Risk Management in Construction Projects
- A Knowledge Management Perspective from Swedish Contractors

Dario Petrovic
Master of Science thesis

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A Knowledge Management Perspective from
Swedish Contractors

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Abstract
Projects within the construction sector is characterized as fragmented, temporary and complex
which inherently brings upon risk exposure. Decision makers within the industry need reliant
access to information and knowledge in order to manage risks in a sufficient and systematic
way. Thus, the implementation of an effective risk management in relation to managing
associated project risk knowledge may facilitate successful construction project endeavors.

The purpose of this master thesis is to explore and evaluate project risk management within the
Swedish construction industry, with the emphasis on the perspective of Swedish contractors.
The aim is to examine the recognition and practical adoption of risk management in order to
investigate how project knowledge is utilized in the process.

The methodology consists of a literature review on risk management fundamentals, the diverse
risk attitudes and knowledge management in relation to risk. Data collection and analysis are
based on a mixed method approach in which conclusions are made in relation to theoretical
groundwork. The empirical data is collected through the usage of an online survey and in-depth
semi structured interviews with key professionals within the Swedish construction industry.

The results from this research indicate that theoretical models and processes for risk
management is fairly unknown within the industry, analogous methods are used within
respective organizations but the sharing of definitions and concepts within the industry are
absent and the methods are not as structured as described in risk management theory. However,
findings suggest that the perception of actors within the industry regarding risk and the risk
management process is one of high importance for obtaining project objectives. Furthermore,
findings indicate that the interplay between knowledge- and risk management and the
incorporation of these processes is underutilized among the contractors and developers.
### Examensarbete

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### Sammanfattning

Projekt inom byggsektorn karakteriseras ofta som fragmenterade, tillfälliga samt komplexa vilket i sin tur medför riskexponering. Beslutsfattare inom byggbranschen behöver tillförlitlig tillgång till information och kunskap för att kunna hantera risker på ett effektivt och systematisk sätt. Implementering av en produktiv riskhantering i samband med hanteringen av associerad projektriskkännedom och kunskap kan således underlätta framgångsrika byggprojektinsatser.

Syftet med denna masteruppsats är att utforska och utvärdera projektriskhantering inom den svenska byggbranschen, med tonvikt på svenska byggentreprenörers perspektiv. Syftemålet är att undersöka erkännandet och det praktiska utförandet av riskhantering och på så vis undersöka hur projektkunskap utnyttjas i processen.

Metoden består av en litteraturöversikt gällande riskhantering, diverse riskattityder och uppfattningar samt kunskaphantering i förhållande till risk. Datainsamling och analys baseras på en ”mixed-method research” där slutsatser görs i förhållande till teoretiskt grundarbete. Den empiriska insamlingen gjordes genom tillämpning av en online-undersökning samt djupgående semi-strukturerade intervjuer med professionella inom den svenska byggbranschen.

Resultaten från denna forskning visar på att teoretiska modeller samt processer inom riskhantering är relativt okända inom branschen. I praktiken används likartade metoder inom respektive organisation men definitioner och begrepp skiljer sig sinsemellan, metoderna är dessutom inte lika strukturerade i jämförelse med riskhanteringsteorier inom litteraturen. Fynden i denna studie tyder dock på att uppfattningen kring risk och riskhanteringsprocessen, bland aktörer inom branschen, är att den är av stor betydelse för att uppnå projektmål. Vidare tyder resultaten på att samspelet mellan kunskap- och riskhantering samt dess inkorporering är underutnyttjad bland byggentreprenörer och byggherrar.
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1. Introduction
1.1 Background
Risk management is according to Project Management Institute (PMI) one of the nine knowledge areas and the integration of an effective risk management is considered a crucial element and essential for project success. Construction projects can be described as tremendously complex projects in which uncertainty might arise from various sources. Risk management is therefore increasingly becoming an extensive component of the project management of construction projects in a pursuit to efficiently deal with unexpected events and ambivalence. It is important due to the damaging consequences imposed by risk and uncertainty (Banaitene and A. Banaitis, 2012). However, for years the industry has had a poor reputation for managing the adverse effects of change resulting in delays and a failure to meet quality and cost targets (Smith et al., 2006).

The objective of an efficient risk management procedure is to facilitate risk neutral decision-making, which in turn till result in superior performance. Systematic methods for obtaining more information about uncertainty on the project is needed to achieve that objective (Winch, 2010). The implementation of various techniques and methods for risk management and assessment will however not remove all risks but the aim is to ensure that the risks are assessed and managed in a manner allowing the overall objectives of the project to be achieved (Potts, 2008).

Risk management involves the establishment of risk consciousness, integration of basic principles of risk policy and organizational integration. This allows, through proactive action, the project to be prepared for unavoidable problems and an increased transparency (Schieg, 2006). It is an ongoing process throughout the entire the project life cycle as risks will continually change. Risk management is the process of identifying, assessing and responding to risk and it is important to work as an integrated project team from the earliest possible phases, in order to identify and efficiently deal with risks when they arise (Potts, 2008). The benefits of the process are clearer understanding of the specific risks associated with a project, supported decisions by detailed analysis and a build up of historical data that can be used to assist future risk management procedures. Unfortunately, many project managers have still not realized the importance of implementing project risk as an integral part of the delivery of a project (Smith et al., 2006).

An inefficient implementation of risk management is often caused by the lack of formalized procedures, the lack of continuity in the different project phases and an inadequate integration of knowledge management and interaction between processes and parties. During the construction process the major responsibility to deal with risks is laid upon contractors by deciding if the risks should be reduced, avoided, transferred or retained (Liu et al., 2007). In order to manage risk effectively the contractor needs to understand risk responsibilities, risk management capabilities and event conditions (Banaitene and A. Banaitis, 2012).
1.2 Purpose
The overall aim and objective of this master thesis is to investigate the perception, attitude and practical implementation of RM within the Swedish construction industry as well as exploring how knowledge is managed in relation to risk management.

Following objectives will be explored in order to reach the overall aim of this paper.

- Examine the perception and attitude of risk and RM within the construction industry.
- Examine how knowledge is managed in relation to RM
- Explore the practical implementation of Risk Management

1.3 Limitations
The focus of the research conducted in this study is on risk management within the Swedish construction industry, thus including the perspective of both developers and contractors in small and large organizations, in terms of data collection from the conducted survey. However, the emphasis in the study is put on the perspective of Swedish contractors, thus the usage of in-depth interviews with solely contractors. Therefore, the study will be limited in terms of gaining an in-depth perspective from developers in the construction industry. In addition, the research is limited to the Swedish construction sector.

1.4 Disposition
Chapter one provides the reader an introduction, including background information about the research, the purpose and limitations. Chapter two explains the methodology used in the study, the approach taken by the author and comments regarding the validity and reliability of the research method. Chapter three presents the literature review, in which definitions and concepts are explained regarding risk and uncertainty, classification of risks and the fundamentals of risk management. Previous studies and theoretical processes and concepts in the field of both risk- and knowledge management are presented, including theory in terms of perception and attitudes of risk and the process of risk management. Chapter four presents the empirical result obtained by the online questionnaire and in-depth semi-structured interviews, this chapter acts as the basis for the analysis in chapter five. The results are divided into three sections, the attitude and perception towards risk, knowledge in relation to risk, and finally the process of risk management. Chapter five includes the analysis of the empirical data, it further provides discussions in relation to previous theories and concepts and answers the questions proposed for the purpose of this research. Chapter six presents the final conclusions of the thesis and gives recommendation for future studies in the field of risk management.
2. Methodology
In order to investigate the perception and knowledge management of contractors in regards to risk as well as the implementation of risk management within the construction sector, an application of a comprehensive method is essential. The methodology consists of a thorough literature review on the subject and an empirical data collection comprising of two sources, a survey research in form of a questionnaire and semi-structured interviews.

2.1 Research Approach
There are two types of basic approaches to research, the quantitative and the qualitative approach. The former includes the generation of data in quantitative form which can be subjected to quantitative analysis in a rigid fashion. This type of research approach can further be categorized into following sub-classes; inferential, experimental and simulation approaches to research. The purpose of the inferential approach is to gather a data base from which to infer characteristics of population. The usage of questionnaires is a way to study a sample of population to determine its characteristic, inferring that the population has the same characteristics (Kothari, 2004). In contrast, the qualitative approach is used for any data collection technique or analysis procedure that generates non-numerical data, such as structured, semi-structured or unstructured interviews (Saunders et al., 2009).

The study in this research is conducted using a mixed method approach/design, which is the general term for when both quantitative and qualitative data collection techniques and analysis procedures are used in a research design (Saunders et al., 2009). This form of inquiry thus integrates two forms of data and the core assumption of this type of approach is that the combination of qualitative and quantitative approaches facilitates a better understanding of a research problem than either approach alone (Creswell, 2013). Although the mixed method approach uses both types of world views at the research method stage, quantitative data are analyzed quantitatively whilst qualitative data are analyzed qualitatively. (Saunders et al., 2009). Hence, the mixed method research legitimizes the use of multiple approaches in answering research questions, rather than restricting or constraining researchers’ choices (Burke Johnson & Onwuegbuzie, 2004).

The pre study consisted of a thorough understanding of the research area and the formulation of research questions. The next step involved the preparation of a set of semi-structured interview questions as well as a formulation of an online questionnaire on the basis of the theoretical framework. These measures were needed to help achieve the purpose of this study, which is to explore the perception, knowledge and practical implementation of the risk management process within the Swedish construction sector. The questionnaire was made in order to realize attitudes, knowledge and RM implementation among actors within the Swedish construction industry, and the interviews enabled an in-depth examination of their views and organizational implementation.

2.2 Literature Review
A variety of books and articles had to be studied in order to obtain and comprehend various concepts and theories within the extensive literature on the subject of risk management. This process enabled the findings of existing research in the field of project- and risk management
within itself and in relation to the construction industry. The theoretical framework in this study covers primarily the fundamentals of risk management, the diverse risk attitudes and knowledge management in relation to risk. The general process and techniques used within risk management are reviewed in order to provide the reader with a comprehensive understanding of the subject.

2.3 Questionnaire

The usage of a survey strategy is associated with the deductive approach and tends to be used for exploratory and descriptive research. It allows for the potential collection of a large sum of data from a sizeable population (Saunders et al., 2009). The purpose of descriptive research is to obtain an accurate representation of persons or situations, thus describing the characteristics of the phenomenon being studied. Questionnaires is one of the most commonly used data collection techniques within the survey strategy. Each individual who is provided with the questionnaire is asked to respond to the same set of questions, enabling a resourceful way of collecting responses from a large sample prior to analysis (Saunders et al., 2009). Following Kothari (2004) a successful questionnaire should be short and simple, the questions should proceed in a logical sequence moving from easy to more difficult questions whilst personal questions should be left to the end. A provision for indications of uncertainty should also be included, in case respondents don’t have a preference or don’t know the answer.

The variety of questions provided in the survey may be open-ended allowing unlimited answers, two-way questions in which answers are limited to alternative responses such as yes or no, ranking/rating scale questions and finally multiple choice questions in which the respondent is requested to choose the most applicable alternative (Phillips, 2008). The questionnaire presented in this study is conducted through an online survey design software at SurveyMonkey.com™.

An email invitation where sent out via email to a large number of Swedish construction companies, including both small, mid-sized and large actors. The aim was to obtain an overall representation of the industry with regard to RM. There were 29 questions divided into three sections. The first section where designed to collect background information as well as reveal the respondents’ perception and attitude towards RM. The aim with the second section where to explore how knowledge is managed and transferred within respective organizations and finally the third section consisted of RM methods and the practical implementation within the industry.

