Aalto University
School of Science
Degree Programme in International Design Business Management

Kati Pihko

Efficient and Effective Execution of Recurrent Construction Projects

Master's Thesis

Espoo, 30.6.2015

Supervisor: Professor Kari Tanskanen

Instructor: MSc Jouni Kukko

AALTO UNIVERSITY
School of Science
International Design Business Management

ABSTRACT OF THE
MASTER´S THESIS

Author:
Kati Pihko

Subject of the thesis:
Efficient and Effective Execution of Recurrent Construction Projects

Number of pages:	Date:	Library location:
95	30.6.2015	TU

Professorship:	Code of professorship:
Operations and Service Management	TU-22

Supervisor:
Kari Tanskanen, Professor

Instructor:
Jouni Kukko, MSc Eng. and MSc Econ.

This study examines increasing efficiency and effectiveness of construction projects by reducing non-value adding activities from the contracting process and benefiting from repetitive nature of projects. The construction industry in general suffers from low productivity growth and processes that contain a considerable amount of waste and thus companies have lately begun to invest in developing their execution process in addition to the outcome. The study focuses in operations executed in pre-construction phase as most costs and objectives are determined before construction begins and thus efficiency and effectiveness can also be influenced significantly at that stage.

The empirical part of the research was executed as a qualitative case study. The case organisation of this study is a Finnish municipal contracting organisation that operates in the construction industry. The study also included benchmarking of other organisations' processes. In total 20 semi-structured were conducted for data collection.

The research identifies that efficiency of project-based production is highly dependent of several actors that are often included into projects. Thus, people also affect process development practices and in order to increase efficiency and effectiveness of a contracting process, all project team members and stakeholders have to be motivated to eliminate waste and develop the process continuously. In general waste is generated if the actors don't share objectives or the collaboration isn't effective. These issues can be addressed with successful project network management. Also it was found out that the preparatory work done with stakeholders prior to construction design sets a basis for an efficient process. In addition, the study concludes that recurrent nature of projects can be exploited by standardising the project network and transferring people from project to project, replicating process and solutions to a certain extent to subsequent projects and creating bids so that suppliers can anticipate realising economies of repetition.

Keywords: project-based production, pre-construction process, waste reduction, economies of repetition	Publishing language: English

AALTO-YLIOPISTO
Perustieteiden korkeakoulu
International Design Business Management

DIPLOMITYÖN
TIIVISTELMÄ

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<tr><td colspan="3">Tekijä:
Kati Pihko</td></tr>
<tr><td colspan="3">Työn nimi:
Toistuvien rakennuttamisprojektien tehokas toteuttaminen</td></tr>
<tr><td>Sivumäärä:
95</td><td>Päiväys:
30.6.2015</td><td>Työn sijainti:
TU</td></tr>
<tr><td colspan="2">Professuuri:
Tuotannon ja palvelujen johtaminen</td><td>Koodi:
TU-22</td></tr>
<tr><td colspan="3">Työn valvoja:
Kari Tanskanen, Professori</td></tr>
<tr><td colspan="3">Työn ohjaaja:
Jouni Kukko, DI ja KTM</td></tr>
<tr><td colspan="3">Työssä tutkitaan rakennuttamisprojektien tehostamista karsimalla arvoa tuottamattomia toimintoja prosessista sekä hyödyntämällä projektien toistuvuutta. Rakennusala on yleisesti ottaen kärsinyt vaatimattomasta tuottavuuskasvusta sekä prosesseista, joihin sisältyy paljon hukkaa, minkä vuoksi yritykset ovat hiljattain alkaneet panostaa myös tuotantoprosessiensa kehittämiseen rakennusten kehittämisen lisäksi. Tutkimus keskittyy suunnitteluprosessin aikaisiin toimintoihin, sillä suurin osa kustannuksista sekä projektin tavoitteista määräytyvät ennen rakentamisen aloittamista, joten myös tehokkuuteen voidaan vaikuttaa merkittävästi siinä vaiheessa.

Tutkimuksen empiirinen osuus toteutettiin kvalitatiivisena tapaustutkimuksena. Tutkittu tapausorganisaatio on suomalainen kunnallinen rakennuttajaorganisaatio. Tutkimus sisälsi myös muiden organisaatioiden prosessien vertailuanalyysia. Empiiristä tutkimusta varten toteutettiin 20 teemahaastattelua.

Tutkimuksessa todettiin, että projektituotannon tehokkuus on vahvasti riippuvainen monista tahoista, jotka usein kuuluvat projekteihin. Täten ihmiset myös vaikuttavat prosessin kehitykseen ja jotta prosessin tehokkuutta voitaisiin nostaa merkittävästi, on kaikkien projektitiimin jäsenten sekä vaikutusvaltaisten sidosryhmien edustajien oltava motivoituneita hukan poistoon sekä prosessin jatkuvaan kehittämiseen. Yleisesti ottaen hukkaa syntyy, mikäli eri tahoilla ei ole yhteisiä tavoitteita tai yhteistyö ei ole tehokasta. Näitä haasteita voidaan käsitellä onnistuneella projektiverkoston johtamisella. Tutkimuksessa myös selvisi, että sidosryhmien kanssa tehtävät valmistelevat työt ennen rakennussuunnittelua luovat alustan tehokkaalle prosessille. Lisäksi huomattiin, että projektin toistuvuutta voidaan hyödyntää vakioimalla projektiverkosto ja siirtämällä ihmisiä projekteista toisiin, monistamalla prosessin elementtejä sekä suunnitteluratkaisuja jonkin asteisesti myöhempiin projekteihin sekä luomalla tarjouspyyntöjä siten, että toimittajat ymmärtävät hyötyvänsä hankinnan skaalasta.</td></tr>
<tr><td colspan="2">Asiasanat: projektituotanto, suunnitteluprosessi, hukan vähentäminen, toistuvuus</td><td>Julkaisukieli: englanti</td></tr>
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ACKNOWLEDGEMENTS

This Master's thesis was done for the City of Espoo, Premises Department as a part of my studies in Aalto University School of Science.

I am grateful for my instructor Jouni Kukko for his enthusiasm towards the research topic, time he invested into discussing the thesis with me and his wise guidance during the study. I also wish to thank Professor Kari Tanskanen for supervising this thesis and giving me valuable advice about conducting academic research and words of encouragement during the process.

I am also thankful to all the people who took time to give an interview for the purpose of this study - discussing the topic with several people made the research process interesting, but also taught me excessively about the topic. In addition, I want to thank all the employees of the Premises Department for relaxing discussions at coffee breaks and making me feel part of the work community.

Finally, my gratitude belongs to my family and friends who constantly encouraged me during the research process. Especially I'm thankful to my flat mates with whom I often spent intensive writing weekends in our kitchen.

ACRONYMS

IPD	Integrated Project Delivery
LPDS	Lean Project Delivery System
LPS	Last Planner System
TCO	Total Cost of Ownership
TPS	Toyota Production System
VSM	Value Stream Mapping

TERMINOLOGY

Economies of repetition
"Reductions in costs and improvements in project effectiveness gained by moving from the first-of-its-kind bid or project to the execution of many similar projects within cost, schedule and the required specifications." (Davies and Brady 2000)

Economies of scale
Improved efficiency gained by carrying out a process on a larger scale than before.

Inter-project learning
Acquiring, creating and capturing knowledge gained through experience and transferring it to a succeeding project. (Prencipe and Tell 2001)

Lean
A production philosophy that originates mainly from Toyota Production System

Pre-construction phase
Pre-construction phase includes the operations prior to construction and e.g. phases of initial planning (in Finnish tarveselvitys), conceptual planning (in Finnish hankesuunnittelu) and construction design.

Project team
In this thesis project team refers to the design and implementation team that supervise and execute the design and implementation of a construction project.

Purchasing
"Management of the external resources of an organisation. Operations, maintenance, management and development of the organisation require several products and services as well as know-how and knowledge from outside the organisation. Purchasing aims to exploit opportunities of supplier markets in order to satisfy end-customer's needs with an approach that maximises the total benefit of the organisation." (Iloranta and Pajunen-Muhonen 2008)

Similar projects
Projects that are implemented with same capabilities and routines. (Davies and Brady 2000)

Stakeholders
In this thesis stakeholders refer to parties that affect a construction project with objectives and requirements but aren't included into the direct project team i.e. don't participate in designing and implementing a project.

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1 INTRODUCTION

1.1 Background

Project-based production is prevalent in the modern society as it is common that major societal investments and economic activities are organised around projects. However, project-based production has been accused of not being as efficient as high-volume manufacturing to which researchers have compared it repeatedly to (Hobday 1998, Davies and Brady 2000) in order to understand whether successful methods that are capitalised in the manufacturing environment could also benefit project-based production. Yet, researchers have found several differences between the nature of high-volume production and project-based production, which complicates the transfer of best practices. Unlike in high-volume manufacturing, products of project-based production are tailored to specific customer requirements. The involvement of a customer is much higher in project-based production than in manufacturing of standardised customer goods, since the customer is involved in modifying the product in product development and implementation phase. (Davies and Brady 2000). The active role of a customer makes systems integration and project management core capabilities of project-based supplying (Hobday 1998). Because of the small tailored batches of products supplied by project-based production, similar scale and scope advantages as in high-volume production are difficult to reach (Davies and Brady 2000). Projects are also usually executed by a unique project team that is created in the beginning of a project. Also a significant feature of projects carried out by project-based firms is that the project teams usually involve more than one company. (Artto and Kujala 2008).

Previous research argues that because of unique customer requirements, varying project teams and one-off nature of project activities, project-based production doesn't provide as good environment for efficient repetition than high-volume production (Winch 1997, Hobday 1998). Usually after a project finishes, the team dissolves and has little time to reflect on the project or document the experience before moving on to other projects (Brady and Davies 2004). This is troubling since there is a risk that knowledge is lost and same mistakes are repeated in subsequent projects unless the experience gained in a project can be transferred to future projects (Winch 1997). Despite the difficulties of capturing learning gained through projects and transferring it to future projects and wider organisation, Davies and Brady (2000) argue that projects do offer opportunities for learning since companies tend to undertake similar projects, which involve repeated and therefore predictable patterns of activities. Similar projects are defined as projects that are executed with same capabilities and routines. They claim that project-based

activities shouldn't be equated with non-routine behaviour and suggest that since projects are often seen as performing only unique and non-routine tasks, many lessons that would have potential to be transferred are left uncaptured.

Davies and Brady (2000) argue that project-based firms can gain economies of repetition by learning to execute a growing volume of similar projects more efficiently and effectively. Economies of repetition mean cost reductions and increased project effectiveness realised by moving from first-of-its-kind project to undertaking many similar projects within cost, schedule and other specified requirements. Horman and Kenley (1996) argue that efficient and effective are often used in a synonymic manner even though the words have slightly different meaning. Effective implementation means maximising the value of outputs whereas efficient execution refers to eliminating or minimising non-value adding activities from production. Davies and Brady (2000) argue that in project-based production advantage can be gained more from the repetition of projects and execution of repeatable solutions than from scale or scope. In addition to resulting in lower costs, staying in schedule and meeting other required specifications, the repetition of projects enables organisational learning as recognisable patterns tend to occur and are therefore able to be captured.

1.2 Research context

Project-based firms are companies that organise their core design and productive activities into projects in order to provide unique solutions for their clients and thus reach their business objectives (Davies and Brady 2000, Hobday 2000). An example of project-based firms is companies operating in the construction industry. The context of this study is the public sector of the Finnish construction industry.

The productivity growth of the Finnish construction industry has been slow compared to other industries. The phenomenon has been widely recognised by industry experts who have begun to develop approaches to eliminate non-value adding activities from production processes and to increase the productivity growth. (Merikallio and Haapasalo 2009). Non-value adding activities are also called waste (Womack et al. 1990, Merikallio and Haapasalo 2009). Researches have concluded that for example large variety of production practices, scattering construction projects to several actors, common low-bid tendering method, unequal risk sharing, unreliable plans and inability to exploit the recurrent nature of projects increases the amount of waste occurring in the industry and make productivity growth challenging. (Merikallio and Haapasalo 2009).

1.2.1 Description of the case organisation

The studied organisation is a Finnish municipal contractee organisation, the City of Espoo, Premises Department. Espoo is located in southern Finland and is the second largest city of Finland in terms of population. The population of Espoo increases

approximately by 3500 people annually. Especially the amount of young children and elderly is estimated to increase rapidly in the near future. (Espoo 2013). The fast growth of population raises the demand for public services. Consequently, new venues must be acquired in a fast pace to accommodate the increased amount of services.

The Premises Department is a public utility that procures new premises and maintains existing buildings. They aim to offer functional, cost-effective and safe premises for the services and citizens of Espoo and to supervise that the value of the premises is preserved. In order to reach the goals, the department is responsible for an investment budget worth of approximately 100 million euros annually. (Espoo 2014). Since the department manages numerous construction projects, development of their contracting process has potential to result in major savings. They also want to understand how the recurrent nature of their similar investment projects could be exploited in order to procure high-quality buildings in an even faster pace.

The City of Espoo has five sectors: Corporate Group Administration, Education and Cultural Services, Social and Health Services, Technical and Environment Services and Public Utilities Sector. The sectors are guided by city council, city board and corresponding committees and boards. In the organisational chart, The Premises Department is located under the Technical and Environment Services with e.g. City Planning Department, Building Control Department and Technical Services Department. (Espoo 2015 a). Construction projects managed by the Premises Department involve collaboration with the other departments of Technical and Environment Services as well as departments from other sectors depending on the nature of a project. (Espoo 2014).

The empirical part of this study focuses in nursery school projects as they form a significant share of projects contracted by the Premises Department and the demand for new ones is constant since the amount of young children in Espoo is estimated to increase in the upcoming years. In figure 1 is presented an estimate of the amount of children that are entitled for nursery schooling in the upcoming years.

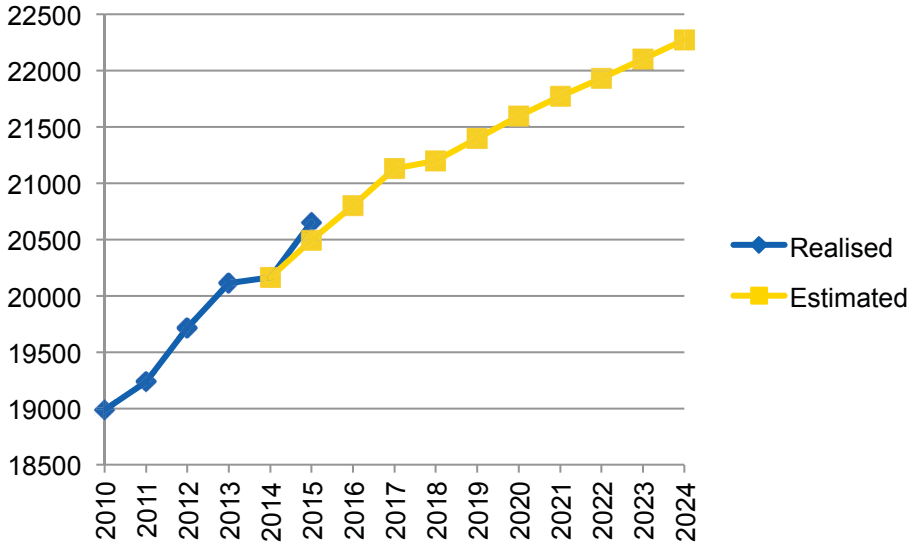


Figure 1 *Amount of children entitled for nursery schooling (reproduced from Espoo 2015 b)*

1.3 Research objectives and questions

The objective of the study is to understand how a municipal contractee in the construction industry can execute their similar and recurrent projects more efficiently and effectively. In other words the study aims to find out how waste can be eliminated from a public contracting process. On the other hand, the aim is also to find out how the repetitive nature of similar projects can be utilised in the waste elimination. Increasing the efficiency and effectiveness of project implementation will result in reduction of lead times and total costs of projects and high quality of buildings.

Before proceeding to the construction phase, a construction project is planned and the construction is designed. Lindholm (2009) argues that majority of the costs of a construction project are determined before the actual construction begins. Also the ability to influence project objectives is on its highest level before the construction begins (Abdul-Kadir and Price 1995). Therefore, the objective of the study is not to examine how a contractor could reduce the lead time or cost of the actual construction phase, but to research how a public owner could organise their own activities in order to enable increased efficiency and effectiveness of their similar recurrent construction projects. The researched actions occur in the phases of initial and conceptual planning and construction design. The activities include project management duties like for example organising procurement of design team and contractor and collaborating with stakeholders.

The context of the study is investment projects in the construction industry and the viewpoint is that of a public owner. However, the literature review also includes research from other industries that organise their core design and productive activities as

projects. The study extends previous research by locating the pursuit of economies of repetition and waste elimination to the context of a public owner organisation in the construction industry. In addition, most of the existing research that focuses in the effect of repetition in construction projects, only examines the actions occurring in the construction phase at site (For example Gottlieb and Haugbølle 2010). This research concentrates in actions executed in the pre-construction phase.

In order to investigate, how a public owner in the construction industry can execute their similar recurrent investment projects more efficiently and effectively, two main research questions and two sub-questions are set. The research questions are created so that in the first question the context is actions occurring inside a single contracting process. In the second question the scope is larger - the context includes several projects.

The research questions are:

1. How can a municipal contractee organisation increase the efficiency and effectiveness of the pre-construction process of their single construction project?
    a. What factors in the pre-construction phase increase the lead time and total costs of a project?

2. How can a municipal contractee organisation exploit the recurrent nature of similar projects in order to enable efficient and effective execution of projects?
    a. How does simultaneous implementation of similar construction projects affect the efficiency of the process?

1.4 Structure of the thesis

The thesis is structured as follows: a literature review introducing literature about topics relevant to the research questions follows this chapter. In the third chapter, the methodology for empirical research as well as data and analysis of the empirical research are presented. In the fourth chapter, the research questions are answered based on the results of the study. Finally, a conclusion and evaluation of the study as well as recommendations for the case organisation are presented in the fifth chapter.

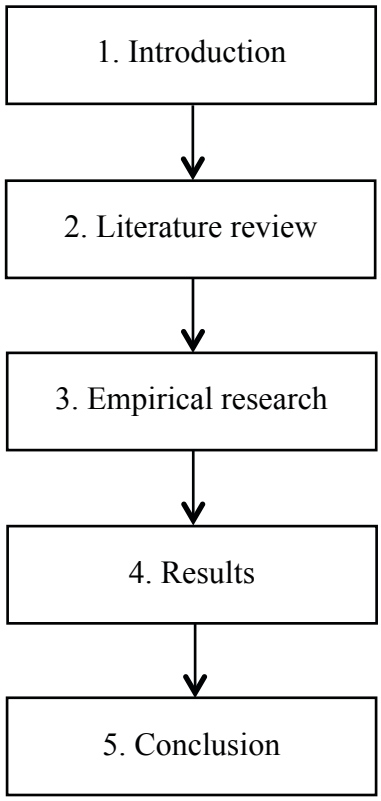


Figure 2 *Structure of the thesis*

2 LITERATURE REVIEW

The literature review introduces research from four main areas in order to generate a comprehensive understanding of the research context. First, the literature review discusses front-end phase of project execution since the research context limits to the pre-construction phase of construction projects. Second, waste reduction from a process in a project context is discussed. Third, since the case projects include various suppliers and the projects are highly dependent on their actions, literature concerning purchasing and supply chain management is introduced. Finally, literature about economies of repetition in a project environment is presented, since the context of the study is recurrent and similar projects.

2.1 Execution of the early stages of a project

This chapter introduces literature about execution of the early phases of a project emphasising the value as well as challenges of the beginning of the process. The topic is included in the literature review because the research focuses in activities implemented in the pre-construction phase of construction projects. In order to understand the context properly, literature concerning construction projects is included in the chapter, but not solely limited to, as there isn't a considerable amount of research concerning the early phases of construction projects.

2.1.1 Process of the pre-construction phase

Pre-construction phase refers to the stage that occurs prior to construction including work like inception, design and tendering (Wood 2010). Rakennustieto (2013) divides the pre-construction stage into five main phases: initial planning, conceptual planning, preparation for design, design and preparation for construction. After these phases, a project proceeds to construction and maintenance. However, Abdul-Kadir and Price (1995) note that in real life the project phases might not be consecutive but somewhat parallel.

During initial planning the necessity of space acquisition or space modification is justified. A preliminary description of requirements regarding the spaces is also given. In addition, different alternatives are investigated and the profitability of the solutions is estimated. The phase ends with a project decision. (Rakennustieto 2013). At this stage the information about the project is highly insufficient. Therefore, estimating the costs

explicitly is challenging. The cost estimation that is drafted at this stage should include considerable risk factors to address multiple risks and uncertainties. (Rissanen 2013).

