. Two options are available when retaining the risk: either to develop a contingency plan in case a risk occurs, or to make no actions until the risk is triggered. Several studies (Baker et al. 1999, Lyons and Skitmore 2004, Tang et al. 2007) have identified risk reduction as the most frequently used technique within the construction industry. The results of a questionnaire survey (Akintoye and MacLeod 1997) report that risk transfer is the most preferable strategy among the UK practitioners.

3.4 Risk allocation through construction contracts

It is impossible to eliminate all potential risks in a construction project. Therefore, an appropriate allocation of risks among project actors is very important. Risk allocation influences the behaviour of project actors and, therefore, has a significant impact on the project performance in terms of the total cost. Unclear allocation of the project risks leads to disputes between the client and the contractor. One of the problems identified in the literature is the actors' different perceptions of to whom a specific risk or group of risks should be allocated. Usually, contractors indicate that they have to bear the majority of project risks and price these risks through adding a contingency to the bid price (Andi 2006).

Using contingency funds has been identified by the researchers and practitioners as a significant source of the project's cost increase (Zaghloul and Hartman 2003). Evaluation and conscious allocation of risks to the appropriate actor under the contract allows reducing the bid price by decreasing contingency funds and, therefore, leads to lower total cost (Zack 1996).

A number of models providing a framework for risk allocation decisions can be found in the literature (Lam et al. 2007, Li et al. 2005, Olsen and Osmundsen 2005). Smith et al. (2006) highlight the importance of considering the following issues when making risk allocation decision:

- who has the best ability to control risk events;
- who has the best conditions to manage risks;
- who should carry the risks that cannot be controlled;
- how much does it cost to transfer the risks.

Risk allocation strategy in construction projects is defined through the contractual arrangements. The contract is a written agreement between a client and a contractor where the liabilities and responsibilities of each party are assigned. The contract can also be defined as a trade-off between the contractor's price for executing the project and his willingness to take the risks (Flanagan and Norman 1993). There are different contract strategies available (Figure 6). The objective of clients is to choose the strategy that ensures achievement of the project objectives in the most efficient way.

Two contract strategies that are mostly used in Sweden are separated (design-bid-build) contracts and integrated design-build contracts. These forms are discussed in detail in Sections 3.4.1 and 3.4.2. The collaborative form of partnering has become popular in Sweden during the last decade. In contrast with the UK, partnering does not have the status of a contractual form in Sweden. As a form of project implementation, partnering is intended to create effective collaboration between the project's actors. The concept of partnering is discussed in Section 3.5.1.

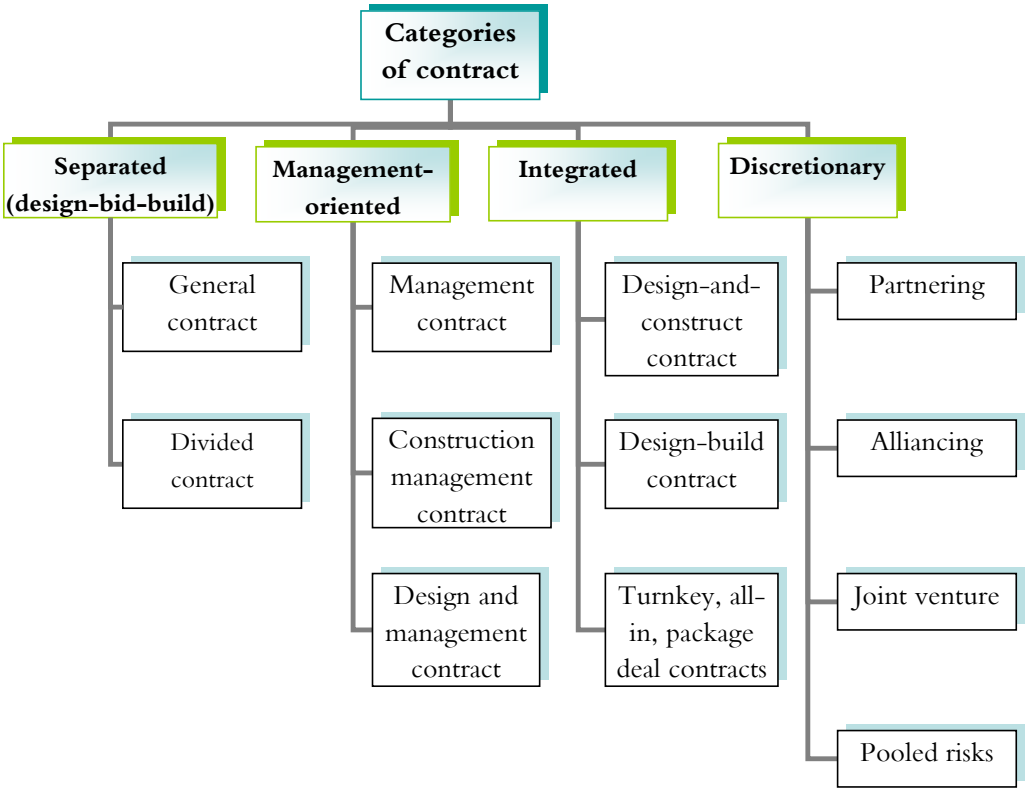

Figure 6. Categories of construction contract (derived from Harris et al. 2006).

Many countries have developed standardized conditions of contract that are intended to be used in construction projects. In Sweden, the majority of contracts are based on the general conditions of contract. These documents are developed and issued by the Building Contracts Committee (BKK), a non-profit association consisting of authorities and organizations in the sector. "General Conditions of Contract for Building, Civil Engineering and Installation Work" (AB) are used in design-bid-build projects. The design-build projects are regulated by "General Conditions of Contract for Building, Civil Engineering and Installation Work performed on a package deal basis" (ABT). AB and ABT assign responsibilities and liabilities of each contracting party regarding job performance, organisation, timeframes, guarantees, insurances, errors and payment.

3.4.1 Design-bid-build

Separated contracts are characterised by a traditional separate appointment of a design team and a construction firm. First, the client appoints an architect or engineer to produce design documents (Design) and then procures (Bid) the contractor to execute (Build) the project. Thus the client is responsible for the planning, design and function of a construction and the

contractor is responsible for the job execution. The DBB procurement is the most widely used strategy in many countries, e.g. the UK, USA and Singapore (Ling et al. 2004). Within this contract strategy, two main organisation alternatives are possible: divided contracts and general contracts. Schematically their organisation structures are shown in Figure 7.

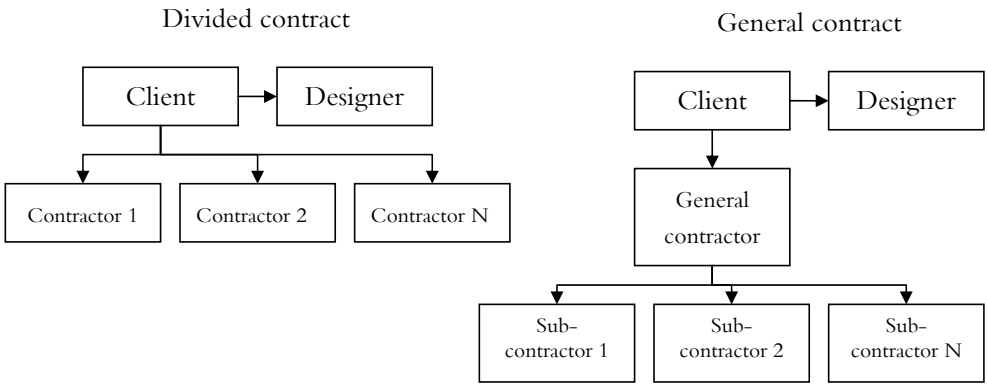

Figure 7. Organisation structure in design-bid-build contracts.

A divided contract implies that the client appoints several contractors and signs a separate contract with each contractor. It allows the client to choose the best possible tender for every part of the work. On the other hand, the coordination costs are very high and it might be difficult to identify exactly which contractor is responsible for a particular error. A general contract implies that a client signs only one contract with a general contractor, who in turn appoints subcontractors to carry out the work. The general contractor is solely responsible for the coordination of subcontractors. This type of organisation is more often used in Sweden than divided contracts.

3.4.2 Design-build

In design-build contracts the contractor is responsible for both design and construction. The client signs only one contract, thus this form is the most straightforward from the perspective of responsibility. In the procurement documentation, the clients set their demands in terms of functionality. The popularity of DB contracts has increased in recent years, because a single point of responsibility is attractive to clients. A study by Ernzen and Schexnayder (2000) shows that the average profit margin for a DB project was higher than that for DBB. Konchar and Sanvido (1998) confirm that DB projects on average show a better performance than DBB in terms of unit cost, construction speed, delivery speed, cost growth and schedule growth. From the risk allocation perspective, DB contracts are more attractive for the client

as the responsibility for design implies that more risk is allocated to the contractor. On the other hand, the DB alternative may be more expensive compared with DBB contracts. Furthermore, the quality of the final product may be lower if the contractor uses cheaper solutions, trying to decrease his own costs (Gransberg and Molenaar 2004). This problem is especially relevant in contracts with a lump sum payment mechanism. In terms of time, the DB system arguably provides an earlier start for project execution than is the case for other forms. Toolanen (2004) found that clients choose DB contracts more often when the project's timeframe and availability of resources are critical factors. From the contractor's point of view, DB construction projects can be very risky when the contractor lacks knowledge and experience of the design-build system. Håkansson et al. (2007) highlight that the competence requirements are higher in DB contracts, and hence structured risk analysis should be made very early in the project. Simu (2006) shows that smaller contractors in Sweden prefer DBB to DB contracts. In the case where a DB contract is used, contractors increase their price by including insurance for the extra risks involved.

3.5 Collaborative relationships in construction projects

Adversarial and opportunistic behaviour is common in the construction industry (Cox and Thompson 1997, Zaghloul and Hartman 2003). It means that the actors are focused on the short-term relationship and economic results rather than on long-term cooperation. In response to this behaviour, many researchers try to find the concepts for more collaborative relationship between the project actors. Two concepts are of special interest in this research: relational contracting and joint risk management. Both focus on improvement of contractual relationships, better risk allocation, and, therefore, on more effective risk management.

3.5.1 Relational contracting and partnering

Over the last decade, the researchers and practitioners have recognised that the relationships between the client and the contractor play a significant role for successful project implementation. Relational contracting (RC) is a concept that concentrates on the relationship between the contract parties. RC recognises mutual benefits and win-win scenarios through cooperative relationship (Rahman and Kumaraswamy 2002). A study by Akintoye and Main (2007) shows that UK contractors are positive about collaborative relationships and believe they lead to cost and risk reduction. The results of the other study (Drexler and Larson 2000) show that relationships in partnership projects are much more stable than in other types of projects.

The collaborative form of partnering is based on the RC principles. The concept of partnering is variously defined in the research literature (Drexler and Larson 2000, Kadefors 2002, Rahman and Kumaraswamy 2004a, Rhodin 2002). To summarise, partnering is a way

to create effective collaboration between the project's actors. Components such as common goals, continuous improvement and structures for problem solving form the concept of partnering. Effective collaboration is claimed to lead to fewer disputes, lower construction costs and a better quality product. Positive experiences of partnering in the USA, UK, Norway and Denmark have led to the partnering concept being adopted in Sweden. Examples of partnering projects are presented in Rhodin (2002) and Kadefors (2002). The three largest construction companies in Sweden, Skanska, NCC and Peab, actively work with partnering projects and report positive results. One of the goals of partnering is better utilisation of the overall qualifications of the project actors. The concept of trust is tightly connected to partnering. Trustful relationships between project actors result in a more effective risk allocation process, decrease of contingency funds and, finally, to project cost reduction (Zaghloul and Hartman 2003). Furthermore, partnering helps in transfer knowledge and experience between the project actors. It is important to note that the partnering concept demands high professionalism and very good knowledge of the project on the part of the client *and* the contractor.

3.5.2 Joint risk management

Even efficient allocation of the identified risks through the contract in the procurement phase does not guarantee that no conflicts occur in the project. During the project life cycle the nature and extent of identified risks may change and new risks may appear. Sometimes new risks may require joint efforts to manage them effectively. Joint risk management (JRM) is about working together at mitigating unforeseen project risks at the postcontract stage (Rahman and Kumaraswamy 2004b). Participants in a questionnaire survey of the Hong Kong construction industry (Rahman and Kumaraswamy 2004a) recommend JRM as the best option for managing unforeseen risks and indicate a high motivation towards the JRM approach.

4 Summary of results

4.1 Paper 1

Title:

"Risk management in different forms of contract and collaboration – case of Sweden"

Keywords: Risk management, risk allocation, construction project, contracts, Sweden

Research questions in focus:

RQ2: What impact does the chosen procurement option have on risk management?

Purpose:

The paper presents the results of the initial phase of the research project: state-of-the-art analysis in the area of project risk management. The main purpose was to characterize different procurement options frequently used in Sweden: design-bid-build (DBB) and design-build (DB) contracts, and collaboration through partnering. In particular, two objectives were formulated. The first objective was to analyse how risks are allocated among the actors in construction projects adopting different forms of contract and collaboration. The second objective was to highlight strengths and weaknesses of each procurement option from the perspective of dealing with risks. Note that the design-bid-build option is called performance-based contracts in this paper (for details see Section 2.6).

Results:

The DB contracts are attractive for the client due to their single point of responsibility. In terms of time, the DB option arguably provides an earlier start for project execution than DBB. However, this option may be more expensive for the client compared with DBB where the client may choose the best possible tender for both design and construction. Furthermore, the quality of the final product may be lower if the contractor uses cheaper solutions, trying to decrease his own costs. The DBB contracts give the client more flexibility in terms of the design but imply more risk allocated to the client. Moreover, separated responsibilities for design and construction may result in lack of information and knowledge transfer between the project actors. The collaborative form of partnering is an acceptable alternative for project implementation when a trust relationship between the actors exists. Partnering projects show good results with a shorter building time, fewer disputes, and knowledge transfer between the actors. However, the partnering concept demands high professionalism from both the client and the contractor.

4.2 Paper 2

Title:

"Risk management in the different phases of a construction project – a study of actors' involvement"

Keywords: Risk management, construction project, questionnaire survey

Research questions in focus:

RQ1: In what ways and to what extent are the actors involved in risk management through the different phases of the construction project?

Purpose:

The objective of the paper was to analyse the risk management process in a construction project from the perspectives of the client, contractor and consultant. The paper examines the actors' participation in the project phases and their involvement in risk identification, assessment and response. Furthermore, the importance of risk management in the different phases and the influence of the actors on the risk management processes are evaluated. Finally, the collaboration between the actors in managing risks is assessed. The study is based on a literature review and the results of a questionnaire survey of construction project actors.

Results:

Despite the recognised importance of the early phases in the project, our study shows a very low degree of risk management activity in the programme phase. The design and production phases, in which risk identification, assessment and response took place, were the most important phases for risk management. Moreover, collaboration in terms of risk management between the actors was most intensive in these phases. Risk identification and assessment are the processes where the strongest collaboration was found. In risk response collaboration decreases significantly, showing that each actor protects his own interests. In the procurement phase the communication of known risks between the client and the contractor was very low. Contractors participate more actively in the risk management process in comparison with other actors and have the largest influence on project risk management. Clients are active in risk identification and assessment, but their role in risk response decreases dramatically. This can be generally explained by their transferring identified risks to the production phase, i.e. to the contractors. The study indicates that the role of consultants in risk management is very limited, however, it is impossible to generalise these findings due to the limited sample size.

4.3 Paper 3

Title:

"The impact of procurement options on risk management in Swedish construction projects"

Keywords: Risk management, construction project, questionnaire survey, interview, Sweden

Research questions in focus:

RQ2: What impact does the chosen procurement option have on risk management?

Purpose:

The aim of the study was to investigate the impact of the chosen procurement option on risk management in construction projects. The study focuses on three procurement options, which are typically used in Sweden: design-bid-build contracts, design-build contracts and the collaborative form of partnering. The research results are based on a questionnaire survey and a series of interviews with clients, contractors and consultants involved in nine construction projects recently performed in Sweden.

Results:

The major finding of the study is that there is a clear connection between the procurement options and risk management. Traditional design-bid-build contracts do not create the opportunities for open discussion of project risks and joint risk management. Design-build projects offer a higher degree of collaboration in risk management due to the involvement of the contractor in early phases. Partnering helps to establish cooperative relationships because the actors work together throughout the project and each actor participates in joint risk management. The lack of trust and personal commitment is an important obstacle for effective communication of project risks and joint risk management. The overall conclusion is that those forms that support early involvement of the actors and create opportunities for open dialogue and collaboration result in the more effective risk management process.

4.4 Paper 4

Title:

"From project-oriented to process-oriented risk management in construction"

Keywords: Risk management, construction project, interview, process modelling

Research question in focus:

RQ3: What are the main factors that contribute to more effective risk management in the construction projects?

Purpose:

The paper presents the results of a series of interviews with clients, construction and consultants involved in nine construction projects recently undertaken in Sweden. The objective of the study was to explore the factors that lead, more or less, to effective risk management in the projects. In particular, the involvement of the actors in risk management in individual projects is examined. Risk transfer and communication of risks between the project phases are discussed. Finally, the factors that determine whether or not the actors regard an open discussion of risk management and risk sharing as beneficial are analysed.

Results:

Despite the fact that risk management was a part of each project, many projects suffered from variations in cost for one or several actors. The majority of respondents do not have any special training in risk management and identify experience within the construction industry as the main source of knowledge. The actors' participation in the risk management process is generally limited by their roles in the project. Systematic scrutiny of potential and possible risks is identified as a very important factor for successful risk management. However, risk management is not carried out systematically in all phases of a project. The absence of systematic risk management is especially noted in the programme phase, where it arguably has the greatest potential impact. The production phase is where most interest and activity are to be found. Unfortunately, this can easily prove to be too late to mitigate some risks, including those that might have been avoided in an earlier phase. The communication of risks between the actors in the procurement phase does not work to the extent that it must if projects are to be delivered with certainty. Open communication and information exchange, active participation in discussions of risks, mutual respect for the roles and competence of those involved, personal commitment, motivation and responsibility, and trustful relationships are argued to be important factors in achieving effective risk management.

5 Discussion and conclusions

This chapter finalises the first part of the thesis by providing answers to the research questions, recommendations to the industry practitioners and directions for further research.

5.1 Answering the research questions

The overall aim of the research was to increase the understanding of risk management in the different procurement options in Sweden. In order to achieve the aim, three research questions were formulated and treated during this study.

1. In what ways and to what extent are the actors involved in risk management through the different phases of the construction project?
2. What impact does the chosen procurement option have on risk management?
3. What are the main factors that contribute to more effective risk management in the construction projects?