There were in total 43 responses out of 336 invitations, which results in a response rate at approximately 13%. The average response rate for external surveys is around 10-15%. About 70% of the respondents had more than 15 years of experience within the construction industry and the majority where contractors at approximately 88%, 24% where developers and 2.38% where consultants. The size of the companies where equally represented, approximately 48% had more than 1000 employees while 52% had less than 1000 employees.
2.4 Interviews
The categorization of interviews is related to the level of formality and structure, they can be highly structured and formalized or they may be informal and unstructured. The type of interviews chosen in this study is the categorization of semi-structured interviews, i.e. non standardized and often referred to as qualitative research interviews (Saunders et al., 2009). This type of interview allows for the generation of qualitative data in the form of respondents’ detailed answers, and investigation of sources of knowledge within the organization. In order to validate findings from questionnaires these type of interviews may also be used as a part of mixed method research (Bryman et al., 2011). Hence, semi-structured interviews can be used in order to comprehend the relationships between variables revealed from a descriptive study such as survey research (Saunders et al., 2009).

The advantage of using a semi-structured interview as opposed to a strictly structured formation is that it enables a wider understanding of the respondents’ perspective and framework deprived of any influence of assumptions on the researchers’ part. A semi-structured interview might also have the benefit of being more attentive than the usage of an unstructured formation, while still enabling the respondent to answer freely and spontaneously as well as maintaining a high degree of flexibility (Bryman et al., 2011).

In order to realize the attitude and practical implementation of RM in the Swedish construction industry as well as how knowledge is managed and distributed in relation to risk 7 interviews were conducted. The interview questions where designed to be open ended in order to facilitate a discussion as well as additional questions about the subject.

All interviewees had more than 15 years of experience in the industry and the professions where 3st site managers, 2st construction manager, 1st head of department, 1st construction engineer. The length of the interviews varied from 30 min to 1 hour, and 4 of them where conducted by telephone while 3 where interviewed at their head quarters. All respondents where asked for permission to be recorded during their interview and all of them gave consent. The reason for recording the interviews where in line with semi structured methodology, it facilitated more focus on the interview rather than taking notes and it strengthens the reliability of the research since quickly taken notes isn’t as reliable as the recording and transcripts.

2.5 Reliability and Validity
As described by Bryman et al (2011) and Saunders et al (2009) reliability refers to the extent to which the data collection and analysis procedures yields consistent results and whether the results of a study are repeatable, validity on the other hand is concerned with the actual precision of the research findings, i.e. the integrity of the conclusions generated from the research.

The internal validity and reliability of the collected data and response rate depend much on the design of the questions and the structure of the questionnaire. The questions must be understood by the respondent as intended by the researcher, and the answers must be understood by the researcher as intended by the respondents. Hence, a valid questionnaire enables the collection of accurate data. Four stages must occur in order for the questions to be valid and reliable, as
illustrated in fig.1 (Saunders et al., 2009).

Fig. 1. Four stages that must occur in order for a question to be valid and reliable

In regard to the use of semi-structured interviews there are some threats that can be identified concerning trustworthiness and credibility. Preparation is key in order to avoid or reduce potential data quality issues related to reliability and response bias (Ibid.). The measures taken by the researcher in this study was to make sure to properly convey the confidential nature of the study, thus protecting respondent confidentiality in the research. Another measure taken was to provide participants with relevant information and question themes before the interview, thus enabling respondents to consider the information being requested and also allowing them time to assemble any potential documentation needed. These efforts should promote the validity, reliability and overall credibility of the research (Ibid.).
3. Literature Review

3.1 Uncertainty and Risk

The distinction and relationship between uncertainty and risk may be described as the risk being measurable uncertainty whereas uncertainty is unmeasurable risk. It is the interaction of uncertainty on objectives that gives rise to risk, which means that only relevant uncertainties that have the potential to affect project objectives can become risks. In other words, a risk is an uncertainty that matters and the importance is defined in relation to the particular objectives in question. However, the term risk is used widely in variety of applications but the most common application of risk management is in projects, where project risks are defined as those uncertainties that could affect project objectives (Hillson, 2004).

3.1.1 Definition of Risk

Risk is always present when making decisions on the basis of assumptions, expectations and estimates of the future. It characterizes situations where the actual outcome for a specific event or activity is likely to deviate from the estimated value (Raftery, 1994). The definition of risk is diverse and can be assessed in terms of fatalities and injuries, sample of a population, in terms of probability and reliability or in terms of the likely effects on a project. One can distinguish uncertainty from risk by defining risk as being where the outcome of an event is possible to predict on the basis of statistical probability. This implies that there is knowledge about a risk as a combination of circumstances as opposed to the term uncertainty in which there is no knowledge (Smith et al., 2006). Risk is often explained in terms of probabilities and consequences, or impact on various objectives. In order for a potential event to be considered a risk it must have a probability of between 0 and 1, which reveals a spectrum in which the event is either impossible or is certain to happen (Loosemore et al., 2006). Hence, the occurrence of risk is present when a decision is described in terms of a series of possible outcomes and when known probabilities can be attached to set outcomes (Smith et al., 2006).

Hillson and Murray Webster (2005) explain an interesting trend when examining various official published risk management standards. They state that the definition of risk had an exclusively negative connotation before 1997, hence risk equals threat, with the term being synonymous with hazard, danger and so on. Although, from 2000 onwards, the definition of risk presented in various publications in relation to risk management has changed, a clear majority of the official standards have unequivocally treated risk as including both opportunities and threats.

Risk – an uncertain event or condition that, if it occur has a positive or negative effect on a projects objectives (PMI, 2000)

Risk – exposure to the possibility of financial loss or gain, physical damage or injury, or delay as consequence of the uncertainty associated with pursuing a course of action (Chapman C., 1991)

Risk – exist when a decision is expressed in terms of a range of possible outcomes and when known probabilities can be attached to the outcomes (Smith et al., 2006).
3.1.2 Definition of Uncertainty
Uncertainty can be deemed as the chance occurrence of some event where the probability distribution genuinely is unknown, meaning that uncertainty relates to the incidence of an event about which little is known except the fact that it might occur. (Smith et al., 2006). Thus, it is the absence of information required for a decision to be made at a point in time (Winch, 2010). The occurrence of uncertainty is therefore present when an action leads to more than one possible outcome but the probability of each outcome is unknown (Smith et al., 2006).

3.1.3 Opportunities
It is essential to understand the relationship between opportunities and threats, especially in the context of project risk management (Hillson, 2004). The definition of risk does not necessarily refer to the chance of exclusively bad consequences. Instead it should also include the possibility of good outcomes (Smith et al., 2006). Both threats and opportunities are usually involved in any given decision situation, and both should therefore be managed. It is not advisable to concentrate on the reduction of potential threats without also considering associated opportunities. It is simultaneously not advisable to chase opportunities without regard for potential threats (Chapman & Ward, 2003). Opportunities and threats both involve uncertainty, which has the potential to affect objectives. An opportunity can be defined as a set of conditions or an uncertain event that, if it occurs, would benefit the project. A threat however might be defined as an uncertain event or condition that, if it occurs, would damage the project in some way. The only difference between them is the type of effect on objective. Given the similarity in description, it is reasonable to bring the two together under a common definition that combines the element of uncertainty with the potential to affect objectives, which is how risk is defined (Hillson, 2004).

3.2 Project Risk Classification
Risks can be divided into different types or classifications or categories, the important aspects of these are as follows:

Known risks: these risk events are frequently occurring in all construction projects and are inevitable, thus including minor fluctuations in material costs and productivity (Smith et al., 2006). It is the cognitive condition of risk, where the identification of the risk source has been made and the probability of occurrence regarding the risk event has been assigned (Winch, 2010). Known unknowns, these risk events are somewhat predictable meaning there is some knowledge regarding either the probability of occurrence or their effect (Smith et al., 2006). It is the cognitive condition of uncertainty, where at least the risk source has been identified.

Unknown unknowns, it is the cognitive condition of uncertainty in which somebody might have knowledge about the risk source and probabilities but keeps the information private. The risk source is not identified and the risk event can therefore not be known (Winch, 2010). Thus, these risk events are incidents whose effect and probabilities of occurrence are unforeseeable, even by the most knowledgeable and experienced members of a project (Smith et al., 2006).
In project risk management, events or risks with a low impact can be divided into the elements of trivial and expected as presented in fig 2. The illustration compares the probability of occurrence of an event compared with its impact on the construction project. Hence, risks with both high impact and a high likelihood of occurring depend on risk management (Ibid.).

![Fig 2. Risk classification in relation to probability and impact (Smith, Merna, & Jobling, 2006)](image)

Smith et al (2006) gives an example of a hazard event with low probability and high impact, they state that these might arise but aren’t considered since they are too remote in reality. For instance, parts from a satellite might some day crash on a building project but few buildings are designed with that event in mind. However, even though the probability may be low the event should not be ignored if it is a high impact risk in project management. Thus, arrangement of response plans should be covered for risk events even if the financial impact is too large to be managed.

3.3 Fundamentals of Risk Management
Traditionally risk in construction was either ignored or dealt with in an arbitrary way (Potts, 2008) but today risk management is an integral part of project management (Serpella et al., 2014). Thevendran et al (2004) described the concept of an effective risk management as a continuously monitored integrated formal process for defining objectives, identifying sources of uncertainties, analyzing them and formulating managerial responses in order to produce an acceptable balance between risk and opportunities. It includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives (PMI, 2000). The adoption of risk management ultimately can serve as an instrument to help facilitate the decision making process in order to prevent, eliminate and reduce the risks.
3.3.1 Risk Management Model and Process within the Construction Industry

There are many methodologies or models in regards to managing the risks in various projects but the core process of risk management is comprised into four stages in the construction industry. Identification and classification of the risk sources, risk assessment analysis, development of management responses to risk and to control and monitor them (Smith et al., 2006). The method of risk management helps to observe and determine all the risks to which the project is exposed in hopes of making an aware decision that is pursued with the coordinated and economical application of resources, in order to control and reduce the effect and overall probability of events considered undesirable (Dehdasht et al., 2015). Thus transparency increases through risk management and the project can be prepared for unavoidable problems, also many problems can be averted from the outset through proactive measures (Schieg, 2006).

Loosemore et al (2006) describes risk management as a proactive process of looking forward as opposed to indicating a reactive framework. They state that the distinction is often confused within the construction industry where managers might think they are practicing risk management, but in reality they often demonstrate a backward looking and reactive approach.

Winch (2010) describes the model as being designed in a circular fashion to emphasize that risk management is a learning process through time, using the same four elements or stages as Smith et al (2006) and Hillson (2004). In literature, the core principle of risk management is the same but the process might differ somewhat depending on the industry and organization, but the components illustrated in fig 3 are usually present. A systematic implementation of the process throughout the lifecycle, from planning to completion, of any construction project is needed in order for the practice to be truly beneficial, thus the process needs to be iterative (Loosemore et al., 2006). PMBOK’s model differs by incorporating risk assessment with qualitative and quantitative risk analysis. The importance of feedback within each phase is emphasized in ISO 31000, in which monitoring and review ensures that the organization monitors risk performance and learns from experience.

![Fig 3. The iterative process of Risk Management (Hillson, 2004)](image-url)
Construction projects are from the start of their existence immediately exposed to risks (Schieg, 2006). Hence, the implementation of risk management from the early stages of a project is essential due to the fact that major decisions such as choice of alignment and selection of construction methods can be influenced during this stage (Eskesen et al. 2004). Other reasons for investigating risk events early in the project life is that useful information about the risks might emerge enabling the implementation of a strategic approach to be defined and adopted as early as possible. This will in turn help clarify internal project goals and priorities as well as enabling an improved estimation of safety, budget and schedule (Reilly & Brown, 2004). By incorporating risk management into the planning phase one can facilitate the identification and reduction of potential risks for the project success (Schieg, 2006).