After the project decision has been made, the project continues to conceptual planning. At this stage the precise objectives regarding the construction's scope, functionality, quality and costs as well as the project's budget and schedule are set. The site of the construction and the procurement method of the project are also decided. The conceptual planning phase ends with an investment decision. (Rakennustieto 2013). Pitkänen (2009) argues that in the capital area in Finland, site selection plays a major role in total costs since majority of the sites with easy conditions are already occupied and new buildings must be established on sites with challenging soil. When building on challenging soil the excavation costs are significant. Masterman (2003) suggests that a primary cause for construction project failures is failure to choose the best procurement method. The effect of design-bid-build, design-and-build and Integrated Project Delivery procurement methods will be discussed more in detail in chapter 2.2. The target cost for a project is also set during conceptual planning by estimating the costs based on the volume of required space (Kankainen and Junnonen 2001). Also initial sketches of the construction can be utilised when making the estimation. Even though the information about the project is much more precise at this stage than before, the target cost should still include risk factors (Rissanen 2013).

When the investment decision has been made, preparation for construction design begins. In this phase the project owner is responsible for organising the design process by holding possible competitions, selecting the designers, and creating a contract with the entities. (Rakennustieto 2013). In case the owner is a public organisation and the cost of a project exceeds the threshold values presented in national or EU directives, the owner must tender the job (Iloranta and Pajunen-Muhonen 2008, Morledge and Smith 2013). Purchasing in the context of a public organisation will be discussed more in detail in chapter 2.3.

The construction design includes several cycles of design and iteration as the design team produces several rounds of increasingly detailed plans. The project management and representatives of client participate actively in the design phase by examining the plans and supervising that the requirements are attended and different alternatives are considered in terms of e.g. price, energy consumption et cetera. The price of the plans is estimated twice during the design phase. The estimate shouldn't exceed the target cost or design iterations will continue until the required cost is reached. After all litigant stakeholders have approved the main construction drawings the project owner applies for a building permit. (Rakennustieto 2013).

During preparation for construction, a project owner is responsible for organising the construction process by organising possible competitions, selecting a contractor and

negotiating a deal with them. The procurement of sub-contractors can be included in the duties of the main contractor or the owner can procure them as well. (Rakennustieto 2013). Similarly as when procuring the construction design, public organisations must tender the job if the cost exceeds the threshold value set in the public procurement law.

2.1.2 Influence of the pre-construction phase

Williams and Samset (2010) argue that effective management of the front-end phase of a project contributes to the overall project as better design and improved productivity in the later stages. However, they acknowledge that development of actions taken in the planning phase of projects has been much slower than the development of the implementation phase, even though the value of the early stages has been understood for a long time. Consequently, the early stages of construction projects have attracted only little interest among researchers (Kolltveit and Grønhaug 2004) as a prevalent focus in research has been the activities occurring at the site during construction (Abdul-Kadir and Price 1995). Kolltveit and Grønhaug (2004) claim that the quality of the early stages of a construction project can have a significant influence on the overall project performance and therefore project success. They define early phase as the stage from starting a project to finishing the activities that are implemented after project has been decided to be executed. Effective execution of the activities in the early stage can also notably contribute to value generation. They conclude that conceptual development and strategic planning should take place in the early phase of a project. Abdul-Kadir and Price (1995) add that proper exploitation of the pre-construction phase is a prerequisite for productivity improvement on site. Thus, a construction project should be examined holistically instead of stressing only one phase.

The decisions made in the conceptual phase affect the nature of decisions to be made in further stages. Unsuccessful implementation of the beginning of a project can lead to conceptual changes that can be expensive at later phases of a project since the decisions made in the conceptual phase of a project have a significant influence on the total cost of a project (Abdul-Kadir and Price 1995). Accordingly, majority of the costs of a construction project are determined before the construction begins even though major share of costs is realised on site (Vuorela et al. 1998, Lindholm 2009, Abdul-Kadir and Price 1995). In figure 3 is presented the ability to influence the total cost and the actualisation of them during a construction project.

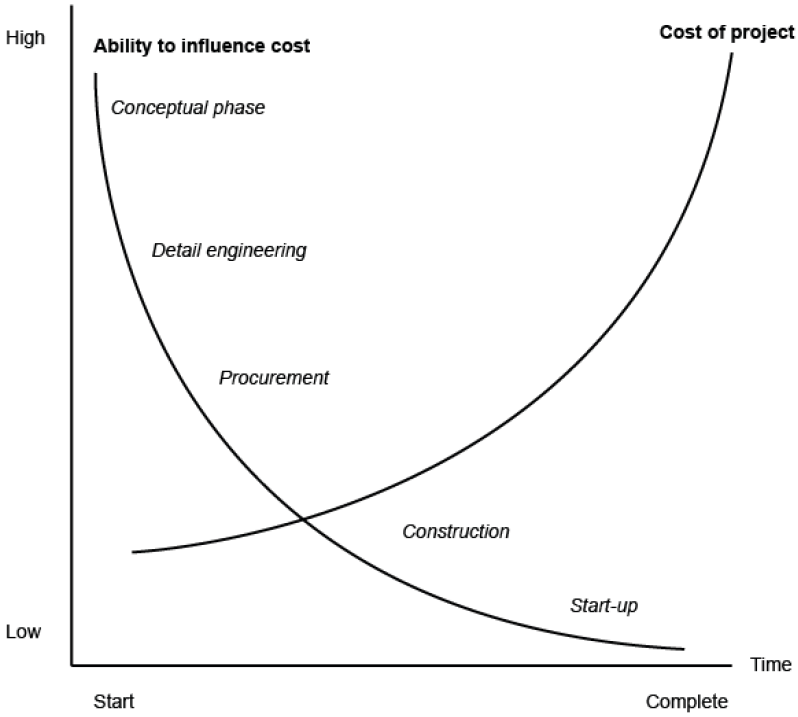


Figure 3 *Comparison of the ability to influence final cost and the determination of costs (reproduced from Abdul-Kadir and Price 1995)*

However, Perttilä and Sätilä (1992) argue that even a bigger share of costs than those realised during construction, accumulates during the maintenance phase of a building. In figure 4 is presented the relative shares of costs that occur during a building's whole life cycle.

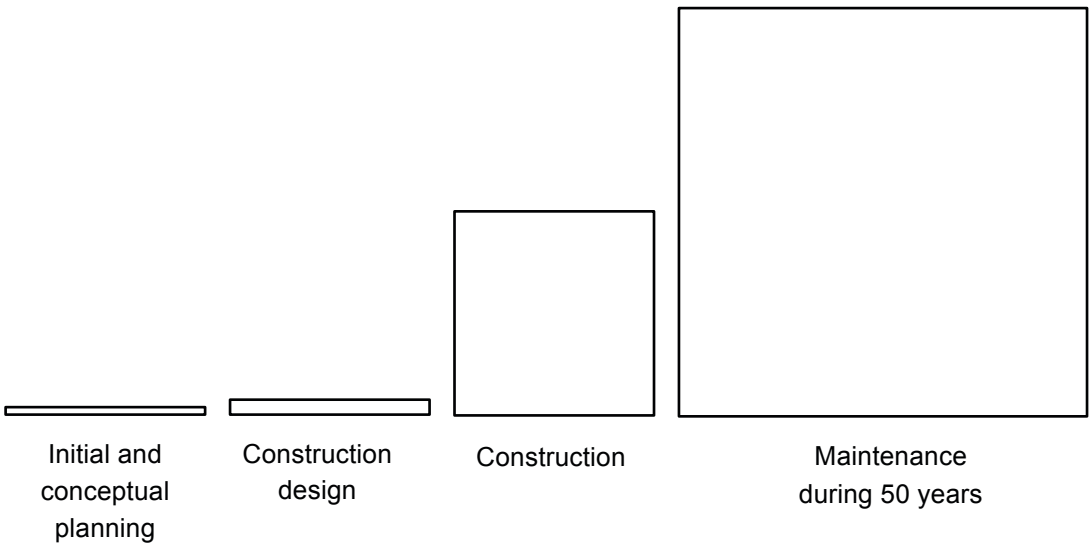


Figure 4 *The relative share of costs of a building during its life cycle (modified from Perttilä and Sätilä 1992)*

Figures 3 and 4 identify that the share of costs of the construction and maintenance phase are significantly bigger than the share of cost of the pre-construction phase. On the other hand, the ability to affect the final cost is high before the construction phase. Therefore, it is wise to invest in the design phase by ensuring enough time, money, effort and other resources. (Perttilä and Sätilä 1992). Haahtela and Kiiras (2013) argue that when setting objectives for a project the client must understand how their decisions affect the total cost of a building during its life cycle. Therefore, cost management activities should be involved in a project right from the beginning in order to estimate the effect of suggested design solutions, to compare alternatives and to produce information for the client in order to guide their decision-making.

2.1.3 Challenges of the pre-construction phase

Kolltveit and Grønhaug (2004) argue that there exists a high degree of project uncertainty in the early stages of a project. The uncertainty can be fundamentally problematic for overall project performance since the most important decisions concerning the project life cycle are made at this point. Dvir et al. (2003) claim that effort to explicitly define project goals and objectives - including both functional and technical specifications - should be maximised at this stage since there is a significant correlation between the effort and project success, especially from the viewpoint of an end-user. They also stress the importance of involving the end-user in the project right from the beginning. Williams and Samset (2010) state that in order for a project to succeed in strategic terms the team should have a broad long-term vision. Succeeding in strategic terms means producing the right solution.

However, in the context of construction projects, it is challenging to have a broad long-term vision because the level of uncertainty is significantly higher in the future and actions more hypothetical, since even the conceptual phase of a project can span over several years. Due to the nature of a construction project, management of costs differs significantly from e.g. accounting in a manufacturing environment. In a project context the costs are estimated as early as possible in order to have time to make changes and improvements. (Pelin 2004). However, vast amount of information that becomes more exact as the project proceeds is characteristic for a construction project. Especially in the beginning explicit information is rarely available and therefore the person making the cost assessment must make assumptions and estimations based on their experience and expertise. Nonetheless, when the project proceeds it is common that some of these assumptions are found incorrect. (Rissanen 2013). Especially incorrect or incomplete information about site conditions can be troubling for cost management since total costs can be significantly influenced in the pre-construction phase by proper site selection and location of the building on site (Lindholm 2009).

In the beginning of a project, the influence of all external stakeholders is on its highest level and can have a significant impact on the overall performance. Construction

projects at this stage have several stakeholders, such as the client, users, possible sponsor, project manager and employees. The stakeholders all have different interests depending on their role in the project. In the beginning of a project when the objectives and agenda of a project aren't defined and the cost of making changes is still low, the external stakeholders can express their wishes and therefore influence the direction of a project. Their influence can be positive, but also create challenges in situations where different stakeholders have conflicting aims. (Kolltveit and Grønhaug 2004).

In the construction design phase, problems arise if client's needs aren't defined precisely and communicated well to the architect and other designers. Tangible needs concerning the space e.g. volume and surfaces are in general understood and communicated efficiently. However, fundamentally troubling is when abstract needs, such as architectural expression, feeling or beauty, are misunderstood due to for example vague vocabulary. Also clients are eager to suggest solutions instead of pure requirements. If clients can't master their demand it's not likely that they can correctly evaluate the offer in terms of evaluating the proposal's consistence with their requirements. As a result, changes in plans occur repeatedly increasing the costs and delaying the process. (Mauger 2012).

Experts in the construction industry believe that more effective execution of the early phase of a construction project can indeed lead into better overall performance and project success. However, some industry experts notice that currently clients tend to dominate this phase and therefore the talent of industry experts can't be exploited to the fullest. Clients and external stakeholders tend to be less qualified to deal with the strategic issues that have major impact on project success than with the ones that have only a marginal effect on the results. The conservative nature of the construction industry also limits major experiments to exploit the opportunities of the conceptual phase. The industrial culture doesn't encourage companies for this type of behaviour. Also contracts and incentives, competence, management commitment, the execution process, and public framework conditions hinder the interest towards evolvement of the conceptual phase. (Kolltveit and Grønhaug 2004). Belayutham and Gonzalez (2014) claim that the conceptual phase differs from actual construction since it involves more organisational than technical knowledge. The processes included in the pre-construction phase tend to be complex (Wood 2010). Problems occurring at this stage can originate from poor communication, insufficient documentation and information, disintegration and lack of construction knowledge (Tzortzopoulos and Formoso 1999).

2.2 Reducing waste from a process

In this chapter waste reduction from production process is examined. Eliminating waste from a process is linked to increasing efficiency of a process and therefore relevant for the research questions. Also Lean thinking and Lean construction are introduced in this

chapter as the concepts are closely related to waste reduction as one part of the Lean philosophy addresses waste elimination from production process.

Waste is the actions that are executed in a production process but don't produce value for a customer (Womack et al. 1990). Piirainen and Saarinen (2013) note that these non-value adding activities can neither be charged from a customer. GoLeanSixSigma (2015) categorises types of waste into the eight following groups:

1. Defects – Efforts that are caused by rework
2. Overproduction – Production of more than is needed than before it is needed
3. Waiting – Time wasted for waiting for the next step in the process
4. Non-utilised talent – Underutilisation of people's talent, knowledge and capabilities
5. Transportation – Unnecessary movement and transportation of items and information
6. Inventory – Inventory and information that is not being processed
7. Motion – Unnecessary motion caused by e.g. workspace layout and ergonomic questions
8. Extra processing – Production of something else than required by the customer e.g. too high quality or extra work

Piirainen and Saarinen (2013) evaluate that biggest sources of waste in the construction industry are inefficient communication and documentation, insufficient exploitation of suppliers and employees, production of a wrong product or service, made mistakes and lengthened lead times. Merikallio and Haapasalo (2009) argue that in the construction industry large variance of procedures and large amount of actors increase the amount of waste in processes. The current general bidding habits of the industry and way of organising production also generate waste. Also a considerable amount of waste stems from the unreliable execution of plans and schedules. In addition, the unique and one-off nature of projects generates waste as the standard parts of projects are not exploited but solutions are planned from scratch.

2.2.1 Lean philosophy

Lean is a production philosophy that aims to maximise the value created for a customer and eliminate all the actions that don't generate value for them from the production process. The five main principles of Lean include identifying value from the customer's perspective, recognising what activities don't add value and eliminating this waste from the entire production process, arranging the value-adding activities into a continuous flow, responding to customer pull and pursuing perfection. Therefore, the aim of Lean philosophy is to create an efficient process that creates maximum value for a customer with the utilisation of minimum resources. Lean thinking derives mostly from Toyota

Production System (TPS) (Womack et al. 1990). Hines et al. (2004) argue that Lean has become one of the most significant contemporary paradigms concerning production.

Lean philosophy has evolved from its origin and keeps developing as new ways to enhance processes are realised. Thus, a core principle of Lean is continual improvement and Lean organisations continuously aim to increase their efficiency and generate more value for a customer as the fifth principle of Lean guides. (Womack et al. 1990, Hines et al. 2004). Morgan and Liker (2006) claim that when an organisation starts to practice Kaizen – a Japanese paradigm of continuously making small improvements that together have a potential to result as considerable upgrades – the organisation is beginning to become Lean. Important in Kaizen is that senior management is also committed to making small continuous improvements and shows their example for other employees. A standardized process creates a basis for Kaizen practices.

Lean production can be divided into three categories: development of processes, people as well as tools and technologies. The development should be holistic and include all of these aspects. (Morgan and Liker 2006). Womack et al. (1990) stress the importance of people: motivated employees are a prerequisite for Lean since continual improvement stems from employees' every day actions. Weele (2010) notes that in Lean production a scapegoat for a possible error is not searched, rather it is assured that the error will never occur again. In addition, in Lean management, the responsibility that is given to the employees that create the offering, is maximised. Managers' duty is to support and enable the employees' activities with applicable strategy implementation and enabling proper training. Therefore, Lean philosophy and continual improvement requires total commitment of the whole organisation. However, Lean practices can also raise obligation towards change among employees in the beginning especially if the practices are not implemented well. (Womack et al. 1990).

An important success factor of TPS is the attitude towards suppliers: Toyota treats their suppliers like their own resources. After selecting a supplier, they are required to perform as efficiently as Toyota but in return Toyota offers their know-how and resources to help the suppliers to reach the efficiency level and to continuously develop their process. In order to gain maximum benefit, Toyota and the suppliers have a long-term business relationship. (Merikallio and Haapasalo 2009, Iloranta and Pajunen-Muhonen 2008). Iloranta and Pajunen-Muhonen (2008) claim that long-term partnering with suppliers is the factor that has differed Toyota from Western car manufacturers who in general have preferred competitive bidding over partnering. Chapter 2.3 will discuss supply chain management more in detail.

Merikallio and Haapasalo (2009) note that even though Lean is relatively easy to understand, systematic daily activities are demanded in order to maintain the on-going development and to standardise processes. Also successful Lean thinking requires a

suitable organisational culture, management style, strategy, communicational skills and environment. Even though Lean philosophy includes several tools like for example 5S, Six Sigma, JIT, value stream mapping et cetera, these tools are not the actual purpose of Lean and every organisation should consider which tools can produce value in their case. (Merikallio and Haapasalo 2009). Also the idea behind the philosophy should be understood comprehensively before implementing parts of it (Iloranta and Pajunen-Muhonen 2008). Researchers (for example Green 1999, Cox 2001) have criticised Western organisations for trying to copy Toyota's success without understanding the Japanese business environment holistically and the real factors that result in Toyota's competitive advantage. Iloranta and Pajunen-Muhonen (2008) note that Toyota is in a different position compared to Western companies due to the nature of Japanese business environment that encourages continuous training of employees and utilisation of everyone's assets. It should also be noted that Toyota is a considerably large actor that operates globally and therefore has leverage over several other companies. Therefore, not all firms can or should copy their practices straight. Nevertheless, organisation can interpret the practices in a way that fits their organisational culture, strategy and operating environment.

2.2.2 Lean construction

In the beginning Lean was a philosophy utilised by mass-manufacturers. However, Lean Project Delivery System (LPDS) is an adaptation of the original Lean philosophy that was created to fit a project environment. A derivative of LPDS that is utilised in the construction industry is called Lean construction. (Merikallio and Haapasalo 2009, Sarhan and Fox 2012). The idea behind LPDS is the same than in Lean manufacturing: to create a perfect outcome for a customer with a process that includes only value-adding activities and continuously pursue a more effective process. LPDS includes all the phases of a project beginning from defining objectives and lasting until the investment is utilised. It also considers the needs that occur during the life cycle of an investment. Waste is eliminated from all the phases of a process. (Ballard 2008).

Important for LPDS is involving the customer and end-users to the project from its first phases and collaborating with them until the project ends. Production management aims to reduce errors in process and guarantee that actions are performed in the right time. Feedback is collected after each phase in order to enhance the process continually. One way to organise Lean construction is to create an integrated project team that shares the risks and benefits equally. (Ballard 2008). LPDS approach aims to reduce the waste by training people to identify the waste that occurs in their own work and to motivate them to continually improve the overall process (Merikallio and Haapasalo 2009). Also the performance of the project team should be continuously measured in order to enhance it (Sarhan and Fox 2012).

Johansen and Walter (2007) have created a conceptual framework that addresses eight areas that are fundamental attributes to Lean construction. The framework is presented in figure 5.

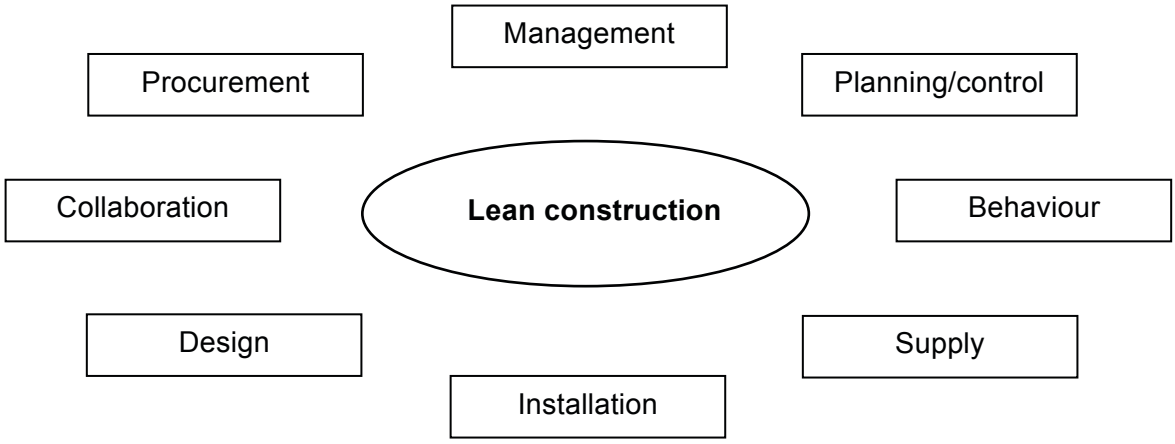


Figure 5 *Framework including eight attributes to Lean construction (reproduced from Johansen and Walter 2007).*

Sarhan and Fox (2012) studied Lean construction in UK. Based on the results of the study they evolved further the framework presented by Johansen and Walter (2007). They conclude that there are nine cornerstones that are fundamental attributes for Lean construction. The attributes are Lean culture, collaborative relationships, performance measurement and evaluation, procurement, management concepts, planning and control, design, installation of design and supply. They call the first two cornerstones as soft aspects as the other cornerstones that were also recognised by Johansen and Walter (2007) are called hard aspects. Sarhan and Fox (2012) stress the importance of leadership and management as well as explicit production planning in Lean construction. They recognised that Lean construction is eased by long-term supplier relationships, cross-functional project teams, collaborative planning of schedules, project document and management banks and Integrated Project Delivery.