In three sections below the answers to the research questions are presented and discussed. The content of each research question forms titles of the sections. The discussion is based on the respondents' opinions and the researcher's reflections. Project actors' quotations are used to open the discussion and summarize the important observations within each research question.

5.1.1 Actors' involvement in risk management within the project life cycle

"Risk is a problem". (Client)

It is impossible to study risk management without understanding the perceptions of project actors about risk and the risk management process. Most of the respondents see risk as a negative event that can affect the project and cause problems. Only few persons mentioned opportunity as an opposite side of risk. This confirms the results of a study by Akintoye and McLeod (1997), which show negative perception of risk among industry practitioners. In response to the question of what types of risks the respondents dealt with in the project, the following risks were mentioned (listed in the decreasing order): financial, technical, work environmental, environmental, quality, time. This indicates that the risks connected to design and production were subject to risk management. Only one respondent mentioned contractual risks and nobody noted organisational risks connected to the relationship between the project actors.

"I have only my experience. It would be good to get more theoretical knowledge". (Consultant)

Most of the respondents have what might be described as a fair understanding or knowledge of risk management. In spite of general awareness of the risk management process, implementing risk management systematically in the project is still limited in practice. Risk identification is the most frequently applied element with checklists and brainstorming as the main techniques. The interviews revealed that formal risk assessment is not performed in the projects. Experience, feelings and intuition are the most commonly used "tools" for risk assessment. Risk response is a less frequently used element because not every identified and assessed risk is subject to risk management. These findings are very similar to several surveys conducted among the construction industry practitioners in the UK, Australia, Sweden and China (Akintoye and MacLeod 1997, Lyons and Skitmore 2004, Simu 2006, Tang et al. 2007, Uher and Toakley 1999).

"It happens very often that people involved in different phases do not see the overall picture". (Client)

The actors' participation in the project phases can be generally explained by the traditional separation of their roles in the construction process. The client requests, the consultant designs, and the contractor executes and delivers the project. Thus, all contractors participated in the production phases and all consultants participated in the design phase. The participation in the programme phase was very low and resulted in limited risk management activities in this phase. In contrast, the production phase was where most interest and activity were found. These results confirm the findings of two surveys (Lyons and Skitmore 2004, Uher and Toakley 1999), which show a higher degree of risk management in the design and production phases than in the programme phase. However, the majority of respondents feel that risk management should be more important in the early phases for several reasons. First, early risk identification makes the client aware of project risks and facilitates the choice of the optimal procurement option. Moreover, significant savings are possible in the early phases, since changes in the programme phase cost less money than in the production phase. Finally, the client simply cannot proceed with a project without taking into consideration all possible risks.

"Contractors have to deal with most risks; we are forced to be active in risk management". (Contractor)

Within three groups of actors, contractors were the most active in performing risk management. Almost all contractors documented potential project risks and preventive measures. Moreover, contractors had the largest influence on risk management from the perspective of all actors. This finding can be generally explained by risk management being carried out in the production phase. The influence of the consultants was surprisingly low despite the fact that the design phase was considered to be very important by all actors. The respondents were agreed that this is due to the current practice when risk management is not a part of consultants' assignment. The client's role in the project was argued to be very

important. The client is seen as the one responsible for project organisation and, therefore, for other actors' engagement in risk management. Contractors are able to manage many risks, but they need the dialogue with the client, not the situation when risks just appear in the production phase.

For a more detailed discussion of the actors' involvement in the risk management process within the project life cycle, see Paper 2.

5.1.2 Impact of the procurement options on risk management

"Time and price determine the choice of the procurement option". (Client)

Before proceeding with the project a client has to choose the optimal procurement option. A number of factors influence this choice. The most important and often mentioned factors are time and price. Both clients and contractors said that the client often chooses the design-build option when time constraints are very important. Thus, the contractor can start execution when construction drawings are not fully completed. A study by Toolanen (2004) showed similar results: clients choose DB more often when time constraints are critical. Price is another factor influencing the choice. A design-build-bid form gives the client the opportunity to choose the best possible tender for both design and construction. There is an indication that more competent clients choose DBB contracts partly because the cost may be lower, partly because they want to have a higher degree of influence on the project. A client's willingness to bear risk also influences the form of contract. The clients who want to minimize their own risks choose DB contracts due to the single point of responsibility for both design and construction. Some clients mentioned that the contractor's competence is a very important factor when procuring DB projects.

"There is no room for discussion in design-bid-build projects". (Contractor)

According to the general conditions of contract (AB), in design-bid-build projects the contractor receives rigorous instructions from the client and follows them. Thus, there is no dialogue or collaboration between the client and the contractor for the purpose of finding the optimal design solutions. As a result, the actors focus primarily on their own responsibilities and risk management in their own part of the project. On the other hand, with a DBB contract the client has more opportunities to influence the project, and some clients find this reason significant enough to sacrifice early involvement of the contractor. From the contractors' point of view, in DBB projects the quality of documents and drawings is often insufficient with many inaccuracies involved. This brings additional risks to the projects. However, collaboration in risk management between the actors was evaluated higher in DBB than in DB contracts. This can be the case when the client shifts responsibility to the contractor in DB form and does not participate actively in the project.

"The sooner we get the contractor's expertise in the project, the greater is a chance to avoid the problems in production". (Client)

From the perspective of dealing with risks, early involvement of the contractor in design-build projects is considered to be the main advantage of this form. Moreover, contractors' risk management is more thorough in the DB contract due to assigned responsibilities for design. Cooperative work of the architects and contractors is argued to result in better technical solutions and help in avoiding many design and technical risks. On the other hand, consultants felt higher pressure in DB contracts in terms of cost; contractors are believed to be more cost aware than clients. Many actors are positive about more fruitful risk management in DB contracts. However, personal commitment of the clients is argued to be the most important factor for securing effective risk management. When the client is an active party, the DB form is claimed to create conditions conducive to better collaboration because the clients and contractors are forced to have a dialogue.

"I have never participated in partnering projects, but I believe that this form is very effective". (Contractor)

Great expectations in partnering arrangements were found among the project actors including those who have no experience of partnering. It was argued that partnering allows the actors to see the project as a whole and influence risk management throughout the construction process. The fact that the contractor is involved in the programme phase makes risk management more effective and easier in terms of better collaboration. The consultant has an opportunity to assess technical solutions together with the client and the contractor, which results in better solutions and fewer risks involved in the production phase. Moreover, the actors deal with indistinctness before signing the contract. However, a successful partnering project requires greater professionalism and open attitudes from all partners. An interesting observation of the contractors is that in partnering projects the actors lose business opportunities and winner feeling in a short-term perspective. However, in a long-term perspective the actors have more stable results of construction activities, neither big profits, nor big losses.

To summarize, different procurement options provide different opportunities for open dialogue and can, therefore, influence project risk management. For a more detailed discussion of this research question, see Papers 1 and 3.

5.1.3 Factors that contribute to more effective risk management

"Deviations from the general conditions of contract can be very expensive for us". (Contractor)

Construction contracts form the behaviour of the project actors and, therefore, have a significant impact on the successful completion of the project. The general conditions of contract (AB and ABT) are widely used in the Swedish construction projects and assign responsibilities and liabilities to each contracting party. Most of the respondents were agreed that AB and ABT are well-developed documents that facilitate clear risk allocation between the project's actors. However, the clients often deviate from AB and ABT trying to transfer more risks to the contractor. Deviations make the contract more indistinct for the contractor and may result in conflicts and disputes.

"We have to minimize project risks, every actor will then benefit from it". (Contractor)

A conscious risk allocation is not a single condition for effective risk management. It is important to prevent risks in the project and minimize their consequences. When considering the effect that risk management has on the project's goals in terms of quality and cost, it would be reasonable to expect that it was an open process across all phases of the project. It was already mentioned above that early risk management results in fewer problems during the project execution phase. Open discussions of possible risks in the early phases as well as collaborative management of risks throughout the project life cycle are noted to be important drivers of effective risk management. However, it was found that communication of known risks in the procurement phase does not work. The reason can be that the actors do not want to raise problems that can influence the price. Many respondents were agreed that in current procurement practice the low bid price when signing the contract is more important than a thorough analysis of the potential risks. However, to keep quiet about the known risk to get a lower price is a dangerous solution. Detailed communication of the known risks in early phases means that these risks and eventual high costs can be avoided, and both the client and the contractor would benefit.

"All identified risks are manageable, the problem is unforeseen risks". (Contractor)

It is impossible to identify all potential risks in the project, as some unforeseen risks always appear during the project implementation. The strategy of avoiding risks as far as possible and letting someone else in the value chain manage them is not conducive to safeguarding project objectives. Joint risk management is argued to be the best option for managing unforeseen risks. In practice, the actors often have their own management systems and do not use a common database for risk management documents. When describing their work on project risks, the actors often say 'contractor's risk management" and 'client's risk management'. 'Joint risk management' where all actors participate and perform identification,

assessment and response together is a weakness in the current practice. All respondents acknowledged the importance of open dialogue and collaboration to achieve effective risk management. The factors that create the opportunities for open dialogue are summarised below.

- Every actor's involvement in dialogue;
- Effective communication and information exchange;
- Mutual respect for the roles and competence of those involved;
- Trustful relationship;
- Open attitudes;
- Clients' commitment;
- Understanding of benefits of long-terms relationships.

Other factors that were mentioned by the project actors were related to the complexity of the project, management systems and payment mechanisms. It was argued that more complex projects require more attention to the risk management process. As a matter of practice, more advanced tools and better support from risk management consultants are available in large projects. In smaller projects, risk management is seen as an additional time-consuming task (Simu 2006). Systems and procedures that are easy to handle are important drivers of more effective risk management. Quite low use of quality management systems was noted in the projects. The actors argued that the complexity of the systems makes them difficult to apply in practice. When the management system becomes a paper product, it does not benefit the project actors. Fair distribution of opportunities through incentive agreements (contracts) was recognised as an efficient instrument for risk management. Incentive agreements stimulate better collaboration for finding the best possible solutions, and, therefore, lead to cost decrease.

For more discussion of the factors that influence risk management, see Paper 4.

5.2 Recommendations to the practitioners

The findings of this research are expected to contribute to a more effective risk management process and, therefore, benefit construction projects' actors. To achieve this objective, this study proposes a set of recommendations to the industry practitioners.

1. As many actors identified the lack of theoretical knowledge, it would be reasonable to suggest advanced vocational training in risk management for companies' personnel. The training is expected to increase knowledge of the subject and understanding of the importance of risk management for safeguarding project objectives. This recommendation is directed to the companies' management because the administration is responsible for staff development. The lack of further training is

especially noted in clients' organisations and among consultants. Construction companies organise in-service courses in risk management more often, but further development is required in order to increase the level of awareness of project risk management.

2. Regarding actors' involvement in the project phases, the author recommends to ensure all actors' participation throughout the project life cycle. This involvement facilitates better understanding of project goals and better collaboration through intensive information and knowledge exchange between the project actors. Different procurement options imply different degrees of the actors' involvement and different opportunities for collaboration in the project. From the perspective of dealing with risks, the design-bid-build contracts give no space for discussion about technical solutions between the client and the contractor. On the other hand, the client's responsibility for design forces the actors to have a dialogue when problems appear during the project implementation. The design-build contracts offer early involvement of the contractor, but demand an active engagement of the client for ensuring the quality of the final product. There is an indication that the newer organisational forms like partnering, which create opportunities for the actors' involvement in all phases of a construction project can result in a better project performance.

3. A client is a party that owns the project, and should therefore be an active part of the risk management process and demand active participation from the other actors. In current practice, very limited interest and activity are found in the programme phase. This aspect must be addressed by the project actors as the early phases are commonly recognised to be very important for effective project risk management. Thorough attention to the project risks must be paid in the programme phases in order to safeguard projects' objectives. The architects and design managers should be involved more in risk management because design is a very significant risk source in a construction project. Currently, risk management is not a part of consultants' assignment in traditional contracts. Incentive contracts, where the consultant is involved in profit sharing, create opportunities for consultants' engagement in risk management. Moreover, it is reasonable to expect that consultants have to participate in risk management in the production phase in case there is a need for change or design risks occur.

4. The general conditions of contract (AB and ABT) formalize risk allocation between the project actors. The deviations from AB and ABT make risk allocation more indistinct and may lead to disputes. Thus, deviations are not recommended if the actors want to keep conscious risk sharing and create a trustful relationship in the project. The procurement phase should play a more important role in risk management. It is of crucial importance to communicate known risks before signing

the contract. In this case both the client and the contractor are aware of potential risks and are therefore able to prevent them and potential higher costs. Moreover, open communication of known risks may result in a lower contingency fund, and, in turn, in lower total cost. It is important to note that this recommendation requires a change of current practice when the low contract sum plays the most important role in the tender.

To conclude, if risks are to be properly managed, it is self-evident that the risk management process must be present, transparent and activated in the whole project life cycle. There are many factors that influence project risk management. This research explored risk management on the example of nine construction projects and contributed to better understanding of risk management in the different procurement options. The main findings, discussed in Section 5.1, are summarized in the model shown in Figure 8. When exploring the factors that affect project risk management, both drivers and obstacles have been found and included in the model. The left part, obstacles, shows weaknesses in current risk management practice. The right part of the model, drivers, presents the success factors that contribute to more effective management of risks in construction projects.

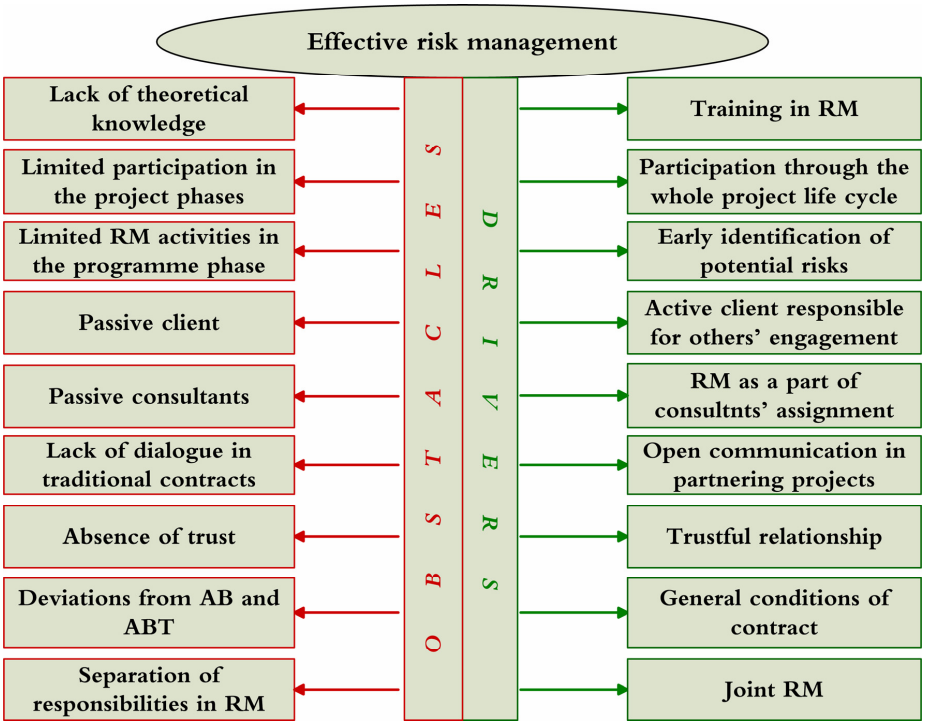

Figure 8. Drivers of and obstacles to more effective risk management in a construction project.

5.3 Further research

The findings of this research provide several directions for further work. For example, the study shows great belief in partnering projects among the industry practitioners. Thus, it is interesting to study risk management in several partnering projects and explore if partnering is the optimal form for achieving effective risk management. In this study procurement options were limited to those that are most frequently used today in the Swedish construction projects: design-bid-build, design-build and partnering. However, there is an ongoing development of organisational and contractual forms of project implementation. In the further research such forms as construction management contracts, public/private partnerships (PPP), build-operate-transfer (BOT), design-build-finance-operate (DBFO) etc. should be explored from the perspective of dealing with risks.

Another important finding is a very low degree of communication of known risks in the procurement phase. This problem was found in all projects included in this study irrespective of the form of contract and collaboration. Taking into account that in the procurement phase the contractor calculates contingency funds, it would be reasonable to expect that the parties jointly perform risk identification and assessment. Joint risk management during the procurement phase is expected to result in a more accurate tender price. Thus, a deeper study of risk management in the procurement phase and its effects on the project performance is of particular interest.

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APPENDIX 1. Questionnaire survey

2006-12-04 Luleå

Dear Respondent

The Construction Management Research Group at Luleå University of Technology conducts the research project "Risk management in the different procurement options". The aim of the project is to investigate conditions for the choice of procurement option, taking uncertainty aspects into account. Another aim is to explore factors that, within the framework of the chosen procurement option, facilitate the management of a project's uncertainties. The research project is managed by Professor Jan Borgbrant and Adjunct Professor Lennart Apleberger. The active researcher in the project is doctoral student Ekaterina Osipova.

This questionnaire is an important part of data collection in the project. The questionnaire consists of five sections with a total of 34 questions. It takes approximately 40 minutes to answer the questionnaire.

Outline of the questionnaire:
Section 1 contains general questions about the respondent.
Section 2 explores the aspects of the risk management process through the different phases of the project.
Section 3 investigates relationships between the actors in the project, i.e. client, contractor and consultant.
Section 4 focuses on software management systems, which the company uses in the risk management process.
Section 5 is a concluding one for miscellaneous comments regarding the risk management process in the project.

Each question is accompanied by an instruction on how to answer it. In order to get an accurate picture of the current risk management practice, it is important that the questionnaire be completed and returned. Answer the questionnaire electronically, save a file and mail it to the address below. **The questionnaire will be treated as strictly confidential** and no reference will be made to companies or persons. By way of thanks for participation, the respondents will be informed about the preliminary results of the study.

NB! All questions should be answered from the project perspective, not from the general perspective.

Thank you in advance!

Ekaterina Osipova
PhD student, Construction Management Research Group
Luleå University of Technology
Phone: 0920 49 14 63, E-mail: ekaterina.osipova@ltu.se

1. General questions

1. Name:

2. Company / organisation:

3. Age:

4. How long have you worked in the construction industry?

5. What is your education? (Tick off your answer)

	Vocational training	Upper secondary school	University
Construction	☐	☐	☐
Economics	☐	☐	☐
Law	☐	☐	☐
Other:	☐	☐	☐

6. Did you study risk management or/and project management courses? Yes ☐ No ☐

If yes, what courses?