3.4 Risk Identification
The identification of risk is arguably recognized as the most crucial step within the risk management process (Banaitene & Banaitis, 2012). The aim is not to obtain perfect predictions of future events, rather it is the recognition of potential risk sources with high impact on a particular project, should they occur. It is impossible to identify all potential risks and the purpose should not be to do so (Smith et al., 2006). Thus, the intention of identifying and assessing the risks is to ensure that potential risks are assessed and managed in a manner, which allows for the overall objectives to be achieved. Due to the constant changing nature of risks throughout a project's life cycle the management of risk must be an ongoing process (Potts, 2008). Before risks can be managed they must be identified, and knowledge from previous experiences might apply to the current project (Karimiazari et al., 2010).

The descriptions of most risk management processes emphasize the need to identify the risks early in the process. Chapman and Ward (2003) discusses the need to identify sources and associated possible responses as well as secondary sources that arise from these responses. The quality of the primary identification phase within the risk management process has a big impact on the success of later phases within the process (Chapman R., 2001). The initial step at the early phase of the project should form the basis by which strategies, policies, uncertainties and risks are established when it comes to management and allocation (Potts, 2008). However, given that all risks are not completely recognizable before the start of a project and the fact that additional risks might arise during the implementation of the project, the identification of risk must be implemented in a manner that is in line with the progress of the project as well as being forward-looking (Schieg, 2006). The PMBOK describes the importance of an iterative approach to the process of risk identification, and the development and implementation of simple and effective responses as soon as risks are identified. However, they also mention that there is no significant sense of an overall iterative process to filter out risks in need of cautious scrutiny.

The different methodologies regarding risk source identification usually consist of checklists, brainstorming, workshops, expert interviews and analysis of different scenarios as well as analysis of historical data and project plans. Furthermore, known unknowns and sources of risk and uncertainty should be documented (Klemetti, 2006). The usage of interviews with experienced project managers can be useful for solving and avoiding similar problems that might arise, all relevant participants in the project can be interviewed on factors affecting risk.
The method of using past experience or historical data from similar projects provides insights about common factors in a comparison between the projects. The usage of checklist is a simple yet useful tool which usually covers risks identified in previous projects and the associated responses to those risks (Mhetre et al., 2016).

Winch (2002) describes risk source identification being done through brainstorming sessions and that this phase generally relies on experience. Furthermore, he emphasizes the benefits of producing some kind of risk register that covers all known risks and recognizes from an uncertainty and risk perspective, what has to be managed. The authors Skitmore and Lyons (2004) described the former method as the most common and preferable risk identification technique. Smith et al (2006) further describes brainstorming as a method where team members within a particular project focus on the risks specific to the project, also stressing the importance of avoiding potential group or individual biases by carefully managing the process. In order to generate an enhanced and balanced project risk source assessment, and to avoid the fact that the group might have insufficient collective experience to identify key risks, a common practice is to use external consultants.

The process of risk source identification as well as risk analysis may generally be viewed as the most essential phases of the risk management process given that these might have the strongest impact on the precision of risk assessment (Maytorena et al., 2005).

3.5 Risk Assessment
The identification of risk is only the first phase, some of the identified risks may be considered more significant and need to be further analyzed. The next step is to determine their significance quantitatively, before the response management stage.

The objective in risk assessment and analysis is to describe the risk situations as completely as possible and to prioritize them (Schieg, 2006). In general, there are two major categories distinguished in the literature on risk assessment, specifically qualitative and quantitative analysis. The former is a process that consists of interviews, checklists and brainstorming while the latter is performed through a data driven methodology (Banaitene & Banaitis, 2012). Risk assessment through quantitative analysis defines the impact of each risk in the spectrum of high and low and the probability of occurrence. Whereas qualitative risk assessment often involves the evaluation of impact and the development of lists in order to further analyze the highlighted risks (X.W Zou et al., 2007). The assessment of risks through both types of analysis should transpire on an individual level as well as include the interrelationship of their effects (Schieg, 2006).

It is essential that the major predictable risk factors are quantified and effectively analyzed. The impact of potential risks might be a duration increase resulting in delays, productivity decrease, and a cost increase of an activity among many others. Given that resources might be shared among different projects it may be common that disturbance in one project can result delays in other projects. Subcontractors may also cause delays (Schatteman et al., 2008).
3.5.1 Methods for Conducting Risk Assessment and Analysis

Bahar et al (1991) describe the first step in risk analysis and evaluation process as the collection of relevant data to the risk exposure, which might be historical data collected through past project experience by the contractor. Furthermore, they describe the modeling of uncertainty of a risk exposure where the likelihood of occurrence is presented in terms of probability and potential consequences in financial monetary terms. Having formed the uncertainty of various risk events the next step according to them is to assess the overall impact of these risks, through techniques such as Monte Carlo simulation.

The quantification of risks is the magnitude and frequency of each event, and every event can be a collection of incidents or a single incident. In order to quantify and evaluate the risks one can implement various analysis methods, everything from subjective estimation to probability analysis etc. (Williams, 1995).

One of the most common used methods for assessing risk sources according to Winch (2010) is the probability and impact matrix as illustrated in fig 4. The classification of the risks is made in terms of their probability of occurrence and the extend of their impact. It allows a prioritization of the risks on the project in terms of them being manageable or not. Qualitative high to low scales can be used for the assessment of known unknowns as well as the subjective assessment of known knowns as presented in fig x (Winch, 2010). PMI (project management institute) describes the probability and impact as dimensions of risk that are applied to specific events, as opposed to the overall project.

![Probability & Impact Matrix](image)

*Fig 4. Illustration of probability & impact matrix (Winch, 2010).*
The usage of a risk matrix as shown in fig 5. is often applied when dealing with static risk, i.e. risks that only have a negative effect. It resembles the probability matrix described above. A decision on how the risk are going to be dealt with is made depending on where the risk end up in the matrix. Each particular project dictates what type of risk that is acceptable or unacceptable and the colors areas should be determined with the project in mind (Flanagan et al, 2007).

![Risk Matrix Diagram](image)

**Fig. 5. Illustration of a risk matrix (Flanagan et al, 2007).**

By positioning various risks on the matrix it facilitates an overall view of them, which makes the most urgent and important risks more visible. Additionally, it helps to indicate if the risks can be mitigated through a decrease of their probability or of their consequences (Chan & Wang, 2013).

### 3.5.2 Qualitative and Quantitative Analysis

A compilation of the most commonly used methods when assessing the identified risks are listed below, including a description of each one.

#### 3.5.3 Qualitative Methods

**Probability & impact assessment** can be applied in order to evaluate the likelihood of a specific risk to occur. The risk impact on project objectives is assessed in terms of opportunities and positive effects as well as threats and negative effects. It is important to adapt and define the probability and impact to the specific project.

The **risk matrix method** can be used additionally by having probability and impact as a basis for further analysis. The priority score can be computed as the average of the probability and impact and the priority score range, rate and color are given to illustrate each risk’s significance. The high priority score threats, meaning high impact and likelihood, are viewed as high-risk and could necessitate an urgent response while low scored threats could be further monitored and given attention only if needed.

**Risk categorization** is applied as a way to systemize the threats according to their sources, in hopes of identifying areas with the highest exposure to those risks. The usage of this method...
breaks down activities into small units and creates hierarchical series of activities, additionally the method can include risk dependencies and a prioritization of them depending on how quick response they require.

3.5.4 Quantitative Methods

Sensitivity analysis is implemented in order to identify uncertain components in the project, which will have maximum impact on the outcome. The aim is to look at the sensitivity of various elements of the risk model on project outcome, by changing the values of one variable at a time and then showing the impact on the project.

Probabilistic analysis is a method used to show the potential impact of different level of uncertainties on project objectives. It quantifies the effect of risks on project schedule and budget and it uses three point estimates such as worst case scenario, most likely scenario and finally best case scenario for each task. Monte Carlo Simulation is most often used for this type of analysis.

Decision trees is a useful method to frame the problem and evaluate various options. The usage of this method consists of decision tree diagrams used to represent the project and show the effects of each decision (Mhetre et al., 2016).

3.5.5 Risk Register

The risk database as shown in fig 6 is a central tool in risk management for monitoring the risk management process (Cooper et al., 2005). The design of the register depends on the organization, the type of projects and the people involved. It is essential that the organization creates a customized version of the register that suits them in order for it to be fully used as intended, as opposed to being an additional burden in a demanding work schedule. In order to facilitate registration, storage, management and sorting of information the register should be incorporated in a database (Flanagan et al., 2007). All the identified risks and results of their analysis, associated action plans and evaluation as well as the status of the particular risk are registered within this list. Throughout the entire project life cycle there should be updates and reviews of the risk register. The register is a central component because it facilitates monitoring and correcting progress on risk mitigation measures, it helps identify new risks and close down expired risks as well as adjusting the assessment of existing risk etc. (Potts, 2008) Risks that are no longer relevant due to avoidance or if they already are managed can be removed from the register together with the associated action plans. The status of action plans and specific risks should be reviewed consistently (Cooper et al., 2005).

According to (Schieg, 2006) new additional risks, risk status and the progress of the measures is required to be included. The risks that already have occurred must be documented including the amount of damage they have produced. Furthermore, he states that a big part of the monitoring of risk (which is the last phase) is the internal control system, where the responsibility of monitoring early indicators is allocated to specific people. In order for this process to work effectively there should be a reporting and meeting arrangement in place for the project and the organization as a whole.
3.6 Risk Response

The third step in the process of risk management signifies what actions should be taken towards
the various risks and threats previously identified (Mhetre et al., 2016). The planning process of
risk response is defined by PMBOK as the development of options and determining actions to
enhance opportunities as well as reduce threats to the project objectives. This process involves
the assignment of parties to take responsibility for each agreed risk response, and the efficiency
of this phase will determine if the risks increase or decrease for the project. Literature suggests
that there are mainly four risk mitigation strategies that can be implemented in order to reduce
exposure to the risks associated with a project.

Mills (2001) provides an example where incorporated risk control measures resulted in an
added value, showing how risk and opportunity go hand in hand. The example he gave was an
instance where a hoist was provided instead of ladders to reduce the risk of people falling. The
additional benefit from the risk control measures taken was an increase in people’s mobility
and in turn their productivity. Hence, illustrating an example of potential opportunity arising
from risk.

3.6.1 Avoidance

A response in form of avoidance can be justified if the risk is estimated to have serious
consequence on such level that may warrant a reappraisal of the entire project (Potts, 2008).
One can use avoidance to cope with risk by changing project plans in a way that makes the risk
irrelevant (Klemetti, 2006), it might be necessary to reappraise the concept or maybe cancel the
project. This method promotes changing project plans to facilitate the elimination of the risk or
to protect the project objectives from the potential negative impact. An example might be
avoiding an unfamiliar subcontractor (PMI, 2000). Other examples are extending the schedule
or reducing the scope of the project (Karimiazari et al., 2010). The aim of risk avoidance might
also be to reduce the risk via contractual countermeasures. Additional measures that can be
taken into account is procedural changes, regular inspections, skill and training enhancement,
more detailed planning, preventive maintenance and the selection of alternative approaches

<table>
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<tr>
<th>IDENTIFIED RISK</th>
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<th>POSSIBLE IMPACT ON THE PROJECT</th>
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Fig. 6. Illustration of a risk register (Flanagan et al., 2007).
(Cooper et al., 2005).