Lean Construction Institutes have proved that by exploiting LPDS, total costs of construction projects can be reduced by ten to forty per cents. Also it has been recognised that the approach has a shrinking influence on the lead time of projects and increasing effect on the customer satisfaction. (Lean Construction Institute Finland n.d.). However, researches (for example Green 2001, Sarhan and Fox 2011) have noticed that there is not available significant amount of critical empirical research regarding Lean construction.

Finland has also a Lean Construction Institute that has been established in 2008 and that aims to research and develop Lean construction practices and apply them to the Finnish

construction industry (Lean Construction Institute Finland n.d.). However, Lean construction is not a common approach in Finland yet as pilot projects that exploit the philosophy were executed during the time of writing this thesis.

2.2.3 Challenges for Lean construction

The results of Sarhan and Fox (2012) showcase that the construction industry lacks a clear understanding of how the lean principles can be applied to specific activities. They recognised ten key structural and cultural barriers that hinder successful implementation of Lean construction. The identified barriers are:

1. Lack of adequate Lean awareness and understanding
2. Lack of top management commitment
3. Culture and human attitudinal issues
4. Time and commercial pressure
5. Fragmentation and sub-contracting
6. Procurement and contracts
7. Educational issues
8. Lack of process based measurement systems
9. Financial issues
10. Design and construction dichotomy

The first three barriers were named the most significant based on their empirical results. They also highlight that Lean is a philosophy and therefore successful implementation of the Lean approach requires and organisation to adapt to the Lean culture and understand the Lean philosophy thoroughly in addition to using the Lean tools. Pekuri et al. (2012) claim that several construction companies have pursued value by applying Lean tools and techniques to reduce waste from processes. Yet, they argue that there hasn't been much research or conversation about the principles and philosophy behind Lean as the conversation in the industry has mainly focused in utilisation of different tools and production levelling and has neglected the aspect of maximising value for a customer. Hines et al. (2004) acknowledge that often a challenge for exploiting Lean thinking is changing the organisational culture and way of thinking.

Merikallio and Haapasalo (2009) researched implementation practices of Lean construction in Finland. They found out that a current challenge for the industry is to create competent project teams that include all important stakeholders in an earlier phase of a project than traditionally so that benefits and risks can be shared equally and everyone is motivated to develop the process and therefore maximise generated value.

2.2.4 Lean tools

Lean philosophy includes a large variety of tools that ease the waste reduction and value maximisation for a customer. However, the Lean philosophy should be comprehensively understood in order to utilise the tools in a right way (Bhasin and Burcher 2006). Hines et al. (2011) argue that by only exploiting the Lean tools, a company can improve performance but it doesn't result in long-term development.

In this thesis three tools for Lean construction are introduced. The tools are Last Planner System, Value Stream Mapping and Integrated Project Delivery.

Last Planner System (LPS) is a project planning system that aims to create a stable production schedule and program so that projects can be delivered predictably and safely. In LPS the key team members draft the schedule in collaboration. Key members include representatives of client, owner, designers, general contractor and significant sub-contractors. The collaboration has three goals: first, all available knowledge and capabilities are exploited in the planning when all the key team members are involved. Second, understanding of own role and responsibility as a part of the whole production increases. Finally, collaboration among team members increases trust and ability for successful co-operation. Therefore, the main ideas behind LPS are sharing of information and gaining a more comprehensive understanding of the project outside own area of responsibility. LPS aims to ensure that everyone finishes their work when promised and thus waiting is minimised, which increases the performance. LPS includes several cycles of planning and also weekly measurement of what actions were completed as planned. The plan per cent complete (PPC) is calculated as well as the reason for variance. The information is utilised for continuous improvement. (Merikallio and Haapasalo 2009).

Value Stream Mapping (VSM) is a tool for recognising and eliminating waste (Morgan and Liker 2006, Liker 2008). Porter (1985) created the concept of a value chain. A value chain consists of the organisational actions that are executed in order to design, produce, market, supply and support a product. VSM helps an organisation to recognise the parts in the process where waste is generated and in which other Lean tools should be utilised. Womack (2006) suggests that the process and the challenges should be examined both from the viewpoint of a customer and the organisation.

Integrated Project Delivery (IPD) is a project delivery approach where the emphasis lays on maximising the value created for a customer and to eliminate waste from the production process by exploiting the capabilities and talents of all team members. Characteristic for IPD teams is that they include several actors to the project right from the beginning in order to ensure that all the possible talent is utilised in the process. (Merikallio and Haapasalo 2009). In figure 6 is presented a framework for an IPD team.

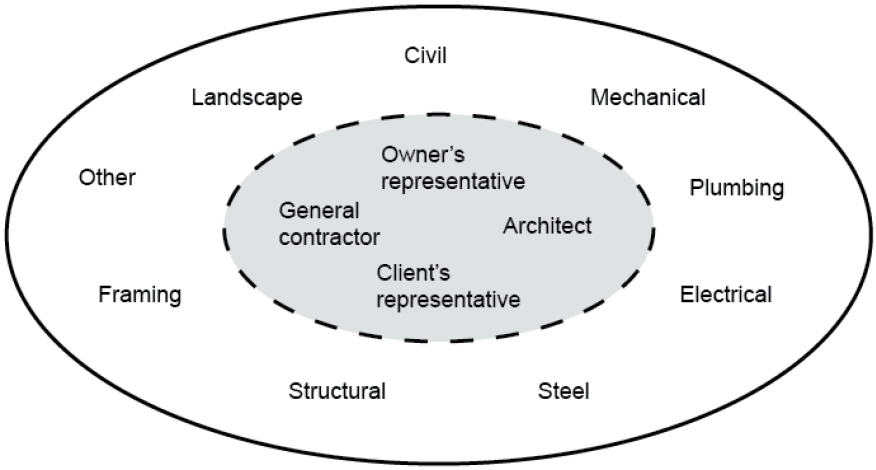


Figure 6 *Possible team members of an Integrated Project Delivery team. In the centre is the core team of IPD. (reproduced from Merikallio and Haapasalo 2009)*

Important for IPD approach is that the objectives of the team members are aligned and risks and benefits are shared equally (Merikallio and Haapasalo 2009). Freeman and Beale (1992) point out that the level of project success varies according to the person making the estimation. For example, in a construction project an architect might estimate success in terms of aesthetics, an engineer in terms of technical competence, an accountant in terms of money spent and a human resources manager in terms of satisfied employees. Therefore, the objectives of team members can also vary significantly.

The team members should also be trained to understand Lean philosophy and develop the process based on the Lean principles. IPD also emphasises efficient knowledge transfer among the team members. (Merikallio and Haapasalo 2009). Efficient knowledge transfer can be eased with working methods such as Building Information Modelling and Big Room working.

IPD is an alternative for more common procurement methods such as design-bid-build and design-and-build. The traditional design-bid-build procurement method has been heavily criticised, as it doesn't encourage integration, coordination and communication between the participating organisations and can therefore hinder project success. Also, organisations involved in a project can have contradicting goals, which consequently slows down the process and hinders the outcome. Use of a variety of design-and-build approaches and partnering has reduced some of these problems but also generated new ones in some contexts. (Love et al. 1998). In a design-and-build method a single contractor is responsible for designing and building a construction. Design-and build approaches can lead to significant lead time savings as construction can begin before detailed design is completed (Morledge and Smith 2013). Design-and-build method also enables innovation already when negotiating with suppliers (Piirainen and Saarinen

2013). Usually the contractor is rewarded with a fixed price agreed on in advance if the quality and requirements are met. Therefore, the client will be prevented from costly surprises. (Morledge and Smith 2013).

2.3 Purchasing

A major part of academic research concerning project management has traditionally concentrated in the management of an individual project from the viewpoint of a single organisation. Nevertheless, characteristic for projects is that they usually involve several organisations. (Artto and Kujala 2008). Therefore, the management of the network formed of several organisations should be considered when these types of projects are executed (Hellgren and Stjernberg 1995, Eloranta et al. 2006). In figure 7 is presented a framework where management of a project network is distinguished of three other distinctive areas of project business. The separation is made according to the number of projects and firms included in a project.

	One firm	Many firms
One project	Management of a project	Management of a project network
Many projects	Management of a project-based firm	Management of a business network

Figure 7 *Four distinctive management areas of project business (reproduced from Artto and Kujala 2008)*

The case projects of this study also include several external organisations. Therefore, management of a project network is an appropriate viewpoint for this study. Having several organisations participating in a project causes uncertainties that are to be managed by the purchasing organisation (Artto and Kujala 2008). These uncertainties can be result of for example different interests and identities, inefficient information transfer, dependence on other actors, risk management processes that aren't applicable for the context (Hellgren and Stjernberg 1995, Eloranta et al. 2006), organisations being unaccustomed of collaborating on a daily basis (Artto and Kujala 2008) and nature of inter-organisational relationships (Ahola 2009). Hence, management of a project network addresses managing the temporary project organisation that includes actors from several firms that all have their own, and sometimes controversial, objectives and interests for the project. Consequently, the challenge of project network

management is creating contractual arrangements that align goals of the multiple entities and facilitate coordination within organisations. (Artto and Kujala 2008).

Management of a project network is closely related to purchasing and supply chain management. Literature concerning purchasing is introduced in this chapter because the case organisation's projects are highly influenced by suppliers. Also a considerable share of the projects' costs is accumulated due to the actions of suppliers and therefore purchasing relates to the research questions.

2.3.1 Developing purchasing process

In recent years, managers have recognised purchasing as a major strategic function for creating sustainable competitive advantage and have begun to integrate it with firm's overall strategy (Iloranta and Pajunen-Muhonen 2008, Weele 2010). Depending on the industry and the definition (Iloranta and Pajunen-Muhonen 2008), purchasing expenses form from 66 per cent to 80 per cent of revenue (Iloranta and Pajunen-Muhonen 2008, Weele 2010). This means that if an organisation only concentrates on managing and developing the operations that exclude external entities, they can only affect the operations that form a maximum of one third of their whole cost structure. Consequently, it's difficult to imagine that an organisation can stay competitive for a long time by only focusing in such a small percentage of revenue. (Iloranta and Pajunen-Muhonen 2008). In figure 8 is presented the evolvement of the cost structure of companies during the past sixty years. The growing share of purchases can be explained by an increased amount of companies focusing in their core operations and capabilities. This has created a demand for outsourcing other activities and therefore increased the proportion of purchases of total expenses. (Weele 2010).

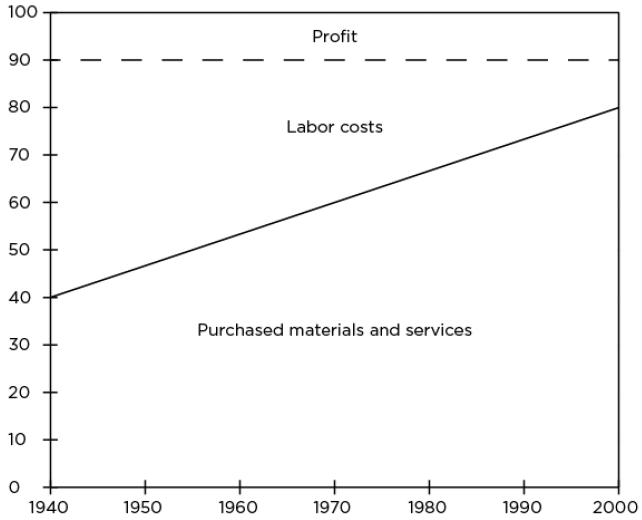


Figure 8 *Development of organisations' cost structure (modified from Iloranta and Pajunen-Muhonen 2008)*

Yliherva and Merikallio (2008) estimate that in the Finnish construction industry the share of made purchases is also 60 – 80 % of total costs.

Previous research has shown that due to the extent of purchasing expenses, investment in purchasing expertise and company's success are positively correlated (Iloranta and Pajunen-Muhonen 2008). The added value that efficient purchasing creates can be realised in several ways. In figure 9 is concluded how efficient purchasing can contribute to an organisation's financial performance.

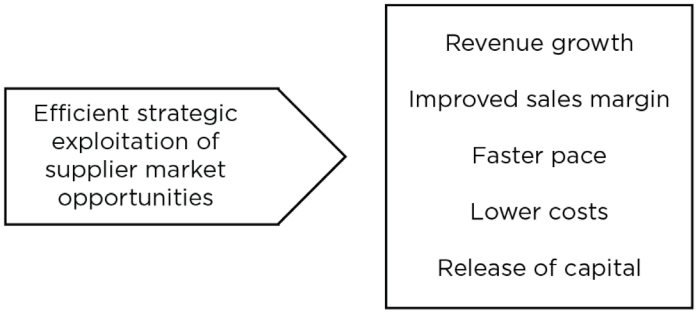


Figure 9 *Prospective effects of efficient strategic exploitation of supplier market opportunities (modified from Iloranta and Pajunen-Muhonen 2008)*

This thesis doesn't elaborate further on the aspect of how purchasing contributes to competitiveness, but discusses instead how an organisation's purchasing process can be developed.

In order to make purchasing part of an organisation's competitive advantage and to achieve the goal of purchasing - to satisfy end-customer's needs and maximise the total benefit of an organisation by exploiting the opportunities of supplier markets - developed management capabilities and improved purchasing processes are required. Management skills are required to manage efficiently and effectively supplier networks, since production might include various suppliers. Other crucial development areas that contemporary firms have recognised include integration of purchasing and firm's overall strategy, increased inter-organisational and horizontal collaboration, improved processes to find new supply chains and to exploit global supplier markets, systematic collaboration with suppliers and development of their capabilities as well as constant training of the purchasing experts. (Iloranta and Pajunen-Muhonen 2008).

Yliherva and Merikallio (2008) claim that a major challenge for the construction industry is to develop purchasing expertise in a manner that encourages the whole supply chain to create new innovations. A considerable amount of fresh ideas and practices can be gained from suppliers. Other challenges include unfair distribution of risks and benefits and inefficient or too short-term collaboration with suppliers.

2.3.1.1 From reactive to proactive purchasing

A traditional view considers purchasing as buying the right quantity and quality on time and with the right price from the right supplier in order to guarantee that other departments such as production as well as research and development can proceed in their tasks. In this type of reactive purchasing operational routine tasks are executed in order to support other departments. However, the direction of development is to create a more proactive process. Main difference between reactive and proactive purchasing is that the main focus of proactive purchasing is not the on the operational level duties, but rather on the implementation of strategic tasks, such as finding new suppliers, developing their capabilities and managing the supplier networks also after a contract has been created. (Iloranta and Pajunen-Muhonen 2008). In proactive purchasing suppliers are seen as a source for long-term competitive advantage (Weele 2010). Consequently, by concentrating in strategic level tasks, proactive purchasing aims to fully benefit from the opportunities of the supplier markets on the long term. Therefore, proactive purchasing increases an organisation's competitiveness on the long run by strengthening their bargaining power, but also by improving their suppliers. (Iloranta and Pajunen-Muhonen 2008). Weele (2010) stresses that purchasing should be aligned with the organisation's overall strategy so that sub-area optimisation will not occur.

In table 1 are defined some characteristics of professionals of reactive and proactive purchasing.

Table 1 Characteristics of experts of reactive and proactive purchasing (modified from Iloranta and Pajunen-Muhonen 2008)

Expert of reactive purchasing	**Expert of proactive purchasing**
Incurs costs	Seeks added value
Aims to reduce costs	Aims to develop business
Waits for suppliers' contact	Seeks new suppliers
Waits for an active supplier to reason the superiority of their solution	Markets their organisation, idea and need to suppliers
Trusts the information given by suppliers	Visits suppliers and evaluates their resources and capabilities
Selects purchases based on solutions suppliers have developed	Determines actively needs in order to develop solutions in collaboration with suppliers
Approves or rejects suppliers' solutions	Develops suppliers' solutions further

Even though recent research inclines that organisations have started to value the strategic side of purchasing over operational one (Iloranta and Pajunen-Muhonen 2008, Weele 2010, Morledge and Smith 2013), it should be noted that the operational tasks

still need to be accomplished and the task are still stressed in many organisations. Also, development of operational tasks, such as negotiation skills and creation of call for tenders and contracts, can also result in major benefits (Iloranta and Pajunen-Muhonen 2008).

Management practices in general encourage efficiency and productivity over strategic development and employees tend to be fully occupied with implementing operational duties. Therefore, development of strategic purchasing requires above all a change of attitude from all employees in order to generate long term benefit. Enough resources should be guaranteed for both operational and strategic sides of purchasing and management should encourage the change. However, as organisations must adapt to sometimes rapid changes in the environment, people should be constantly trained and the purchasing strategy and process continually improved. (Iloranta and Pajunen-Muhonen 2008). In addition, metrics to evaluate the performance of suppliers should be introduced to the purchasing process (Piirainen and Saarinen 2013).

2.3.1.2 Total Cost of Ownership thinking

An important feature of developing the strategic side of purchasing is mastering Total Cost of Ownership (TCO) thinking. Weele (2010) defines TCO as the total cost an organisation will incur during the entire life cycle of a purchased product. TCO is sometimes also called life cycle costing (LCC) as both of these philosophies aim to analyse and understand the true costs including operating, maintaining and disposing a product in addition to pure acquisition (Ellram and Siferd 1993). In contrast to LCC thinking, TCO also acknowledges the cost of internal purchase activities (Ellram 1995a).

Traditionally purchasing decisions and supplier selection have been made based on the direct price of a tender (Ellram and Siferd 1993). However, often the purchase price is not as significant contributor to the total cost than other direct and indirect costs that occur during the life cycle of a product (Iloranta and Pajunen-Muhonen 2008) and low cost of a bid doesn't ensure maximum value in the future (Weele 2010, Morledge and Smith 2013). When selecting a bid, the client should focus in maximising the value for money, which is not analogous with lowest price (Morledge and Smith 2013). Understanding the cost elements of investment projects beyond the purchase price is especially important because products of these projects tend to have a long life cycle and therefore a considerably large share of costs occurs after the acquisition phase. Not understanding the total costs of purchases can have a significant negative effect on an organisation's competitiveness, profitability, pricing decisions and overall strategy (Ellram 1995a).

Ellram (1995a) suggests that companies can benefit of TCO thinking when selecting suppliers, evaluating and measuring their performance and rationalising major changes

in processes. TCO analysis benefits companies since they can compare existing suppliers and their performance, define expectations for them in advance (Ellram 1995a) and evaluate other alternatives (Ellram and Siferd 1993). Companies that practice TCO philosophy have an increased understanding of suppliers' cost structure and therefore they gain valuable data to be utilised in negotiation situations (Ellram and Siferd 1993). These companies also have an evolved purchasing culture that focuses more on long term value creation than direct price. TCO analysis helps the purchasing department to justify other decisions than those based on the initially lowest price. (Ellram 1995a).

Even though TCO philosophy is logical and easy to understand (Ellram and Siferd 1993) and its benefits are apparent, implementation of it is pretty complex as the analysis process requires relatively much time, know-how and other resources (Ellram 1995a). Especially the indirect costs are challenging to evaluate (Ellram and Siferd 1993). In addition, companies' reporting systems don't in general encourage TCO thinking as the performance is evaluated every quarter year and TCO analysis aims to generate profit in the long term (Iloranta and Pajunen-Muhonen 2008).

2.3.1.3 Partnerships and bidding

Partnering has become a prevalent trend of contemporary purchasing. Partnering differs from a more traditional supplier relationship in terms of sharing mutual interests, risks, information and benefits of the agreement. (Ellram 1995b). In a fast paced environment, collaborative development of a product or service together with a supplier can lead to considerable reductions of lead time and total costs and improved quality (Iloranta and Pajunen-Muhonen 2008, Morledge and Smith 2013). Partnering has potential to contribute to management, technology and financial sides of business. For example partnering reduces the supplier base, increases mutual dependence, reduces time used to search for new suppliers, enables efficient information sharing and increased attention due to loyalty, allures partners to share their ideas or give access to their technology and can lead to more stable supply prices and smaller storages. (Ellram 1995b). Partnering also enables a supplier to move down the learning curve (Weele 2010).