7. How do you evaluate your knowledge of risk management? Low ☐ Fair ☐ Advanced ☐

8. Name of the project

8a.Your role in the project:

- Client - representative ☐
- Client - project manager ☐
- Contractor - representative ☐
- Contractor - site manager ☐
- Contractor - estimator ☐
- Consultant ☐
- Design manager ☐
- Other, namely: ☐

2. Risk management in the different phases of the project

Any construction process can be divided into four main phases: programme, design, procurement and production. This section of the questionnaire explores the aspects of the risk management process through the different phases. Risk management in the project consists of risk identification, risk assessment and risk response. The aim of risk management is to maximise opportunities and minimise consequences of a risk event.

9. How do you evaluate the project implementation in terms of the following parameters?
(Tick off the most appropriate alternative for each parameter)

	Very bad	Fairly bad	Fairly good	Very good
Functionality	☐	☐	☐	☐
Cost	☐	☐	☐	☐
Time	☐	☐	☐	☐

10. In what phases of the project did you participate?
(Tick off your answer)

Programme	☐
Design	☐
Procurement (Bid/Cost estimate)	☐
Production	☐

11. Were the following risk management processes carried out systematically in the project?

	Yes	No
Risk identification	☐	☐
Risk assessment	☐	☐
Risk response	☐	☐

12. In what phases of the project were the risk management processes performed?
(Tick off one or more alternatives that are suitable in every process)

	Programme	Design	Procurement (Bid/Cost estimate)	Production
Risk identification	☐	☐	☐	☐
Risk assessment	☐	☐	☐	☐
Risk response	☐	☐	☐	☐

13. Did you participate in risk management?

Yes	No
☐	☐

If yes, what was your role in risk management?

14. What types of risk did you assess in the project?

15. How large influence did the project actors have on risk management?
(Tick off the most appropriate alternative for each actor)

	Very small	Fairly small	Fairly large	Very large
Client	☐	☐	☐	☐
Contractor	☐	☐	☐	☐
Consultant/Design manager	☐	☐	☐	☐

16. Assess the importance of risk management in the different phases of the project.
(Tick off the most appropriate alternative for each phase)

	Unimportant	Not so important	Fairly important	Very important
Programme	☐	☐	☐	☐
Design	☐	☐	☐	☐
Procurement (Bid/Cost estimate)	☐	☐	☐	☐
Production	☐	☐	☐	☐

17. Were there deviations in the project in terms of the following parameters?
(Tick off the most appropriate alternative for each parameter)

	Yes, positive deviations	Yes, negative deviations	No
Functionality	☐	☐	☐
Cost	☐	☐	☐
Time	☐	☐	☐

	Yes	No
18. Have identified risks that resulted in problems occurred in the project?	☐	☐

18a. If yes, what impact on the project cost did they have?

Very small	Fairly small	Fairly large	Very large
☐	☐	☐	☐

18b. If yes, why did the risks occur?

18c. If yes, how the problems were solved?

	Yes	No
18. Have unforeseen risks that resulted in problems occurred in the project?	☐	☐

19a. If yes, what risks?

19b. If yes, what impact on the project cost did they have?

Very small	Fairly small	Fairly large	Very large
☐	☐	☐	☐

19c. If yes, how the problems were solved?

20. How were unforeseen risks caught in the project?

21. Who did carry out the following risk management processes in the project's different phases? (Tick off the most appropriate alternative for each process in every phase)

	Client	Contractor	Consultant/ Design manager	Jointly	Some-one else
Programme					
Risk identification	☐	☐	☐	☐	☐
Risk assessment	☐	☐	☐	☐	☐
Risk response	☐	☐	☐	☐	☐
Design					
Risk identification	☐	☐	☐	☐	☐
Risk assessment	☐	☐	☐	☐	☐
Risk response	☐	☐	☐	☐	☐
Procurement (Bid/Cost estimate)					
Risk identification	☐	☐	☐	☐	☐
Risk assessment	☐	☐	☐	☐	☐
Risk response	☐	☐	☐	☐	☐
Production					
Risk identification	☐	☐	☐	☐	☐
Risk assessment	☐	☐	☐	☐	☐
Risk response	☐	☐	☐	☐	☐

22. Who did have the best conditions to manage the following risks in the project? (Tick off the most appropriate alternative for each risk)

	Client	Contra-ctor	Consultant/ Design manager	Joint RM	Risk didn't occur
1) Financial risks	☐	☐	☐	☐	☐
- Price (changes in the contract amount due to variations in prices and salaries)	☐	☐	☐	☐	☐
- Delayed payments	☐	☐	☐	☐	☐
- Market (e.g. competition, recession)	☐	☐	☐	☐	☐
- Bankruptcy (subcontractors)	☐	☐	☐	☐	☐

	Client	Contra-ctor	Consultant/ Design Management	Joint RM	Risk didn't occur
2) Design risks	☐	☐	☐	☐	☐
- Unsuitable technical solutions	☐	☐	☐	☐	☐
- Changes in design	☐	☐	☐	☐	☐
- Delays in design	☐	☐	☐	☐	☐
3) Organisational/contractual risks	☐	☐	☐	☐	☐
- Quality of contractual documents	☐	☐	☐	☐	☐
- Lack of resources during the project execution	☐	☐	☐	☐	☐
- Indistinct contractual relationship	☐	☐	☐	☐	☐
- Supply of labour	☐	☐	☐	☐	☐
- Collaboration problems	☐	☐	☐	☐	☐
4) Production risks	☐	☐	☐	☐	☐
- Changes in the project conditions	☐	☐	☐	☐	☐
- Delays	☐	☐	☐	☐	☐
- Lack of quality in project performance	☐	☐	☐	☐	☐
- Lack of material quality	☐	☐	☐	☐	☐
- Lack of materials	☐	☐	☐	☐	☐
- Capacity and productivity of labour	☐	☐	☐	☐	☐
5) Force majeure risks	☐	☐	☐	☐	☐

23. How were risks allocated in the project?

	Yes	No
1) Through the general conditions of contract, i.e. AB/ABT:		
- AB92(04), Chapter 5 Responsibilities and assistance	☐	☐
- ABT94(06), Chapter 5 Responsibilities	☐	☐
2) Specific risks were transferred to other project actors	☐	☐

If yes, what risks?

	Yes	No
24. Were demands set on special insurances?	☐	☐

If yes, what demands?

3. Relationships between the project actors

This section investigates relationship between the project actors, i.e. client, contractor and consultant.

25. Did you earlier collaborate with other actors in the project?

No one	One actor	Most of the actors	All actors
☐	☐	☐	☐

26. How do you evaluate collaboration between the actors in the project?

Very bad	Fairly bad	Fairly good	Very good
☐	☐	☐	☐

Comments:

27. Was there collaboration between the actors in managing project risks?

Yes	No
☐	☐

27a. If yes, in what processes? (Tick off one or more alternatives)

Risk identification ☐
Risk assessment ☐
Risk response ☐

27b. If yes, in what phases? (Tick off one or more alternatives)

Programme ☐
Design ☐
Procurement (Bid/Cost estimate) ☐
Production ☐

27c. If yes, how do you evaluate collaboration in risk management?

Very bad	Fairly bad	Fairly good	Very good
☐	☐	☐	☐

Comments:

28. To what extent did the client communicate known risks and opportunities in the procurement phase?

Not at all	Little extent	Some extent	Great extent
☐	☐	☐	☐

29. To what extent did the contractor communicate known risks and opportunities in the procurement phase?

Not at all	Little extent	Some extent	Great extent
☐	☐	☐	☐

30. Assess how important the following factors were in the project.
(Tick off the most appropriate alternative for each factor)

	Unim-portant	Not so impor-tant	Fairly impor-tant	Very impor-tant
- Open communication between the actors	☐	☐	☐	☐
- Understanding of other actors' goals	☐	☐	☐	☐
- Effective coordination	☐	☐	☐	☐
- Attitudes of the project actors (trust and commitment)	☐	☐	☐	☐
- Joint responsibilities	☐	☐	☐	☐
- Personal responsibilities	☐	☐	☐	☐
- Established process for dispute resolution	☐	☐	☐	☐
- Frequent meetings	☐	☐	☐	☐
- Readiness for compromises	☐	☐	☐	☐
- Opportunities for future cooperation	☐	☐	☐	☐
- Effective information exchange between the actors	☐	☐	☐	☐
- Fair and open allocation of identified risks	☐	☐	☐	☐
- Fair and open allocation of unforeseen risks	☐	☐	☐	☐

4. Software systems for risk management in the project

31. How important was quality management software for risk management in the project?

Not at all	A little bit	Fairly much	Very much
☐	☐	☐	☐

32. What other management systems were used for risk management in the project?

33. To what extent were these systems used?

Not at all	A little bit	Fairly much	Very much
☐	☐	☐	☐

34. To what extent should the project actors use the following management systems?
(Set the figures: 1 – not at all, 2 – a little bit, 3 – to some extent, 4 – fairly much, 5 - very much)

System	Client		Contractor			Consul-tant	Design manager
	Repre-senta-tive	Project mana-ger	Respre-senta-tive	Site mana-ger	Estima-tor		
Quality management							
Planning system							
Cost estimation software							
Construction management							
Environmental management							
Risk management							

5. Other comments

Thank you for your participation!

APPENDIX 2. Interview questions

Part 1. General discussion and main definitions.

Could you please describe the project?

How did you work with the risks in the project?

Why did you choose design-bid-build/design-build/partnering?

What was of decisive importance for this choice?

What does the term *risk* mean to you?

What does the term *risk management* mean to you?

What does the term *risk identification* mean to you?

What does the term *risk assessment* mean to you?

What does the term *risk response* mean to you?

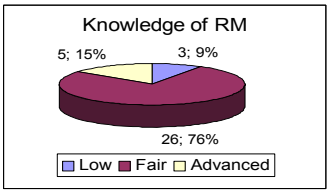
Is there any connection between the procurement option and risk management in the project?

Why do clients make deviations from the general conditions of contract (AB)?

What do these deviations cause for the project actors?

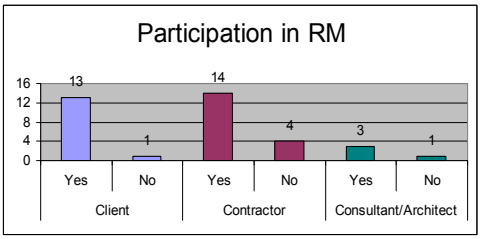
Part 2. Discussion of the questionnaire survey results.

1.



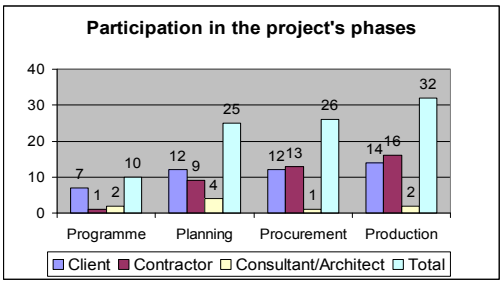
- Describe your knowledge of risk management.
- What risk management techniques do you use?
- Do you feel lack of theoretical knowledge in risk management?

2.



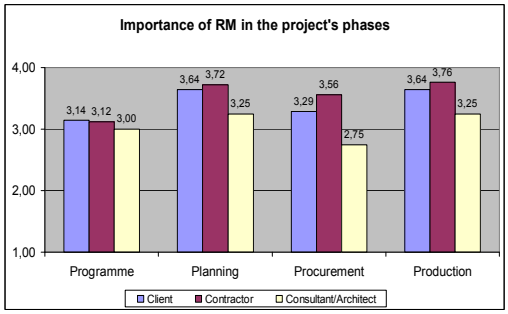
- Why were not all actors involved in risk management?
- Who decides which project participants are involved?
- Do you take an external help in risk management?

3.



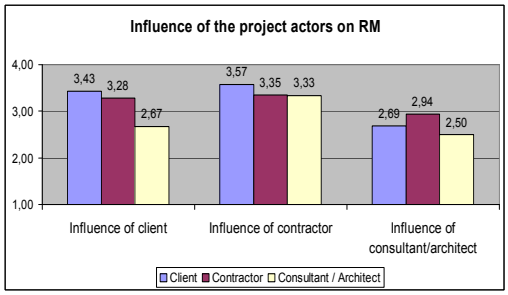
- What is the role of the client in the production phase?
- Why is it so limited participation of the contractors in the design and production phases?
- What can the actors win by the earlier participation in the project?

4.



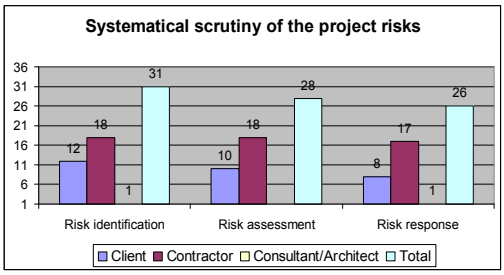
- Why is risk management less important in the programme and procurement phases?

5.



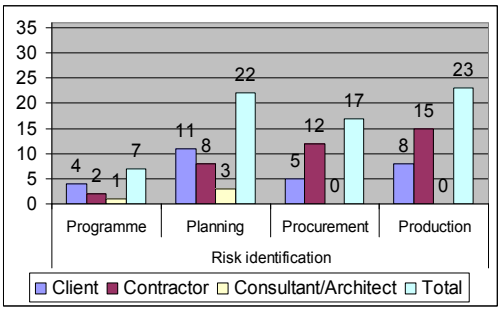
- Why has the contractor the largest influence on risk management?
- Why is the consultant's influence so low?

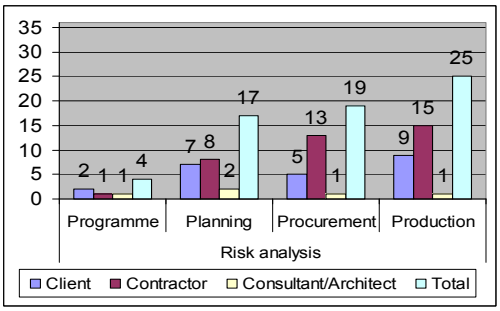
6.



- Why some identified and assessed risks are not subject to risk response?
- What happens to these risks?

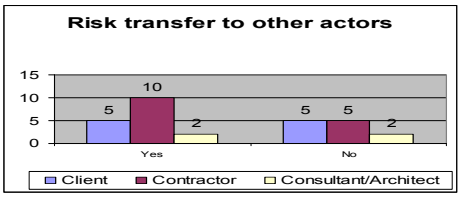
7.





- Risk identification (RI) and risk assessment (RA) were mostly performed in the design and production phases. Why not earlier? What roles do the programme and procurement phases have in RI and RA?

8.



- To whom did you transfer risks in the project?
- In what forms?

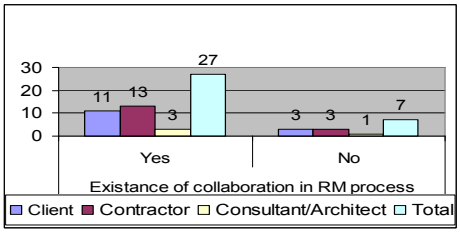
9.

Collaboration between the actors

	Client	Contractor	Cosultant
DBB	3,80	3,63	3,50
DB	4,00	3,20	4,00
Partnering	4,00	4,00	4,00

- How can you explain the differences in evaluations between the different procurement options?

10.



- What did collaboration consist of?
- Does collaboration minimize risks?

11.

Collaboration in RM

	Client	Contractor	Consultant
DBB	3,75	3,50	3,00
DB	3,60	3,25	--
Partnering	3,00	3,33	4,00

- How can you explain the differences in evaluations between the different procurement options?

12.

	To what extent did actors communicate known risks and opportunities in the procurement phase?	
	Client	Contractor
Client	2,73	2,69
Contractor	2,06	2,39
Consultant	3,00	3,00
Total	2,36	2,53

- Why are there so low numbers?

13.

Importance of quality management software

Client	Contractor	Consultant
2,77	2,8	2,25

- Why did quality management software have a quite low importance in RM?

14. What factors play the most important role for an open discussion of risks in the project?

Part 3. Concluding remarks.

Paper 1

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Risk management in different forms of contract and collaboration – case of Sweden

Ekaterina Osipova, Lennart Apleberger

ABSTRACT

Risk management in construction projects depends on the choice of contractual and collaboration form. In this paper we analyse three major forms used in Sweden: performance-based contracts, design-build contracts and collaboration form partnering. From the perspective of dealing with risks in construction projects we highlight strengths and weaknesses of each form. We show that the design-build contracts are attractive for the client due to their single responsibility and more risk allocated to the contractor. The performance-based contracts give the client more flexibility in terms of the design but imply more risk allocated to the client. Recently the collaboration form partnering shows promising performance in Sweden and may be successfully used when a trust relationship exists between project actors. We conclude that additional research is needed in how the risk management process can be further developed, based more on openness and trust rather than on sharp contract formulations.

Keywords: **Risk management, Risk allocation, Construction project, Contracts, Sweden**

123.1 INTRODUCTION

The construction sector is one of the largest segments in Swedish economy. It provides jobs for almost ten percent of all Swedish employees and contributes with four percent to the country's GDP in 2005. As the quality of the buildings and infrastructure has a direct impact on the level of people's life, a well-functioning construction sector is an important factor for the development of society.

Due to their project-oriented nature, construction activities are usually characterized by many and varying uncertainties that can be conceived of as both risks and opportunities. In order to be able to carry out a construction project with the expected final result professional risk

management as well as a conscious risk sharing among the partners in the project are required from both the client and the contractor. It should be natural for different risks to be divided and managed among the project's different actors on the basis of who has the best qualifications for dealing with a specific risk. Instead it often happens that the efforts are directed at avoiding risks as far as possible and often at the expense of other actors.

Risk management in construction projects is to a large extent governed by the choice of contractual form and what is stated in the related contractual documents. Two contractual forms that are mostly used in Sweden are performance-based contracts and design-build contracts. There is an ongoing development of organisation and contractual forms of project implementation. Based on the experience from the UK and Denmark such form as partnering is adopted in Sweden. So far, the experiences of partnering are positive, however further development of the form is required. A question of a particular interest for the actors in Swedish construction industry is the way how the project risk management needs to be further developed, based more on openness and trust rather than on sharp contract formulations.

In this paper we present the results of the state-of-the-art analysis in the area of project risk management. We describe three forms of contract and collaboration that are typically used in Sweden: performance contracts, design-build contracts and collaboration form partnering. We analyse how project risks are allocated between the actors in a construction project depending on the chosen form of contract and collaboration. From the perspective of dealing with risks in construction projects we highlight strengths and weaknesses of each form. Finally, we discuss directions for further research.