3.6.2 Transfer
This response approach involves transferring the risks and consequences to third parties who are willing to accept responsibility for its management and the liability of the risk (Mhetre et al., 2016). This method is most effective in regards to dealing with financial exposure to risk. It includes the use of both contracts and insurance to transfer liability to other parties, for instance by contractor to subcontractor and often involves payment of risk premium to the party that is taking on the risk and responsibility of the consequences (PMI, 2000). In order to avoid secondary risk in case the agent (third party) fails to meet obligations, the transfer should only be done when the agent is in a better position to manage the risk than the principal (Winch, 2010). The main purpose is to ensure that the risk is owned and managed by the party best able to handle the task successfully (Mhetre et al., 2016).

3.6.3 Mitigation and Reduction
This approach means to mitigate the risk by changing the scope of the project to minimize the likelihood of the damaging event occurring (Winch, 2010). Implementing risk management early in the project to reduce the probability of the risk event occurring is more effective than trying to repair the damage and consequences after the risk has passed. The mitigation of risk may be done by adopting less complex processes or changing conditions so that the probability of impact is reduced, other forms of action is adding resources and extra time to the schedule (PMI, 2000). Flanagan et al (2007) describes implementing an altered construction method and the use of other materials to reduce potential risks, or executing a new or more detailed planning. Additional reduction strategies include contingency planning, quality insurance, separation or relocation of activities and resources. In practice these categories might often overlap in some fashion as in this case where insurance also can be a mitigation strategy, sharing characteristics with risk transfer (Cooper et al., 2005). However, risk reduction can only be used a few times in a project before the project might become unmanageable (Flanagan et al., 2007).

3.6.4 Acceptance
It is impossible in reality to take advantage of all opportunities and eliminate all threats to the project, but it is possible to at least be aware of the threats and opportunities through the documentation and identification of them. The usage of this strategy is justified when it is not possible to respond to the risk by the other strategies, or when the grandness of the risk makes a response unreasonable (Mhetre et al., 2016). This risk response approach essentially means taking a conscious risk and to deal with the consequences as they occur. This indicates a decision not to change any project plans in order to deal with the risk or engaging in any other response strategies (Cooper et al., 2005).

As described above the risk response stage involves planning and execution and should be iterative. Having an effective control process adjacent can ensure the correct execution of this phase (Klemetti, 2006). When it comes to specifically high-impact risks but also with all types of risks, one of the most beneficial risk management strategies is to delay the decision until more information comes to light (Winch, 2010).
3.7 Risk Monitoring
Continuous monitoring and review of potential risks is an important in regards to the implementation of the risk management process. It guarantees new risks are detected and managed. The project manager should monitor a list of the major risks that have been identified for risk treatment action, which should be a primary tool used management meetings (Cooper et al., 2005).

This is the final phase of the process and it is equally important as the others. Given that more information emerges one can reassess the probability and impact of the risks, and once the potential risk event has been passed they can be removed from the risk register (Winch, 2010).

3.8 Knowledge in relation to Risk Management
The construction industry is an industry where knowledge is the core competence, execution of construction activities requires expert knowledge and experience-based problem solving solutions. Most of the knowledge in the construction sector is obtained through the firms various projects, it is therefor desirable that lessons learned from previous projects is captured and used again in future projects (Maqsood, 2006).

The management of knowledge is a discipline that is associated with risk management, the process of knowledge management both influences employees’ know-how as well as enhancing the knowledge distribution among team members (Rodriguez & Edwards, 2008).

The new knowledge that is generated within each of the previous projects is often lost as involved parties retire or move to a new assignment, resulting in a loss of both tacit knowledge and a potential source of competitive advantage. It is only possible to truly reflect on the real consequences of actions when they are evaluated in hindsight (Anumba et al., 2005). A lack of storing, distributing and sharing information and knowledge generated by each project will ultimately affect the decision making process negatively (Serpella et al, 2014). The process of managing knowledge in the construction industry might not be the easiest undertaking given the inherent characteristics of the industry, in which phases are fragmented and temporary in nature (Tan et al., 2010).

Construction projects are often inherently complex and filled with uncertainty. Risk- and knowledge management are increasingly becoming an extensive component of the project management of construction projects, in a pursuit to efficiently deal with unexpected events and uncertainty (Banaitene & Banaitis, 2012).

3.8.1 The Concept of Knowledge
The most fundamental distinction, when describing the concept of knowledge, is between “tacit” and “explicit” knowledge. Tacit knowledge inhabits the minds of people and is difficult to articulate (King, 2009). It is the knowledge that you need in order to succeed in an endeavor, it is not formally taught and is can usually not be verbalized. The implicit or tacit knowledge, i.e. experience based knowledge has the potential to be transferred to a community at large or the whole organization at question (Sternberg, 1997). Explicit knowledge is knowledge that is easily conveyed and codified (Frappaolo, 2006). It exists in the form of documents, organized data, and computer programs. A fundamental issue that often is discussed when describing
knowledge is the notion of explaining tacit knowledge and then be able to make it accessible for use by others (King, 2009).

3.8.2 Knowledge Management
In order to establish an efficient risk management, it is of course required to have a systematic methodology but also various knowledge and experience, the latter might be considered even more important in a lot of cases (Serpella et al., 2014). Given the potential economic and technical implication of loss of knowledge that is bestowed on organizations and individuals, it is considered crucial that strategies exist that deals with the issue of knowledge preservation.

Although describing knowledge management might be a hard task given the lack of a singular definition, it can be stated that knowledge management is the leveraging of collective wisdom to increase responsiveness and innovation. Further, it also requires a culture that promotes faith in the notion of a collective thinking and sharing practice (Frappaolo, 2006). Knowledge management is often described as the retaining, using and sharing experiences and knowledge learned and the transfer of best practices, it is the management of experiences and tacit knowledge at a personal and organizational level. The sharing of knowledge and lessons learned is a critical area of knowledge management, hence why it is important to be able to capture experiences learned from other projects (Ly et al., 2005).

The contractual parties should adopt and maintain a continuous learning approach, from which they can gain further experience leading to a better future state for the parties when a new risk is encountered. The management of information and knowledge of a construction projects is therefore essential in order to achieve a successful risk management (Perera et al., 2009). Knowledge management is an organized and systematic approach in order to improve the firm’s ability to mobilize knowledge resulting in an enhanced decision-making, enabling proactive action and delivering results in line with the business strategy (Hsu & Shen, 2005).

The use of information in order to capture risk management experience enables project managers to share and learn from others by tapping into a centralized knowledge repository. Data should be stored and organized so that individuals as well as teams can be able to access, evaluate, and share it with colleagues and act upon the findings effortlessly (Tah & Carr, 2001).

3.8.3 Organizational Learning in the Construction Industry
Previous research from Serpell et al (2015) has observed an unwillingness among companies to contribute to research in risk management within the construction industry, given their lack of knowledge. A way to conceptualize the relationship between knowledge management and organizational learning is by motivating the creation and application of knowledge. The initiatives pay of by facilitating the organization to embed knowledge into various organizational processes, such as risk management, in order to continuously improve its behaviors and practices. Therefore, organizational learning is intrinsically important in the pursuit to sustainably improve the organizations utilization of knowledge (King, 2009).

3.8.4 Communities of Practice
The challenge is to incorporate the right method in order to enable the process of uncovering tacit knowledge and knowledge sharing. The best possible solution to the issue might be the
implementation of Communities of Practice (Khuzaimah & Hassan, 2012). These are social, interactive networks of individuals, with similar experience and problem solving skills, within a defined topic of knowledge and it is a tool to facilitate knowledge sharing in a learning environment (Wenger & William, 2000).

3.8.4.1 SECI-model
A specific knowledge conversion model for explaining the transfer of knowledge was presented by Nonaka and Takeuchi (1995), namely the SECI-model. The model consists of several methods, however only two of them are going to be mentioned given their relevance.

Socialization (from tacit to tacit knowledge):

This method is the process of sharing tacit knowledge through practice, participation in various communities, imitation and observation (Yeh, Huang, & Yeh, 2011). The purpose of Communities of Practice is to promote the uncovering of tacit knowledge by encouraging socialization among employees with similar interests, i.e. socialization is bringing together like-minded individuals (Frappaolo, 2006). Hence, new knowledge can be converted through shared experiences when using this approach. This can be applied to the construction industry by implementing apprentice-based professions, where more experienced senior project managers have the opportunity to mentor junior project managers.

Externalization (from tacit to explicit knowledge):

This method refers to the transfer of knowledge from the minds of people to an external repository in a way that is most efficient, creating for example knowledge maps (Frappaolo, 2006).
3.8.5 The Interplay between Risk and Knowledge Management

An overview is presented in fig. 7 in which one can observe the connection between risk and knowledge management. By incorporating risk management as an essential part of the corporate culture within an organization one could facilitate its development and implementation in construction projects. A key component of this is to generate an effective management of knowledge so that lessons learned could be distributed and reused in upcoming project (Serpell et al., 2015).

Fig. 7 Illustration of the interplay between Risk Management and Knowledge Management (designed by the author).

3.9 The Attitudes toward Risk

The subject of various attitudes towards risk is important since it is key to understanding behaviors associated with activities related to risk management (Baranoff & Kahane, 2009). Therefore, in order to investigate the decision-making behaviors of decision makers within the domain of construction risk management, a good understanding about their risk attitudes needs to be established (Wang & Yuan, 2011). Especially since the lack of knowledge retention and communication has always been a serious problem for the construction industry (Liu et al. 2007). There are three types of attitudes towards risk according to literature, these are the following: Risk-averse, risk-neutral and risk-seeking. People have different attitudes towards risk and the individual’s particular attitude will determine the way that they perceive risk and how they respond to risk (Raftery, 1994). Attitudes are valuable in enhancing the self-esteem of a person and serve to express an individual’s self-identity and guiding values. They are therefore important to managers because they determine the direction of people’s behavior in response to a particular stimulus and provide insights into motivating mechanisms. Individuals’ attitude is based on their own positive or negative evaluation, beliefs and knowledge about the
consequences of a certain behavior (Teo & Loosemore, 2001). Thus, peoples risk attitudes is a reflection of their personal experience and characteristics as well as the management environment in which they belong to. This explains why different project managers make different, and sometimes even opposite judgments in the same decision situations (Wang & Yuan, 2011). Winch (2010) describes project managers’ preferences in regards to risk as their propensity or appetite for the level of risk and uncertainty they are willing to accept. The model presented by Winch is based on the three different attitudes as previously stated and allows the identification of various decision making criteria in terms of risk profiles:

3.9.1 Risk-averse
People and groups are risk-averse when they are uncomfortable with uncertainty. The characteristics of this type of attitude are common sense and support of established methods of working. The presence of threat causes discomfort and leads to increased sensitivity leading to a preference for aggressive risk responses in order to minimize the risks. However, a risk-averse attitude might underrate the significance of potential opportunities (Hillson & Murray-Webster, 2005). They desire to have to have as much security as is reasonably affordable in hopes of lowering the level of distress (Baranoff & Kahane, 2009).

3.9.2 Risk-neutral
Individuals and groups with a risk-neutral attitude pursue strategies that have high future pay-offs. Hence, they view present risk-taking as a price worth paying given the future benefits. The characteristics of this type of attitude are fearlessness in face of change and the unknown, instead they visualize possibilities. The risk-neutral approach focuses on longevity when it comes to threats and potential opportunities. Thus, only taking action that is expected to result in significant benefits (Hillson & Murray-Webster, 2005).