Japanese car manufacturing - especially Toyota Production System (TPS) - has been a pioneer of partnering and their models to collaborate with suppliers have been widely studied and interpreted globally (Merikallio and Haapasalo 2009). The Lean philosophy derives from Toyota's model of taking responsibility of developing not only the internal organisation, but also the supply chains and rewarding their development with new commissions. A significant benefit of partnering is the generated access to a supplier's innovation capabilities. (Iloranta and Pajunen-Muhonen 2008).

Nonetheless, a successful partnership requires that the organisations have similar objectives and the risks are shared evenly (Iloranta and Pajunen-Muhonen 2008). Also

their culture should fit together (Morledge and Smith 2013). Risks are usually divided more even if both of the organisations are highly dependent on the other and want to ensure future collaboration. Partnerships aim to minimise the amount of arguments and conflicts that increase the lead time of projects and thus the costs. (Iloranta and Pajunen-Muhonen 2008). Yet, generation, maintenance and development of partnerships require specific knowledge and attitude (Ellram 1995b, Morledge and Smith 2013) that are not included in traditional bidding. The selection of a partner is also a demanding process. Even though partnering can generate considerable added value, it has many risks as well. Problems may occur for example if parties naively think that their objectives are align, the status quo doesn't encourage improving performance, suppliers' performance can't be measured, supervised and developed or majority of generated profit is collected only by one party. (Iloranta and Pajunen-Muhonen 2008).

A more traditional alternative for partnering is competitive bidding. In a bidding approach there are no long-term supply contracts as the suppliers and products are seen as interchangeable (Weele 2010). Competitive bidding is believed to keep suppliers motivated to constantly aim for better performance, as they fear to lose a contract unless they are able to decrease their prices (Ellram and Siferd 1993). Also creating a call for tenders is seen as a relatively faster and easier action than actively searching for suppliers. Competitive bidding can indeed motivate suppliers to improve their business and provide a customer with the best supplier in a case where all the best suppliers leave tenders, their solutions and expertise is explicitly on the same level, suppliers are not collaborating with other parties, it is easy to estimate the solutions based on their cost or quality or some other easily measurable feature (Iloranta and Pajunen-Muhonen 2008) and there exists a perfect economic competition (Morledge and Smith 2013). Nevertheless, the situation is rarely if never like described. A major risk of competitive bidding is low quality of a product as suppliers don't even offer their best quality in order to win the bid but participate with the minimum quality that still fulfils the minimum requirements. This shifts the risk to the customer on the long run. Especially in construction projects this can be risky as repairing of some goods and systems that are installed in a building can be difficult and expensive or even impossible. Competitive bidding can generate value on the short term, but if suppliers can't truly improve their business, in the long run it can result in lower quality. Bidding might neither exploit suppliers' capabilities to the fullest as one supplier can be a pioneer in one area, but their expertise isn't utilised as they don't have resources to win the entire bid. Best suppliers might also not be interested in leaving tenders as they already have secured enough work or they don't have the resources to concentrate in creating good tenders. On the other hand, suppliers might also promise more in a tender than they are actually capable of just in order to get the commission. If a call for tenders is not good, also the solutions in general result in bad quality. Illegal cartels are also a threat for bidding. (Iloranta and Pajunen-Muhonen 2008).

The risks of competitive bidding can be reduced by creating the call for tenders carefully, defining explicitly the required resources and thoroughly estimating the prospective suppliers and interviewing them. The need and scope of the purchase have to be communicated precisely in the call for tenders. Collaboration with suppliers can be done in advance in order to understand the capabilities of the industry. Also risk reduction actions can be included in the call for tenders or discussed with prospective suppliers. The customer should also invest in being an attractive customer in order to guarantee that best suppliers leave tenders. (Iloranta and Pajunen-Muhonen 2008). In order to allure good suppliers, incentives to participate in a tender, can be generated (Piirainen and Saarinen 2013). The procedure for tendering - open procedure, restricted procedure, competitive dialogue, negotiated procedure with or without a prior publication of a contract notice, design contest or framework agreement – also has an influence on the success of the purchase (Morledge and Smith 2013) and should therefore be chosen appropriately depending on the nature of the purchase.

Merikallio and Haapasalo (2009) argue that selecting a supplier with a low-bid method is especially problematic as it only considers the immediate cost. This means that possible significant savings during buildings' life cycles are left uncaptured because of the tendering method. However, the bid price is often used as a criterion because it makes comparison of bids simple and it is easy to define as a selection criterion in advance. The low-bid method doesn't only affect individual projects, but also prevents the whole industry from improving. The low-bid method doesn't encourage companies to come up with innovative solutions as these often cost more. Yet, Larson (1995) argues that a low-bid status of a project isn't an impediment for a project. Rather partnering and correct management style are more significant contributors to project success. Partnering can be applied as successfully to low-bid projects as to projects where the team has been chosen by a different approach.

As a conclusion, both partnering and bidding contain opportunities and threats and there aren't best practices that will be successful in all situations. Figure 10 presents some of the benefits and drawbacks of emphasising partnering and costs.

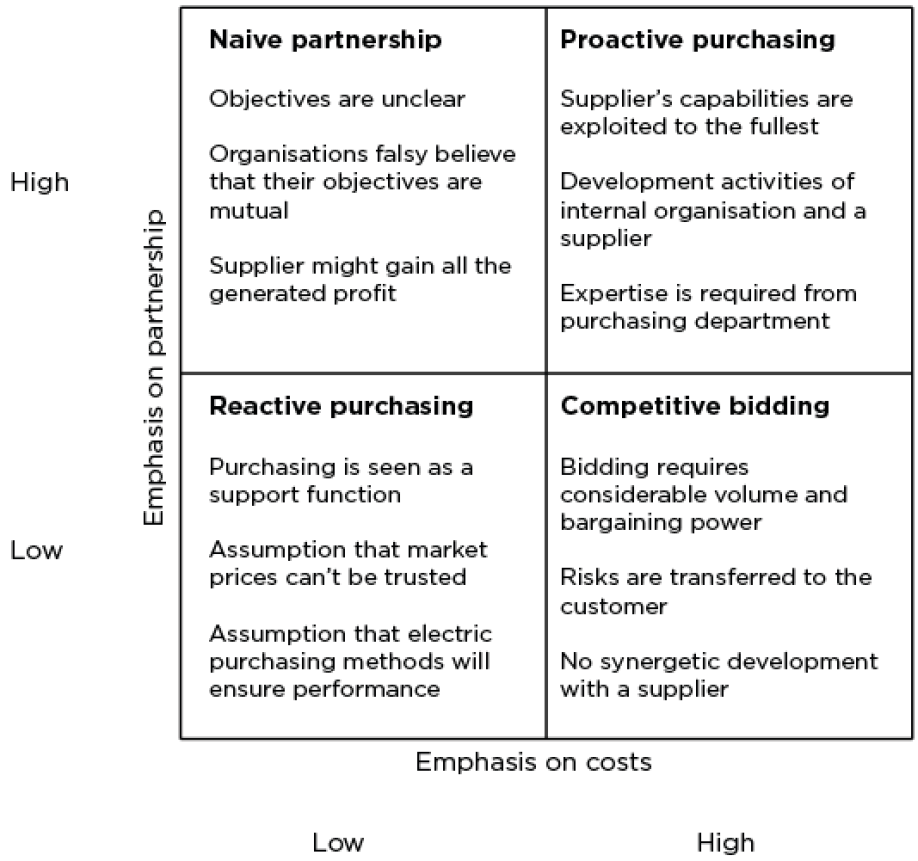


Figure 10 *Characteristics of purchasing strategies that emphasise partnership and costs (modified from Iloranta and Pajunen-Muhonen 2008)*

A constant challenge of professional purchasing is to decide how actively new suppliers are searched, what is the level of collaboration with suppliers and whether partnering or bidding is a better alternative for their current situation (Iloranta and Pajunen-Muhonen 2008).

2.3.1.4 Economies of scale

Economies of scale refer to improved efficiency gained by carrying out a process on a larger scale than before (Porter 1980, Reynolds 1983). The improved efficiency can be realised as reduction of unit costs. Even though manufacturing, equipment and facility management are most often described as business functions where economies of scale can be exploited, scale economies can be gained from almost every other operation of a business, such as purchasing, research and development, marketing et cetera. Economies of scale can be captured from an entire business function or from smaller specific operations that are included in a business function. (Porter 1980). However, it must be noted that increasing the scale doesn't always result in better performance as diseconomies of scale may occur (Reynolds 1983).

Pearson and Wisner (1993) categorise economies of scale into economies gained from learning and from volume. Learning economies refer to situations where resources can be exploited more efficiently and effectively as knowledge gained through previous experience is utilised. Learning economies – economies of repetition – are discussed more in chapter 2.4. Volume economies are generated by increasing product capacity and therefore reducing unit costs. Increased product capacity might increase the fixed costs of production expenses but the improved unit costs cover them. Pearson and Wisner (1993) claim that even though, small organisations can also pursue economies of scale in theory, big corporations usually have the required resources to do so.

Gottlieb and Haugbølle (2010) add buying power as a third category to Pearson and Wisner's (1993) definition. For example an owner of a construction project can exploit this category when creating a call for tenders by increasing the amount of ordered units. Gottlieb and Haugbølle (2010) suggest that in the bidding phase unit costs decrease as the amount of units increases. The suppliers realise that they can gain economies of scale or repetition in the implementation phase when the contract is large and therefore they bid with lower prices. When a buyer can anticipate that a supplier can move down the learning curve they can use it to negotiate a better price (Weele 2010). Suppliers in general are more interested in a contract, the bigger the scope is and therefore possible revenue is (Iloranta and Pajunen-Muhonen 2008, Weele 2010). This adds customer's level of attractiveness and their bargaining power. A customer is likely to receive more bids and reduce the costs if they create one call for tenders that is large in scope by combining purchases instead of having several smaller tenders. (Iloranta and Pajunen-Muhonen 2008). Morledge and Smith (2013) add that a customer can gain considerable savings in time and other resources, as they don't have to negotiate and contract with several suppliers separately if they bid large bulks at a time. On the other hand, Iloranta and Pajunen-Muhonen (2008) also acknowledge that decreasing the amount of suppliers doesn't ensure successful purchasing and shouldn't become an actual purpose of purchasing. Instead the customer should consider already in the early phase of purchasing whether they have the resources to have several separate bids that are small in scope or should they have few bigger ones and pursue economies of scale. Managing several suppliers requires good managerial skills, but also enables to exploit suppliers' capabilities in more areas, which can lead to a better outcome. (Iloranta and Pajunen-Muhonen 2008).

2.3.2 Purchasing of services in a project environment

In the modern society, companies are buying increasingly more services than tangible goods (Weele 2010). In Finland services form 59 per cent of purchase expenses in municipal economies (Iloranta and Pajunen-Muhonen 2008). A major share of these services consists of external expert services. Purchasing of this service type is more challenging than acquisition of a tangible product (Weele 2010) even though researchers have recently argued that the difference between products and services isn't

as major as traditionally seen (for example see Rust 1998, Fisk, Grove and John 2012). Winch (2002) argues that purchases made in the construction industry are mainly services since a supplier sells capacity to produce rather than products.

There are several aspects that should be stressed when purchasing external expert services. First, the scope of the service as well as the needs and objectives of the purchase should be defined explicitly (Iloranta and Pajunen-Muhonen 2008, Morledge and Smith 2013). Defining the scope explicitly eases to determine what is required from a supplier. The scope of a service is somewhat more challenging to define than that of a tangible product and definitions might vary based on subjective opinions (Weele 2010). Therefore, service level agreements should be precise (Iloranta and Pajunen-Muhonen 2008). Second, since the quality and outcome of the service depends on the level of expertise of the supplier, the selection should be done with extra care. Traditionally this aspect is managed by demanding for example a specific profession and applicable references from a prospective supplier. However, this doesn't ensure the best possible outcome since suppliers with same profession and similar experience can still have a huge difference in expertise. (Iloranta and Pajunen-Muhonen 2008, Morledge and Smith 2013). Third, TCO philosophy should be applied also to purchasing of external expert services. However, assessing the total costs of services might be even more challenging than when estimating the total cost of products. (Iloranta and Pajunen-Muhonen 2008, Weele 2010). Finally, when purchasing services, the personal relationship between a supplier and buyer plays a more significant role than when buying goods since services are produced in a close collaboration between the parties. Therefore, human chemistry should be taken into account in addition to TCO and quality aspects when deciding on a supplier. In general it requires time to develop a successful and constructive relationship between a buyer and a supplier. (Weele 2010).

Despite the special features, successful purchasing of services requires similar systematic approach than purchasing of goods. The systematic process includes careful definition of the need and goals for purchasing, thorough analysis of the supplier markets, reflection of needs and supplier markets and identification of the best strategy, thorough estimation of the total cost of the acquisition, careful criteria creation for supplier selection, negotiations carried out with a professional strategy, creation of a good contract that decreases risks and continually instructing the supplier in the process. (Iloranta and Pajunen-Muhonen 2008).

Purchasing in a project environment doesn't in theory differ from other purchasing. However, a unique nature of a project might complicate estimating the total cost. Also since the tasks are one-off in nature, the contracts are usually created to cover a specific action only once. Therefore, developing the supplier might not be valued by the owner organisation of a project. Projects also tend to have a tight schedule, which doesn't encourage to develop the strategic side of purchasing, but to execute operational duties

efficiently. Yet, purchasing is a relevant contributor to project success and the difference between successful and unsuccessful purchase is obvious in a project environment. (Iloranta ja Pajunen-Muhonen 2008). Consequently, development attempts shouldn't be ignored.

2.3.3 Purchasing in public sector

EU procurement law guides governmental and regional entities' purchasing process by formally describing how purchases ought to be made and how contracts should be awarded when the price of a purchase exceeds set threshold values. The aim of the public procurement law is to ensure non-discriminative, equal, transparent and proportional treatment of suppliers. (Weele 2010). This thesis doesn't elaborate on the content of the law, but discusses how to develop current purchasing practices in the public sector. The public procurement law will undergo some changes in 2016 (Hankinnat 2013).

Merikallio and Haapasalo (2009) claim that the procurement law stiffens the purchasing process and hinders chances for innovative solutions. Yet, Iloranta and Pajunen-Muhonen (2008) suggest that public sector can develop their purchasing expertise in a similar manner than any private organisation even though they must simultaneously acknowledge the influence of the law. The aim of the procurement law is not to prevent smart purchases. Weele (2010) claims that in general the public procurement law has met considerable resistance and is being accused of being inflexible and preventing supply chain collaboration. However, he suggests that actually many of the challenges origin from the fact that public organisations don't have professional purchasing organisations and systems or staff holding expertise in purchasing. In Finland public purchases form 15 per cent of the gross domestic product. Yet, it has been estimated that in general, in the public sector there is even a bigger need for improving purchasing activities than in the private sector. Improved processes have potential to result in major savings and productivity increase. (Iloranta ja Pajunen-Muhonen 2008). Montonen (2014) argues that biggest challenges of Finnish public sector purchasing are lack of time, insufficient organising of purchasing documents, obligation towards change and selecting the bid with the lowest price. The collaboration of the customer and supplier is not productive as suppliers in general aim to increase the amount of additional tasks in order to improve their profit. Therefore, quality should be valued over price when creating a call for tenders. In order to reduce the resources required in bidding, many public organisations have begun to draft framework agreements.

Similarly than in the private organisations, purchasing department of a public organisation should also determine properly the need and goals for the purchase and define explicitly the service level, be familiar with supplier markets and reflect the needs on their capabilities and continuously develop their practices. (Iloranta ja Pajunen-Muhonen 2008). A public organisation should also consider which purchasing

procedure – open procedure, restricted procedure, competitive dialogue, negotiated procedure with or without a prior publication of a contract notice, design contest or framework agreement – will create most value in their case (Weele 2010). In addition, in general a change of attitude is required: the procurement law should not be seen only as bureaucracy, but as a helpful tool to ensure successful purchasing. Since winding up into the Market Court is a serious hindrance for a project, as it increases the lead time and therefore total cost, a significant amount of time is usually invested in making a legal and transparent call for tenders. The selection criteria for a supplier should be presented clearly. Yet, it should be acknowledged that a good call for tenders includes also other aspects than legality. Also a public organisation shouldn't passively wait for suppliers to find them, but to actively search for best ones and attract multiple tenders by ensuring that they are an attractive organisation. Unlike sometimes thought, flexible partnerships can be created successfully in the public sector. (Iloranta ja Pajunen-Muhonen 2008).

2.4 Economies of repetition

This chapter discusses economies of repetition, inter-project learning and replication in the context of project-based production, since the topics relate to the objective of understanding how repetitive nature of projects can be capitalised on.

Davies and Brady (2000) define economies of repetition as follows:

"Economies of repetition refer to the reductions in costs and improvements in project effectiveness gained by moving from the first-of-its-kind bid or project to the execution of many similar projects within cost, schedule and the required specifications."

Economies of repetition can be pursued by implementing organisational changes, routines and learning processes in order to enable execution of a growing number of similar projects more efficiently and effectively. Projects are described as similar when they are implemented with same capabilities and routines. In project-based production, cost advantages are merely realised from the repetition of projects rather than from scale or scope of an individual project. Similarly, efficiency can be measured by the reduction in costs per implemented project. (Davies and Brady 2000).

2.4.1 Inter-project learning

A concept related to economies of repetition is inter-project learning. Inter-project learning refers to acquiring, creating and capturing knowledge gained through experience and transferring it to a succeeding project (Prencipe and Tell 2001, Brady et al. 2002). Argote et al. (2000) argue that organisations that succeed in inter-organisational knowledge transfer are more productive than others. Brady and Davies

(2004) argue that learning from projects is crucial for competitive success since it helps to avoid repetition of same mistakes.

Even though inter-project learning is challenging (Hobday 1998, Grabher 2004, Brady et al. 2002), repetition of similar activities creates a platform for learning (Davies and Brady 2000). Nonetheless, the timing of projects is crucial as long duration of projects and time gaps between projects reduces the chances of inter-project learning (Brady et al 2002). On the other hand, simultaneous projects are also problematic since inter-project learning requires time to reflect on the experience and transfer the knowledge further (Lajunen 2010).

The concept of a learning curve was first developed in the US in the aircraft industry. It was discovered that as the produced amount of a particular type of an aircraft increased, the price decreased on a fixed percentage. However, this reduction in price didn't have anything to do with scale, as the volume of production was kept constant. Thus, the effect was attributed to learning and further ascribed to reduced supervision, improved efficiency, reduced defects and line reject rates, possible improved production machinery, improved process time and reduced changes in the production equipment and product. The rule of a thumb for an 80 per cent learning curve is that if the cumulative amount of products is doubled, 80 per cent of the original time is needed for production of one unit. (Weele 2010).

The effect of the learning curve has also been studied in the construction industry. However, the research is not extensive in scope and mainly considers only the activities implemented on site. Yet, the published research proves that the learning curve effect really does exist and it is not just a theoretical idealisation. The economic benefits result from reduction of operational costs and construction time. As for, the reduction of construction time results from reduced labour, machine and equipment costs. The size of the learning curve effect varies according to the nature of executed work and environment. The more complex the work is the higher benefits repetition produces. In order to enable moving down the learning curve the work executed should be as identical as possible, the work should be properly planned, organised and supervised, the work should continue without interruptions as long as possible and the scope of work should be limited enough to allow sufficient specialisation. (Gottlieb and Haugbølle 2010).

An organisational learning cycle presents how an organisation can move down the cycle from the execution a novel vanguard project to a new business unit or division, which results in gained economies of repetition (Davies and Brady 2000). An organisational learning cycle is presented in figure 11.