The paper is organised as follows. In section 2 we discuss main theoretical issues of risk management in construction: definition of term risk, classification of risk sources and main steps of the risk management process. In section 3 we describe different forms of contract and collaboration in Swedish construction sector and discuss risk allocation in these forms. Discussion and directions for further research are presented in section 4. Section 5 is a final section for conclusions.

123.2 RISKS IN CONSTRUCTION

Project risks are uncertain events or conditions that may have an impact on one or several project objectives. A risk has a cause and, if it is triggered, also a consequence. Different research studies offer different definitions of the project risk (e.g. IEC 62198, 2001, PMBOK, 1998, Baloi and Price, 2003, Barber, 2005). A formal definition of the concept of project risk is given in the international standard IEC 62198 as combination of the probability of an event occurring and its consequences for project objectives. Ward and Chapman (2003) discuss the concept of risk in greater detail and suggest using a more general concept of *uncertainty*. The questionnaire survey conducted by Akintoye and MacLeod (1997) shows that the majority of project actors perceive risk as a negative event.

Different risks occur in different phases of a project. In many cases risks are inherited from one project phase by the next one. There are several approaches for classifying project risks and risk sources (Leung *et al.*, 1998, Tah and Carr, 2000, Baloi and Price, 2003, Li *et al.*, 2005). In general the sources of risk in construction projects may be divided into three main categories:

- Those related to external factors, for example financial, economic, political, legal and environmental risks;
- Those related to internal factors, such as design, construction, management and relationships;
- Force majeure risks

The overall goal of risk management process is to maximise the opportunities and minimise the consequences of a risk event. According to the Guide to the Project Management Body of Knowledge (PMBOK) (1998), developed by Project Management Institute (PMI), risk management in a project consists of risk identification, risk assessment and risk response processes. The risk identification process aims at deciding potential risks that may affect the project. During the risk assessment the identified risks are evaluated and ranked. The risk response process is directed to identifying the way of dealing with the project risks.

Several surveys conducted among the construction industry actors (Akintoye and MacLeod, 1997, Uher and Toakley, 1999, Lyons and Skitmore, 2004) show that checklists and brainstorming are the most usable techniques in risk identification; subjective judgment, intuition and experience are used mostly in risk assessment; and transfer, reduction and avoidance are the most applied methods for risk response.

Number of methodologies for the risk analysis in a construction project was proposed in the research literature. Baccarini and Archer (2001) describe a methodology for the risk ranking of projects, which allows an effective and efficient allocation of the resources for management of the project risks. Öztas and Ökmen (2005) develop the judgmental risk analysis process. This is a pessimistic risk analysis methodology, which is effective in uncertain conditions in construction projects. A fuzzy system proposed by Motawa *et al.* (2006) helps to determine potential changes, which occur during the construction project lifetime.

123.3 CONSTRUCTION CONTRACTS AND RISK ALLOCATION

Construction contracts deal with project risks through their allocation to the involved parties. The contract is a written agreement between a client and a contractor where liabilities and responsibilities of each party are assigned. Construction contracts form the behavior of different actors in a project and have a major impact on the successful completion of the project.

Today the majority of Swedish contracts are based on the standardized conditions of contract. These documents are developed and issued by the Building Contracts Committee (BKK). BKK is a non-profit association consisting of authorities and organizations in the Swedish construction sector. The main objective of BKK is to constitute a negotiation body for the principals regarding general conditions for different kinds of contracts, to draw up such conditions, to work for the observance of agreements made within the association and to conduct other activities connected therewith.

123.3.1 Forms of contract and collaboration

Performance-based contracts are the contracts where the client is responsible for planning, design and function of a construction object and the contractor is responsible for job execution. Within this contract form two main organisation alternatives are possible: divided contracts and general contracts. Schematically their organisation structure is shown in fig. 1.

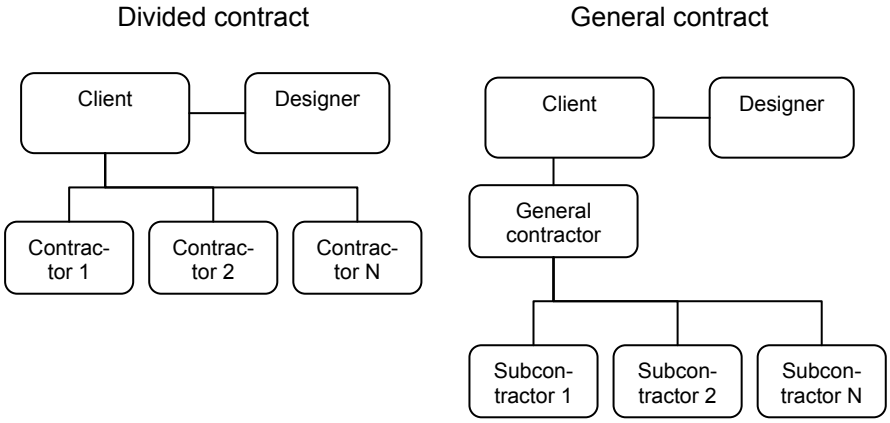

Figure 123.1 Organisation structure in performance-based contracts

A *divided contract* implies that a client appoints several contractors and signs a separate contract with each contractor. This form allows the client to choose the best possible tender for every part of the work. On the other hand, the coordination costs are very high and it could be difficult to identify exactly which contractor is responsible for a particular error. A *general contract* implies that a client signs only one contract with a general contractor, which in turn appoints the subcontractors to carry out the work. The general contractor is solely responsible for coordination of subcontractors. This type of organisation is more often used in Sweden than divided contracts.

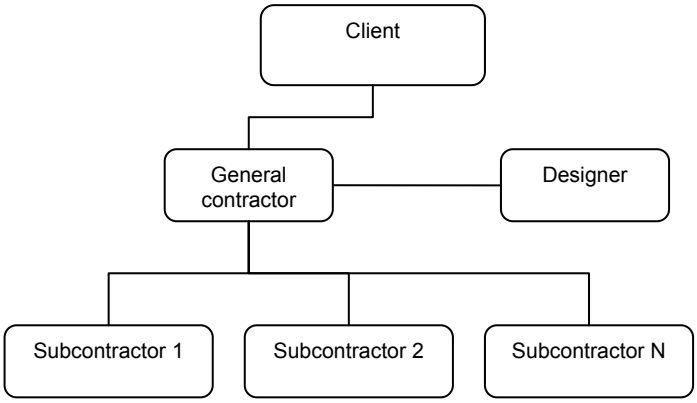

Figure 123.2 Organisation structure in design-build contracts

The organisation structure of design-build contracts is illustrated in fig. 2. In this type of contracts the contractor is responsible for both design and construction. The client signs only one contract, thus this form is the most straightforward one from responsibility point of view. In the procurement documents the clients set their demands on functionality. The contractors carry out design and construction. Öztas and Ökmen (2004) state that popularity of design-build contracts are increasing in recent years because single point of responsibility attracts the clients.

Over the last decade collaboration form *partnering* has become popular in the construction industry. The concept of partnering is differently defined in the research literature. To summarise, partnering is a way to create an effective collaboration between the projects actors. Such components as common goals, continuous improvement and structures for problem solving form the concept of partnering. Effective collaboration leads to decreased number of disputes, lower construction costs and a better quality of the product. Based on the experiences from the USA, the UK, Norway and Denmark partnering concept has been adopted in Sweden. One of the goals of partnering is better utilisation of the overall qualifications of the project's actors. Some current examples of partnering projects are presented in Rhodin (2002) and Kadefors (2002). Since 1999 NCC, one of the largest construction companies in Sweden implemented about one hundred partnering projects. According to NCC's assessment these projects showed good final results.

123.3.2 Risk allocation in different forms of contract and collaboration

An appropriate allocation of risks between actors in a construction project is important due to impossibility to eliminate all potential risks. Risk

allocation influences the behaviour of the project actors and, therefore, has a significant impact on the project performance in terms of the final total cost.

Many countries have a legislation that regulates contract relationship. In Sweden the relationships between the client and the contractor are regulated by general conditions of contract. The performance contracts are based on ”General Conditions of Contract for Building, Civil Engineering and Installation Work” (AB) (BKK, 2004). The design-build contracts are regulated by ”General Conditions of Contract for Building, Civil Engineering and Installation Work performed on a package deal basis” (ABT) (BKK, 1994). AB and ABT assign responsibilities and liabilities of each contracting party regarding job performance, organisation, timeframes, guarantees, errors and economy. These documents are very well known for both the client and the contractor and regularly used in the majority of construction projects. Even partnering projects are based on the general conditions. Parties often consider deviations from the general conditions as a risk by itself.

Table 123.1 Strengths and weaknesses of different form of contract and collaboration from the risk perspective

Form	Strengths	Weaknesses
Performance - based contract	Flexibility for the client in terms of design Possibility to choose the best tender for both design and construction	Higher coordination costs Higher construction costs Lack of information and knowledge transfer between actors
Design-build contract	Shorter building time Single responsibility	Cost uncertainty Quality uncertainty Necessity of high professional skills from the contractor
Partnering	Increased returns Shorter building time Openness for alternative solutions Knowledge transfer between actors	Increased number of meetings Necessity of high professionalism from all actors Difficulty to get a fix price of the contract

From the risk management perspective the design-build contracts are more attractive for the client as the responsibility for design implies more risk allocated to the contractor. On the other hand, the design-build alternative may be more expensive compared with the performance contracts. Furthermore, the quality of the final product may be lower if the contractor

uses cheaper solutions, trying to decrease own costs. This problem is especially relevant in the contracts with the fixed price type of payment. When the project has relatively simple design and the technical solutions are not of a great importance to the client, the design-build contract is the easiest one from responsibility perspective. In terms of time the design-build system provides the quicker start of project execution. From the contractor's point of view the design-build construction projects could be very risky when the contractor lacks knowledge and experience of the design-build system.

Partnering is a good alternative for project implementation when a trust relationship between the actors exists. It allows a more efficient risk management process based on the common goals. Both parties get a final product with a good quality, shorter building time and less disputes. Furthermore, partnering helps in transfer of knowledge and experience between the project actors. It is important to mention that partnering concept demands high professionalism and very good knowledge of the project from both the client and the contractor. One of the problems is that such close collaboration may create a false feeling of easy problem solving and lead to hiding of the serious conflicts. Table 1.1 summarises strengths and weaknesses of the contract and collaboration forms mentioned above from the risk management perspective.

Several studies of the risk management aspects in different forms of contract were performed in Sweden. Toolanen (2004) made a survey of choices of contractual forms in different decision environments where uncertainty was a parameter. He found that the clients choose the design-build contracts more often when the project's timeframe and availability of resources are critical factors. Håkansson *et al*. (2007) highlight that the competence requirements are higher in the design-build contracts, and structured risk analysis should be done very early in the project. Simu (2006) showed that the smaller contractors in Sweden prefer the performance-based contracts or general contracts in particular. In the case when a design-build contract is used the contractors increase the price by including the insurance for the extra risks.

123.4 DISCUSSION AND FURTHER RESEARCH

The research literature identifies several problem areas in risk management in construction. One of the problems is that project actors often focus on the short-term economical results and protect own interest rather than the project overall. Risk management in construction projects depends on the choice of contractual form and the content of the corresponding contractual documents. General contract conditions that are widely used in Sweden formalise risk allocation between the client and the contractor. However, according to the Construction Commission report (SOU 2002:115), the number of errors is not decreasing in the Swedish construction sector.

A stronger focus on how risks are managed in the different forms of contract seems necessary in order to decrease the number of errors and

construction costs for both the clients and the contractors. Considering the effects that risk management and risk allocation have on the project goals in terms of both quality and economy, these processes ought to take place in an open and conscious way, preferably starting out from the party that has the best qualifications for dealing with the risk. The risk management in the particular project could then be based on the partners shared view on what the risks are and who should carry them, whereby the contract would express a form of joint risk management. One model might be that the client prepares its view on the risk aspects of the project and the tendering contractor responds with its respective risk analysis. The total picture of the client's and the contractor's risk analyses and a shared insight will then form the basis of a conscious risk management process and risk allocation in the contract. Collaboration form partnering is of special interest here as it allows to base risk management process on trust and openness rather then on sharp contract formulation.

In our future work we will perform case studies on several construction projects with varying contract and collaboration forms. These case studies will aim at understanding the two major questions. We will study the ways and the degree of actors' involvement in the risk management process through different phases of the construction project. Secondly, it is important to understand the factors, which determine whether or not the actors consider an open discussion, risks management and risk sharing are advantageous.

123.5 CONCLUSIONS

In this paper we presented the results of the initial phase of the research project, which aims at creating improved profitability and a better final product for the construction project actors. We considered questions of risk management within the framework of the chosen contract form from the point of view of clients and contractors. From the perspective of dealing with risks in construction projects we discussed three forms of contract and collaboration that are typically used in Sweden and highlighted their strengths and weaknesses.

In particular we showed that the design-build contracts are attractive for the client due to their single point of responsibility; however, the quality of the final product might suffer due to the contractor's attempt to decrease the costs. The performance-based contracts give the client more flexibility in terms of the design but imply more risk allocated to the client. When trust relationships between project actors exist, collaboration form partnering shows good results of the project implementation.

One important observation is that the number of errors is not decreasing in the Swedish construction sector despite the wide use of general contract conditions, which formalise allocation of project risks. We concluded that the risk management in the particular project should be based on the partners shared view of potential project risks, whereby the contract would express a form of joint risk management.

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Paper 2

Osipova, E. (2007). Risk management in the different phases of a construction project – a study of actors' involvement. Proceedings of 4th Nordic Conference on Construction Economics and Organisation, Luleå, Sweden.

RISK MANAGEMENT IN THE DIFFERENT PHASES OF A CONSTRUCTION PROJECT – A STUDY OF ACTORS' INVOLVEMENT

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ABSTRACT

The results from a questionnaire survey of risk management in the different phases of a construction project are presented. The participants of the study were clients, contractors and consultants working in Sweden. We analysed the involvement of these actors in the project phases, their roles in the risk management process in particular and their influence on risk management. We show that the planning and production phases of a construction project are the most important for risk management, wherein risk identification, assessment and response take place. Moreover, collaboration in terms of risk management between the actors is most intensive in these phases. Contractors participate more actively in the risk management process in comparison with other actors and have the largest influence on project risk management. Despite the recognised importance of the early phases in the project, our study shows a very low degree of risk management activity in the programme phase.

1. INTRODUCTION

Construction projects are usually characterised by many varying risks. Being able to manage risks throughout the construction process is an important and central element preventing unwanted consequences. Risk management is also decisive for achieving a good final result with secure economy. Many different actors are involved in a construction project and often they have no or limited experience of earlier collaboration with each other. In many projects there is an attempt by actors to try to avoid risks as far as possible and let somebody else in the value chain deal with them. Considering the effects that risk management and risk sharing have on project goals in the form of both quality and economy, these processes ought to take place in an open and conscious way. In each phase of a construction project, namely programme, planning, procurement and production, the management of a specific risk should be allocated to the party that has the best corresponding qualifications.

One of the problems identified in the reports of Swedish Construction Cost Delegation and Construction Commission (SOU, 2000; SOU, 2002) is that many actors are involved only in some of the project's phases. They often focus on short-term economic results and protect their own interests rather than the project overall. This leads to a less effective risk management process. Little attention in the

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research community so far is paid to identifying the roles of individual actors in risk management through the project's different phases.

The objective of the paper is to analyse the risk management process in a construction project from the perspective of the client, the contractor and the consultant. In particular, we examine the ways and extent to which the actors are involved in risk management through the different phases of the project. The study is based on a literature review and the results of a questionnaire survey of construction project actors.

The paper is organised as follows. In section 2 we overview relevant literature. In section 3 the research methodology of the study is described. Section 4 presents the result of the questionnaire survey and analyses risk management process in the projects' different phases. Discussion and directions for future work are presented in section 5. The concluding remarks follow in section 6.

2. REVIEW OF RELATED LITERATURE

2.1. Risk and risk management in construction

There are several definitions of the project risk in the literature (e.g. IEC, 2001, PMI, 2000, Baloi and Price, 2003, Barber, 2005). A formal definition is given in the international standard IEC 62198 as a combination of the probability of an event occurring and its consequences for project objectives. Ward and Chapman (2003) discuss the concept of risk in greater detail and suggest using the more general concept of *uncertainty.* A questionnaire survey conducted by Akintoye and MacLeod (1997) shows that the majority of project actors perceive risk as a negative event. More detailed literature review on risks in construction is presented in Osipova and Apleberger (2007).

Project risk management is a formal process directed to identification, assessment and response to project risks. The process is defined differently in research literature (e.g. Flanagan and Norman, 1993; Uher and Toakley, 1999; PMI, 2000; Chapman and Ward, 2003). However, all definitions agree that the aim of project risk management is to maximise opportunities and minimise the consequences of a risk event in the construction project. The Guide to the Project Management Body of Knowledge (PMI, 2000) identifies four main steps in the risk management process: risk identification, risk assessment, development of risk response and management of risk response. Several authors develop more detailed models. Baloi and Price (2003) use the model of seven steps: risk management planning, risk identification, risk assessment, risk analysis, risk response, risk monitoring and risk communication. Chapman and Ward (2003) introduce the SHAMPU model, which consists of nine phases. Del Cano and de la Cruz (2002) present a generic project risk management process of eleven phases, which can be used in large and complex projects. For the purpose of this research we use a simplified risk management process of three main steps: risk identification, risk assessment and risk response. The reason for the simplification is that this model is well-known for the project actors and frequently used in practice.

The goal of the risk identification process is to decide on potential risks that may affect the project. There are several approaches for classifying project risks and risk sources (Leung *et al.*, 1998; Tah and Carr, 2000; Baloi and Price, 2003; Li *et al.*,

2005). The main categories are financial, economic, managerial, legal, construction, design and environmental risks. During the risk assessment the identified risks are evaluated and ranked. The goal is to prioritise risks for management. Baccarini and Archer (2001) describe a methodology for the risk ranking of projects, which allows for an effective and efficient allocation of the resources for management of project risks. The JRAP model proposed by Öztas and Ökmen (2005) is a pessimistic risk analysis methodology, which is effective in uncertain conditions in construction projects. The risk response process is directed to identifying a way of dealing with the project risks.

Several surveys conducted among the construction industry actors (Akintoye and MacLeod, 1997; Uher and Toakley, 1999; Lyons and Skitmore, 2004) show that checklists and brainstorming are the most usable techniques in risk identification; subjective judgment, intuition and experience are used mostly in risk assessment; and transfer, reduction and avoidance are the most applied methods for risk response.