3.9.3 Risk-seeking
People and groups that embody a risk-seeking attitude tend to have a slightly casual approach towards the presence of threats. During the risk process the risk-seeking individual inclines to identify fewer threats due to their framework in regards to risk. Threats are likely to be underestimated when it comes to potential impact and probability of the event occurring. In regards to possible opportunities, risk-seeking attitudes might overestimate their importance and pursue them in an aggressive manner (Ibid.).

The definition of attitude is twofold, the first relates to the inner working of the human mind where attitude is the mental view with regard to a fact. The second definition describes the direction of lean, this may be seen as a metaphor for the internal approach adopted by a group or individual towards a particular situation. Some attitudes are deeply ingrained and some are more malleable but they nevertheless represent a choice, hence they are situational responses and may differ depending on influences. The possibility of changing the attitudes is introduced if the influences are identified and understood. Attitudes are therefore not fixed inherent attributes of individuals or groups, rather they can be modified which is essential to the case of understanding and managing risk attitudes (Hillson & Murray-Webster, 2005).
A survey presented by Akintoye and Macleod (1997) showed that the majority of contractors perceived risk as the likelihood of unforeseen factors occurring, which could adversely affect the successful completion of the project in terms of cost, time and quality. Only one contractor saw risk as an opportunity instead of an event that will always have adverse effects. Wang and Yuan (2011) conducted a study presenting the critical factors affecting risk attitudes of contractors in the context of the Chinese construction industry. The factors considered most important where categorized into groupings such as knowledge and experience, contractor’s character, personal perception and economic environment. By deepening the understanding of the various factors that affect contractors risk attitudes, further support in regards to decision making can be facilitated.
4. Results
The following results is the data collection gathered from the questionnaire in which the questions were divided into three sections, the attitude, the knowledge, and the risk management process. Furthermore, the findings and results from the conducted interviews are presented last in this chapter. The attitude section reveals the respondents’ perception of risks and how they view risk management in terms of importance. The knowledge section focus on the respondents’ views on organizational learning and transfer of knowledge. Finally, the risk management process section reveals the practical application of risk management within the respondents’ organizations.

The respondents consisted of a variety of professions in the Swedish construction industry, hence representing the overall picture regarding the level of RM perception and implementation. The majority of the respondents in both the questionnaire and interviews had more than 15 years of experience which enhances their credibly. Contractors comprised of 86%, developers (clients) at 23% and consultants at 4.65%. Thus, some of the respondents worked in organizations consisting of both contractors and developers. The interviews consisted solely of contractors. An equal distribution among company sizes where attained in the data collection, resulting in approx. 47% of companies with more than a thousand employees and approx. 53% of companies with less than a thousand employees. A difference of opinion related to the company size will merely be mentioned when a significant differentiation can be observed between them, otherwise an overall picture of the industry will be presented due to similar answers to the questions. The respondents’ profession, experience, company size and work orientation is summarized in the appendix 8.3.

4.1 Questionnaire
4.1.2 SECTION 1: Attitude towards Risk and the Risk Management Process

Q1 How do you perceive risk within the construction industry?

The questionnaire revealed that the overwhelming majority of the respondent’s attitudes towards risk was a combination of both threat and opportunity, as presented in figure 8. Only two respondents perceived risk as being solely a threat, additional two respondents perceived risk as being something positive, i.e. solely an opportunity. However, approximately 90% (30 people) of the respondents perceived risk within the construction industry as a combination of both positive and negative associations.

Q2 What is your attitude in relation to risk?

Around 7% of the respondents perceived themselves having a risk-seeking personality while 9% observed being risk-averse. The overall majority, approximately 84%, had a risk-neutral approach and being able to balance between avoiding and seeking risks. Hence, a correlation between the perceived personalities and their attitudes is observable.
Q3 Which stage/phase do you consider most important for Risk Management?

The respondents’ answer differed quite a bit when asked at what stage they considered the implementation of risk management to be most important. The reason for this is probably due to the variety of professions amongst the respondents since business developers and consultants probably value the closeout phase more in relation to construction and site managers where planning and production risk is in higher priority. However, the findings still showed a pattern where the majority considered the planning phase as the most important phase to implement risk management. Followed by production, then conceptual phase and lastly the completion and closeout phase, as presented in fig. 9.

Q4 Which Risk Management process is most important?

Risk identification was perceived by the respondents as the most important risk management process as presented in fig 10. Risk assessment, risk response and risk monitoring phase was
considered rather equally important with small variances in opinion.

![Graph showing respondent's opinion on which risk management process they consider to be most important (the weighted average)](image)

**Fig 10.** Respondent's opinion on which risk management process they consider to be most important (the weighted average)

### 4.1.3 SECTION 2: Knowledge in Relation to Risk Management

**Q5 Have you read any courses in Risk Management and how knowledgeable are you in this area?**

The respondents’ answers varied somewhat, approximately 60% stated that they have taken courses in risk management while 40% of the respondents didn’t. Regarding how knowledgeable the respondents perceived themselves to be they had the option of grading themselves in a scale between 1 (no knowledge) to 5 (very knowledgeable). The majority, at around 69%, chose the number 4 which means they view themselves to be somewhat knowledgeable. 29% chose number 3 which means they where neither knowledgeable nor unknowledgeable while 2% chose number 5, i.e. very knowledgeable. None of the respondents chose number 2 or 1, which would be considered limited knowledge or no knowledge.

**Q6 What is the reason for inadequate Risk Management in your organization?**

The questionnaire revealed that lack of time was the main cause for inadequate risk management within the organizations of respondents. Followed by reasons such as lack of competence and lack of resources, as presented in fig 11. The contrast between lack of information and lack of competence is distinguishable, exposing that the organizations might have the available information needed in order to improve their risk management but since competence is one of the biggest factors for inadequate implementation it may fall short. Respondents who chose other reasons expressed that clear processes for risk management is the biggest liability.
Q7 Do your organization provide any education in Risk Management?

The respondents were asked if their organization provided any courses or other education in risk management and if so was the case, how beneficial or qualitative did they perceive them to be. Approximately 62% of the respondents said that their organization offers risk management education while 38% doesn’t. However, the quality of the education offered by the organizations varied, the questionnaire consisted of a star rating scale from one star to five starts in regards to quality, and on average the respondents choose three stars revealing a medium satisfaction with the education provided. A distinction between contractors and developers could be observed in which a higher amount of contractors provided education in risk management within their organizations, specifically 64% of contractors provided education in RM while 40% of developers provided education in RM.

Q8 How do you draw lessons learned from previous projects?

In regards to storing lessons learned the respondents were asked how they draw knowledge and lessons from previous projects. The results unveiled that knowledge repositories and documentation as well as the usage of communities of practice was the most frequently adopted methods used, at 64% according to fig 12. The respondents’ main comments were that they incorporate lessons learned and feedback at gatherings such as Construction Manager meetings and Site Manager meetings as well as closing meeting at the end of each month. Other statements where the usage of business and management systems. Workshops seem to be used moderately at 31% while 24% of the respondents didn’t use any specific methods for capturing knowledge within their organization.
Q9 What kind of obstacles exists for transferring knowledge and organizational learning within Construction projects?

The respondents had the opportunity to freely write their opinions on the biggest obstacles in transferring knowledge within their organization. Some of the most common comments where as follows:

- “Time and resources to handle the knowledge and database to easily identify and gather relevant knowledge and experience”
- “We do “as we’ve always done”. More clear areas of responsibility are needed for those who face the risk”
- “A fear or unwillingness of sharing both good but especially bad experiences from the projects”
- “A lack of systemized thinking with standardization of technical solutions and production methods”
- “Knowledge tend to stay within each person unfortunately”
- “The construction industry is very conservative and bad at retrieving experience and knowledge”
- “The human factor as well as time, one may rather start a new project without evaluating the previous one in sufficient way”
- “The traditional culture and behavior of project organizations”
- “We need more standardized solutions to reduce the scope of risk”

According to the respondents the biggest factors preventing the transfer of knowledge and organizational learning was the lack of time, lack of good systems, lack of resources and the organizational culture and tradition. 32 respondents out of the total 43 answered this question and the most commonly used words is presented in fig 13, which reveals that lack of time was by far the most frequent answer.
Fig 13. The frequency of the most commonly used words by respondents to describe the difficulties in learning and transferring knowledge

For some of the following questions a Likert scale was used in the questionnaire containing various statements and answer options ranging between “completely agree”, “partly agree”, “partly disagree”, “completely disagree” and finally the option of “don’t know”.

**Q10 How efficient are the communication regarding risks in your construction projects?**

The majority of the respondents at approximately 73% chose the option of “partly agree” for the following statement: “We have good and effective communication concerning risks in our projects”. The option to “completely agree” with the statement was chosen by 17% of the respondents while approximately 10% chose the option of “partly disagree”. However, a difference can be observed related to the size of the construction companies. The results indicate that larger companies with more than a thousand employees where overall less satisfied with the communication regarding risk, compared to the smaller companies.

Approximately 57% of larger companies with more than a thousand employees chose “partly agree” in having an effective communication while 22% chose “partly disagree” and 21% chose “completely agree”. On the other hand, 87% of smaller companies with less than a thousand employees chose “partly agree” while 13% chose “completely agree”.

4.1.4 SECTION 3: Risk Management Process

**Q11 Statement: “My organization has a clear risk identification process”**

The majority of the respondents at approximately 55% answered “partly agree” while 34%
agreed completely on the statement and 11% partly disagreed. No respondent answered “completely disagree” or “don’t know”.

**Q12 How do you personally identify risks?**

Approximately 60% of the respondents (25 people) stated that they identify risks by experience, 19% (8 people) was using analysis for risk identification and 12% chose knowledge as their answer as presented in fig 14. No one of the respondents chose “Intuition” as an option nor “don’t know”. Around 9% chose other as an answer stating they usually combine all of the options when identifying risks or only some of the options, such as experience and analysis. One of the respondents stated that he used BF9K certification which is a management system such as ISO certification but adapted for companies in the construction industry.

![Fig 14. Respondents answers on how they personally identify risks](image)

**Q13 Which method do you use for risk identification?**

Experience from previous projects as well as the usage of checklists was equally chosen amongst the respondents, at approximately 88% (37 out of 42 respondents) and thus exposing them as the most frequently used methods for risk identification. Thereafter came brainstorming at around 48% as presented in fig 15 and third party at 38%. Finally source identification at around 33%, interviews at 12%, no method at 0% and other at about 7%.
**Q14 Statement: “My organization has a clear risk assessment process”**

The majority of the respondents answered “partly agree” at about 50%, 28% agreed completely while approximately 17% disagreed somewhat. 3% chose “completely disagree” or “don’t know”. When comparing this statement with the previous regarding having a clear risk identification process a 5% and 6% decrease in the percentage can be observed, regarding the options “partly agree” and “completely agree”. On the other hand, one can observe 6% increase in the option “partly disagree” chosen by the respondents as well as a 3% increase in “completely disagree” and “don’t know”.

**Q15 Which Qualitative Risk Assessment method do you use?**

The respondents chose probability and impact assessment at approximately 29%, followed by risk matrix at 26% and risk classification or risk register at 22%, as can be seen in fig 16. No implementation of any method ended up at 9% while the option of “don’t know” and “other” ended up at 7% each.
**Q16 Which Quantitative Risk Assessment method do you use?**

Probability and impact analysis was the most frequently chosen option by the respondents at about 48% (20 people), followed by the lack of any particular method used option at 20%. Sensitivity analysis as well as the unawares of any risk assessment method was estimated at approximately 11% for each one of them. The usage of decision trees for risk assessment was conveyed by 7% of the respondents. Other methods used was estimated at 3% of the total participants stating that the assessment method varies depending on the situation, as illustrated in fig 17.