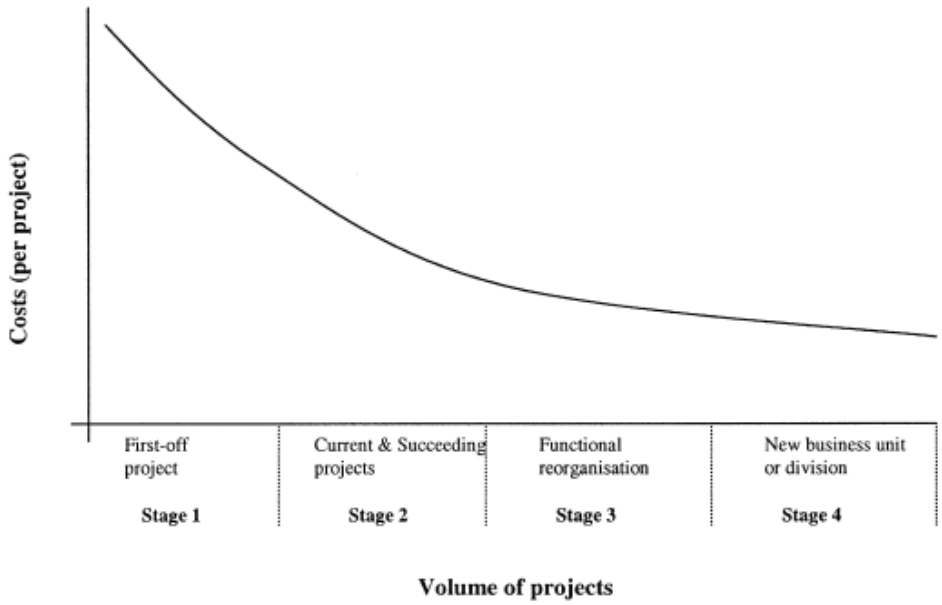


Figure 11 *An organisational learning cycle (Davies and Brady 2000)*

At the first stage of the organisational learning cycle a vanguard project that is novel in nature or has to be implemented by a new procedure, is executed. In this phase knowledge about the project and required activities are gained (Davies and Brady 2000). Usually, the project is separated from other projects and the use of new innovative processes is encouraged (Brady and Davies 2004). In the second phase, project-to-project learning is pursued by capturing and transferring the knowledge and improvement ideas from the vanguard project to other subsequent projects (Davies and Brady 2000). To ease the knowledge transfer, key members of the pilot project are moved to the following projects and investments in knowledge codification are made in order to provide the succeeding projects with e.g. manuals, projects accounts and lessons-learnt exercises. However, learning at this stage still tends to be on an ad hoc basis without efforts to spread the initial learning throughout the entire organisation. (Brady and Davies 2004). Once enough projects are executed, the third phase might begin. If a project becomes a permanent effort to be pursued, changes in the organisation's structure might be required and a new group within the business unit might be established. At the fourth stage the new division is separated entirely from the parent organisation in order to execute a growing number of projects. However, whether a company reaches the last stages of an organisational learning cycle depends on the volume and need for such projects. (Davies and Brady 2000).

In the early stages of the learning cycle the learning is exploratory in nature as the organisation builds new capabilities by coping with unfamiliar activities and exploring new options. The learning becomes exploitative after new activities to standardise and routinize developed processes are implemented in order to make them available for the entire organisation and thus. Standardised practices enable the organisation to increase

the amount of executed projects. Also top-down strategic decisions are made in order to ease the exploitation i.e. refine and extend the new capabilities and processes realised during the earlier stages. However, it should be noted that the model should be applied only to projects that have potential to become new major lines of business. (Brady and Davies 2004).

2.4.1.1 Mechanisms for inter-project learning

In general projects tend to emphasise activities that are implemented in order to ensure project completion over activities related to reflection and communication of lessons learned (Brady et al 2002). However, since the perks of inter-project learning are considerable, some project-based organisations have begun to create required mechanisms to allow systematic knowledge collection, analysis, restoring, and smooth knowledge transfer (Prencipe and Tell 2001). There is a large amount of mechanisms for inter-project learning and the use of them can vary according to the phase of a project and nature of the company. Not all mechanisms suit all projects and firms. As inter-project learning includes knowledge acquiring, creation and capturing in addition to knowledge transfer, there are also different types of inter-project learning mechanisms that suit the different tasks. (Brady et al. 2002). In table 2 are presented several knowledge transfer mechanisms introduced by Brady et al. (2002)

Table 2 List of knowledge transfer mechanisms originally recognised by Brady et al. (2002) (modified from Lajunen 2010)

Phase handover meetings	Newsletters and company magazines
Project summaries and bulletins	Information videos
Cross-project meetings	Centres of competence/excellence
Internal conferences and seminars	Best practice teams
External conferences and seminars	Company intranets
Participation in industry groups and institutions	Standard processes, procedures and guidelines
Learning from suppliers	Inter-organisational extranets
Learning from customers	Electronic/virtual universities
Project management systems	Hyperlinked documents
Quality management systems	Discussion forums
Records of successful/failed bids	Electronic chat rooms
Lessons learned database	E-mail communication
Feedback and suggestions database	Global e-mail distribution lists
Groupware	Video/audio conferencing
Reference projects	Collocation of team
Technical and organisational audits	Shared interaction spaces e.g. coffee area
Document and design archives, electronic and hard copy	“Travelling” experts who move around the organization transferring knowledge
Informal/ad hoc communication	Social networks
Formal/informal social events	Mentoring and “buddy” systems
Boundary spanning individuals	

However, to enable successful inter-project learning, the recipient has to use mechanisms to capture the knowledge in addition to pure transfer process (Brady et al. 2002).

Codification of knowledge refers to conversing knowledge into information that can be processed by various agents. Codification of knowledge contributes significantly to an organisation when people change, since created manuals and documents guarantee that all knowledge isn't stored into individuals. Codification can also be highly educative as the learning process that occurs during the creation of a manual can be more valuable than the guideline itself. However, the learning benefits of the codification process has been somewhat neglected in research as the attention has tended to focus on the outcome. (Prencipe and Tell 2001). Especially in complex projects codification efforts can be valuable since the tasks are usually unique and one-off in nature (Prencipe and Tell 2001, Zollo and Winter 2002). Nevertheless, proper time for codification should be carefully considered. In order to avoid generalisations codification shouldn't be done too early, but neither should it be done too late since that might result in increased level of tacit knowledge. (Zollo and Winter 2002). The need for codification of knowledge has increased considerable debate. One viewpoint is that all knowledge can be codified if enough resources are available. Nonetheless, according to another viewpoint, all codified knowledge requires tacit knowledge in order to be useful. Codification can increase rigidity of an organisation and force them to create new document sharing systems. (Prencipe and Tell 2001). If knowledge is not codified, people should be able to locate other people that have important knowledge.

Nelson and Winter (1982) emphasise the role of standardised activities and routines in knowledge transfer. Manuals and guidelines can contribute to a company in knowledge transfer, but aren't sufficient in maintaining an organisation's tacit knowledge. Routines on the other hand succeed in this, as an organisation's knowledge is located in its memory and therefore routines and practices. Firms that operate in an unchanging environment under stable conditions can rely on their routines. However, when a company pursues a novel technology or customer base, it must develop new capabilities and explore opportunities instead of relying on routines. (Davies and Brady 2000, Brady and Davies 2004). When creating new products, an effective learning mechanism is to analyse the differences of the project plan and realised results (Bartezzaghi et al 1997).

2.4.2 Replication

Replication refers to a strategy where an organisation intentionally reproduces or diffuses the success it has generated before into another setting or locale (Baden-Fuller and Winter 2005). Brady and Davies (2004) claim that learning and effective knowledge transfer are prerequisites for successful replication.

Several service providers in restaurant and banking industries are using a replication strategy in order to for example create many similar outlets or other venues. For example McDonalds and Starbucks are famous for creating competitive advantage by exploiting a replication strategy. (Winter and Szulanski 2001, Szulanski and Winter 2002). Replication enables an organisation to move quickly down the learning curve and gain economies of repetition. Improved effectiveness as well as cost and lead time reductions result in a possibility of reaching large markets quickly, which is the main strength of a replication strategy. Reaching large markets quickly can be a vital success factor for a replicator who wants to benefit from first mover advantage and develop capabilities before other organisations are able to reach the market. Replication is also utilised to reduce a product's time-to-market and to enable focused mass purchasing or production of inputs. (Winter and Szulanski 2001). Grabher (2004) notes that if suppliers are replicated, the purchasing costs can be lowered due to long-term collaboration. Replication reduces the level of risk of a replicated element since practices and processes have been tested in advance.

However, replication has also several disadvantages and the replication process is not easy. Therefore an organisation should carefully decide whether they should include it in their strategy. (Winter and Szulanski 2001). Galbraith (1990) suggests that in general replication is thought to be easier in advance than it turns out to be. Winter and Szulanski (2001) argue that successful replication requires a lot of time and effort. Most processes require tacit knowledge, which makes replication difficult as tacit knowledge is challenging to transfer (Baden-Fuller and Winter 2005). Organisations have to evaluate what they should replicate since only value-adding elements that are replicable should be replicated. If these traits are not chosen successfully, replication can result as repeating irrelevant features or even mistakes and hindrances of a process. In order to gain benefit from a replication strategy an organisation must have thorough understanding of the traits to be replicated, the methods by which the replication is implemented and of the characteristics of an applicable receiving environment. Replication can become expensive and challenging if the environments of replicated traits differ much from each other. (Winter and Szulanski 2001). Brady and Davies (2004) argue that in rapidly changing environments a replication strategy can become unsustainable and too standardised processes can create new problems. Winter and Szulanski (2001) also claim that replication can lead into reduction of innovation. Too standardised processes can result in employees not learning or understanding the practices, but rather just executing the process. Standardising practices can also reduce the amount of initiatives for incremental improvements. If suppliers or internal organisations are replicated there is a threat that the amount of fresh ideas and innovations as well as competitive pressure are reduced (Grabher 2004). Galbraith (1990) stresses that documentation and knowledge codification, which are required for successful replication, also generate costs and require investment of time.

Brady et al (2002) draw a difference between technical knowledge and process knowledge. Technical knowledge includes design and implementation aspects of a product as process knowledge includes aspects of performing project activities. Replication of a technology requires transfer of technical knowledge and replication of a process requires similarly transfer of process knowledge. Galbraith (1990) describes replication of technology as the relocation of a manufacturing technology and the applicable manufacturing process. Replication of a process includes standardizing process practices and certain procedures. Milosevic and Patanakul (2005) argue that in addition to individual processes, project management tools and practices can be replicated. However, they conclude that flexibility is also required in project management and therefore the process shouldn't be replicated too precisely. Bartezzaghi et al (1997) argue that transferring same employees to following projects is an effective replication method as they bring their experience and know-how with them. People are also able to transfer tacit knowledge as well as interpret and structure knowledge in a way that it applies to different contexts (Berry and Broadbent 1987), which eases the replication process. However, transferring the whole team can be impossible due to other duties or costs. Brady et al (2002) suggest that in this case the core team members should be transferred to the following project. In the context of a multi-firm investment project, the structure of a project organisation is also a replicable element (Lajunen 2010).

A replication process begins by an organisation evaluating what elements they want to replicate and also whether there are some things they want to perform totally differently than before. The selection should be done carefully since the selection of replicated traits has a major influence on the success of replication and overall project. The replicable element should at least be moderately easy to replicate and add value for the organisation. However, threat of imitation should also be considered – if the element is too easy to replicate the threat of competitors copying it increases. The elements should be chosen so that they can be diffused to the receiving environment. Therefore, in construction projects a careful site selection eases the success of replication. In addition to selection of replicated traits, the success of replication depends of selected time to move from exploration phase to exploitation. Before an element can be replicated the element has to be created and refined. Replication dilemma refers to the choice of moving from exploration - improving and refining the replicated element - to exploitation of the model and realising benefits of the replication process. The choice is not self-evident as too little amount of exploration increases the risk of ignoring important improvements. However, too many modifications in the element can also result as new problems created by the dependency of new environments and models. Also, the estimated level of the significance of improvements tends to be overoptimistic in the exploration phase. (Winter and Szulanski 2001). The exploration and exploitation phases can be somewhat parallel if employees are allowed to suggest and make modifications to the replicated element during the replication process. Winter and

Szulanski (2001) argue that in order to enable successful replication new specific capabilities and supportive mechanisms have to be built. These capabilities are different in the exploration and exploitation phases. Also the environment and attitudes of employees have to be favourable for replication. Since knowledge transfer is fundamental for replication, employees should be guaranteed enough time to reflect on their experience and codify the gained knowledge. Therefore, replication strategy requires investment of time and money and the whole organisation should be committed to it.

Two main methods to be used in a replication process are templates and principles. A template guides the replicator by the example of an extant working example (Winter and Szulanski 2001, Baden-Fuller and Winter 2005). It can be for example a real-life building or plant that is copied to a certain extent. Use of templates is less likely to create expensive surprises than the use of principles. Principles approach emphasises rules and phenomenon behind the replicated element. This approach doesn't provide a working example but aims to guarantee that the replicator understands why something works and therefore eases the making of decisions. Principles are argued to capture knowledge on a much deeper level than templates because principles don't allure to copy an element without developing understanding. Principles are evaluated to be a more successful approach for replication if the receiving context is much different than the donor. Usually in a replication process the emphasis is on another approach even though they can be mixed to a certain degree. (Baden-Fuller and Winter 2005).

Lajunen (2010) argues that replication in a multi-firm investment project environment has somewhat the same advantages and disadvantages than replication in another context. However, due to the nature of a multi-firm project, successful replication can be extremely challenging (Lajunen 2010) as one part of a system can significantly affect other parts and create new problems (Brady et al. 2002). The number of stakeholders increases the risks and therefore all of the participating organisations must be committed to the replication process. This must be addressed in advance to the project in order to avoid contractual issues. Time between projects is crucial in order to enable effective knowledge transfer and improvements. A robust design that fits various environments can become significantly expensive and therefore replicable elements should be considered carefully. However, in this context it can be difficult to estimate what should be replicated due to unique characteristics of an environment or project. In addition, replication dilemma is continuous as the replicated model should be constantly improved and only certain elements replicated. (Lajunen 2010). Brady et al. (2002) claim that project environment doesn't enable the use of previous approach without modifying it. For example, used technologies and customer wishes can change. However, replication can also considerably reduce the risks of a project, since the process has been undertaken before and the outcome can be enhanced. Careful site selection, robust design, co-location of project teams, standardised structure of project

organisation, a responsible unit for knowledge collection, a favourable climate, efficient knowledge transfer and processes to handle unplanned actions and modifications ease the replication process in a multi-firm project context. (Lajunen 2010).

3 EMPIRICAL STUDY

This chapter introduces the methodology utilised in the empirical research. Also the data gained in the empirical study is presented and analysed.

3.1 Methodology for the empirical research

According to Yin (2003) the research approach should be selected based on the ability of the researcher to influence the phenomenon, whether the researched events are contemporary or historical and whether the research questions are qualitative or quantitative in nature.

The empirical part of this research was carried out as a mainly qualitative case study. A case study is an applicable research approach when the researcher has little ability to influence the events, the studied phenomenon is contemporary and located in its real-life context and the research questions are qualitative (Yin 2003). The empirical study consists of researching the processes of the case organisation but also includes benchmarking of three other processes. However, the emphasis lies significantly on the processes of the case organisation as the results of benchmarking were mainly utilised to form a wider understanding of the phenomenon.

The study is mainly qualitative since the research questions are of type ”how”, which motivates to adopt a qualitative research approach since qualitative data is in general richer in description compared to quantitative data (Yin 2003). However, quantitative data is also utilised in the research but notably less than qualitative. Yin (2003) names three different types of a case study: exploratory, descriptive and explanatory. The research questions of this study are both descriptive and exploratory. First, they are descriptive since in order to answer them one should be able to describe the studied contracting processes. Nonetheless, the study has also exploratory features since as an attempt to answer the research questions, novel approaches have to be explored and existing approaches have to be interpreted into a new context.

Eisenhardt (1989) argues that in a case study context, case selection, data collection and reliability and validity are significant. These aspects are discussed in the following chapters.

3.1.1 Selection of case processes

The study emphasised studying the contracting process of the case organisation. However, as one of the objectives of the study was to understand how simultaneous execution of projects influences the efficiency and effectiveness of a contracting process, two types of contracting processes were examined: a traditional process in which a single project is executed one at a time and a process in which two projects are executed simultaneously.

In order to study the contracting processes, six nursery school projects were examined. The execution of projects A and B was combined and therefore studying these projects offered a platform to research the impact of simultaneous execution on a process. Projects C, D, E and F were executed one by one and thus examining these projects enabled researching the traditional contracting process and also comparison between the two contracting approaches. However, the processes weren't totally distinctive as the difference between the approaches was that projects A and B included one common design team as the other projects included separate design teams. Otherwise the processes were implemented with same principles. Also the phases executed prior to procuring the design team were similar in both of the approaches.

All of the six projects were in the pre-construction phase at the time of the study. Since the research was conducted by interviews, it was important that the interviewees remembered correctly the discussed events. Proximity of studied events and the research increases the chances for reliable results (Yin 2003). Consequently, projects that were active were chosen for the study. The selection was done by pre-interviewing the chief executive officer and the chief of the pre-construction phase department. However, since the projects were in the pre-construction phase the realised costs of construction or the total costs occurring during the buildings' life cycles couldn't be utilised in this research.

In addition to researching the case organisation's contracting process, the study included benchmarking. The benchmarked processes were chosen based on the organisations' experience in efficient and effective contracting of nursery schools.

3.1.2 Data collection and analysis method

The primary source of data was interviews. Interviews are an applicable research technique for qualitative research as in general they can capture data that is rich in description.

In total 20 interviews were conducted. 17 interviews concerned research about the case organisation's processes and three interviews were held to benchmark novel prospective

approaches. The interviews are presented in table 3. The interviewees working at the case organisation are highlighted in the table.

Table 3: Held interviews

Interviewee	**Date of interview**
Principal designer (project B)	24.3. and 7.5.
Project manager, pre-construction phase (projects A and B)	9.4.
Superintendent, structural engineering	9.4.
Superintendent, geotechnical engineering	14.4.
Superintendent, cost engineering	15.4.
Principal designer (project A)	20.4.
Conceptual designer, user department	21.4.
Project manager, pre-construction phase (project C)	22.4.
Chief of department, pre-construction phase	28.4.
HVAC engineer (projects A and B), *interview via e-mail*	28.4.
Chief of department, geotechnical engineering	29.4.
Project manager, construction phase (projects A and B)	5.5.
Project manager, pre-construction phase (projects D and E)	8.5.
Consultant, benchmarked process C	11.5.
Chief executive officer, benchmarked process A	12.5.
Project manager, pre-construction phase (project F)	13.5.
Principal designer, benchmarked process B	19.5.
Chief of planning, user department	26.5.
Electricity designer (projects A and B), *interview via e-mail*	2.6.

The interviewees were chosen based on their relation to the studied projects and the case organisation. In order to improve the validity and reliability of the study, several people with different roles in the projects and case organisation were interviewed. The interviewees consisted of both internal employees as well as external consultants working on the projects. As seen from table 3, several team members of projects A and B, including external consultants, were interviewed. The structural designers were excluded of the study since the projects had different structural designers. Project managers of projects C, D, E and F were also interviewed but external consultants working on these projects were excluded of the study due to limited resources of the research. Four of the interviewees were manager level employees who had not participated directly in the projects but were interviewed in order to achieve a broader understanding the contracting process. The interviewed superintendents and conceptual designer had knowledge about all of the projects. However, the interviews often included discussion about the contracting process on a general level instead of limiting into discussing specific events of a project.

Two of the interviews were held by the interviewees answering open-ended questions in a written format due to lack of time to meet in person with the researcher. The other interviews were held in person and were semi-structured in nature. The themes that were discussed were drafted in advance, but new topics emerged in some interviews and the emphasis of the themes as well as the order of questions varied from interview to interview. The amount and nature of questions also varied depending on the interviewee's role in the examined projects and relation to the case organisation. Project documents were studied prior to drafting the interview topics and questions in order to enable more detailed conversation. The interviews lasted approximately from one hour to two and half hours. The interviews were taped and notes were written down.

Project documents such as cost estimates, meeting minutes, construction blueprints, conceptual plans, inquiries for quotation, contracts et cetera of the studied projects were utilised as a secondary source of data. Also internal organisational guidelines and manuals were studied. The researcher also worked in the case organisation for six months and participated in few development and project meetings and therefore gained some tacit knowledge about the organisation's processes.

The benchmarking was done by interviewing representatives of the benchmarked organisations and by studying the organisations' web pages.

The collected data is analysed as follows: first, the contracting process of the case organisation is analysed in terms of discussing factors that have an influence on the efficiency and effectiveness of the process. The factors that are distinctive to the process, in which two projects are combined, are separated from the factors that are shared by both contracting processes of the case organisation. Second, the benchmarked processes are analysed separately in terms of factors that have an influence on the efficiency and effectiveness of the process. Finally, all of the processes are compared with each other and the emerged factors are divided into further categories in order to answer the research questions.

3.1.3 Ensuring reliability and validity

Reliability of a study refers to whether similar results can be achieved if the research is repeated later with a similar research approach and data collection technique (Singleton and Straits 2005). Yin (2003) argues that the reliability of a case study can be increased by utilising a case study protocol to describe the data collection methodology and by creating a case study database. The research plan and interview structures of this study as well as all utilised documents stored in one file enhance the reliability of the research as these actions enable that the study could be conducted later with similar results.