2.2 The roles of the project's different phases in risk management

Traditionally, a construction process is divided into four main phases: programme, planning, procurement and production. In the programme phase the client has an idea about the project and analyses conditions for its execution. During the planning phase the architects produce construction drawings according to the client's requirements. In the procurement phase the parties sign the contract. Finally, the contractor executes the job in the production phase.

Since it is impossible to foresee all project risks in the programme phase and due to the tendency of the identified risks to change during project implementation, joint and consistent risk management is required throughout all project's phases (Rahman and Kumaraswamy, 2004). Motawa *et al.* (2006) propose a model, which helps in determining potential changes in the project based on available information in the early stages of the project. Baccarini and Archer (2001) introduce a methodology for a risk rating process in the procurement phase, which allows the effective and efficient allocation of resources for project risk management.

Several authors highlighted the importance of the early phases in project risk management since the decisions taken in these phases often have a significant impact on the final result (Kähkönen, 2001). However, according to Uher and Toakley (1999), the actual usage of risk management techniques in the early phase is very low.

Lyons and Skitmore (2004) conducted a survey where one of the aspects was the use of risk management in each of the project phases. The results showed that risk management in the planning and production phases was higher than in the programme phase. Risk identification and risk assessment were more often performed in the risk management processes than risk response.

3. RESEARCH METHODOLOGY

The study involves nine construction projects recently performed in Sweden (Table 1). In order to obtain an accurate picture, the projects included in the study satisfy the following requirements:

- the projects are located in large and small cities;
- they use different forms of contract and collaboration, i.e. performance-based contracts, design-build contracts and partnering;
- the types of the projects are building and civil engineering;
- all projects are medium-sized (between 5 and 100 MSEK).

Table 1. Characteristics of construction projects included in the study

Nr.	Location	Type of the project	Form of contract/collaboration	Contract amount (MSEK)
1	Norrbotten	Building	Design-build	41
2	Norrbotten	Building	Performance-based	18
3	Norrbotten	Civil Engineering	Design-build	53
4	Norrbotten	Road	Performance-based	20
5	Norrbotten	Road	Performance-based	5
6	Stockholm	Building	Design-build	81
7	Stockholm	Building	Design-build	48
8	Stockholm	Civil Engineering	Performance-based	95
9	Stockholm	Building	Partnering	15

As the objective of the study is to get a picture of the risk management process from different actors' perspectives, a questionnaire survey was chosen as the most appropriate research method. The survey sample comprised clients, contractors and consultants. Within each group we identified those persons who worked with risk management in a particular project. The respondents from the client's side are the representative signing the contract and project manager. From the contractor's side the respondents are the representative signing the contract, site manager and estimator. Finally, the respondent from the consultant's side is the architect or design manager.

A draft questionnaire was developed consisting of five sections. The first section contained general questions about the respondent. In the second section, the aspects of the risk management process through the different phases of the project were covered. The third section investigated relationships between the actors in the project. The fourth section focused on software management systems, which the company uses in the risk management process. The fifth section was a concluding one for miscellaneous comments regarding the risk management process in the project.

We organised two workshops where we met about 50% of prospective respondents and presented the research project and the objectives of the survey. The workshop participants were given an opportunity to answer the draft questionnaire and give their comments on the content. Following the workshop, the final version of the questionnaire was developed and sent in the electronic form to the respondents. After the questionnaires were completed, the answers were analysed using the statistical processing software, SPSS, and Microsoft Excel.

4. RESULTS OF THE SURVEY

In total, 54 questionnaires were sent and 43 responses were received, resulting in a response rate of 80%. From the received responses, 36 were completed questionnaires and seven respondents explained the reasons for non participation. A response rate of 100% was for those people who attended the workshop. This shows that the respondents who were aware of the survey objectives were more interested in taking part in the project. The sample composition aggregated according to actors' roles in the project is shown in Figure 1.

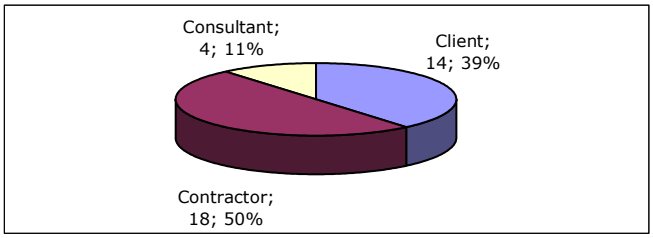

Figure 1. Sample composition

4.1 Respondents

Analysis of gender distribution confirms that the Swedish construction industry is traditionally male-dominated sector. 34 survey participants are men and two participants are women. The age distribution shows that 89% are over 41 years old. Most of the respondents (92%) have more than ten years experience in construction industry, and 64% have more than 20 years of experience. 44% of survey respondents have a university degree in construction, 53% finished upper secondary school, and only one person has vocational training only. 33% respondents participated in risk management or project management courses within their organisations or during the period of university studies.

Despite a relatively high education level and large experience, the majority of the respondents (75%) estimate their knowledge of risk management as fair. Table 2 summarises the risk management knowledge within each group of actors.

Table 2. Knowledge of risk management

	Role in the project			
	Client	**Contractor**	**Consultant**	Total
Low	1	0	1	2
Fair	10	14	3	27
Advanced	2	3	0	5

4.2 Risk management in the different phases of the project

Figure 2 shows that the majority of the respondents (32) participated in the production phase. For the contractors it is quite natural because they are always involved in the production phase and very seldom in the programme phase. Therefore contractors' participation increases as the project goes forward: one contractor participated in the programme phase and 16 in the production phase. It was quite unexpected that only seven clients participated in the programme phase compared to 14 clients in the production phase. This may be partially explained by the types of the projects. Often there is no programme phase in civil engineering projects. Therefore, most of the respondents from this group answered that they did not participate in that phase. All four consultants participated in the planning phase and two of them followed into the production phase.

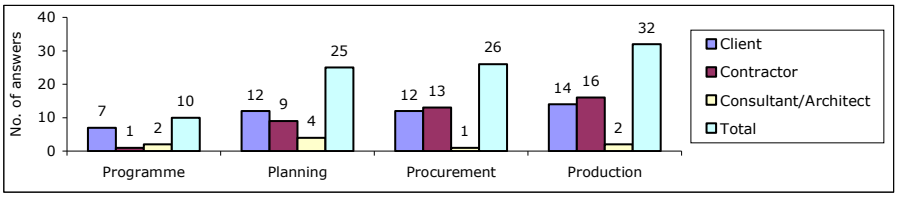

Figure 2. Participation in the project phases

When the respondents were asked to estimate[2] the importance of risk management in every phase of the construction project (Figure 3), the estimates were similar in both the client and contractor groups. The production and planning phases were identified as the most important for the management of risks. Then the procurement and programme phases follow. Consultants' estimates differ from those of clients and contractors. Overall, we observe that they underestimate the importance of all phases compared with the other actors. However, the planning and production phases are identified by consultants as the most important. From this distribution we can conclude that many actors link risks to the production phase.

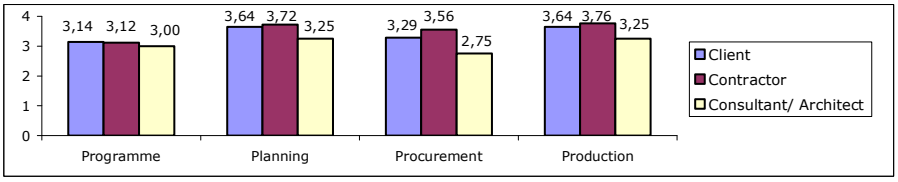

Figure 3. Importance of risk management in the different phases

Figure 4 illustrates how many actors carried out risk management processes systematically in their projects. The most active group is contractors, where all respondents identified and assessed project risks and 94% performed risk response systematically. In the client group 86% identified risks, 71% assessed them and only 57% systematically responded to project risks. The explanation of low risk response rate may be that the clients let other actors in the value chain deal with identified risks. Consultants are the most passive actors when it comes to project risk

[2] Scale is between 1 and 4, where 1 is unimportant, 2 – not so important, 3 – fairly important, 4 – very important

management. Among consultants only 33% identified risks and responded systematically, and none assessed project risks.

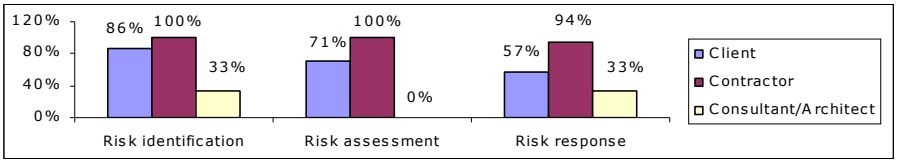

Figure 4. The risk management processes systematically performed in the project

4.2.1 Risk identification process

Risk identification (Figure 5) was mostly performed in the planning and production phases. The earlier risks are identified, the less is the probability that they occur. Despite this only seven respondents answered that risk identification was performed in the programme phase. Most of the clients indicate that risk identification was carried out in the planning phase, whereas contractors mostly identify risks in the production phase.

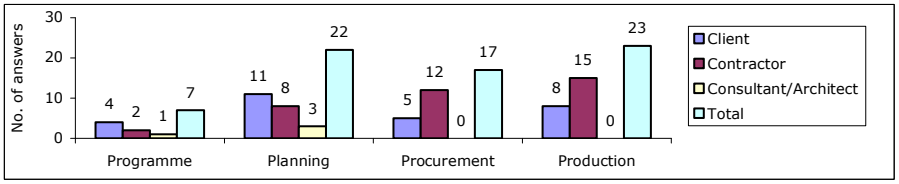

Figure 5. Risk identification in the different phases

In the programme phase 75% of the respondents answered that risks were identified by the client. In the planning phase 39% responded that risks identification was performed jointly by all actors and 25% responded it was performed by the client and the consultant. In the procurement phase the contractor plays the most important role in risk identification (52%). In the production phase risks were identified by the contractor (39%) or jointly by all actors (39%).

4.2.2 Risk assessment process

Figure 6 shows that risk assessment has a similar tendency as the risk identification process: the majority of the respondents perform it in the production phase. However, the procurement phase is more important for the risk assessment process than for risk identification and risk response. This is because the risk premium is calculated in the procurement phase and therefore it is important to assess earlier identified risks.

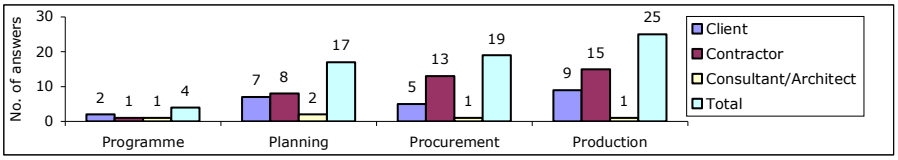

Figure 6. Risk assessment in the different phases

Similarly to the risk identification process, the risk assessment in the programme phase is performed mostly by the client, in the planning phase jointly by all actors or by the client and consultant. However, the contractor's involvement in the risk assessment in the planning phase was higher than in the risk identification. The procurement and production phases do not differ much from the risk identification process: in both phases the contractor plays the most important role.

4.2.3 Risk response process

Risk response (Figure 7) is also associated with the production phase. Both the clients and the contractors mostly manage risks in this phase. This is due to the traditional approach in the construction industry: contractors do not put enough effort into preventing problems and solve them as they appear in the project.

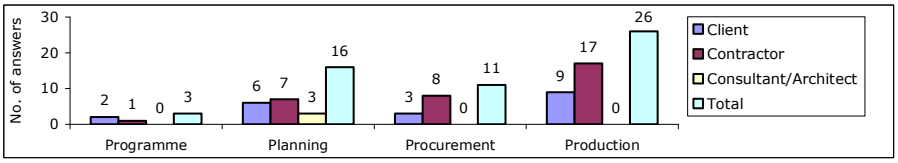

Figure 7. Risk response in the different phases

In the programme phase, similarly to the risk identification and assessment processes, risk response is performed by the client. In the planning phase the client together with the consultant responded to the project risks. In the procurement phase risk response is performed mainly by the contractor. In the production phase the role of the contractor is large and the degree of joint risk management is high.

4.3 Collaboration in managing risk and actors' influence on the risk management process

In the questionnaire we define the term *collaboration* as joint work in risk management process. Almost all respondents had collaboration in risk management with other actors in the project: 11 clients, 13 contractors and three consultants. Seven respondents (three clients, three contractors and one consultant) answered that no collaboration in risk management existed in the project. Evaluations[3] of collaboration (Table 3) vary from "fairly good" to "very good".

[3] Scale is between 1 and 4, where 1 – very bad, 2 – fairly bad, 3 – fairly good, 4 – very good.

Table 3. Evaluation of collaboration in risk management

Role in project	Evaluation
Client	3.55
Contractor	3.38
Consultant/ Architect	3.33

The degrees[4] of communication of known risks and opportunities between actors in the procurement phase are presented in Table 4. Overall evaluations are not high and vary between "little detailed" and "fairly detailed". The contractors answered that the client communicated known risks moderately (2.06). On the contrary, the clients state that their communication of known risks is higher (2.73).

Table 4. Degree of communication of known risks and opportunities between actors in the procurement phase

	Clients' communication	Contractors' communication
Client	2.73	2.69
Contractor	2.06	2.39
Consultant/ Architect	3.00	3.00
Total	2.36	2.53

Figure 8 presents the respondents' judgement[5] of their own and other actors influence on risk management in the project. The results show that the contractor has the largest influence on risk management from the perspective of all actors. It is interesting that even the clients estimate the contractors' influence to be larger than their own. This can be linked to the Figure 3, where the actors connect risk management to the production phase. The influence of the consultant is surprisingly low despite the fact that the planning phase is considered to be very important by all actors.

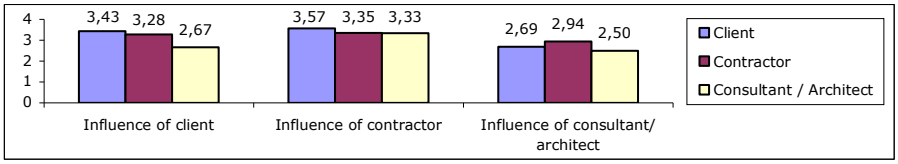

Figure 8. Influence of the actors on the risk management process in the project

The existence of collaboration in risk identification, risk assessment and risk response is shown in Figure 9. Risk identification (RI) is the process where collaboration existed according to most of the actors: 82% of clients, 92% of contractors and 67% of consultants answered that they collaborated identifying the project's risks. During the risk assessment process (RA) both the clients and the contractors collaborated with each other, while only 33% of consultants answered that collaboration existed. The risk response process (RR) has a lower degree of collaboration according to the contractors: 62% of them had collaborated in taking care of risks.

[4] Scale is between 1 and 4, where 1 – not at all, 2 – little detailed, 3 – fairly detailed, 4 – very detailed.
[5] Scale is between 1 and 4, where 1 – very small, 2 – fairly small, 3 – fairly large, 4 – very large.

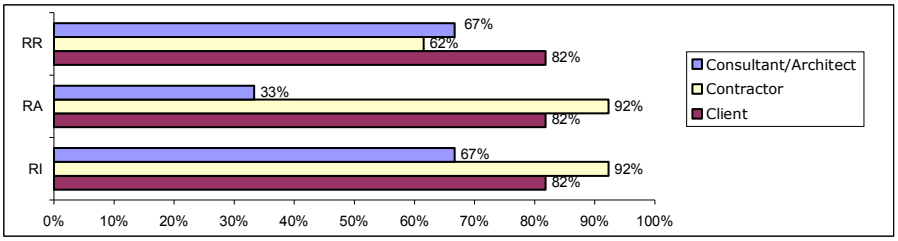

Figure 9. Existence of collaboration in risk management processes

The existence of collaboration in the projects' different phases is presented in Figure 10. It shows that in the programme phase there was minimum collaboration in risk management. Only 14% of clients, the most active participants of the programme phase, answered that collaboration existed in the phase. In the planning phase 70% of clients, 75% of contractors and 100% of consultants collaborated in risk management. This result can be linked to the importance of risk management in that phase, which was ranked high by the actors. In the procurement phase the collaboration between the clients and the contractors in risk management existed in half of the projects. In the production phase the collaboration between the actors is the most intensive because many risks appear in this phase and should be eliminated to achieve a good final result.

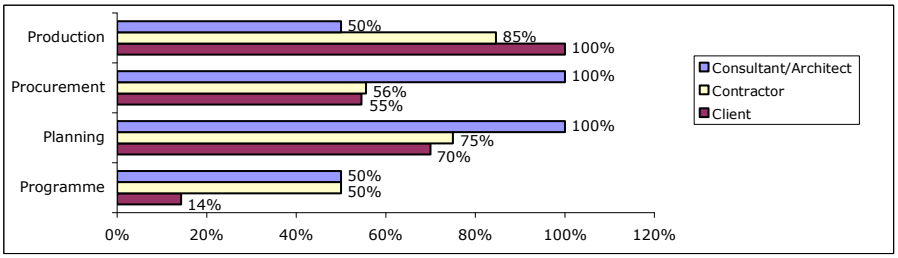

Figure 10. Existence of collaboration in risk management in the project's phases

5. DISCUSSION AND FUTURE WORK

In the previous section we presented the results of the questionnaire survey. In particular we focused on the following issues: the actors' participation in the project phases, importance of risk management in different phases, risk identification, analysis and response through the phases, collaboration in managing risks and influence of the actors on the risk management process. This section aims at discussing the results and developing directions for future research.

We found that participation in the different phases of a project was governed by the actors' roles in the construction process. In particular all contractors participated in the production phase and all consultants participated in the planning phase. Production was the phase where the majority of respondents participated, while the participation in the programme phase was very low. Neither contractors nor clients were sufficiently involved in the programme phase. The planning and production phases were identified by all actors as the most important for risk management. In

these phases risk identification, risk assessment and risk response were mostly performed. An important question to investigate further is: what the actors can gain by participating in all phases of the project? We foresee that participation of the actor in all phases of the construction process leads to more effective risk management through more intensive information and knowledge exchange and earlier identification and assessment of potential project risks.

The results of the survey show that the roles of the actors in risk management processes are strongly connected to their participation in the project's phases. Thus risk identification, risk assessment and risk response were mostly performed: in the programme phase by the client; in the planning phase jointly by the client and the consultant; in the procurement and production phases mostly by the contractor. The planning and production phases are those where joint risk management was mainly used by the actors. We suggest that the procurement phase should play a more important role in joint risk management. The risk management in the project should be based on the actors shared view of what the risks are and who should carry them. One model might be that the client prepares its view on the risk aspects of the project and the tendering contractor responds with its respective risk analysis. The total picture of the client's and the contractor's risk analyses and a shared insight will then form the basis of a conscious risk management process and risk allocation in the contract. There is a clear indication that collaboration through all phases of the project increases the probability that a specific risk is managed by the actor who has the best corresponding qualification.