![Quantitative risk assessment methods used according to the respondents](image)

**Fig 17. Quantitative risk assessment methods used according to the respondents**

**Q17 Statement: “My organization has a clear risk response process”**

The overwhelming majority of the respondents answered “partly agree” at 76% which is an increase in 21% and 26% in comparison with risk identification and risk assessment. 17% of the respondents agreed completely at approximately 17% and about 7% disagreed somewhat with the statement. The where no responses to the option of “completely disagree” and “don’t know”. Another distinction that can be observed is a 18% decrease for the option of “completely agree” in relation to risk identification and a 12% decrease in relation to risk assessment.

**Overview of the statement questions**

An overview of the statement questions Q11, Q14, Q17 is presented in fig 18. The respondents viewed their organizations as having best clarity in regards to the risk response process, although the they didn’t fully and completely agree with that statement but rather moderately. The figure reveals that the majority of the participants viewed their organization as having somewhat clear processes for identification, assessment and response to risks, hence implying
that probably more could be done to implement more well-defined processes for all employers to embrace.

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**Fig 18.** Respondents answer in regards to whether their organization has clear processes for identification, assessment and response to risk.

**Q18 How do you respond to risks?**

The questionnaire consisted of additional statement questions in regard to risk response methods in order to estimate which methods they usually implement within their organizations. The majority of the respondents chose the "partly agree" option regarding avoidance at 62%, mitigation at 61% and acceptance at 55% while transfer had a response rate of 36%. Regarding the "completely agree" option the respondents most often chose mitigation of risks at 32%. The transfer of risks was the most divided opinion since 36% of the respondents chose to "partly agree" while 38% chose to "partly disagree", aditionally 22% chose to completely disagree, as presented in fig 19.

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**Fig 19.** Respondents answer on how they respond to risk according to response methods such as avoidace, transfer, mitigation and acceptance.
as avoidance, transfer, mitigation and acceptance.

4.2 Interviews
The interviews conducted in this study where in line with the survey with the aim to obtain more depth regarding the subject area. Thus, the questions asked where also divided into attitude, practical implementation, and knowledge in relation to risk management.

4.2.1 The Perception of Risk Management
All of the respondents viewed management of risk as very critical for the project success since risks could be detrimental for the project if not managed in time. However, it varied amongst the respondents depending on their profession. None of the interviewees had previous knowledge about the risk management concepts as described in this study. Nonetheless, even though they didn’t know the scientific methods according to literature they still described the process of managing risks very comparable in terms of identification, assessment, response and monitoring. Every respondent felt that managing risks at an early stage was very important. A construction manager amongst the respondents mentioned that since they have high turnovers and small profit margins around 3-5% that risk management is absolutely essential, he further stated that a failed project required a lot more successful projects in order to even out. The majority of the respondents felt that their risk management where more robust in the production phase since they where more solution oriented rather than business oriented, and that they where more likely to deliver a good product and achieve client satisfaction than economical gain, which they felt where equally important. Another respondent’s opinion regarding the perception of risk within the construction industry was that many developers deny it, and that they think the contractor should solve a lot of the problems.

4.2.2 Risk Management Process
4.2.2.1 The Identification of Risks
The common denominator in terms of risk identification among the respondents was the use of checklists as well as individual experience and experience from previous projects.

According to all of the respondents, from a contractor’s perspective the identification of risks starts when they receive an inquiry from a developer, by evaluating the location, circumstances, surroundings and communication, as well as assessing the developer before any decision on a partnership is made. Hence, the initial assessment is made from an economical point of view, whether the project will be profitable or result in big financial losses and is done by the calculation division within respective organizations. One respondent stated that they recently rejected a major project due to unsatisfactory drawings and descriptions. Other criteria where developers’ insufficient liquidity or poor references such as displeased customers and previous contractors, one respondent articulated it as “do we dare to work with a particular developer? We have to get paid for our work”.

Then, when a project starts as well as throughout the entire duration of the project the biggest risk factor was the work environment which would receive the main focus, according to the majority of the respondents. Construction managers who worked with all types of risk such as production, financial and work environment emphasized the importance of finding the
economically most advantageous execution, which brings about a cost and time. He stated that they try to keep down the execution and production time as much as possible in order to facilitate monetary gain, but identified risks might result in choosing execution that might be more expensive and take longer time.

The usage of checklists and documentation was frequent amongst the respondents in terms of risk identification in the early stages of a project. One respondent described the checklists as a “living document” since they continuously expand it with experience. An example of a checklist regarding environmental risk used by Swedish contractors is presented in the appendix 8.2. The method of brainstorming was also commonly used where every individual could contribute with their own experience as well as having discussions about lessons learned from previous similar projects. Checklists was described as essential for identifying risks in the work environment, especially when it comes to inventory of work with risks that require special measures and these are in line with work environment legislation. One respondent that works as a project manager stated that they strive for zero risks in regard to safety among workers, by implementing special security days in which they could shed light on various risks and make sure the rules are followed such as personal protective equipment and fall protection etc. This was a way to give the employees an opportunity to tell the management what they find troubling during the project, so that the management could explore ways to reduce the risks. Other respondents had security checks every week or even every day depending on the size of the project, in which checklists was the main method for risk identification. One respondent stated that also the architects must ensure that there is a manual for safety hazards during the conceptual phase as well, which may be used as a foundation for additional checklists.

4.2.2.2 The Assessment of Risks
Brainstorming in terms of discussions and experience was a frequently implemented method amongst the respondents when it came to assessment of potential risks. These kind of meetings required the collection of relevant data from previous experience as well as governing documents. The most shared answer was the use of probability and impact analysis. However, the practical implementation varied amongst the interviewees given that none of them had any previous knowledge about any of the specific scientific methods for risk assessment underlined in this study. The application of assessment methods had similarities with literature but with more of a simplistic approach rather than a structural and rigid one. The probability and impact analysis was generally described as a process of evaluating the risks by giving it a number between one to five, from the smallest to the highest risk. The numbers assigned to specific risks was determined on the basis of experience rather than probability calculations and was prioritized accordingly in a descending order. The impact was analyzed such as if the specific risk occurs what type of damage it would bring, and if the risk is high and have the highest negative consequences in accordance to their probability criteria then that risk would receive the biggest focus on trying to eliminate or minimize. One respondent stated that they often have joint risk assessment together with the developer, in which they go through checklists have meetings and discussion where brainstorming is done automatically. The usage of interviews was mentioned as an indirect method in areas where professionals had experience from similar projects, such as various consultants with expertise, knowledge and information within their professional field. An essential part of the assessment was to include in the documents how the
risk was going to be managed if the situation occurred, and the process was continually
implemented and reviewed on a regular basis, in accordance with the description of a risk
register.

4.2.2.3 The Response and Monitoring of Risks
The application of risk responses and monitoring of risk was implemented in various ways
depending on the organization and profession of the respondents. One respondent stated “in
construction projects there is a lot that isn’t technically solved, and there is uncertainty, thus it
is important to have an action plan for how to find out solutions to the problem”. Discussions
was the most shared answer in regard to mitigating and avoiding problems in the production.
Respondents emphasized the importance of brainstorming and discussing the plan of works
with the employees in production who would perform the job as well as include them in the
assessment process, since they might prefer other kind of technical means than the one that the
site manager suggests. Respondents underlined the usage of an internal system where they
report all types of incidents, even the smallest ones such as if an employer stumbled upon some
wood which no one cleaned up or if they got something in the eyes due to neglecting protective
goggles. The document is used in order to learn from past incidents and avoid that particular
risk in the future.

None of the respondents had knowledge of the risk management strategies outlined in literature
but they all used them subconsciously in some capacity. Some of the respondents revealed a
reluctance in regard to transferring any risk except for financial risks while others expressed a
necessity depending on the situation. One respondent stated “we try to isolate the risks through
contractual agreements with subcontractors, consultants and suppliers”, further explaining that
the use of risk transfer was usually done for specific risks such as fire hazards rather than
general risks such as traffic. A majority of the respondents had experience feedback on their
projects, both internally as well as with the client in regard to monitoring the risks and capture
the knowledge for future references.

4.3 Knowledge in relation to Risk
The level of implementation in regard to organizational learning related to risk varied among
the respondents but all of them facilitated some type of platform for knowledge transfer and
learning within their organizations.

One respondent stated that his organization had a meeting once a month with all officials in his
department. That purpose of the meeting was to share experience and communicate what what
they managed to accomplish well but also things that went badly. Furthermore, once a year they
arranged site manager meetings for discussions and to further their experiences. Another
respondent described it as dialogue meetings, in which the officials get to tell each other what
projects they are working on and what they are facing at the moment. His organization arranged
more frequent site manager meetings which they called site manager forums, these meeting
facilitated a platform for them to review each others monthly reports, discussing upcoming
challenges and giving them the opportunity to get tips and advice from colleagues. There where
no specific segment about risks in these meeting but they perceived challenges to be the same
as risks and that risk is a topic that blends in all conversations. Respondents also described
construction site meetings once a month with the craftsmen for the purpose to review and improve their work until next time, expressing the importance of involving the craftsmen in the process. One respondent mentioned that his organization arranged work environment training and education for both site managers and the craftsmen (occupational workers?) at least once a year, in which they focus on highlighting different risk factors and situations.

The usage of knowledge repositories was also a common answer among the respondents with varied degrees. Some respondents where fairly satisfied with them while others felt that they needed to be improved. One respondent stated that she could easily add her experience into their knowledge repositories and that other site managers within their organization all around Sweden could receive the information and have an exchange of ideas and solutions. It was described as a search engine in which they could type in keywords related to their challenges and get information from other colleagues. Another respondent described a similar platform in which they would try to find previous similar projects and see who participated, then they would do a deeper informal interview with them in order to understand what type of risks they faced in the project as well as how they managed them. Other respondents experienced difficulty in documenting knowledge, specifically the transfer of individual knowledge between team members. One respondent stated “we could be better at spreading the knowledge within the organization and trying to find systems where we can view observed risks from previous projects to the next project that might have similar risks”. Other complaints about knowledge repositories where the massive amount of documents and data. One respondent stated “if you are to gain experience from other projects, you must go through the protocols which is a quite heavy job, besides you may feel that its not applicable to your new project since we construction managers tend to think that their own project is special”.

Respondents emphasized when they are in the final phase of a project they immediately start another project making it quite stressful, one respondent said “you don’t try to stop and think about what you managed well or failed in the previous projects”.

The biggest obstacles in organizational learning where the fear of admitting mistakes, and the idea that “this is how we have always done things”, as several respondents expressed it. One respondent implied that “the challenge is to find a good system to reach the staff that needs the knowledge, the right knowledge to the right person, at the right time”.
5. Analysis

5.1 What is the perception of risk and risk management?
The findings indicate that the attitude among Swedish contractors regarding risk is a combination of both opportunity and threat. This contradicts the results presented by Akintoye and Macload (1997) where the construction industry is predominantly risk averse. However, the findings in this study correspond to the explanation given by Hillson and Murray Webster (2005) concerning how risk is perceived when observing official risk management standards, i.e. including both opportunity and threat rather than solely a negative connotation which was more common before the turn of the millennium. Furthermore, the overwhelming majority of the respondents in both the questionnaire and the interviews described themselves as being risk-neutral rather than risk-averse or risk-seekers, which coincides with previous studies such as Lyons and Skitmore (2004). Hence, their attitudes and perception of risk is in line with their risk approach profile as risk-neutral decision makers.