Validity means whether the research really examines the phenomenon it intends to study (Singleton and Straits 2005, Yin 2003). In the context of a case study validity can be

divided into two types of validity: construct validity and external validity. High construct validity means that the operational measures that are utilised are relevant to the objectives of the study. High external validity means that the results can be generalised to other similar contexts. Construct validity can be improved by having multiples sources for data, establishing a clear chain of evidence and reasoning and receiving feedback of the case study report by key informants. (Yin 2003). Numerous interviews and utilisation of multiple secondary sources as well as constant feedback gained from several employees of the case organisation enhance the construct validity of this study.

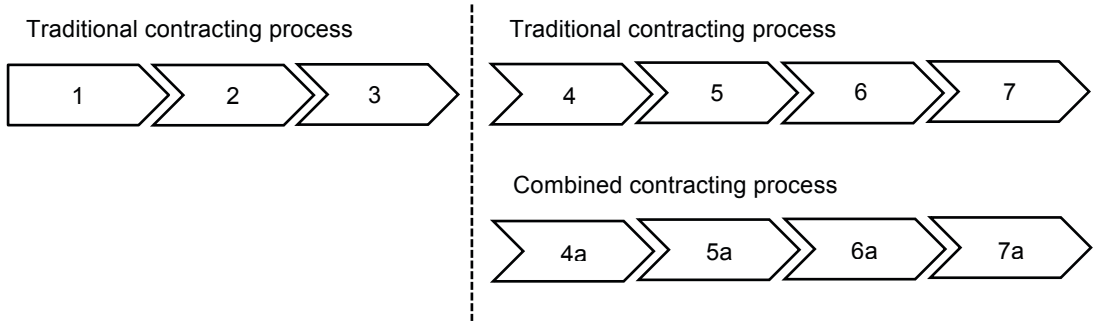
3.2 Case analysis

In this chapter the data gained from the empirical research is presented and analysed. The analysis regarding the case organisation's processes and benchmarked processes is separated.

3.2.1 Case organisation's processes

In this chapter the data concerning the contracting processes of the case organisation is introduced and analysed.

In figure 12 is presented the two studied processes.



1 - Land use planning and service network development
2 - Initial planning
3 - Conceptual planning
4 - Procurement of design team
5 - Design
6 - Procurement of general contractor and sub-contractors
7 - Construction

Figure 12 *Two studied contracting processes of the case organisation*

As visualised in the figure, the process in which two projects are executed simultaneously, distinguishes from the traditional process, in which one project is executed at time, when the design team is procured. Thus, this chapter is structured as follows: first, the contracting process of the case organisation is described briefly as using the process of projects A, B, C, D, E and F as an example. Second, factors that

influence the efficiency and effectiveness of the contracting process are discussed. These factors are general features of the contracting process and can affect the process independent of whether several projects are executed simultaneously. Finally, influential factors that stem from the combined execution and thus only occur in the process in phases of 4a, 5a, 6a and 7a are discussed.

3.2.1.1 Description of the contracting processes

In all of the studied projects the need for new space was caused by the increased amount of children in the area. The user department created an initial plan for every project in collaboration with the case organisation. The land use plan and service network plans guided this stage of planning. The user committees accepted the initial plans and made investment suggestions to the case organisation based on all accepted initial plans. The case organisation then made suggestions to the city council that added the projects to the budget and economic plan.

After a project decision was made the project manager in collaboration with the user department begun to create conceptual plans for the projects. While the projects were in the conceptual planning phase, the case organisation executed a development project in order to update the nursery school design manual and to finalise the conceptual plans of the projects. The updated design manual was utilised for the first time in the case projects. During the development project the case organisation also decided to pursue economies of scale by combining the design and implementation of projects A and B. After the conceptual plans were finalised the user committees reviewed them. Afterwards the plans proceeded to the executive board to be accepted.

After the investment decision was made, the procurement of the design team begun. The projects were procured with a design-bid-build procurement method. Principal designers were procured by utilising a framework agreement that had been recently created for procurement of nursery schools and analogous buildings in order to streamline the tendering process. The framework agreement included 15 architect firms. An invitation for tenders was sent to from two to five most applicable offices. The final selection was made based on the lowest price. HVAC, electrical and structural superintendents were responsible for tendering the corresponding designers. The geotechnical department was responsible for selecting geotechnical designers and utilised a framework agreement in the bidding process. Since the case organisation had decided to pursue economies of scale and execute projects A and B simultaneously, these projects were tendered mostly to same designers. One architect firm, as well as one HVAC, electrical and geotechnical designer were selected to participate in both projects. Both projects had their own structural designers from distinctive firms.

In the design phase the project teams met once a month to discuss the process and the designs in terms of requirements and constructability. The meetings of projects A and B

were combined since most of the team members participated in both projects. The designers also had several other meetings to e.g. plan and decide on technical solutions and to gain feedback of the designs. In addition to the meetings, the teams were constantly in touch with each other and utilised a common project bank, but worked in their own venues. During the design phase the costs of created plans were estimated twice and compared to the target cost that was set during conceptual planning. If the target cost was exceeded, the plans had to be modified until the target cost was reached. The cost estimation means utilised at the design phase assesses the price based on building blocks and materials and utilises average cost data in the calculation. In figure 13 is presented the relative share of costs estimated to occur in project A. The figure was created based on the final cost estimates that were done in the design phase. The shares of costs of other projects were similar with project A's cost estimate, with only a maximum of few percentage point differences, and not presented in this thesis in order to avoid unnecessary repetition.

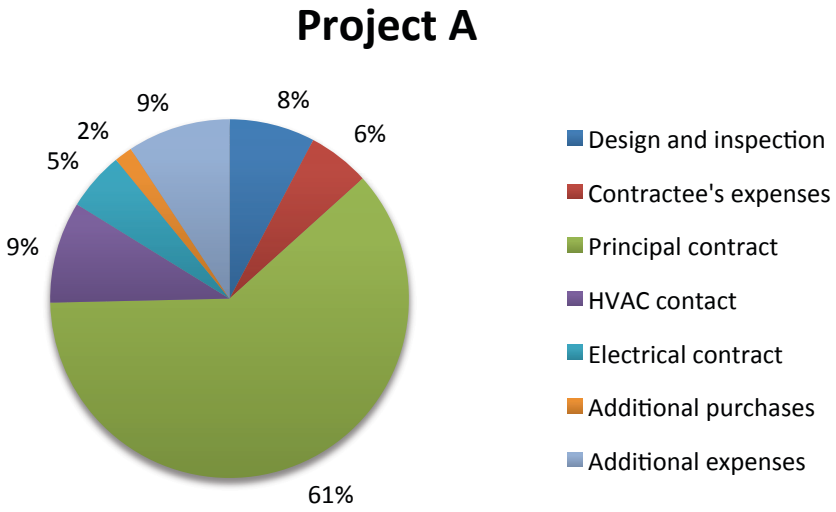


Figure 13 *Relative shares of estimated costs of project A*

In addition to the project team, several stakeholders reviewed the plans to ensure that the designed constructions were safe, healthy and easy to maintain. After the plans were approved by all stakeholders a construction permit was applied and the designers created detailed plans for the use of the contractor.

At the time of the study project A had applied for a building permission. Projects B, D and E were also in the design phase, but hadn't proceeded to applying for a building permission. The conceptual plan of project C hadn't been approved as the site hadn't been decided on, since different options were reviewed in order to find a site that would fulfil the requirements of stakeholders but wouldn't increase project costs excessively. Conceptual planning of project F was meant to begin later because money for the project was reserved for upcoming years. In table 4 is presented the target costs and progress of the studied projects.

Table 4: Target cost and progress of studied projects

	Target cost	Initial plan is approved	Conceptual plan is reviewed and approved	Construction design begins	Procurement of contractor
Project A	5,72 M €	4/2009 and 8/2013	Reviewed: 10/2013 Approved: 11/2013	7/2014	1/2016*
Project B	6,3 M €	6/2013	Reviewed: 11/2013 and 2/2014 Approved: 3/2014	7/2014	9/2015*
Project C	4,75 M €	5/2012	n/a	10/2015*	9/2016*
Project D	3,83 M €	6/2013	Reviewed: 9/2013 Approved: 11/2013	7/2014	7/2015*
Project E	6,98 M €**	8/2013	Reviewed: 9/2013 Approved: 11/2013	6/2014	11/2015*
Project F	n/a	n/a	n/a	9/2016*	11/2017*

* Intended date

**Information from a conceptual plan that wasn't up to date

When the projects proceed to procurement of contractors the project manager will change. The new project manager has participated in the design phase by attending the project meetings. The procurement of contracts is typically done with a restricted procedure. The final selection of a contractor is in general made based on lowest price. After the construction finishes the case organisation will continue to maintain the premises.

3.2.1.2 Factors affecting the efficiency and effectiveness of the contracting process

In this chapter the contracting process is analysed so that factors that have an influence on the efficiency and effectiveness of the contracting process are presented. The factors are independent of the amount of projects that are executed at the same time. The analysis includes examples of the events of the studied projects when applicable.

Decision-making in the beginning of the process

Various interviewees identified that the early phase of nursery school projects was often lengthened because the discussion about whether an old building should be renovated or replaced with a new construction was lengthened at the initial planning stage. Project E begun initially as a combined renovation and replacing construction but after the project proceeded to the design phase the condition of the existing building was discovered to be so poor that it wasn't practical to renovate the building. Consequently, the project had to begin again and was executed as a replacing construction, which lengthened the process and increased the costs. An interviewee estimated that the condition inspection concerning structures should have been more profound when the decision about renovation was made in order to avoid the scenario. Also another interviewee identified that the process is lengthened in the beginning if the decision-making concerning to which site a building is constructed is not efficient. At the time of the study the site for project C hadn't been decided yet because several sites had been examined, which had postponed conceptual planning. However, the length of the early stages varied significantly from project to project as in some projects the decisions were made quicker than in others.

Few interviewees mentioned that in a nursery school context the most fundamental issues such as location of the service and amount of child groups are decided during land use planning. These issues also have a considerable influence on the total costs of a project. Therefore, the interviewees stated that the case organisation could be involved more profoundly in projects already at that early stage in order to assure that they can affect the fundamental issues and establish common objectives with other stakeholder groups.

City plan updates

Interviewees acknowledged that several nursery school projects had included an update of the city plan during conceptual planning. It had been common that the amount of children groups had increased or that another service had been attached to the same building due to strategic development of the service network. An interviewee identified that by constructing bigger units, smaller buildings or buildings in poor condition could be divested. The operation and maintenance costs of small nursery schools are relatively bigger than those of larger units and therefore the interviewee argued that development of the service network should address locating operations into big units. Thus, the city plan updates are crucial. However, the updates lengthen the lead time of projects and increase the amount of waiting as an interviewee estimated that in general the lead time of a project could lengthen approximately by one year if the city plan has to be updated during the project. Yet, conceptual planning could be done to some extent at the same time as the city plan update. Also whether the amount of users or offered services is increased after the initial plan has been approved, the initial plan has to be updated which results in rework.

During projects A and B the city plans concerning the corresponding sites were updated. The updates were done because the permitted building volume had to be increased in order to construct nursery schools that would serve more citizens and fulfil the objectives of the planned service network. Building B also included a youth space in addition to a nursery school. Interviewees acknowledged that other nursery schools had been combined with e.g. schools and maternity clinics. A city plan concerning the site of project F had been created in which the permitted building volume had been increased. However, when the plan proposal had been displayed for public inspection it received a considerable amount of complaints from litigant citizens and therefore at the time of the study the project was intended to proceed with the original city plan. In the other examined projects city plan updates hadn't occurred. The site for project C hadn't been decided yet at the time of the study. The sites of buildings D and E were so compact that bigger buildings would have not fitted there and building permit was left unutilised. It seems that if the conceptual plan is executed relatively fast after the initial plan had been approved, modifications in the requirements are less likely to happen and therefore efforts caused by updating plans aren't required.

Timing of including the principal designer into the project

During conceptual planning external architects are hired to projects to create the preliminary designs for the buildings. The aim of a preliminary design is to address the layout and architecture of the building on an initial level and suggests a feasible location for the building on site. However, the architect who creates the preliminary designs doesn't necessarily continue in the project, because the final design team is procured after conceptual planning and some other architect might get selected to the project.

In project D the same architect who was involved in the conceptual planning was chosen to do the actual construction design. The project manager felt that this arrangement produced significant value for the project because the planning could continue smoothly since the architect had a high level of understanding already in the beginning of the design phase. In other studied projects the principal designers had changed. Several interviewees argued that the principal designer should already be involved in conceptual planning because in the projects in which the architect had changed, the planning had started almost from the beginning. It was also recognised that using two distinctive architects during the process can result in unnecessary work if same work is done twice due to e.g. inefficient knowledge transfer or changed plans. In addition, few interviewees recognised that in general architects aren't motivated to offer their best ideas during the conceptual planning because there is no guarantee that they get to continue in the project.

Procurement practices

All of the superintendents procure the corresponding designers for projects distinctively. One of the project managers suggested that the separate procurement of team members

could have a negative impact on the project team, as the team members can't affect whom they work with. They thought that especially the principal designer should have an influence on the procurement of the structural and HVAC designer since their work has the biggest influence on the principal designer. They suggested that instead of procuring the members separately the whole team or several team members could be procured at once since the design process is in general much more efficient if the team collaborates well together.

Another interviewee noted that currently the case organisation didn't have a coherent procurement strategy as project managers and superintendents were responsible for procuring designers and contractors. Also the procurement practices differed significantly from superintendent to superintendent and weren't transparent to others as some superintendents emphasised quality criteria as others made the selection based on price. The case organisation utilised framework agreements to procure some of the designers. The project managers assessed that this approach accelerated the process a bit as the invitation for tenders was simple to create and the amount of received tenders was smaller than in general in a public bid. However, even though framework agreements were utilised, one project manager acknowledged that the level of principal as well as other designers varied from project to project, but the public procurement law and utilised low-bid method prevented from choosing the designers they wanted to.

Collaboration among the project team

Various team members of the studied projects claimed that the information transfer between the team had been sufficient and collaboration successful. However, in some of the projects, the principal designers were not satisfied with the motivation and working methods of some team members. One designer had a distinctive understanding about the utilised materials than the rest of the project team. Some team members had avoided extra work by not contributing to the project before the planning had proceeded so far that major changes weren't likely to happen and the principal designer had already created considerably detailed plans. Then they produced the required plans with small threat of double work. Yet, this had resulted in the principal designer and therefore other designers having to update their plans excessively quite late in the process. An interviewee assumed that this phenomenon could be explained by lack of motivation, which was due to the lump sum that was paid for the designers instead of paying them based on the working hours. They argued that often external consultants bid with considerably lower working hours than they estimate to be realistic in order to get the job, which however can hinder their work motivation.

An interviewee had recognised that the projects that involved consultants who had been working with the case organisation before had leverage over projects that had novel consultants. The experienced consultants had already become familiar with the

objectives and requirements of the case organisation, which made the process and collaboration more efficient.

Objectives and requirements for a building

Several interviewees identified that the principal designer is given considerable freedom to direct the design process into a direction they wish as long as the client's requirements are taken into account and the cost estimates of the plans don't exceed the target cost even though the process is supervised and feedback about their proposals is given constantly. Some people saw the freedom as risky since they had experience of projects where the principal designer had emphasised for example the architectural expression over cost-efficiency, quality and user-friendliness. Thus, the arrangement works if the objectives of the principal designer and owner and client are aligned.

The case organisation had created a nursery school design manual in which objectives and requirements for new nursery schools are presented. The requirements concern technical solutions, functionality, room sizes, design of the outdoor areas et cetera. In addition to the manual, a separate more detailed set of space requirement cards is utilised in the design process. Both of the guidelines were utilised for the first time in the process in the studied projects. External consultants mentioned that the guidelines were valuable especially in the beginning of the process because they helped to create a rough idea about the direction for the project and therefore accelerated the process. However, several designers had recognised that some of the requirements were contradicting between the guidelines. Some of the principal designers of the studied projects had also identified that fulfilling all the requirements and objectives would have a hindering effect on the overall outcome and therefore negotiated if some of the requirements wouldn't have to be fulfilled. Especially some requirements concerning space location were perceived as troubling since these requirements resulted in increased amount of unnecessary area and therefore hindered the building efficiency. Dealing with the contradicting requirements slowed down the process as the requirements had to be discussed and increased the amount of rework.

Few interviewees also pointed out that the superintendents representing different disciplines had all multiple separate requirements that had to be fulfilled precisely. They felt that the disciplines were not willing to be flexible about their individual requirements even though they were somewhat contradicting to others' requirements. Fulfilling all of these requirements precisely didn't lead into the optimal overall outcome and sub-optimisation resulted in design solutions that increased the construction costs of the building.

Project B involved two user departments who both had distinctive requirements for their spaces. Some spaces of the building were meant to be utilised by both user groups. During the construction design it was recognised that some of the user departments'

requirements were contradicting and the process was slowed down as the plans had to be updated and modified several times due to changed requirements. It was also noted that not all user representatives necessarily understood how their requirements and wishes influenced the overall outcome and total costs or how much extra work some modification suggestions that were given in a late stage of the process would result in.

In addition to the design and implementation team, projects involve several other stakeholders that have their individual requirements. In the city plan several requirements regarding e.g. the amount of floors and façade material are expressed. The building control has their own objectives concerning the architectural expression of buildings. However, in some of the studied projects the requirements set by the case organisation and city plan were contradicting and therefore during the design process the parties negotiated what requirements should be fulfilled, which increased the amount of waste. The different views of the case organisation and land use plan concerned for example a vegetative roof and treatment of urban runoff. An interviewee recognised that establishing a common understanding with stakeholder groups in advance to project commencement forms a basis for efficient execution of projects.

Cost management practices

An interviewee suggested that the cost estimation means utilised in the design phase wasn't sufficient because the calculation didn't consider the constructability of plans. They argued that when a contractor assesses the price to create a bid they put high emphasis on how easy and efficient it is to construct structures. The more constructible the structures are, the lower the bids are. The interviewee indicated that the constructability of the plans was highly dependent on the expertise of the principal designer and the project team since the current cost management process didn't guide necessarily to solutions that would be simple to construct. Therefore, the total costs can vary considerably from project to project depending on the design team's ability to reflect suppliers' capabilities to the designs. It was also acknowledged that bid prices were highly dependent on the market situation and a contractor's desire to get the contract. Yet, one interviewee noted that contractors are aware of the high price level of executed nursery schools in Espoo and therefore they might bid with high profit margins even though the structures would be constructible.

The target cost of for projects are calculated in the conceptual planning phase based on area requirements, initial information concerning site conditions and risk factors. Several interviewees found problematic that a target cost is set so early in the process since the available information at that stage is often too limited to enable proper estimation. The interviewees pointed out that if some expenses increase due to changed conditions some other expenses have to be reduced and were concerned that these reductions would be done on the expense of the value experienced by end-users. Various interviewees also pointed out that life cycle costs should be analysed and

estimated more when decisions are made. The binding target cost is problematic in terms of total cost of ownership thinking as it can be alluring to exclude thinking about the costs occurring during the life cycle if it is otherwise challenging to reach the target cost.

The sites reserved for small public buildings in Espoo have in general challenging soil conditions. Several interviewees had noticed that usually the estimated expenses of foundation work had changed considerably during the design process. One interviewee suggested that the risk factors regarding foundation work should be bigger if the target cost had to be reached because the information concerning soil conditions becomes more explicit when the design process proceeds. Also the principal designer's decisions affect the costs of foundation work significantly.

Additional and modification work

The case organisation's nursery schools are often procured with a design-bid-build method, which means that the contractor will join the project team after the construction plans have been created. None of the studied projects had proceeded to procurement of a contractor at the time of the study. However, interviewees identified that collaboration with contractors had been occasionally challenging in other projects as contractors had tried to generate higher profit by seeking additional work that wasn't mentioned in the contract and had demanded additional and modification work to the construction plans. The project manager will also change when the contractor is procured. An interviewee felt that changing the project manager in the middle of the process hindered the development of procurement practices.

Several interviewees argued that the realised expenses of foundation work had often been considerably higher than the final estimated costs due to excessive modifications in the foundation plans done after the contractor had been chosen. Often this had happened because the results of final soil studies had not been available yet when the contractor was tendered and the modifications had to be done as additional and modification work. Proper soil studies are executed in three cycles but the interviewees estimated that in general some of the studies are skipped or postponed due to lack of time. The interviewees also emphasised that the last round of soil studies couldn't be done before the HVAC designs were finalised. Often there hadn't been enough time reserved for the final studies before the contractor had been procured and therefore the information concerning foundation work had come in too late. Also replacing constructions were perceived as problematic since the soil couldn't be tested before the existing building was demolished. Even though modifications concerning foundation work were most common, also other disciplines' plans had to be modified occasionally after the contractor had been procured.