Collaboration in risk management was evaluated high by all actors and was most intensive in the production phase. On the contrary, evaluations of actors' communication of known risks in the procurement phase are low. In particular the contractors state that the client communicates the risks on a low level. Collaboration between actors was very strong in the risk identification and risk assessment processes. In the risk response process the degree of collaboration decreases significantly according to the contractors' opinion. This indicates that the project's actors protect own interests and try to transfer the identified risks to other actors.

According to our studies contractors were most active in performing risk identification, assessment and response systematically in the project. Moreover, they had the largest influence on risk management in the project from the perspective of all actors. Consultants had very low influence on project risk management. They were not familiar with risk identification, risk assessment and risk response. However, it is difficult to generalise the results because the consultant group is very small in the sample. We suggest that the consultants should be involved more in risk management because design is a very significant risk source in a construction project.

In our future work we will perform a series of interviews with the construction project actors. The goal of the interviews is to investigate deeper the possible changes in a traditional construction process, where risk management is performed in late phases. Finally, it is important to understand the factors, which determine whether or not the actors consider an open discussion on risk management and risk sharing as beneficial.

6. CONCLUSIONS

Considering the effects that risk management has on a project's goals in the form of quality and cost, it should be an open and conscious process through all phases of the project. The aim of the paper was to examine the ways and extent to which the actors are involved in risk management through the different phases of the project. For this purpose we conducted a questionnaire survey of clients, contractors and consultants. The overall conclusion is that, according to project actors, risk management is strongly linked to the production phase. Most of risk processes are performed in that phase and contractors tend to be the most active group with a large influence on the risk management process. These findings confirm some results of previously conducted surveys. Despite of the recognised importance of the programme phase, this study showed that this phase does not play an important role in the risk management process.

7. ACKNOWLEDGEMENT

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The impact of procurement options on risk management in Swedish construction projects

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Abstract. *In order to be able to carry out a construction project with the expected final result, professional risk management as well as conscious risk sharing between the actors in the project are required. A question of a particular interest for the actors in the Swedish construction industry is the way in which project risk management needs to be further developed, based more on openness, trust and collaboration rather than on sharp contract formulations. The objective of the study is to investigate the impact of the chosen procurement option on risk management in construction projects. We analyse three major options currently used in Sweden: design-bid-build contracts, design-build contracts and collaboration through partnering. A questionnaire survey and a series of interviews with clients, contractors and consultants involved in nine construction projects were conducted. The major finding of the study is that there is a clear connection between the procurement option and risk management in the construction projects. The forms that support early involvement of the actors in the whole project life cycle and create opportunities for open dialogue and collaboration result in a more effective risk management process.*

1 INTRODUCTION

In recent years, the Swedish construction industry has been criticized for increasing costs, low productivity, quality problems and project delays (SOU 2002). As construction projects are characterized by many and varying uncertainties, an ability to manage risks throughout the construction process is an important and central element preventing unwanted consequences. Risk management is also decisive for achieving a good final result within budget. How risks are allocated in a construction project is to a large extent governed by the choice of procurement option and the content of the related contract documents. Different forms of contract imply different ranges of responsibilities in the project. Thus, selecting an appropriate procurement option is a key issue for the project manager. Two procurement options that are mostly used in Sweden are design-bid-build contracts and design-build contracts. However, it has been argued that traditional contractual arrangements do not support effective collaboration in construction projects (Kadefors 2004). Positive experiences of collaborative form of partnering in the USA, UK, Norway and Denmark have resulted in the partnering concept being adopted in Sweden.

The aim of the study is to investigate the impact of the chosen procurement option on risk management in construction projects. This report focuses on two forms of contract, design-bid-build and design-build, and on the collaborative form of partnering. The research results are based on a questionnaire survey and a series of interviews with construction project actors involved in nine construction projects recently performed in Sweden.

The report is organised as follows. In Section 2, a state-of-the-art review is presented. The research method is described in Section 3. Section 4 presents the results of the questionnaire survey and the interviews and analyses risk management in the construction projects. The results are discussed in Section 5. The concluding remarks follow in Section 6.

2 State-of-the art review

2.1 Risk and risk management

Project risks are uncertain events or conditions that may have an impact on project objectives (Baloi and Price 2003, Barber 2005, IEC 2001, PMI 2000, SOU 2002, Ward and Chapman 2003). A risk has a cause and, if it is triggered, also a consequence. Risk management is a formal process directed at identification and assessment of and response to project risks (Baloi and Price 2003, Del Cano and De la Cruz 2002, Flanagan and Norman 1993, PMI 2000, Uher and Toakley 1999, Ward and Chapman 2003). The overall goal of the risk management process is to maximise the opportunities and minimise the consequences of a risk event. Risk identification is aimed at determining potential risks, i.e. those that may affect the project. There are several approaches to classifying project risks and risk sources (Baloi and Price 2003, Leung et al. 1998, Li et al. 2005, Tah and Carr 2000). In general, the sources of risk in construction projects may be divided into external risks (e.g. financial, economic, political, legal and environmental), internal risks (e.g. design, construction, management and relationships) and force majeure risks. During risk assessment, identified risks are evaluated and ranked. The goal is to prioritise risks for management. Baccarini and Archer (2001) describe a methodology for the risk ranking of projects, which allows for an effective and efficient allocation of the resources for the management of project risks. The JRAP model proposed by Öztas and Ökmen (2005) is a pessimistic risk analysis methodology, which is effective in uncertain conditions within construction projects. The risk response process is directed at identifying a way of dealing with project risks and consists of three main techniques: risk reduction, risk transfer and risk retention (Smith et al. 2006). Baker et al.(1999) found that risk reduction is the most frequently used technique within the construction industry in the UK.

2.2 Risk allocation in construction contracts

An appropriate allocation of risks between actors in a construction project is important because it is impossible to eliminate all potential risks. Risk allocation influences the behaviour of project actors and, therefore, has a significant impact on the project performance in terms of the total cost. One of the main problems identified in the literature is the actors' different perceptions of to whom a specific risk or group of risks should be allocated. Usually, contractors indicate that they have to bear the majority of project risks (Andi 2006). This leads to an increasing number of disputes between the parties during project execution. A study by Zaghloul and Hartman (2003) shows a significant relation between risk allocation and trust. Trustful relationships between project actors result in a more effective risk allocation process, decrease of contingency funds and, finally, in project cost reduction. A number of models providing a framework for risk allocation decisions can be found in the literature (e.g. Lam et al.(2007)).

Construction contracts deal with project risks through their allocation to the parties involved. The contract is a written agreement between a client and a contractor where the liabilities and responsibilities of each party are assigned. Many countries have legislation that regulates contractual relationships. In Sweden, the majority of contracts are based on standardized conditions of contract. These documents are developed and issued by the Building Contracts Committee (BKK), a non-profit association consisting of authorities and organizations in the sector. The design-bid-build contracts are based on "General Conditions of Contract for Building, Civil Engineering and Installation Work" (AB). The design-build contracts are regulated by "General Conditions of Contract for Building, Civil Engineering and Installation Work performed on a package deal basis" (ABT). AB and ABT assign responsibilities and liabilities to each contracting party regarding job performance, organisation, timeframes, guarantees, insurance, errors and payment.

2.2.1 Design-bid-build contracts

Design-bid-build contracts are contracts where the client is responsible for the planning, design and function of a construction and the contractor is responsible for the job execution. Within this contract form, two main organisational alternatives are possible: divided contracts and general contracts. A divided contract implies that the client appoints several contractors and signs a separate contract with each contractor. This form allows the client to choose the best possible tender for every part of the work. On the other hand, the coordination costs are very high and it might be difficult to identify exactly which contractor is responsible for a particular error. A general contract implies that a client signs only one contract with a general contractor, who in turn appoints subcontractors to carry out the work. The general contractor is solely responsible for the coordination of subcontractors. This type of organisation is used more often in Sweden than divided contracts. Simu (2006) showed that smaller contractors in Sweden prefer performance-based contracts or general contracts in particular. In the case where a design-build contract is used, contractors increase their price to include insurance for the extra risks involved.

2.2.2 Design-build contracts

In design-build contracts the contractor is responsible for both design and construction. The client signs only one contract, thus this form is the most straightforward from the perspective of responsibility. In the procurement documentation, the clients set their demands in terms of functionality. Öztas and Ökmen (2004) state that the popularity of design-build contracts has increased in recent years, because a single point of responsibility is attractive to clients. A study by Ernzen and Schexnayder (2000) shows that the average profit margin for a design-build project is higher than that for non-design-build. From the risk management perspective, design-build contracts are more attractive for the client as the responsibility for design implies that more risk is allocated to the contractor. On the other hand, the design-build alternative may be more expensive compared with design-bid-build contracts. Furthermore, the quality of the final product may be lower if the contractor uses cheaper solutions, trying to decrease his own costs. This problem is especially relevant in contracts with a lump sum payment mechanism. In terms of time, the design-build system arguably provides an earlier start of the project execution than is the case for other forms. Toolanen (2004) found that clients choose design-build contracts more often when the project's timeframe and availability of resources are critical factors. From the contractor's point of view, design-build construction projects could be very risky when the contractor lacks knowledge and experience of the design-build system. Håkansson et al. (2007) highlight that the competence requirements are higher in design-build contracts, and hence structured risk analysis should be made very early in the project.

2.2.3 Collaborative form of partnering

Over the last decade, the collaborative form known as partnering has become popular in the construction industry. The concept of partnering is variously defined in the research literature (Drexler and Larson 2000, Kadefors 2002, Rahman and Kumaraswamy 2004, Rhodin 2002). To summarise, partnering is a way to create effective collaboration between the project's actors. Components such as common goals, continual improvement and structures for problem solving form the concept of partnering. Effective collaboration is claimed to lead to fewer disputes, lower construction costs and a better quality product. Positive experiences of partnering in the USA, UK, Norway and Denmark have led to the partnering concept being adopted in Sweden. However, in contrast to the UK, partnering does not have the status of a contractual form in Sweden. Partnering is an acceptable alternative for project implementation when a trust relationship between the actors exists. It allows for a more efficient risk management process based on common goals. Both parties

get a final product of good quality in a shorter time and with fewer disputes. Furthermore, partnering helps to transfer knowledge and experience between the project actors. It is important to note that the partnering concept demands high professionalism and very good knowledge of the project on the part of the client *and* the contractor.

3 Research method

The study involves nine construction projects recently undertaken in Sweden (Appendix 1). In order to obtain an accurate picture, the projects included in the study satisfy the following requirements:

- the projects are located in large and small cities;
- they use different forms of contract and collaboration, i.e. design-bid-build contracts, design-build contracts and partnering;
- the types of the projects are building and civil engineering;
- all projects are medium-sized (between 5 and 100 MSEK).

To find out how risks were managed in the project, a questionnaire survey was conducted. The survey sample comprised clients, contractors and consultants. Within each group those who were working with risk management in a particular project were identified. The respondents from the client's side were a representative signing the contract and a project manager. From the contractor's side, they were a representative signing the contract, a site manager and an estimator. The respondent from the consultant's side was an architect or a design manager. A draft questionnaire was developed, consisting of five sections. The first section contained general questions about the respondent. In the second section, aspects of the risk management process through the different phases of the project were covered. The third section investigated relationships between the actors in the project. The fourth section focused on the computer software systems that the companies used in its risk management process. The fifth, concluding section was for miscellaneous comments regarding the risk management process in the project. Before sending the questionnaire, a workshop was arranged where about 50% of the potential respondents participated. During the meeting the aim of the study and the structure of the questionnaire were presented. The workshop participants were given an opportunity to complete the draft questionnaire and offer comments on the content. Following the workshop, the final version of the questionnaire was developed and sent in electronic form to the intended respondents in nine construction projects. In total, 36 completed questionnaires were received and analysed.

Based on the compiled results of the questionnaire survey, 20 interviews across nine projects were conducted. The objective of the interviews was to make a deeper analysis of the risk management process in the projects. Since it was impossible to interview all survey respondents within the time constraints, the number of interviewees was limited to the two or three persons responsible for risk management in the project. From the client side, it was a project manager, from the contractor side a site manager and from the consultant side an architect or design manager. Each interview took approximately one and a half hours and consisted of three main parts. First, the main definitions in the research area were discussed. Since the study deals with the terms risk, risk management, risk identification, risk assessment, risk response etc., it is important to understand the perception of these terms by the respondents. Next, the results of the questionnaire survey were presented and discussed. In particular, the interviewees were asked to comment on the majority of survey questions, try to find motivation for the answers and find solutions to the improvements. Finally, some time was given for concluding remarks.

4 Results

In order to analyse how risk management worked in the projects, the following important aspects were considered:

- Project implementation in terms of function, cost and time.
- Involvement of the actors in four main project phases: programme, design, procurement and production.
- Systematic performance of risk identification, risk assessment and risk response.
- Influence of the actors on the risk management process.
- Importance of risk management in the different phases of the project.
- Occurrence of identified and unforeseen risks and their effect on the project cost/budget.
- Collaboration between the actors in risk management.
- Degree of communication of known risks by the actors in the procurement phase.

4.1 Design-bid-build projects

Four projects in this group are procured on the basis of "General Conditions of Contract for Building, Civil Engineering and Installation Work" and a lump sum payment mechanism.

4.1.1 Project 1

Project 1 comprised the rebuilding, refurbishment and additional construction of university premises, located in the northern part of Sweden. The contract sum was 18 MSEK and the final cost of the project was 20 MSEK. The technical characteristics and functionality of the final product were evaluated as high by all actors. However, the project implementation in terms of cost was unsatisfactory from the contractor's perspective. The contractor's costs increased significantly due to the poor quality of design documents. Time constraints for project execution were kept and the project was finished earlier than planned. The client was involved in all four phases of the project: programme, design, procurement and production. The architect participated in the programme and design phase, but was not involved in the production phase. From the perspective of dealing with risks, non-participation of the architect in the production phase created problems and conflicts because there was a need for design changes during the project execution. The contractor joined the project in the procurement phase, which is the traditional approach for design-bid-build contracts. The actors noted that the risk identification and risk response processes were carried out systematically in the project. Risk assessment, however, was not performed by the client. The contractor assessed risks systematically in the production phase using quality management software. During the design phase, the client cooperated with the consultant in the risk identification process. However, the identified risks occurred in the project and their financial impact was fairly large. Unforeseen risks occurred as well, but had a smaller effect on the project's financial position. The client had the largest influence on the risk management process according to all actors. The influence of the contractor and, especially, the architect was significantly lower. A serious problem identified by the actors is that no collaboration in the risk management process existed between the client and the contractor. Moreover, both the client and the contractor communicated known risks, as if they were of a low priority, during the procurement phase. This created conflicts during the implementation of the project.

4.1.2 Project 2

Project 2 comprised construction of a new road in the north of Sweden. The contract sum was 19.7 MSEK and the final cost of the project was 24.5 MSEK. The contractor explained the cost increase

by mistakes in design, which resulted in a re-design during the project implementation. The quality of the final product was evaluated as fairly good and no delays occurred. The client was involved in the design, procurement and production phases. Non-participation in the programme phase can be generally explained by the absence of this phase in some civil engineering projects, road projects in particular. The design manager participated in the design and production phases. The contractor joined the project in the procurement phase. Risk identification, assessment and response were not carried out systematically by the client. On the contrary, the contractor stated that risk management was performed systematically in the project. As mentioned above, unforeseen design risks occurred in the project and had a fairly large financial impact. The contractor had the largest influence on the risk management process according to all actors. The influence of the client and, especially, the consultant was significantly lower. The client felt that no collaboration in the risk management process existed between the project actors. However, the contractor and the consultant evaluated the collaboration as good. Communication of the known risks in the procurement phase did not work well, both the client and the contractor communicated known risks on a low level.

4.1.3 Project 3

Project 3 comprised construction of a new road in the north of Sweden. The contract sum was 4.9 MSEK and the final cost of the project was 4.7 MSEK. The project execution was fairly good in terms of function and cost and fairly bad in terms of time. The client was involved in the design, procurement and production and the contractor participated in the procurement and production phases. Risk identification, assessment and response were carried out systematically by the contractor in the procurement and production phase. The client said that no risk management was performed in the design phase and explained that this was due to the simplicity of the project. However, the contractor noted that an insufficient geotechnical survey in the beginning of the project led to identified risks occurring in the project, but their effect on the project cost was fairly small. No unforeseen risks occurred during the project implementation. The client argued that all actors had the same degrees of influence on risk management. In contrast, the contractor mentioned that the client had a lower degree of influence and that the consultant had fairly small influence. Both the client and the contractor evaluated the collaboration in risk management as very good. Like other projects, communication of the known risks in the procurement phase was not on a very detailed level.

4.1.4 Project 4

Project 4 comprised the reconstruction of infrastructure facilities in Stockholm. The contract amount was 95 MSEK. The quality of the final product was fairly good. In terms of cost, the project implementation was very good for the contractor and very bad for the client. Incompleteness and inaccuracy in design documents led to many changes during the project execution, which were paid by the client as he was responsible for the design. Unforeseen risks occurred in the project and caused significant delays and high costs for the client. Identified risks occurred as well and had a fairly large impact on the project cost. The client was involved in the design, procurement and production phases. Risk management activities were performed from the very beginning. The client carried out risk identification and risk response, but consciously skipped risk assessment. The contractor joined the project in the procurement phase, and systematically performed risk identification, assessment and response in the production phase. The client mentioned that he had the largest influence on the risk management process. The contractor, in turn, said that his influence was the largest. Both the client and the contractor were agreed that the influence of the project manager was significantly lower. A serious problem identified by the client is that no collaboration existed between the client and the project manager. Moreover, conflicts between them resulted in a dispute. As mentioned above, incomplete design documents led to significant problems in the

project. The collaboration between the client and the contractor was evaluated as very good. The extent to which known risks were communicated in the procurement phase was fairly great from the perspective of the client, and fairly limited from the perspective of the contractor.