One of the interviewees viewed risk as overall negative consequences depending on the type of risk, although he stated that an opportunity might be found when dealing with financial risks. However, the majority of respondents described risks as two fold in terms of threat and opportunity since risks might lead to exploring other ways of managing hazardous situations which may be more prosperous.

The overall perception of risk management in terms of the importance of adopting an efficient process of managing the risks where shared among all the interviewees. They all felt that managing risk is critical in order to achieve project objectives. The projects in the construction industry is filled with risks and uncertainty, thus it is essential to have an effective risk management process in place. The concept described in literature facilitates the ability to maximize the opportunities and simultaneously reduce the threats. However, no universal standard or method could be observed among the respondents in the interviews, the implementation of risk management varied in practice and none of the respondents had previous knowledge of the concepts in the structured manner as can be found in literature. Nonetheless, the four stages (identification, assessment, response, monitoring) where considered the core process within the construction industry even though there are many methodologies used for risk management, as affirmed by Smith et al (2006).

The findings from the interviews revealed that even though the respondents didn’t have previous knowledge regarding theoretical models and processes they still had analogous organizational processes. Hence, they were indirectly practicing risk management similar to the concepts described in literature. Respondents described a general identification process in order to shed light on various risks followed by an assessment of the risks and a prioritization depending on impact and probability, which was determined by experience and discussions. The process was also iterative and continuous throughout their projects according to the respondents, which is an essential information loop principal used when describing the use of an effective risk management implementation, as explained by Winch (2010). In terms of work environment risks one respondent stated that they made sure to manage a high impact risk scenario straightaway while the low risks were allowed to be fixed during a longer time period. All respondents emphasized the importance of discovering risks as early as possible since
influence is easier in the beginning, such as choice of construction methods as described by Eskesen et al (2004).

The questionnaire revealed that the respondents perceived risk management to be most important during the planning and production phase rather than the conceptual and completion phase, the finding corresponds with the study made by Lyons and Skitmore (2004) which contradicts the opinion that the conceptual phase is the most essential for risk management. However, the result illustrates that every phase is considered highly important since the planning and production phase didn’t exceed the other phases significantly. This outcome is probably due to the fact that the participants of the questionnaire consisted of various professions within the industry, in which different risks are considered.

Furthermore, out of the four core processes in risk management the respondents viewed risk identification to be most important while assessment, response and monitoring where rather equally significant. This parallels the claim by Banaitene and Banaitis (2012) that the identification process might be viewed as the most crucial step.

5.2 How is knowledge managed in relation to risk management?

Inadequate knowledge regarding risk management, as it is described in literature, seem to be a common thread amongst the respondents, even though they in practice actually implement some of the theoretical strategies without being aware of it. However, the findings from the interviews revealed that none of respondents had read any separate courses in risk management, instead some of them had RM interwoven in other types of training such as internal education in safety, another respondent had read construction law for instance. Thus, even though 60% of the respondents had education in RM according to the survey, it might be a bit misleading if they perceived the courses as non separate RM courses. Another interesting observation was that a higher amount of contractors provided education in RM as opposed to the developers and the overall quality of the courses seem to be viewed as average. Still, the majority of the survey participants perceived themselves as somewhat knowledgeable in risk management.

The results from the questionnaire indicate that lack of time is the biggest obstacle for an insufficient risk management implementation which is consistent with research by Lyons & Skitmore (2004) and Ly et al (2005). Insufficient knowledge in this area might stem from the lack of time within the construction industry. The findings suggest that there is no shortage of information but the lack of competence is noticeable. Tan et al (2010) states that the phases in the construction industry are temporary and fragmented which complicates the process of managing knowledge. This issue could also be identified though the questionnaire and interviews since lack of time was the predominant factor among both respondents, and new projects often begin without making time for the individual to reflect on the risks from the previous project.

Other obstacles discovered though the data collection was the overall corporate culture within the industry, for instance a fear of sharing bad experience which could contribute to the increase of unknown unknowns as described by Winch (2010) regarding project risk classification. Counterintuitively it is perhaps the most important experience one could share in order to improve on RM in construction projects. Another part of the culture issue is the notion that
things are supposed to be handled as they have always been, indicating some fear of change within the industry. The findings also indicate that one of the biggest difficulties is the transfer of knowledge between employees which is a fundamental issue in terms of making tacit knowledge accessible for use by others, as described by King (2009). Time constraints and the cultural practice within the construction industry have been prominent factors for insufficient capture and transfer of project knowledge in similar research (Ly et al., 2005).

The organizations learn from previous projects mainly through communities of practice and knowledge repositories, both methods had equal frequency among the respondents. The interviews revealed that the majority of respondents felt satisfied with the experience documentation through internal knowledge repositories, although the biggest hurdle was to achieve an effective way to transfer individual knowledge and the distribution of that knowledge throughout the organization. Tah et al (2001) described the capture of RM experience through the use of knowledge repositories but the problem in practice was the extremely high amount of documents and data which could be intimidating, especially when time constraints is a big factor, on top of that another issue was that it was too general and not specific to risks although risks are included in the data. A solution could be to create a specific risk repository as an option besides the ordinary database. Communities of practice was facilitated through the arranged meetings among colleagues at various levels, such as separate site and construction manager gatherings as well as creating meetings including both management and occupational workers. Thus, the method of socialization as explained in the SECI-model was frequent in the process of sharing tacit knowledge among respondents. Review of projects and the challenges faced by coworkers where shared in which risks and threats was discussed but the findings revealed that they generally didn’t have RM as an exclusive segment during theses meeting. A way to enhance the distribution of knowledge for risks in particular could be to incorporate separate risk meetings during these gatherings.

The questionnaire results indicate a significantly better communication about risk among respondents that worked in smaller construction companies compared to larger sized companies. Furthermore, the interviews revealed that smaller sized contractors tend to have one project manager that follows the entire project and is involved in multiple areas such as procurement, planning, makes purchases and has daily contact with production, developers and authorities. That particular person has the best knowledge about the project and it can be critical if that person quits the job resulting in a loss of tacit knowledge but also the new knowledge that is created throughout the particular project, as described by Anumba et al (2005). The decision making routes are naturally shorter for smaller sized contractors yielding a better communication, but the down side is that they become more person-dependent, which in itself is a risk. At larger construction sites it is increasingly important that the person who is responsible for work environment risk is close to production since the risk of being too far from those affected by them is higher. The larger contractors can take more risks due to the financial muscles and a larger property portfolio, so they can afford a bad result for a few years compared to smaller sized companies. However, larger companies mean larger organizations which means that communication among multiple professionals within the organization have a higher possibility to fail. On the other hand, larger contractors have the capacity to employ professionals working exclusively with risk management which is a big advantage.
5.3 How is risk management implemented in the Swedish construction industry?
Risk management for projects within the construction industry is a formal process with the aim to identify, assess and response to potential threats and opportunities. The questionnaire revealed that construction companies in Sweden perceived to have partially clear processes regarding the core elements, i.e. identification, assessment and response to risks. Furthermore, risk identification was viewed as the most rigid process amongst the respondents which corresponds with research made by Uher and Toakley (1999) and Lyons and Skitmore (2004).

5.3.1 The Identification of Risks
Respondents indicated a reliance on mainly experience when it comes to personal identification of risks, after which analysis and knowledge was used. However, a study made by Maytorena et al (2007) suggests that the element of experience for risk identification is less significant than it is commonly assumed to be. Their findings revealed that the level of education and RM training as well as information search style played the biggest part in risk identification performance. The most common methods for identification of risks among the respondents where checklists, experience from previous projects and brainstorming which is consistent with several comparable studies (Chapman 2001; Lyons & Skitmore, 2004; Akintoye & MacLeod 1997). A focus on financial risk identification is the first step upon receiving a bid request according to the interviewees, in which the contractor evaluates the developer and the project at hand in order to see if it is a beneficial endeavor. However, the majority of the respondents worked in production with work environment risks where the usage of checklists where predominant, an example of a checklist is presented in appendix 8.2. They facilitated preventive routines within each project where they could review the construction site at least every week with the aim to identify risks and document them on checklists. The process could be described as proactive rather than having a reactive approach, the latter is often the case within the construction industry according to Loosemore et al (2006). Respondents stressed the importance of a regular implementation of this method given that new risks often arise.

The usage of brainstorming within project teams (communities of practice) where common through arranged meetings, with the aim to discuss the identified risks and share experience from previous projects. The regular meetings usually consisted of site managers and supervisors but in larger projects the construction manager and project managers where involved more often. The management also made sure to have the occupational workers attain the meetings since they work in production and are in the frontline of safety and work environment risk. PMI (2000) describes the importance of involving multiple project stakeholders in the risk identification process, that belief seem to be shared among the respondents and their respective organizations. When combining the findings from the questionnaire and the interviews it can observed that professionals in the construction industry are using risk identification methods as described in literature. However, none of the interviewees had read any courses in risk management, instead they followed their own organizational RM procedures which could be described as analogous to RM in literature.
5.3.2 The Assessment of Risks

The findings from the questionnaire illustrates that qualitative risk assessment where used in higher variety than the quantitative methods. Probability and impact assessment, risk register and risk matrix techniques where used in highest frequency among the respondents in terms of qualitative assessment, while probability analysis or no method where most common when it came to quantitative methods. However, the interviews revealed that brainstorming in terms of discussions among team members was the main method for risk assessment as opposed to a data driven methodology such as quantitative analysis. There seem to be an overall preference for the use of qualitative methods of risk analysis which can be confirmed in this study through the interviews, similar studies have reached the same conclusion (Banaitene and Banaitis, 2012; Lyons and Skitmore, 2004). None of the interviewees had any knowledge of the structured techniques described in literature, instead they implemented their own assessment methods such as scoring the risks based on discussion and experience, in which the highest number where placed on the most critical risks. Respondents mentioned that the assessment process for work environment was done on a regular basis in conjunction with the protection rounds every week, in which the site managers assessed the risks immediately based on their own judgment and experience, which was also the most commonly used risk assessment techniques described by Lyons and Skitmore (2004). An implementation of any data driven methodologies seemed to be unnecessary in terms of work environment risks according to respondents. However, respondents who also worked with financial risks where interested in data driven methods and expressed that they where willing to try out new tools.

5.3.4 The Response and Monitoring of Risks

There are mainly four risk mitigation strategies as described in literature, avoidance, transfer, mitigation and reduction, and finally acceptance. The questionnaire result indicate that the Swedish construction industry most frequently implements avoidance and mitigation, thereafter acceptance. The transfer of risks had the most diverse answers and a difference between the contractors and developers could be observed, developers generally implemented the transfer of risk more frequently than the contractors. Furthermore, contractual agreements where most frequently used for transferring risk as opposed to insurance which is consistent with research done by Lyons and Skitmore (2004), and respondents stated that since risk is usually associated with a cost it is important to include that in the contracts. It is a common practice to “sell the risks” as another respondent expressed it. An example given was to bulldoze, one can see the surface but have no idea how it looks underneath, in that case one could sell off the risk of uncertainty beneath the surface.