Collecting feedback

Most of the project managers stated that after a construction project ends all team members should be encouraged to give feedback and the process should be documented properly. However, there were no organisational guidelines for final documentation and often it hadn't been done due to other more acute work. One interviewee that didn't work in the case organisation mentioned that the case organisation collects feedback rarely and doesn't often give feedback to them either. Several interviewees working in the case organisation also identified that there was a need for a feedback collection system that would involve the external team members. However, one project manager had identified that even though external consultants often had development ideas and were willing to discuss them during the design process on an ad hoc basis, they didn't mention them afterwards if they were asked for feedback in a formal manner. The project manager estimated that this might be due to lack of motivation or fear of being perceived as difficult.

Working methods

A considerable percentage of the staff working in the case organisation had been working there for only few years. Various interviewees mentioned that due to the high turnover rate the process was not standard and the working habits differed radically from person to person. Lack of standardised processes was perceived as problematic since for example tasks had been occasionally executed too late during the process or the team members were uncertain of their areas of responsibility. Also measurement and therefore development of the process is difficult if the working methods vary or the process is executed based on individual preferences.

An interviewee had recognised that usually valuable information gained from a project wasn't documented and codified but it remained in team members' e-mails or as team members' tacit knowledge and therefore wasn't available for other project teams to utilise, which made inter-project learning challenging. High level of tacit knowledge was especially problematic since staff had changed fairly much and the gained knowledge wasn't transferred to new employees. Several interviewees had also recognised that platforms to store information were utilised in a varying manner from project to project based on the preferences of team members. Interviewees also acknowledged that saving plans to various platforms and utilising several places to store information during the whole project life cycle consumed resources excessively.

Standardised solutions

Some employees of the case organisation argued that several building features should be standardised in order to make the design process more standard. Several interviewees were sceptic about creating a replicable concept building because they acknowledged that a building could be replicated only to sites that were large enough and didn't include slopes. Also the land use plan set requirements for permanent buildings and

therefore buildings that were suitable for one area wouldn't get a building permission to another area. However, various interviewees mentioned that the guidelines concerning e.g. furniture, materials, structures and equipment could be more explicit so the quality would be standard regardless of the project team and solutions that have been recognised as cost-efficient and user-friendly would be utilised in all buildings without having to discuss the same issues separately in every project. A HVAC and an electrical designer indicated that solutions that have been successful in earlier projects could be replicated to some extent from building to building if the other plans and requirements enable this. Replication of building elements could have a shrinking effect on the lead time and also total costs if the elements are more cost-efficient than other solutions. Some interviewees mentioned that especially the design guidelines for expensive spaces could be more exact or even a concept room could be created. In a nursery school context the wet spaces were expensive. However, other interviewees argued that concept rooms could create new problems because they wouldn't necessarily fit the overall layout of the building. An interviewee was also concerned about the copyrights of concept solutions since they had experience of not being able to utilise furniture that was designed for one nursery school in succeeding projects.

3.2.1.3 Effect of simultaneous execution on the contracting process

This chapter introduces how simultaneous execution of projects A and B affected the contracting process of the case organisation.

The case organisation pursued economies of scale by combining the contracting process of two projects and executed projects A and B simultaneously. The strategy during conceptual planning was to tender the projects to same design team and contractor since the case organisation estimated that this could have a positive effect on the efficiency of the process.

However, the conceptual plan of project A was approved four months before the conceptual plan of project B. The plans were finalised approximately at the same time, but project B was postponed because the user committees didn't approve the conceptual plan of project B at first because they were concerned about the poor soil conditions of the suggested site and recommended to search a better one. At the end there were no better sites available. Because the procurement was combined, project A didn't proceed during the four months but the procurement of team members was done just after both conceptual plans were approved and the project's lead time was therefore lengthened. Therefore, it seems that combining projects can result in lengthening the lead time as the other project can get postponed or even totally cancelled due to the municipal decision-making process. This increases the need for risk management practices.

The same HVAC, electrical and foundation designer were included in both projects. The principal design of the projects was tendered to the same architect firm. The workload

was divided so that one architect was responsible for project A and other architect for project B. The other principal designer argued that the schedule was so tight that they weren't able to be involved profoundly in both projects. The structural designers of the projects were distinctive.

The interviewed consultants agreed that leaving a bid for two projects at once was alluring since winning the bid would guarantee work and revenue for a longer time and more up-to-date references. Also some of them felt that they saved time in the bidding phase because it was faster to prepare one bid for two projects than two separate bids. The consultants who were involved in two projects had also estimated that synergy benefits could be achieved when two projects are executed simultaneously. Due to these factors they reduced the prices of the bids a bit. However, as the designers' bid prices are considerably small compared to the total costs of projects, also the cost advantage gained from added buying power at this stage is also marginal.

The team members who were involved in both projects experienced that the knowledge transfer among the team members was more efficient than normally because they were more profoundly in touch with each other. Also the same ideas could be used as a foundation for the solutions of both buildings, which enabled synergy benefits. Several team members identified that the combined project meetings were a value-adding approach since having one longer meeting was perceived in general more efficient than having two separate meetings even though the projects were discussed successively. However, since the structural designers were different for both projects several other team members estimated that they were not pleased with the combined meetings, as they had to sit through discussions concerning a project they were not involved in.

The principal designers didn't feel that the combined execution influenced their work much because they were not encouraged to design buildings that included same building blocks or materials and thus they didn't pursue similar outcomes intentionally. Several project team members felt that the projects' requirements were so different that utilising similar design solutions by force would not have been optimal. Building A was a new construction and building B a replacing construction, which affected especially the structural and foundation design. Hence, the projects were tendered to distinctive structural designers. The sites of the buildings were different in nature, which prevented from using same solutions. The surroundings of site A were undeveloped and infrastructure planning was done at the same time as the project, which influenced the design process and schedule. The soil conditions on the site B were worse than on site A and the location of building B was changed several times during the design process. The land use plan had some different requirements for the projects: building A had to include a vegetative roof and an old tree on the site had to be preserved whereas project B had specific requirements concerning noise suppression as the site was located nearby a highway. The cityscape requirements for the buildings were also different in nature,

which affected the architectural solutions. Project B included two separate user departments and therefore some of solutions utilised in building A weren't applicable to building B. Also during the design phase of project A flying squirrels were discovered from the site. The squirrels increased the amount of requirements and stakeholders as the Centre for Economic Development, Transport and Environment had to be included in the project more profoundly than in general. Same façade material was utilised in both buildings. Also some of the structural solutions were common for both buildings. Hence, it seems that if same solutions ought to be used in two buildings, the projects should be selected carefully in advance so that the requirements and context would be as similar as possible.

Several team members noticed that even though the objective for the combined execution was to reduce costs, the team didn't have an explicit plan how costs could be decreased in practice. Neither did the target cost estimate consider the combined execution anyhow, but was created based on the area and space requirements and site as in other projects. At the time of the study, the projects didn't seem to achieve cost or lead time advantage compared to other studied projects.

During the conceptual planning phase the project team discussed about the possibility to bid the projects to not only one design team but also to one contractor. Yet, at the time of the study it had not been decided whether the projects would be tendered with a joint invitation for tenders or with two separate ones. However, the project manager of the construction phase argued that most likely the projects will not be tendered at once. They were concerned that if the projects would be given to the same contractor, it would radically reduce the amount of bidders as only bigger construction companies could participate. They argued that the projects were considerably large in size and smaller companies wouldn't necessarily have resources to construct both of them. Thus, the prices for a joint bid wouldn't necessarily be any lower than prices of bids for two separate projects since bigger construction companies in general had higher prices. Also the risks would increase if the contracts would be combined since it would be a new approach and the contracts would have to be created extra carefully. The benefits gained from possibly lower bid prices could be consumed to increased amount of required management and planning. The project manager was neither sure whether combining the projects to one invitation for tenders would fulfil the requirements set by the public procurement law. Thus, it appears that benefiting from combining two projects increases the amount of required strategic planning and risk management.

3.2.2 Benchmarked processes

In this chapter the benchmarked organisations are introduced briefly and their contracting process is analysed. The analysis emphasises factors that have an influence on the efficiency and effectiveness on the contracting process. Since majority of the

empirical study focused in researching the processes of the case organisation, the analysis concerning benchmarked processes is also significantly smaller in scope.

Organisation A is a private firm that contracts nursery schools to various cities in Finland. Their client base is formed of both private and public sector nursery schools to which they lease out the premises. Most of their nursery schools are designed to be utilised by four, five or six children groups. They have created several concept buildings that can be replicated to some extent and utilised as a basis for the design process. The concept is modified based on the individual wishes and requirements of a client.

The chief executive officer of the benchmarked organisation A identified several positive effects of creating a strategy in which a replicable building template is utilised as the starting point of the design process. They claimed that especially if they had been working with a client before, the design process was really efficient because they were able to use the same solutions as before to a large extent as long as the solutions were applicable for the site. They assessed that the lead time of a project varied from six to twelve months depending on site resources as well as the amount of required modification work and earlier collaboration with a client. The interviewee also argued that clients and end-users were in general highly satisfied with the premises as the spaces were modified for every client based on their individual requirements and needs, but still the rent was fairly low. The interviewee felt that an end-user in general is more interested in the furniture and colour scheme than individual layout and structural solutions. They also felt that the low rent was more important for customers than architectural expression. The organisation collected feedback annually from end-users and customers and also sent out feedback formats after a construction project was finished in order to continuously develop their process and outcome. Also they received feedback during maintenance period about features that were not functioning. The interviewee told that team members were continuously encouraged to share their development ideas and the ones that had potential to improve the process were executed in succeeding projects.

The interviewee indicated that their nursery schools were cost-efficient due to efficient design process and utilisation of pre-fabricated construction elements that are efficient to assemble. The organisation collaborated continuously with two architect offices that were located in the same premises as the benchmarked organisation. The benchmarked organisation was among the biggest clients of the offices. Continuous collaboration with same designers had made the design process efficient and effective. However, the interviewee mentioned that in the beginning working with some of the architects was more challenging, as they didn't seem comfortable with the idea of utilising bulks and not creating every building uniquely. Yet, as time had passed a common understanding and common goals had been established and the architects were comfortable with emphasising cost-efficiency. Thus, it seems that in order to maximise the cost-efficiency

of process and outcome, the whole team should be motivated to pursue the objective. The organisation collaborated with five contractors to whom they tendered contracts. They felt that bidding kept the prices low, but still the quality was ensured as they had experience of working with all of the contractors and had a common understanding of the process and goals.

The organisation A had contracted few nursery schools to Espoo. The interviewee identified that they had met several challenges in their approach during these projects. They told that since the sites in Espoo often included slopes and the soil conditions were poor, they hadn't been able to use same layouts than in other cities, but were forced to make major modifications to the replicable buildings. The interviewee also noticed that the building control in Espoo had more strict requirements about the cityscape than in other cities and therefore the buildings had to be modified extensively regarding the location and the concept buildings couldn't be utilised as such. To get a building permit approximately three iterations of plan modifications had been required. The interviewee felt that in general the building control department wasn't excited about the idea of a replicable building. They estimated that the project costs had increased by ten per cent due to the strict requirements. Thus, it appears that if buildings are replicated with a template method, the authorities should agree with the use of the method in order to ensure that the benefit of replication can be maximised.

Organisation B is a municipal contractee organisation. They executed a project where three new nursery schools were designed successively by utilising the same project team. The aim of the project was to design and construct cost-efficient and user-friendly premises in a fast pace. The principal and structural design of the buildings was done in-house. The other designers were procured from private sector.

The principal designer of the buildings told that the objective of the project was to design user-friendly buildings in which cost-efficiency was maximised by exploiting the same fundamental idea. The interviewee recognised that since the project team had been kept same in all three projects, the design process of the later projects was somewhat faster. The buildings were designed with same principles, but the solutions were interpreted for every project in order to be applicable for the site, to fulfil requirements set by the building control and to maximise the functionality of the outcome. The interviewee argued that using same design principles eased the design because the principles didn't bind the design process too much. They felt that standardising solutions without leaving space for interpretation could result in more problems than benefit. Yet, the principal designer tried to utilise same designs and plans and technical solutions as much as possible. However, as the sites were significantly different in size two of the buildings were two-storey and one building one-storey. Therefore, the design solutions and utilised structures varied as well.

The planning of the projects and buildings started simultaneously but the projects were in the end designed successively due to factors independent of the project team. At the time of the study two of the nursery schools were in use and the third one was at the design phase. In the beginning of the project the objective was to tender the projects at the same time to the same contractor, but the idea was abandoned as two of the projects were postponed. The interviewee also noted that whether the buildings would have been contracted at the same time there would have still been need for three distinctive construction teams. At the end the projects were procured separately and all included different contractors. The construction costs of the first building were approximately twenty per cent smaller than in average. The interviewee argued that this was a result of several factors. First, the building was easy to construct as it included one floor and it was made of wood structures. Second, due to the high level of constructability the chosen contractor was eager to get the contract and therefore tendered a low price. Finally, the soil conditions on the site were fairly good, which resulted in simple foundation work. However, the construction costs of the second project were not lower than on average and the interviewee estimated that was because the building wasn't as constructible as the first one since it included two storeys and therefore the contract didn't allure low bids. Thus, it appears that replication of building elements of ideas doesn't ensure significant cost advantage if the contracts are bid to several contractors even though the design phase would be shorter in the succeeding projects. For a contractor it is insignificant if the elements in the building they are constructing are the same than in another buildings constructed by another contractor. More important is the constructability of structures.

Benchmark C differs from the other two benchmarks, as an existing contracting process wasn't studied, but a consultant with expertise in Lean construction and Integrated Project Delivery was interviewed in order to understand how these approaches influence a contracting process.

The consultant claimed that in general in the context of construction projects, an important area of development is value creation for end-users. Either the user needs haven't been realised properly or then the needs haven't been fulfilled due to the team's contradicting objectives. They expressed that user needs also develop constantly and therefore high emphasis should be put to measuring and developing the means to fulfil the needs. The consultant also emphasised that projects should be implemented in a fast pace so that the user needs haven't developed significantly already before project completion.

They suggested that in order to develop the process continuously during a project, important criteria for project team selection, are the members' experience and enthusiasm about waste elimination and ability to work in an integrated project team in addition to the hourly rate and level of expertise. Also the team members should have

common goals and everyone should be committed to continuous improvement of the process. Time should also be reserved for development and measurement activities. The consultant noted that it is important that the team has authority to decide on the development activities. They assessed that in general a significant amount of waste stems from development activities that are suggested by manager level employees that don't have real-time experience about the developed process, which often results in infeasible suggestions. In addition to continuous improvement, the project team should also emphasise efficient information transfer and visualisation of knowledge and utilise approaches like Last Planner System, Big Room working and Building Information Modelling. The consultant suggested that nursery school projects could be executed as Integrated Project Delivery and the principal designer and contractor should be included into the project team already during conceptual planning so that their expertise would be exploited as early as possible. Also the same design team and contractor could execute several succeeding projects because in the context of nursery schools, one project is considerably small in scope and therefore execution of several projects would offer a platform to utilise the established best practices and therefore have potential to speed up the process.

3.3 Comparison of processes

The findings from studying the case organisation's processes and benchmarked processes are compared in this chapter and analysed further in order to be able to answer the research questions.

In table 5 are concluded findings from the studied processes that have an influence the effectiveness and efficiency of the pre-construction process. The findings are categorised so that the factors that have an influence on one project are separated from those that have an impact on the context of several projects and enable exploiting the repetitiveness of similar projects. In the table the factor, possible effect and process in which the factor was identified, are presented.

Table 5: Findings from examined processes

Factor	Possible effect	Process
Influential factors in the context of a single project		
1. Inefficient decision-making and waiting in the beginning of process	Lengthened lead time	Case organisation's traditional process
2. City plan updates	Waiting and rework, lengthened lead time	Case organisation's traditional process
3. Use of two distinctive principal designers in the process	Rework and non-utilisation of available talent; lengthened lead time and increased total costs	Case organisation's traditional process
4. Framework agreements	Ease of bidding increases; reduced lead time	Case organisation's traditional process
5. Chemistry and ease of collaboration among team members	Amount of plan modifications and success of solutions, effect on lead time, quality and costs	Case organisation's traditional process
6. Contradicting or sub-optimising objectives or requirements of team members or stakeholders	Amount of plan modifications and success of solutions, effect on lead time, quality and costs	Case organisation's traditional process, benchmarked processes A and C
7. Challenging site conditions	Massive foundation work and plan modifications, increased costs and lead time	Case organisation's traditional process, case organisation's combined process, benchmarked processes A and B
8. Guidelines concerning building solutions and objectives	Accelerate beginning of process and standardise quality and costs of outcome	Case organisation's traditional process
9. Amount of additional and modification work	Rework, lengthened lead time and increased costs	Case organisation's traditional process
10. Cost management means that exclude assessing constructability or life cycle costs	Increased total costs	Case organisation's traditional process
11. Information that becomes explicit as the process proceeds / incomplete inspection or tests	Rework, lengthened lead time and increased costs	Case organisation's traditional process

12. Hands-on development of process, team members motivated and able to eliminate waste during the process	Increased lead time on short-term, reduced lead times and total costs on long-term	Benchmarked process C
13. Team members are motivated to maximise value generated for users and cost-efficiency	Effect on quality and costs of outcome	Benchmarked processes A, B and C
14. Use of process development and information visualisation tools and techniques	Amount of plan modifications, effect on lead time and costs	Benchmarked process C
15. Including architect and contractor to process during conceptual planning, IPD execution of projects, sharing risks equally	Exploitation of all available talent, effect on lead time, quality and total costs	Benchmarked process C
Influential factors in the context of several projects		
16. Replication of team members to several projects	Enables increased ease of collaboration, reduced lead time	Case organisation's traditional process, case organisation's combined process, benchmarked processes A, B and C
17. Replication of building elements and systems	Reduced lead time	Case organisation's traditional process, case organisation's combined process, benchmarked processes A and B
18. Feedback collection	Effect on lead time, quality and costs of successive projects	Case organisation's traditional process, benchmarked process A
19. Knowledge codification	Effect on lead time, quality and costs of successive projects	Case organisation's traditional process

20. Coherent procurement strategy for whole organisation	Effect on total costs	Case organisation's traditional process, benchmarked process A
21. Risks generated by municipal decision-making	Lengthened lead time	Case organisation's combined process
22. Added buying power resulting from economies of scale	Reduced costs	Case organisation's combined process
23. Increased amount of strategic planning and risk management	Increased required resources on short-term, reduced lead times and total costs on long-term	Case organisation's combined process

In order to avoid unnecessary repetition, only those factors that were realised in several processes are discussed further and compared in this chapter. Analysis concerning other factors can be found from the preceding chapter.

Contradicting or sub-optimising objectives or requirements of team members or stakeholders were recognised to hinder the efficiency and effectiveness of process in several of the cases. The lead time of the studied processes lengthened if parties had to negotiate with each other about the requirements concerning the outcome and make plan modifications. Also the costs increased if for example authorities demanded features that weren't cost-efficient into the buildings as happened occasionally in the case organisation's process or for example prevented a project from using a replication strategy as had occurred in the benchmarked organisation A's process. The Lean consultant suggested that projects should be carried out with an IPD approach because characteristic for the method is to establish common objectives within project team. However, also the stakeholders should be included into the establishment of common objectives and requirements in addition to the project team.

Challenging site conditions were also identified as a hindering factor in several processes. Sites with poor soil condition or small sites made design more challenging and increased costs and sometimes also lead times if plans had to be modified. In addition, challenging sites also prevented from using a template replication method and required the solutions to be modified considerably as discovered by benchmarking organisation A. However, a principles method can be utilised to some extent even though receiving sites would be distinctive because the principles for solutions could be interpreted to fit the sites as happened in benchmarked organisation B's process. On the other hand, project sites can be affected during land use planning.

Team members are motivated to maximise value generated for users and cost-efficiency - Based on benchmarking of organisations A, B and C, it can be deduced that in order to be able to create an efficient and effective process, all of the team members should be motivated to create buildings that maximise value generated for users and cost-efficiency because the process is highly influenced by the objectives and motivation of people.