4.1.5 The impact of design-bid-build contracts on risk management

During a discussion about a possible connection between the chosen form of contract and collaboration and risk management in the project, the actors expressed the following thoughts. The contractor argued that traditional procurement forms like design-bid-build do not create an opportunity for open dialogue and collaboration in risk management between the client and the contractor. In these forms each actor is focused on his own part of the project and tries to manage the associated risks. *"Conflicts come up very often, especially about technical solutions and associated costs"* (Client). The general conditions of contract (AB) are well-developed documents, which assign responsibilities and liabilities to each party. However, the client often deviates from AB by trying to transfer more risk to the contractor. The client agreed that in the design-bid-build contract, joint risk management is impossible because the contractor follows the client's instruction and executes the project according to the client's requirements: *"There is no room for discussions in the design-bid-build projects"* (Client). On the contrary, the architect was positive about the risk management process in the design-bid-build projects. He argued that the architect has more flexibility and cooperation with the client in such projects than in design-build ones. In the latter, the contractor is a 'filter' between the client and the architect. He is focused on short-term financial results rather than on the life cycle cost and, therefore, may use cheaper technical solutions, which are not always optimal. However, design-bid-build contracts assign more responsibility to the architect, while in a design-build project the architect shares risks with the contractor. On the other hand, collaboration with the contractor is worse in design-bid-build projects, because the consultant usually does not participate in the production phase.

4.2 Design-build projects

The four projects in this group are design-build projects based on "General Conditions of Contract for Building, Civil Engineering and Installation Work performed on a package deal basis".

4.2.1 Project 5

Project 5 comprised the construction of a new house for meetings at the university campus in the northern part of Sweden. The contract sum was 41.1 MSEK and the final cost was 43.5 MSEK. The project implementation was very good in terms of time and fairly good in terms of quality. In terms of budget, the project was very good for the client and fairly bad for the contractor. Identified risks occurred in the project, but their effect on the project cost was fairly small. The unforeseen risks during the project execution led to a fairly large increase in project cost. The client participated in all four phases: programme, design, procurement and production. However, risk management was not performed systematically in the project. The client carried out risk identification and response, but not risk assessment. The collaboration between the project actors was evaluated as very good by the client, and the collaboration in risk management was fairly good. The contractor joined the project in the design phase and carried out risk identification and assessment in this phase and risk response in the production phase. In spite of the fact that the client evaluated general collaboration in the project as very good, the contractor assessed collaboration as fairly bad. The contractor argued that the client's decisions took a very long time, which led to delays in design. However, the collaboration in risk management was evaluated as fairly good by the contractor. Both parties communicated known risks in the procurement phase on a detailed level.

4.2.2 Project 6

Project 6 comprised the construction of infrastructure in the north of Sweden. The contract sum was 53 MSEK and remained unchanged during the project. The project execution in terms of function, time and cost was fairly good. Both identified and unforeseen risks occurred in the project but had a fairly small effect on the project cost. The client participated in all project phases and the contractor joined the project in the design phase. The client did not perform risk management systematically in the project but the contractor carried out risk identification, assessment and response in the design, procurement and production phases. The contractor had the largest influence on risk management according to all actors. Very good collaboration between the parties resulted in a dialogue about the technical solutions and a good final result. The actors had a joint database, where each actor could find the documents about the project.

4.2.3 Project 7

Project 7 comprised reconstruction of a residential building in Stockholm. The contract sum was 47 MSEK and remained unchanged during the project. The project implementation in terms of function, cost and time was very good for both the client and the contractor. Risk identification, assessment and response were carried out systematically in the project. Moreover, these processes were performed in the form of joint risk management in all project phases; neither identified nor unforeseen risks occurred during the project implementation. All actors evaluated the collaboration in risk management as very good. As the contractor was responsible for the project design, he had the largest influence on risk management in the project. The client's influence on risk management was therefore lower. The design and production phases were identified as the most important in risk management. Both the client and the contractor communicated known risk in the procurement phase on a very detailed level. This resulted in a low contingency fund in the contract (2.5%).

4.2.4 Project 8

Project 8 comprised the construction of a residential building in Stockholm. The contract sum was 81 MSEK and the final sum was 84 MSEK. The quality of the final product was evaluated as very good, and the time constraints were kept at a fairly good level. In terms of cost, the client evaluated the project execution as very good while the contractor's evaluation was fairly bad. Both identified and unforeseen risks occurred in the project, but had a fairly small effect on the project cost. Both the client and the contractor were involved in all four phases. The client performed risk identification in the design phase and risk assessment in the procurement phase. Risk response was not performed by the client. The contractor mentioned that risk management was performed systematically in the project. However, it was difficult to assess risks in the programme phase since the project was very abstract. The contractor had the largest influence on risk management, while the client's influence was fairly large. The overall collaboration between the project actors and in particular the collaboration in risk management were evaluated as high by both the client and the contractor. The collaboration was the most intensive in risk identification and assessment during the programme and design phases. In the risk response process during the production phase no collaboration existed.

4.2.5 The impact of design-build contracts on risk management

From the perspective of dealing with risks, early involvement of the contractor in design-build projects is considered to be the main advantage of this form. Moreover, contractors' risk management is more thorough in the DB contract due to assigned responsibilities for design. The actors stated that the design-build contract might lead to deviations in the quality of the final

product because of the client's inability to control the technical solutions chosen by the contractor. To avoid this situation, continual discussion of technical solutions between the actors is required. Therefore, personal commitment of the clients is argued to be the most important factor for securing a final result. *"The client is always responsible for commitment of other actors. I do not believe in 'good' contractors and consultants, they adapt to the clients' requirements"* (Client). When the client is an active party, the DB form is claimed to create conditions conducive to better collaboration because the clients and contractors are forced to have a dialogue. Cooperative work of the architects and contractors is argued to result in better technical solutions and help in avoiding many design and technical risks. Many actors are positive about more fruitful risk management in DB contracts. Cooperation and trust were identified as the most important factors for successful risk management.

4.3 Partnering

Project 9 comprised the reconstruction of a residential building, located in Stockholm. The project was implemented in the form of partnering with a cost reimbursable payment mechanism. The contract was based on "General Conditions of Contract for Building, Civil Engineering and Installation Work" (AB). The project implementation in terms of function, cost and time was good. Jointly the client and the contractor succeeded in decreasing project costs. As there were important time constraints, the project execution had to start when the design was incomplete. This resulted in low degree of communication of known risks in the procurement phase and in re-design of some parts of the project. All actors participated in the early phases of the project and were involved in risk management. Even though the contractor was not responsible for the design, he participated in the design phase. This phase played, according to the actors, the most important role in risk management. Risk identification, assessment and response were performed systematically in the project. At the beginning of the project the client organised workshops, where all actors identified risks and decided who was better qualified to deal with them. In contrast to other projects, in project 9 the client, the contractor and the architect had equal influence on risk management. Despite the fact that identified risks occurred in the project and their financial effect was large, the actors succeeded in cooperating to find the best solution to the problem. They were all agreed that this was possible due to the partnering form: they evaluated their collaboration in risk management as good.

The client in project 9 argued that not only did the contractual form influence risk management, but that a payment mechanism and working procedures within the organisations also played a role. Factors that characterise partnering projects, such as open dialogue, trust and cooperation help to manage risks effectively: *"I don't believe the client can gain something by concealing known risks, because in reality that would result in loss for all partners"* (Client). The contractor said that there is no difference in risk management routines across the different forms of contract; however, the involvement of the actors in the process is different. An advantage of partnering is that risk management processes are carried out from the earliest stages of the project: *"Partnering means that we organise a small enterprise Project C and work together to get a good final product; we share both risks and opportunities and have close collaboration"* (Contractor). Partnering projects allocate more responsibility to the contractor than design-bid-build projects, where the contractor works from construction drawings. According to the architect, the way in which risk management is organised in the project depends to a large extent on the client. He argues that the client has a responsibility for engaging the actors in joint risk management. Different forms of contracts and collaboration give different opportunities for open dialogue and can, therefore, influence project risk management. The organisational structure of partnering projects creates more opportunities for good collaboration. The payment mechanisms also affect the risk management process: *"It is very difficult to raise the problem if the actor knows he/she would pay for that"* (Architect).

4.4 Summary of the results

In the previous sections, we presented the risk management process for nine construction projects adopting different procurement options. In particular, we analysed design-bid-build and design-build contractual forms and the collaborative form of partnering. In Table 2 the factors that influenced risk management in the projects are identified and summarised.

1. Involvement of the actors in the project phases and their responsibilities			
	Design-bid-build	Design-build	Partnering
Description	- Non-participation of the architect in the production phase. - Non-participation of the contractor in the design phase. - The contractor executes the project according to the client's construction documents.	- Participation of the contractor in the design phase	- All actors participated in all four phases of the project. - The client, the contractor and the consultant had the same degree of influence on risk management.
Outcome	- Contractor's cost increased due to the poor quality of design documents. - No collaboration between the contractor and the architect in the design phase. - No discussion of the technical solutions and construction risks between the client and the contractor.	- Contractor's opportunity to influence the project in the early phase. - Fewer conflicts with the client during the project execution. - No deviations in the function of the final product.	- Workshops where all actors identified risks and decided who had better qualifications to deal with them. - Effective joint risk management throughout the project.
2. Trust and collaboration between actors			
Description	- Absence of trust and collaboration in risk management.	- Trustful and collaborative relationships in the case where the client is an active part of the project.	- Trustful and collaborative relationships.
Outcome	- Low degree of risk communication during procurement. - Client's attempt to transfer more risk to the contractor. - Contractor's cost increased.	- Communication of risks in the procurement phase on a detailed level. - Joint risk management in all project phases. - Lower contingency fund.	- The actors succeeded in solving the problems and decreasing the final cost. - Even though the identified risks occurred in the project, it was clear who was responsible for managing them.
3. Payment mechanism			
Description	Lump sum	Lump sum	Cost reimbursable
Outcome	Contractor's cost increased significantly.	Due to effective collaboration the final financial result of two projects was good.	- Open dialogue about project risks and joint search for best solutions. - Cost savings for both the client and the contractor.

Table 1. Factors that influenced risk management in the projects.

5 Discussion and further research

The results of the study show that traditional design-bid-build contracts do not create opportunities for joint risk management and open discussion of project risks. Design-build projects offer more opportunities for joint risk management due to early involvement of the contractor. The opportunity to influence risk management in the early phases results in better control of construction risks. On the other hand, the design-build form demands more control by the client. The combination of the professional client and the contractor, continuously discussing technical solutions, offers effective joint risk management of the project. Partnering project is a very good example of an effective project organisation with very good cooperation likely to occur in risk management. Collaboration between the project actors during all project phases resulted in successful problem solving and cost savings for both the client and the contractor.

Trust and commitment were argued to be the most important factors that influence risk management in the project. Design-bid-build contracts do not create a trustful environment in the project because each actor is involved in a limited number of the project phases and, therefore, focuses on his own work and protects his own interests rather than the project as a whole. The lack of trust is an important obstacle for intensive communication of known risks in the procurement phase. An economically-executed design-build project (Project 7) can be partially explained by the engagement of a very professional and enthusiastic client, who created cooperative and trustful relationships between the project actors. This resulted in a low contingency fund (2.5%) and, therefore, lower project cost. In comparison, contingency funds in Canadian contracts are between 8 and 20% (Zaghloul and Hartman 2003). In this context, the partnering form creates more opportunities for trustful relationships because the actors work together during the whole project and everyone is involved in risk management and enjoys an open dialogue about risks.

6 Conclusions

General conditions of contract that are widely used in Sweden formalise risk allocation between the client and the contractor. However, the Swedish construction industry has been criticized for increasing costs, low productivity, quality problems and project delays (SOU 2002). A stronger focus on how risks are managed in the different procurement options seems necessary in order to decrease the construction cost and quality problems for both the client and contractor. The aim of this study was to investigate the impact of the chosen procurement option on risk management in nine construction projects. The paper focuses on three options that are typically used in Sweden: design-bid-build contracts, design-build contracts and the collaborative form of partnering.

The major finding of the study is that there is a clear connection between the procurement option and risk management in the chosen construction projects. Design-bid-build contracts do not create opportunities for open discussion of project risks and joint risk management. Design-build projects offer a higher degree of collaboration in risk management due to the involvement of the contractor in early phases. Partnering helps to establish cooperative relationships because the actors work together throughout the project and each actor participates in joint risk management. Lack of trust and personal commitment is an important obstacle to effective communication of project risks and joint risk management. The overall conclusion is that the forms that support early involvement of the actors and create opportunities for an open dialogue and collaboration result in a more effective risk management process.

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Appendix 1. The characteristics of the construction projects involved in the study.

Project	Short description	Time	Procurement option	Payment mechanism	The contract sum in MSEK	Project implementation[1] in terms of			Identified risks occurred in the project/ their effect on the project cost	Unforeseen risks occurred in the project/ their effect on the project cost
						time	budget	quality		
1	Rebuilding, refurbishment and additional construction of university premises, located in the north of Sweden	10 months 2004-2005	Design-bid-build	Lump sum	17.9	Very good	Very good for the client/fairly bad for the contractor	Very good	Yes/fairly large	Yes/fairly small
2	New construction of a road in the north of Sweden	14 months 2005-2006	Design-bid-build	Lump sum	19.7	Very good	Fairly good	Fairly good	Yes/fairly large	Yes/fairly large
3	New construction of road in the north of Sweden	10 months 2005-2006	Design-bid-build	Lump sum	4.9	Fairly good	Fairly good	Fairly good	Yes/fairly small	No
4	Reconstruction of infrastructure facilities in Stockholm	3 years 2004-2007	Design-bid-build	Lump sum	95	Very bad	Very bad for the client/very good for the contractor	Fairly good	Yes/very large	Yes/ very large
5	New construction of a house for meetings at the university campus in the north of Sweden	15 months 2003-2004	Design-build	Lump sum	41.1	Very good	Very good for the client/fairly bad for the contractor.	Fairly good	Yes/fairly small	Yes/fairly small
6	New construction of infrastructure in the north of Sweden	13 months 2006-2007	Design-build	Lump sum	53	Fairly good	Fairly good	Fairly good	Yes/ fairly small	Yes/fairly small
7	Construction of a residential building in Stockholm	17 months 2005-2006	Design-build	Lump sum	81	Fairly good	Very good for the client/fairly bad for the contractor.	Very good	Yes/fairly small	Yes/fairly small
8	Reconstruction of a residential building in Stockholm	12 months 2004- 2005	Design-build	Lump sum	47.7	Very good	Very good for the client /fairly good for the contractor.	Very good	No	No
9	Reconstruction of a residential building, located in Stockholm	6 months 2005	Partnering	Cost reimbursable	15	Very good	Very good	Very good	Yes/fairly large	Yes/fairly small

[1] The characteristics of the projects implementation are based on the assessments of projects' participants. Four alternatives were available for assessment of project implementation: very bad, fairly bad, fairly good, very good.

Paper 4

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From project-oriented to process-oriented risk management in construction

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Abstract

The paper sets out the results of a questionnaire survey and a series of interviews with clients, contractors and consultants involved in nine construction projects recently undertaken in Sweden. Despite the fact that risk management was a part of each project, many projects suffered from variations in cost affecting one or more actors. Risk management was not carried out systematically in those projects. Both identified and unforeseen risks often occurred in the projects and generally had a significant effect on the project cost. The purpose of the paper is to examine project risk management in practice and to understand how managing project risks from a process-oriented perspective could improve the situation. In particular, the involvement of the actors in risk management in individual projects is examined. Risk transfer and communication of risks between the project phases are explored. Finally, the factors that determine whether or not the actors consider an open discussion on risk management and risk sharing as beneficial are analysed. The main conclusion is that a shift from project-oriented to process-oriented risk management is required.

Keywords: Risk management, construction, Sweden, process modelling

1. Introduction

According to a report of the Swedish Construction Commission [1], increased construction costs, project delays and deviations in quality are the most common problems in the construction industry. Risk management is a process that aims to maximise opportunities and minimise the consequences of a risk event and is an important part of the project management process. As such, it is intended to help in safeguarding project objectives, even to increase their value to the client. When considering the effect that risk management has on the project's goals in terms of quality and cost, it would be reasonable to expect that it was an open process across all phases of the project. Furthermore, a specific project risk should be managed by the actor who is best able to deal with it. Instead, it is often the case that the various actors try to avoid risks as far as possible and let somebody else in the value chain deal with them. Relatively little

attention has been paid in the Swedish research community to deeper investigation of the possible changes in the traditional construction process in which each actor focuses on short-term economic results and protects his/her own interests rather than the whole project. The purpose of the paper is to examine project risk management in practice and to understand how managing project risks from a process-oriented perspective could improve the situation.

The paper sets out the results of a questionnaire survey and a series of interviews with clients, contractors and consultants involved in nine construction projects recently undertaken in Sweden. The objective of the study is to explore the factors that lead, more or less, to effective risk management in the projects. In particular, we examine the actors' understanding of risk management process and their involvement in risk management in individual projects. We analyse risk transfer and communication of risks between the project phases. Finally, the factors that determine whether or not the actors consider an open discussion on risk management and risk sharing as beneficial are analysed. Since the paper focuses on the findings of research, most space here is given to reporting empirically-derived findings instead of presenting familiar arguments on the nature of risk and the purpose of the risk management process. Nonetheless, we outline the critical issues connected with the risk management process and its application within the construction industry.

Project risks are uncertain events or conditions that may have an impact on project objectives [2, 3]. A risk has a cause and, if it is triggered, also a consequence. A questionnaire survey conducted by Akintoye and MacLeod [4] shows that the majority of project actors perceive risk as a negative event. Ward and Chapman [5] discuss the concept of risk in detail and suggest using the more general concept of *uncertainty*. Risk management is a formal process directed towards the identification, assessment and response to project risks [2, 5, 6]. Risk identification is aimed at determining potential risks, i.e. those that may affect the project. There are several approaches to classifying project risks and risk sources [7-10]. In general, the sources of risk in construction projects may be divided into external risks (e.g. financial, economic, political, legal and environmental), internal risks (e.g. design, construction, management and relationships) and force majeure risks. Several surveys conducted among construction industry actors [4, 11, 12] show that checklists and brainstorming are the most often used techniques in risk identification. During risk assessment, identified risks are evaluated and ranked. The goal is to prioritise risks for management. Several authors [4, 11, 12] cite subjective judgment, intuition and experience as being most commonly used in risk assessment. The risk response process is directed to identifying a way of dealing with project risks and consists of three main techniques: risk reduction, risk transfer and risk retention [13]. Baker et al. [14] identified risk reduction as the most frequently used technique within the construction industry in the UK. Our treatment of risk management in this paper follows broadly along the lines outlined above in terms of the recognised stages in that process.

2. Research approach

The main part of the study was a questionnaire survey followed by a series of interviews with project actors. The survey sample comprised clients, contractors and consultants who employed risk management in a given project. The respondents from the client's side were the representative signing the contract and the project manager. From the contractor's side the respondents were the representative signing the contract, site manager and estimator. Finally, the respondent from the consultant's side was the architect or design manager.