The interviews revealed that respondents performed risk response strategies analogous to the methods described in literature without being aware of it. The importance of establishing long-term relationships with subcontractors was mentioned among some respondents which is an avoidance strategy (PMI 2000), this helped them being more transparent and honest with each other regarding risk. In terms of work environment, respondents engaged in risk avoidance through regular inspections on a weekly basis and preventive maintenance as described earlier. Engagement in risk response early in projects is a risk mitigation and reduction strategy which was shared by all interviewees, such as for example changing work environment conditions immediately when seeing some potential hazard situation. A site manager mentioned that if she
notices that a fall protection is missing, then it is a high priority that the railing returns so that no one falls down and hurt themselves and she makes sure measures are taken immediately to reduce that risk. These type of work environment risks are assessed every week and the priority is often determined by the experience of the site or construction manager. Flanagan et al (2007) describes an example of the mitigation strategy when implementing altered construction methods, this is facilitated through discussions and brainstorming between site managers and the occupational workers, as revealed by the interviews. Risk acceptance was shared among respondents in terms of small risks, meaning they were aware of them stating “let it happen, and we will handle it then”. Thus, a risk response might be considered unreasonable for such risks as described by Cooper et al (2005).

The monitoring of risks was implemented automatically through regular checkups and documentation on checklists by the management, as well as by arrangement of continuous meetings throughout the project. Risk management is definitely implemented within the Swedish construction industry, but it is not adopted in the structured way as suggested in literature. The majority of the respondents revealed that they had no previous knowledge of the RM concepts as they are laid out in theory but they are still responding to risk in ways that can be described as analogous to RM theory.
6. Conclusions
The perception of risk within the Swedish construction industry is two fold, including awareness of both threats and opportunities and the majority of professionals in the industry have a risk neutral approach, contrary to previous research. The importance of implementing an effective risk management is shared among actors in the industry, especially in the planning and production phase while risk identification was perceived to be most important out of the four core processes.

Theoretical models and processes for risk management is fairly unknown within the Swedish construction industry and although they implement analogous methods the adoption of risk management is not as structured as described in theory. Thus, actors partake in risk management indirectly, similar to the concepts described in literature. However, the greatest reason for inadequate implementation of risk management and insufficient capture of knowledge in relation to risk is the lack of time, competence and the corporate culture. Organizational learning in relation to risk management is mainly done through the usage of knowledge repositories and communities of practice. Still, the biggest obstacle was to achieve an effective way to transfer tacit individual knowledge and the distribution of that knowledge throughout the organization. Furthermore, the findings in this research revealed that risk management wasn’t documented separately in the knowledge repositories and communities of practice didn’t include risk management as an exclusive segment however the topic of risk was always present during these gatherings.

In a comparison between larger and smaller actors in the construction industry an observation is that smaller sized contractors evidently had better risk communication due to shorter decision making routes. However, they are more person-dependent which in itself also becomes a risk.

The findings conclude that construction companies in Sweden have partially clear processes regarding the four core elements of identification, assessment, response and monitoring of risk. The research revealed that the most common methods for risk identification among the respondents where checklists, experience from previous projects and brainstorming during arranged meetings. Qualitative risk assessment where used in higher variety than quantitative methods, the findings indicate that a simplistic assessment approach was preferable regarding work environment risks and data driven methodologies was deemed unnecessary except for financial risks. Risk response and monitoring is performed analogous to literature in terms of work environment risk, the most frequent strategies where avoidance, mitigation and finally acceptance while transfer of risks where more common among developers. Thus, the research revealed that the practical implementation of risk management was equivalent to concepts in literature regarding identification, response and monitoring of risks. However, the assessment of risks varied from the literature in a higher degree. The conclusion is that even though companies perform the processes and concepts analogous to theory they don’t share definitions and concepts.
Construction companies can yield great benefit through the usage of combining of risk- and knowledge management. This notion is however underutilized in the present. A solution could be to incorporate specific risk repositories such as the risk register together with the knowledge database in a separate and distinctive manner and thus facilitating an easier way to access information about risks for similar projects. Furthermore, this would promote the importance of risk management since a big issue with the knowledge repositories is the large amount of data, and knowledge of risks are imbedded in large stacks of documents. Exclusive segments of risk management should be integrated with communities of practice in order to endorse risk management in the corporate culture and to further enhance the organizational learning of risk management.

6.1 Recommendations for Future Studies

The research in this master thesis is focused on attaining an overview of the Swedish construction industry with regards to risk- and knowledge management, and the perspective of contractors. Recommendations for further research is to investigate how the combination of risk management and knowledge distribution is applied in a particular construction company, supporting the development of standardized definitions and concepts in the industry. Future studies could examine how a particular risk in construction projects is managed and how it modifies and adjusts throughout the project phases, with an approach grounded in knowledge management. Furthermore, the research done in this master thesis revealed an interest in data driven methodologies with regards to risk assessment of financial risks, it would be of interest to further examine this topic and develop an industry standard data model.
7. References


8. APPENDIX

8.1 Interview questions


Tack på förhand!

Mvh, Dario Petrovic
dariop@kth.se

Bakgrundsinformation

- Vad jobbar du med?
- Hur länge har du jobbat inom byggnärsbranschen?
- Har du läst några riskhanteringskurser?

Attityd i förhållande till risk

- Vad har du för inställning till risker?
- Vad anser du i allmänhet om riskhantering inom byggnärsprocessen? (viktigt/oviktigt)
- Vilken skede/process är viktigast enligt dig?
- Hur ser du på era förutsättningar att hantera risk gentemot stora/små aktörer inom byggnärsbranschen?

Frågor gällande riskhanteringsprocessen

Identification av risker

- Hur identifierar ni risker & potentiella möjligheter?
- Använder ni några specifika metoder? (Brainstorming, intervjuer, checklistor, tidigare erfarenhet osv.).
- Har du några egna förslag på hur man optimerar identifieringsfasen?

Värdering av risker

- Hur värderar ni risker?
- Använder ni några specifika metoder? (Kvantitativ/kvalitativ analys)

- Har du några egna förslag på hur man optimerar bedömningsfasen?

Åtgärder & uppföljning

- Vilka åtgärder görs för att reducera de identifierade riskerna? (Överföring, begränsning acceptans, försäkringar, undvikande, kontrakt osv.).

- Hur följer ni upp risker?

• Kunskap i relation till risk

- Hur ser ni till att fånga upp och bevara kunskap och lärdomar från tidigare projekt? (workshops, kunskapsförråd, kommunikation osv.)

- Vad ser du för hinder vid kunskapsöverföring i relation till riskhantering inom er organisation?

8.2 Example of a Checklist – Work environment risks
### INVENTORY OF WORK WITH RISKS REQUIRING SPECIAL MEASURES

<table>
<thead>
<tr>
<th>Risks</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Work at risk of falling to lower levels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Work near high voltage lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Work that involves drowning risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Work in tunnels/wells and/or construction work underground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Work in which explosives are being used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Work in area of passing traffic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Work involving demolition of bearing structures or hazardous substances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Work involving assembly/dismantling of heavy building elements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Work with chemical substances which present a risk to health and safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Work that involves an exposure to ionizing radiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Work that involves the risk of being buried underground or falling into loose soil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

... ...

### INVENTORY OF OTHER TYPES OF RISK

<table>
<thead>
<tr>
<th>Risks</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Work involving mobile work machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Work that involves the risk of falling objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Work where high negative stress may occur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Work that might involve inappropriate posture during work (ergonomics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Work that involves special means for emergency evacuation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Work involving body vibrations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Risk of working alone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

... ...

Risks that are marked with **YES** are passed further for detailed risk assessment and response measures on the next page.
<table>
<thead>
<tr>
<th>Work activity</th>
<th>Risk</th>
<th>Response Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Caulking, reinforcement, casting</td>
<td>Falling</td>
<td>Do not start any work on the floor coat before the required protective rack is mounted</td>
</tr>
<tr>
<td>2 Excavation &amp; pits</td>
<td>Buried under ground masses</td>
<td>Necessary guard rails around excavations and pits</td>
</tr>
<tr>
<td>3 Sealants, markingcolour</td>
<td>Chemical substances</td>
<td>Read the safety datasheets before use, and use the required protection</td>
</tr>
<tr>
<td>4 Lifting heavy material with crane or tractor</td>
<td>Falling objects and clamping</td>
<td>All employees must use protective helmets, and do not go under hanging material</td>
</tr>
<tr>
<td>5 Displacement of workplace</td>
<td>Passing traffic</td>
<td>All employees must use approved safety clothes in the work area</td>
</tr>
<tr>
<td>6 Mounting window</td>
<td>Heavy lifting</td>
<td>Use necessary tools such as mechanical- and manual glass lifts</td>
</tr>
<tr>
<td>7 Screw plaster</td>
<td>Repetitive strain injuries</td>
<td>Choice of equipment and methods</td>
</tr>
<tr>
<td>8 Drilling and carving with impact drill</td>
<td>Vibrations</td>
<td>Do not use vibrating machines beyond the recommendations of the manufacturer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety data sheet</th>
<th>Installation instructions</th>
<th>Trailing medical check-up</th>
<th>Inspection</th>
<th>Security check</th>
<th>Working’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Signature Safety Officer
Signature Construction Work Coordinator
### 8.3 Questionnaire Respondents & Data

#### All respondents

<table>
<thead>
<tr>
<th>Profession</th>
<th>Nr of Answers</th>
<th>English translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utvecklingsingenjör</td>
<td>12</td>
<td>Construction Manager</td>
</tr>
<tr>
<td>Regionchef</td>
<td>8</td>
<td>Site Manager</td>
</tr>
<tr>
<td>Arbetschef</td>
<td>7</td>
<td>Regional Director</td>
</tr>
<tr>
<td>Arbetschef</td>
<td>4</td>
<td>Business Unit Director</td>
</tr>
<tr>
<td>VD</td>
<td>3</td>
<td>CEO</td>
</tr>
<tr>
<td>Projektledare</td>
<td>1</td>
<td>Project Leader</td>
</tr>
<tr>
<td>Projektutvecklare</td>
<td>1</td>
<td>Project Developer</td>
</tr>
<tr>
<td>Arbetsledare</td>
<td>1</td>
<td>Supervisor</td>
</tr>
<tr>
<td>Affärsutvecklare</td>
<td>1</td>
<td>Business Developer</td>
</tr>
<tr>
<td>Projektkonsult</td>
<td>1</td>
<td>Project Consultant</td>
</tr>
<tr>
<td>Avdelningschef</td>
<td>1</td>
<td>Head of Department</td>
</tr>
<tr>
<td>Miljöchef</td>
<td>1</td>
<td>Environmental Manager</td>
</tr>
<tr>
<td>Arbetsmiljöchef</td>
<td>1</td>
<td>Working Environment Manager</td>
</tr>
<tr>
<td>Utvecklingsingenjör</td>
<td>1</td>
<td>Development Engineer</td>
</tr>
<tr>
<td>Total:</td>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

**Total: 43**
### Companies

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor</td>
<td>86.05%</td>
<td>37</td>
</tr>
<tr>
<td>Developer</td>
<td>23.26%</td>
<td>10</td>
</tr>
<tr>
<td>Consultant</td>
<td>4.65%</td>
<td>2</td>
</tr>
</tbody>
</table>

### Respondents work experience

<table>
<thead>
<tr>
<th>Years</th>
<th>Percentage</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 5</td>
<td>2.33%</td>
<td>1</td>
</tr>
<tr>
<td>5 - 9</td>
<td>9.30%</td>
<td>4</td>
</tr>
<tr>
<td>10 - 14</td>
<td>18.60%</td>
<td>8</td>
</tr>
<tr>
<td>15 &lt;</td>
<td>69.77%</td>
<td>30</td>
</tr>
</tbody>
</table>

### Company size

<table>
<thead>
<tr>
<th>Size</th>
<th>Percentage</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 1000</td>
<td>46.51%</td>
<td>20</td>
</tr>
<tr>
<td>&lt; 1000</td>
<td>53.49%</td>
<td>23</td>
</tr>
</tbody>
</table>

100.00%   43