A draft questionnaire was developed consisting of five sections. The first section contained general questions about the respondent. In the second section, aspects of the risk management process through the different phases of the project were covered. The third section investigated relationships between the actors in the project. The fourth section focused on software management systems, which the company used in the risk management process. The fifth section was a concluding one for miscellaneous comments regarding the risk management process in the project. In total, 54 questionnaires were sent and 36 completed, usable responses were received, representing a two-thirds' response rate.

Based on the compiled results of this questionnaire survey, 18 interviews across eight projects were then conducted. The objective of the interviews was a deeper analysis of the risk management process in the projects. Since it was impossible to interview all survey respondents within the time constraints, the number of interviewees was limited to the two or three persons responsible for risk management in the project. From the client side, it was a project manager, from the contractor side a site manager and from the consultant side an architect or design manager. Each interview took approximately one and a half hours and consisted of three main parts. First, the important definitions in risk management were discussed. Since the questionnaire contains the terms risk, risk management, risk identification, risk assessment, risk response etc., it is important to understand the perception of these terms by the respondents. Next, the results of the survey were presented and the respondents were asked to explain their answers. Finally, the respondents were given an opportunity to express their thoughts about risk management in the project.

3. Description of construction projects

The study involves nine construction projects recently undertaken in Sweden.

Project 1 included the new construction of a house for meetings at the university campus in the northern part of Sweden. The project was executed over 15 months between 2003 and 2004. The contract sum was 41.1 MSEK and the final cost was 43.5 MSEK. Design-build, with a lump sum payment mechanism, was the chosen form of procurement. The project implementation was very good in terms of time and fairly good in terms of quality. In terms of budget, the project was very good for the client and fairly bad for the contractor. The identified

risks occurred in the project, but their effect on the project cost was fairly small. The unforeseen risks during the project execution led to a fairly large increase in the project cost.

Project 2 included the rebuilding, refurbishment and additional construction of university premises, located in the northern part of Sweden. The project was undertaken between 2004 and 2005 and took 10 months to complete. The contract sum was 17.9 MSEK and the final cost of the project was 19.6 MSEK. A lump sum payment mechanism was chosen and a performance-based contract was signed between the client and the contractor. The technical characteristics of the final product were evaluated as high and the time constraints for project execution were kept. However, the poor quality of design documents increased the contractor's costs significantly. Identified risks occurred in the project and had a large effect on the project cost; even so, the consequences of unforeseen risks were fairly small.

Project 3 included the construction of infrastructure in the north of Sweden. The project was executed over 13 months in 2006 and 2007. The contract sum was 53 MSEK and design-build procurement, with a lump sum payment mechanism, was chosen. The project execution in terms of function, time and cost was fairly good. Both identified and unforeseen risks occurred in the project and had a moderate effect on the project cost.

Project 4 included the construction of a road in the north of Sweden and was performed under 14 months between 2005 and 2006. The contract sum was 19.7 MSEK and the final cost was 24.5 MSEK. The contractor was procured on a performance-based basis, with a lump sum payment mechanism. The project implementation was fairly good in terms of cost and function and very good in terms of time. Both identified and unforeseen risks occurred in the project and had a fairly large effect on the contractor's cost.

Project 5 included the construction of road in the north of Sweden and took 10 months between 2005 and 2006 to complete. The contract sum was 4.9 MSEK and the final sum was 4.7 MSEK. The performance-based form of procurement with a lump sum payment mechanism was chosen. The project execution was fairly good in terms of function and cost and fairly bad in terms of time. An insufficient geotechnical survey led to identified risks occurring in the project, but their effect on the project cost was fairly small. No unforeseen risks occurred.

Project 6 included the construction of a residential building in Stockholm. The project was executed between 2005 and 2006 and took 17 months. The contract sum was 81 MSEK and the final sum was 84 MSEK. The procurement form was design-build, with a lump sum payment mechanism. The quality of the final product was evaluated as very good, time constraints were kept to a fairly good level. In terms of cost, the client evaluated the project execution as very good while the contractor's evaluation was fairly bad. Both identified and unforeseen risks occurred in the project, but had a fairly small effect on the project cost.

Project 7 included the reconstruction of a residential building in Stockholm and was executed over 12 months between 2004 and 2005. The contract sum was 47.7 MSEK and design-build procurement, with a lump sum payment mechanism, was chosen. The project implementation

was very good in terms of time and function, very good in terms of cost for the client and fairly good for the contractor. Neither identified nor unforeseen risks occurred during the project execution.

Project 8 included the reconstruction of infrastructure facilities in Stockholm. The building period was three years between 2004 and 2007. A performance-based contract with a lump sum payment mechanism was chosen for the project. The contract sum was 95 MSEK. In terms of cost, project implementation was very good for the contractor and very bad for the client. Unforeseen risks caused significant delays and high costs for the client. The quality of the final product was fairly good. The identified risks occurred and had an impact on project cost.

Project 9 included the reconstruction of a residential building, located in Stockholm. The reconstruction was executed in 2005 and took 6 months. The project was implemented as a form of partnering with a cost reimbursable payment mechanism. The contract sum was 15 MSEK. The project implementation in terms of function, cost and time was good. Together, the client and the contractor succeeded in decreasing project costs. Both identified and unforeseen risks occurred in the project, but did not have a large effect on the project total cost.

4. Results

Despite the fact that risk management was a part of each project, many projects suffered from variations in cost for one or several actors. Risk management was not carried out systematically in those projects. Both identified and unforeseen risks often occurred in the projects and generally had a significant effect on the project cost. In sections below we discuss the factors that lead to more or less effective risk management.

4.1 Understanding of risk management

The majority of respondents have what might be described as a fair understanding or knowledge of risk management and did not have any special training in the subject. Experience within construction industry is the main source of knowledge. To quote from three respondents:

> *"I have worked very long time in construction; no one can do it better than me". (Client in project 7)*

> *"Experience takes over, you learn during all these years of working in construction". (Contractor in project 7)*

> *"I have only my experience; it would be good to get more theoretical knowledge". (Consultant in project 9)*

Some companies organised internal courses in risk management but most respondents identified the lack of the theoretical understanding or knowledge. Many companies have a set of procedures to follow in the risk management process. The largest problem identified with the procedures is their complexity and documentation requirements.

> *"To do risk management systematically on paper is a big problem. We get a lot of documents from the system and nobody looks at them later". (Client in project 4)*

> *"Many people do not like to fill in papers; therefore they skip documentation of risks". (Contractor in project 6)*

In the risk management process, simple tools are familiar to the respondents: checklists and brainstorming for risk identification; probability-consequence judgment in risk assessment; and risk transfer as a way to respond to risk. In practice, the use of theoretical tools was limited.

> *"When assessing risks we do not use any theoretical tools but [instead use] experience, feelings and relationship with the client". (Contractor in project 2)*

Insights into this more theoretical view of risk management is shown in figure 1, which is based on best practice advice informed by numerous studies and reapplied from one project to the next.

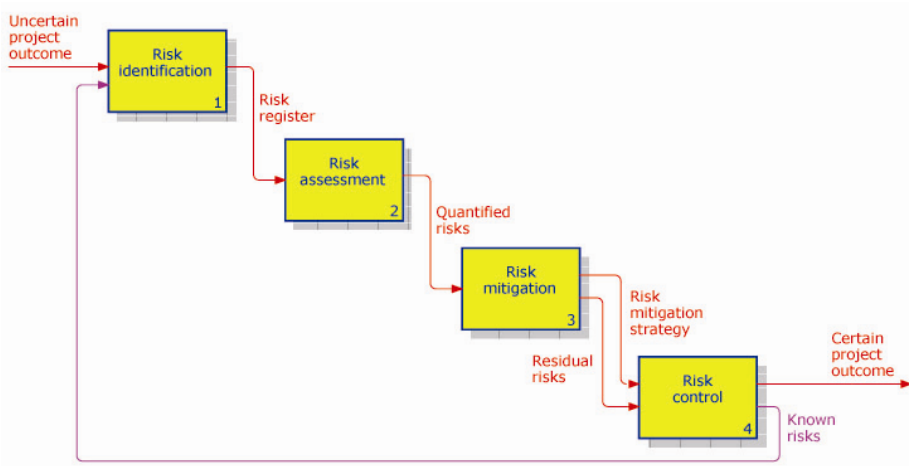

Figure 1: A more theoretical and formal treatment of the risk management process.

Figure 2 decomposes the higher level activity of risk identification into a lower level of analysis.

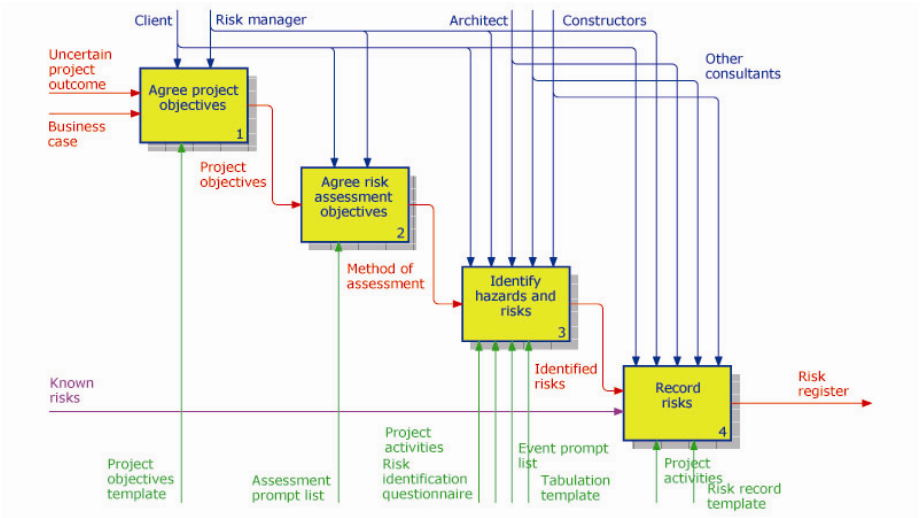

Figure 2: Decomposition of the risk identification activity.

4.2 Participation in different project phases

A construction process is sequential by nature and many actors are involved only in some project phases and focus on their own part of work rather than on the whole project. This leads to the less effective communication of identified risks and the loss of knowledge between the phases.

> *"It happens very often that people involved in different phases do not see the overall picture". (Client in project 7)*

There was a very low participation in the programming (planning) phase overall. In particular, no contractors participated in this phase of the projects. However, the respondents recognised that the early involvement of the contractor is important for effective risk management. It allows the actors to choose the best technical solutions, decrease costs and obtain a deeper understanding of the potential problems.

> *"The sooner we get the contractor's expertise in the project, the greater is a chance to avoid the problems in production". (Client in project 4)*

> *"We lose a lot of important information if we join the project when design is done". (Contractor in project 2)*

The actors felt that the newer organisational forms like partnering can help in ensuring early involvement of the actors and, therefore, better understanding of project risks.

4.3 Risk identification, assessment and response

Systematic scrutiny of potential and possible risks in the project was identified by interviewees as a very important factor for successful risk management. Systematic means that risk identification, assessment and response are performed in each phase of the project and the results of the processes are communicated between the project actors. However, in just one project were these steps in the risk management processes carried out systematically.

> *"We identify and assess risk, fill in the template and it's done! Then we start construction, everybody is busy and forgets about risk management and early assessments". (Contractor in project 1)*

The design and production phases are critical for risk management. Risk identification, assessment and response were mostly performed in these phases. Despite the recognised importance of the programming (planning) phase, very little work in risk management was performed.

> *"The programming phase is very important… We did not work systematically in the programming phase; we did not talk in terms of risks". (Client in project 1)*

> *"Historically we have not worked with risks in the programming phase, but now it is coming". (Client in project 8)*

> *"We have little focus on risks in the programming phase because the project is very abstract". (Contractor in project 2)*

Within three groups of actors, contractors were the most active in performing risk identification, assessment and response in the project. Almost all contractors documented potential project risks and preventive measures. Moreover, contractors had the largest influence on risk management in the project.

> *"Contractors have to deal with most risks; we are forced to be active in risk management". (Contractor in project 2)*

Consultants were not involved sufficiently in work with risks and had a low influence on risk management. The actors agreed that consultants should play a more important role in risk management, because design-related risks can affect the project's performance significantly.

> *"Consultants still have a passive behaviour when it comes to risk management. Risk management is not a part of their assignment". (Client in project 2)*

> *"I think our competence is not used by 100%, probably we have to start talking that we are good and can much more". (Consultant in project 1)*

The role of the client in risk management depends on the form of contract. In the performance-based projects, where the clients were responsible for a design, they had a larger influence on risk management and were more active in risk identification and risk response. The clients concurred that even in design-build projects, where the contractor is responsible for a design, the client has to play an active role in risk management.

> *"The client is always responsible for commitment of other actors. I don't believe in 'good' contractors and consultants, they adapt to the clients' requirements". (Client in project 8)*

Risk identification, assessment and response are needed in each phase of the project. This iterative approach, as illustrated in figure 3, is at odds with the previous portrayal of the risk management process in figure 1, which tends to regard the risk management process as a rather sequential activity running across the project phases.

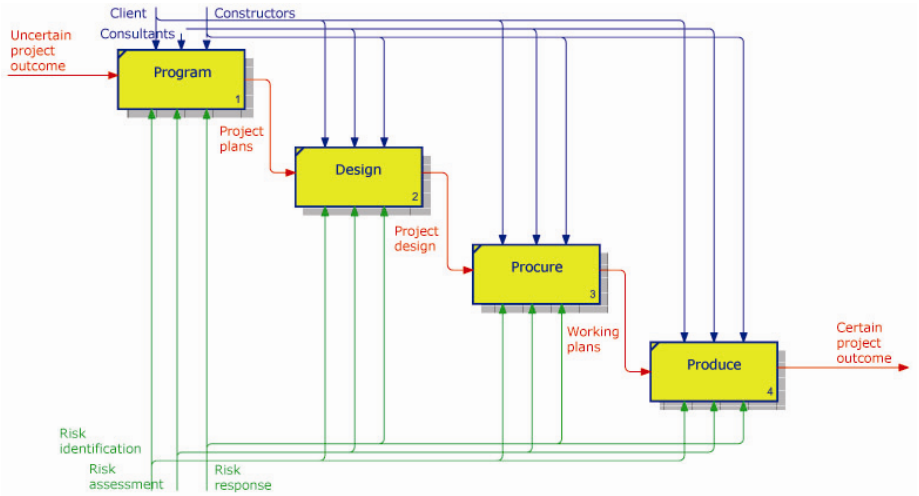

Figure 3: An iterative view of the risk management process to be applied at each phase in the project life cycle.

4.4 Risk transfer and communication of risks

The majority of respondents agreed that the risks always are transferred between the project's actors. Clients transfer risk to contractors because they believe that they, the contractors, have better ability to manage risks. Some risks stay with the client, for example environmental and market risks.

Two ways of risk transfer were identified by the actors: positive and negative. A positive way means that the risk is identified and the actor who will manage the risk is aware of it. This way demands open dialogue about known risks between the actors. A negative way implies, for

example, that the client lowers the cost by omitting important investigations and information before the project start date with the effect that risks appear in the production phase.

> *"Prior investigations are expensive and sometimes the client does not do all necessary investigations". (Client in project 4)*

The contractor transfers risks to the subcontractors and sometimes back to the client; for example, design risks in those cases where the client was responsible for the design. The majority of contractors are convinced that the client tries to transfer all possible risks to the contractor. Despite the fact that risk allocation is formalised by general contract conditions, which are used in all projects, clients tend to make some changes and include special conditions which imply more risk allocated to the contractors.

> *"The client's way of thinking is 'risks to the contractor, opportunities to us!'". (Contractor in project 2)*

The communication of known risks in the procurement phase was very low from both the client and the contractor. Two opposite views were shown: one group stated that it is a strategic choice not to show all risks in the procurement phase in order to keep the bid price at a lower level.

> *"The client feels that he can transfer risks to the contractor and pay a lower price. The contractor thinks there is a possibility for earning more money and keeps silent". (Contractor in project 8)*

The other group said that it happens because the actors, especially the client, are not aware of all possible risks. Both groups agreed that there is a need to change the situation. When risks are not communicated at a detailed level, the chance that they will occur is much higher and their consequences can impact more.

> *"In any case somebody pays for mistakes made by others". (Client in project 7)*

> *"We can put more money to the risk pot but in this case the client will pay higher price for those risks which never will happen". (Contractor in project 2)*

Due to the limited participation of the actors in some project phases, the communication of project risks between them does not function properly. Many problems appear when the consultant and client are not involved in the production phase. Additionally, risk management processes are carried out most intensively in the production phase, which implies more responsibility in managing risks for the contractor and more passive behaviour by other actors.

4.5 Joint risk management

According to the respondents, joint risk management means that each actor is aware of all project risks and takes responsibility for them. It is important to start risk discussions early in the project and risks are discussed continuously. Known risks should be communicated at a detailed level between the actors and the project's phases. Fair sharing of both risks and opportunities is an important driving force for joint management of risks.

In seven of the projects, the actors had good collaboration in risk management. The actors in two projects stated that there was no joint risk management. Most of the actors responded that collaboration existed in the risk identification and risk assessment processes. The risk response process had a lower degree of collaboration according to the contractors. They stated that contractors are usually forced to manage most of risks alone.

To achieve good collaboration in risk management and an open discussion of project risks and risk sharing, the following factors are considered important:

- Active participation of all project actors in discussions on risk and risks;
- Open and effective communication and information exchange: all risks are "placed on the table":
- Project actors' ability to raise the problems as soon as they appear, dare to ask questions and work without prestige;
- Personal commitment, motivation and responsibility;
- Trust;
- Respect for each others' roles and competence;
- Fair distribution of opportunities.

5. Conclusions

The findings of our research show that risk management is not carried out systematically in all phases of a project. The actors' participation in the risk management process is generally limited by their roles in the project. The absence of systematic risk management is especially noted in the programming (planning) phase, where it arguably has the greatest potential impact. The production phase is where most interest and activity is to be found. Unfortunately, this can easily prove to be too late in the day to mitigate some risks, including those that might have been avoided at an earlier phase. Whilst this is self-evident, scant attention to early identification of risks confirms this practice as commonplace. As a concept and matter of practice, the communication of risks between the actors simply does not work to the extent that it must if projects are to be delivered with certainty, irrespective of the form of procurement. If risks are to be properly managed, it is also self-evident that the risk management process must be present, transparent and activated within each phase. It is the lack of an iterative approach to risk management that is a weakness in current procurement practices and this aspect must be addressed if the risk management process is to serve projects and, thus, their clients. Implicit in this thinking is that the project's other actors will be better able to cope with circumstances that

might threaten the time, cost or function of the project if they can be engaged in the risk management process from the outset. A shift from project-oriented to process-oriented risk management is required in order to manage project risks successfully.

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