Replication of team members as well as ***replication of building elements and systems*** were recognised as value-adding approaches in the studied processes. The case organisation's projects as well as the benchmarked projects included team members that had participated before in the organisations' projects. The case organisation's strategy didn't include intentional replication of team members to successive projects but the teams were formed uniquely for every project even though framework agreements were utilised to procure some of the designers. However, it was identified that unintentional replication of people had created value for projects because the external team members who had been collaborating with the case organisation before, experienced the process as more efficient the second time. The designers were already aware of the owner's requirements in the beginning of a project so it was easy to establish common understanding. Also solutions and systems that had been utilised before and were found successful could be utilised again. This resulted in more efficient and effective design process. In the benchmarked organisations A and B's projects the use of standard design team had also shortened the lead time of the design process because same solutions could be utilised to a certain extent. Also the ease of collaboration with the design team was influenced by the amount of executed projects because in succeeding projects the objectives were clear and common from the beginning, which made planning efficient. Also collaboration with same team enabled continuous development of the process. Thus, it seems that involving same designers to several succeeding projects can be an efficient approach for waste elimination. The interviewed Lean consultant also acknowledged that involving same team from project to project could speed up the process in succeeding projects in the context of relatively small construction projects such as nursery schools.

The team members who were involved in the case projects that were executed simultaneously by almost same design team also experienced that the knowledge transfer among the team members was more efficient than normally because they were more profoundly in touch with each other because the designed two buildings at the same time. Also the same ideas could be used as a foundation for the solutions, which enabled synergy benefits in the simultaneous execution. Hence, it seems that utilising same team for two simultaneous projects can produce value for projects because as the collaboration improves, the amount of rework and plan modifications resulting from inefficient knowledge transfer can decrease. However, the design process in the combined approach wasn't faster than normally. On the other hand, the collaboration

effect wasn't maximised since the whole team wasn't involved in both projects. Simultaneous execution of the design phase doesn't enable using one principal designer because the workload would be too big for one person. Yet, the empirical research revealed that a principal designer has a huge influence on the project and therefore having only one principal designer could produce considerable value for the collaboration. By executing projects successively rather than simultaneously the principal designer could be kept the same.

The benchmarked organisations also exploited the repetitiveness of projects by replicating building elements from project to project to a certain amount. It appears that replication of building elements to some extent can decrease the lead time of succeeding projects. Organisation A utilised a template approach as a concept building was replicated to a certain extent from site to site. The approach worked best in environments where the sites were flat and large and the building control authorities accept the strategy. Therefore, an organisation exploiting a template method has to collaborate tightly with the authorities to ensure appropriate sites and share common understanding of the issue. Organisation B had a distinctive approach because they attempted replication with a principles method. The principal designer utilised the same ideas to create cost-efficient and user-friendly solutions for three buildings but didn't have a concept building as a starting point for the process. Construction projects often include unique features and requirements and therefore gained knowledge often has to be interpreted in order to make it suitable for a new context, which makes principles method an applicable replication approach. However, it is vital that the replicator using a principles method understands the phenomenon behind the idea. Therefore, it appears that the process is more efficient if a standard team executes several projects because the information doesn't have to be transferred and captured several times.

In none of the studied projects the contractor was standard even though the design team included same team members. Benchmarked organisation A utilised a standard network of contactors but the network included several firms. Therefore, based on the empirical research it is not possible to deduce how the use of the same contractor in several projects would influence the efficiency and effectiveness. However, as most significant share of the costs of construction accumulate to the contract, use of one contractor could have potential to result in significant cost advantage due to added buying power. Also benchmarking of organisation B showcased that replication of building elements or ideas doesn't guarantee cost advantages in the construction phase if the contracts are bid to several contractors even though the design phase would be shorter in the succeeding projects.

Feedback collection was recognised as an important development activity by the case organisation and benchmarked organisation A. By collecting feedback from all team members and stakeholders after a project phase or the whole project ends the process

can be continually improved. It appears that the reasons behind successes or challenges should be identified after a project has ended in order to understand the phenomenon comprehensively and to diffuse the success or avoid the same mistakes in succeeding projects. Especially the external designers should be motivated to give feedback about the process and outcome in order to incrementally improve them.

Coherent procurement strategy for whole organisation was identified as a factor that has major influence on the efficiency and effectiveness of a contracting process in the context of several projects. Studying the case organisation's process revealed that decisions concerning suppliers could be made within a project team instead of the organisation having a coherent procurement strategy that would be linked to the overall strategy and that would exploit the recurrent nature of projects. Lack of coherent procurement strategy makes process standardisation challenging as the decisions are highly influenced by people procuring the suppliers and the suppliers further influence the process considerably with their own actions. Benchmarking of organisation A identified that establishing a procurement strategy that is utilised in all of the contracted projects enables an efficient process.

4 RESULTS

In this chapter the research questions are answered based on the knowledge gained from empirical research and literature review.

4.1 Increasing efficiency and effectiveness of pre-construction phase

This chapter answers the first research question and its sub-question. In other words, this chapter presents how a municipal contractee organisation can increase the efficiency of the pre-construction phase of their investment projects in the context of one project and what factors can increase the lead time of the process and total cost of projects. Lengthened lead time also often affects the project costs, but the total costs can in addition be increased by factors concerning the outcome.

Increasing the efficiency and effectiveness of the pre-construction process is discussed from two viewpoints: first, preparatory work with stakeholders is examined. In this context preparatory work means the work done before the design and implementation team is included into the project. Second part discusses the execution of an individual project beginning from the moment when the design and implementation team is being procured.

The answer includes letters and numbers in brackets. The letters and numbers refer to table 6 in which the results are concluded at the end of the chapter. The letters refer to factors that can increase the lead time and total costs and the numbers refer to approaches to increase the effectiveness and efficiency of the process.

Preparatory work with stakeholders

During the empirical study it was identified that a construction project has various stakeholders who all affect the objectives and requirements of the building. The stakeholders influence the project especially during land use planning, initial planning and conceptual planning. The finding is consistent with existing knowledge as Kolltveit and Grønhaug (2004) also acknowledge that in the early stages of a project, the influence of external stakeholders is on its highest level. They also claim that the influence of stakeholders can have a significant impact on the overall performance. The case study revealed that site selection has a major influence on the project as a site with challenging soil conditions can increase the construction expenses considerably and can also result in significant amount of plan modifications during the design phase. Also the

size of a building has a significant influence on the project expenses especially because foundation work of big buildings can be massive if the soil conditions are challenging. Therefore, it seems that the ability to affect the total costs of projects is high when the site and size of a building is decided. These two fundamental issues are affected by stakeholders during land use planning. Abdul-Kadir and Price (1995) also note that decisions made in the beginning of a project have a significant influence on the overall project. Pitkänen (2009) and Lindholm (2009) stress the role of site selection. During the case study it was also realised that in some of the projects the requirements presented in the city plan were contradicting with the contractee's requirements (a). The contradicting requirements between stakeholders resulted in negotiations during the design phase, which increased the lead time of the process.

Because in the early stage of a project when the city plan is created or an existing plan is modified the ability to affect project costs is high, a contractee should also actively participate to this stage in order to ensure that their viewpoint is taken into account and that the fundamental objectives for a project enable efficient and effective process (1). Yet, the objectives should be of that nature that one stakeholder doesn't sub-optimise their annual budget on the expense of the total costs occurring during a service's life cycle. For example even though the construction costs of large buildings are bigger than those of smaller ones, the operation and maintenance costs can be significantly smaller because small units can be divested, which in the long-run can result in cost advantage. Therefore, the planning should be done with a long-term vision and total cost of ownership thinking should be applied in the process. During land use planning some buildings' specific requirements can also be affected. By establishing common objectives with stakeholders (2) when a city plan is first created, time that is consumed later to waiting and rework can be eliminated.

Based on the empirical research it seems that the contracting process can be considerably lengthened because of stakeholders' inefficient decision-making in the early stages of a project (b). The case study revealed that the initial and conceptual planning phases can last for even several years if the objectives and requirements for a project aren't clear but the discussion about where and what type of construction ought to be built is lengthened or postponed during the process. Also changes in stakeholders' objectives and requirements can result in city plan updates if the permitted building volume has to be increased or the amount of services included on site increases (c). However, updating the city plan increases the amount of waiting and rework and lengthens the process as projects can't proceed radically before the city plan has been approved. Also it seems that a considerable amount of inactive waiting can occur between initial and conceptual planning, which lengthens the process (d).

Because the early stages include significant amount of waste stemming from inactive decision-making, there is also major potential to shorten the total lead time of a project

by reducing the waste occurring at those stages. The various influential stakeholders should also establish a common long-term vision of the development of the building stock (3). In order to create a long-term vision, the stakeholders should have a clear understanding about what buildings should be renovated, what should be demolished after being in too poor condition to be maintained as well as where and what kind of new buildings ought to be constructed. If the stakeholders of construction projects have a common long-term vision of where, when and what type of buildings ought to be constructed in the future the issues don't have be discussed in the beginning of every project and projects can proceed smoothly from initial planning to construction design. By establishing a long-term vision for the development of building stock, also the objectives for an individual project can be agreed on and a clear vision for a project can be established prior to project start so that the execution can proceed in a streamlined manner without for example changes in project requirements or city plan updates. On the other hand, since the early stages include various influential stakeholders and the process is highly affected by their actions, the stakeholders should be identified and motivated to recognise and eliminate waste from the process (4). A contractee can't solely reduce the waste occurring from the operations of other stakeholders and therefore can't considerably influence the efficiency of the process if the other parties don't want to eliminate waste and pursue an efficient process.

Execution of an individual project

Based on the empirical research it seems that the success of purchasing has a major impact on the efficiency and effectiveness of an individual process as the examined projects were highly influenced by the designers. Existing literature acknowledges that the construction costs and costs accumulating during a building's life cycle are mainly determined based on the decisions made at initial and conceptual planning as well as the design phase (Abdul-Kadir and Price 1995, Lindholm 2009). In a design-bid-build procurement method the design team is responsible for creating plans that they assess that will allure low bids. Based on empirical research it seems that the constructability of the plans has a high influence on the bid prices. In order to create plans which contain high constructability of the structures, the team has to be aware of the capabilities of the supplier markets and be able to reflect the knowledge to the plans. This ability is however dependent on the individual expertise of team members and therefore most likely varies from project to project if the team members change.

The timing of including the external consultants to the project seems to have an impact on the process. The projects that involved the same architect during conceptual planning and construction design had leverage over projects where the principal designer changed. Including several principal designers into a process is problematic (e) because it can generate unnecessary work if same work is done twice due to e.g. inefficient knowledge transfer or changed plans. Also as the ability to influence the total cost of a project is relatively high during conceptual planning (Abdul-Kadir and Price 1995,

Lindholm 2009) and therefore principal designers' expertise should be utilised to the fullest at this stage. However, it was found out that it is common that architects don't invest into the preliminary designs because it is not guaranteed that they get to continue in the project, which is waste of talent.

All of the researched processes included project execution with a design-bid-build procurement method. Therefore, based on the empirical results the effect of different procurement methods can't be measured. However, researchers have argued that better results can be achieved with a procurement method that commits also the contractor to the project prior to construction phase and enables team integration (for example Love et al. 1998, Ballard 2008, Merikallio and Haapasalo 2009). The empirical research also revealed that design-bid-build procurement method often generates fairly much additional and modification work occurring in the construction phase, which increases the costs of projects relatively much and lengthens the lead time (f). Montonen (2014) found out that often contractors try to generate higher profit by seeking additional and modification work. A contractor can't influence the plans when they are first created and thus their possible expertise concerning cost-efficient solutions and constructability isn't exploited (g).

The case study revealed that the lead time of a design process as well as the total costs of a building were influenced by how well the team collaborated with each other. Artto and Kujala (2008) also argue that management of a project network addresses managing the actors of the network, who might have controversial objectives, and facilitating collaborating within those actors. It was also realised that the ease of collaboration might be affected if different people are responsible for procuring different team members there is a chance that the collaboration among team members can suffer if their chemistry doesn't work or if the team members have different objectives (h). Inefficient collaboration of team members can result in plan modifications, which lengthens the lead time. Also costs can be dependent on the level of collaboration. During the case study it was identified that if the co-operation among the team was good and the other designers ideated on the solutions together with the principal designer right from the beginning, the solutions were estimated to be more cost-efficient and feasible than if the principal designer first created their drafts and the other designers created plans that fitted them. In the latter approach the risk of sub-optimisation of some features on the expense of the overall solution is high. However, if the design team is procured with competitive bidding, the members are awarded with a lump sum independent on how much time they actually invest in the project. This can reduce the motivation level of designers and not motivate them to invest much time in ideating on plans even though the collaboration among team members would work otherwise (i). Weele (2010) also noted that when services are purchased, the relationship between supplier and buyer has an influence on the success of the purchase.

The challenges discussed above can be tackled by developing purchasing practices (5). Based on the results of the study it appears that the final members of the design and implementation team should be involved into the project as soon as the design of the buildings begins, in other words during conceptual planning (5.1). Since majority of project costs accumulate to the construction phase, reductions in contract prices have bigger potential to result in major savings than reductions from costs that accumulate in the pre-construction phase. If the contractor is involved in a project already when the designs are created, they can affect the constructability and amount of additional and modification work and therefore influence the efficiency and effectiveness of the process. This approach would also enable partly parallel design and construction, which has a shrinking effect on the lead time (Love et al. 1998). Also including the principal designer into the project during conceptual planning seems to enable a more efficient design process and also exploitation of their expertise, which can have a reducing influence on the total costs because the decisions made during conceptual planning have a major effect on the costs that occur later. However, the principal designers' decisions affect also the costs of other disciplines' plans and therefore the planning shouldn't proceed too far in the beginning without the whole final design team.

It should also be ensured that best suppliers are selected i.e. their expertise, motivation and cost is optimised (5.2). Existing knowledge claims that the quality of consulting services is dependent of the expertise of a supplier (Iloranta and Pajunen-Muhonen 2008, Morledge and Smith 2013), which seems consistent with the empirical study. Therefore, the total cost of ownership thinking is applicable when designers are procured instead of using a low-bid method. However, existing research acknowledges that modelling the total cost of consulting services can be challenging (for example Ellram 1995a, Iloranta and Pajunen-Muhonen 2008, Weele 2010). Procurement should also address that the collaboration among the suppliers is efficient and effective (5.3) as the collaboration of team members has a relatively large influence on the whole process. This could be realised by giving the team a chance to affect whom they work with by procuring several team members or even the whole team at once. The team members don't necessarily need to be employed by the same firm if they have other experience of working successfully together.

Since the efficiency and effectiveness of the pre-construction process is highly dependent on people and their capabilities and motivation, it seems that an efficient process can be created only if the whole project team is motivated to constantly recognise waste that occurs in their work and develop practices how to reduce it (6). Existing knowledge acknowledges continuous improvement as a basis for waste elimination (for example Womack et al. 1990, Hines et al. 2004). Thus, if the whole project team is committed to ideate continuously on more efficient and effective ways of executing the process and reducing waste, the lead time and total costs could be reduced. Yet, the contractee should guarantee that the project team's motivation level

stays high and provide incentives to develop the outcome and process. However, it should be noted that constant development requires increased resources and therefore it can in the beginning increase the lead time and total costs but generate value in the long run. The organisational culture should also enable continuous development and also encourage people to give constructive critique. By collecting feedback from all team members and stakeholders after a project phase or the whole project ends the process can be improved (7). The reasons behind successes or challenges should be identified after a project has ended in order to be able to diffuse the success or avoid the same mistakes in succeeding projects. Also the process and occurred waste can be analysed afterwards by creating a value stream map recognised by existing literature (for example Morgan and Liker 2006, Liker 2008).

The case study revealed that the efficiency and effectiveness of the design process was hindered if the objectives concerning the project and outcome weren't shared by the project team members (j) or if some of the requirements sub-optimised some features on the expense of the overall solutions (k). It was also identified that especially the objectives and decisions as well as the expertise of a principal designer have a major influence on a design process. This arrangement enables that the principal designer's talent and capabilities are utilised to the fullest. However, highly problematic is if the objectives of the principal designer and the client are contradicting and the principal designer guides the design process towards a solution that doesn't generate value for the client and end-users. On the grounds of the empirical research, sub-optimisation can concern also the schedule as for example some inspections and tests can be neglected due to haste, even though this increases the possibility of expensive surprises later in the process (l).

Thus, the design and implementation team should establish common goals for the outcome and project and distribute risks evenly (7). Based on the empirical research, it can be deduced that cost-efficiency and user-friendliness can't be maximised if the designers aren't willing or motivated to maximise them as the process is highly dependent on people. Therefore a contractee should ensure that they collaborate only with team members whom they share objectives with. In order to enable that all of the available talent is utilised the team members should have a permission to also comment on the requirements of a building and suggest improvements if they realise ones. This means that if some requirements are noticed to sub-optimise separate features on the expense of the overall outcome, the requirements wouldn't have to be fulfilled precisely, but a better option would be seeked in collaboration (8). All of the team members should also understand the influence of their requirements – how much the requirements create expenses and how the requirements influence the other requirements. Also by involving the key members of the whole team into drafting and updating the schedule in order to guarantee that it is so detailed that sub-optimisation doesn't occur due to haste (9). Existing knowledge suggests the Last Planner tool for

production scheduling (Merikallio and Haapasalo 2009). Efficient collaboration also contains visualisation of information and use of effective working methods such as BIM (for example Merikallio and Haapasalo 2009) (10).

Based on the empirical research it also seems that a target cost approach in which the target cost is set during conceptual planning isn't an optimal approach for ensuring minimised total costs of a project. First, the information concerning a project is often too limited during conceptual planning to create a reliable estimate. Second, the cost estimates created during design neglect to examine the solutions in terms of constructability. The estimates neither consider how much costs will be produced during a building's life cycle and how much value they produce to the user (m). In order to be able to reduce the total costs of projects the team should also analyse how the solutions affect the costs that occur during the building's life cycle. Often these costs can be bigger than the immediate costs during construction and therefore the team should examine the cost-efficiency on the long run (Perttilä and Sätilä 1992). Thus, the decisions should be made based on total cost of ownership thinking (11).

Table 6: Conclusion of results concerning increasing efficiency and effectiveness of the pre-construction process

Factors that can increase the lead time of process and total cost of project	**Approaches to increase efficiency and effectiveness of the pre-construction process**
a. Stakeholders' contradicting or sub-optimising objectives b. Inefficient decision-making and lengthened discussion about different options c. Stakeholders' changing requirements which result in city plan updates d. Inactive waiting between project phases	1. Affecting the fundamental objectives and requirements of projects during land use planning in order to ensure efficient and effective process 2. Establishing common objectives with stakeholders prior to project start 3. Establishing a long-term vision about the development of the building stock in collaboration with stakeholders 4. Involving and committing all stakeholders to waste elimination and reduction
e. Not including the principal designer into the process during conceptual planning f. Additional and modification work	5. Developing procurement practices - Forming the team on strategically right time

g. Non-utilisation of contractor's capabilities h. Inefficient collaboration among team members i. Unmotivated team members j. Uncommon objectives of team members k. Sub-optimising building requirements l. Sub-optimising schedule m. Target cost method which only considers the direct costs	- Selecting best available consultants - Ensuring that collaboration among consultants works 6. Continuously recognising and eliminating waste 7. Collecting feedback and analysing the process post-project 8. Establishing common objectives with project team members and distributing risks evenly 9. Including key team members to schedule creation 10. Using efficient collaboration methods 11. Exploiting TCO thinking

4.2 Exploiting repetitiveness of similar projects

This chapter answers the second research questions and its sub-question. In other words, the chapter explains how the recurrent nature of similar construction projects can be exploited in order to enable efficient and effective execution process. The numbers in brackets refer to table 7 in which the findings are concluded. Also the effect of simultaneous execution of projects is discussed in the end of the chapter.

On the grounds of the empirical research, it can be argued that in a construction project context, replication of team members (1) adds value in the successive projects and enables faster process execution, because project-based production is highly dependent on the actions of people, as argued earlier. The phenomenon is also identified by existing knowledge as for example Love et al. (1998) claim that a design-and-build procurement method works best if same people are transferred from project to project. Also replication literature (for example Bartezzaghi et al 1997) has identified transfer of employees as a value-adding replicable element, also in the context of multi-firm investment projects (Lajunen 2010). Based on the empirical research it can be concluded that in a construction project context replication of team members produces value for projects because the collaboration among team members and owner becomes more efficient and effective, which for one can reduce waste from the process and have a positive effect on the lead times and costs. Artto and Kujala (2008) claim that having various companies included in a project causes uncertainties that have to be managed by the contracting organisation. Therefore, by establishing a standard project network in which the uncertainties are minimised, can ease the collaboration among organisations.

If team members are replicated from project to project, also the external consultants can move down the learning curve. Weele (2010) notes that if a supplier can anticipate moving down the learning curve, it can also reduce bid prices, and therefore affect the efficiency of the process (2). Also Pearson and Wisner (1993) concluded that learning economies are one category of economies of scale. If the project network is created uniquely around every project, exploitation of the learning curve effect is not enabled since every project is a vanguard project for new team members. Hence, a procurement strategy that enables replication of team members from project to project can have a reducing impact on the lead time and costs of projects. Cost advantages can be gained also by the added buying power (3) resulting from increased scale (Weele 2010, Gottlieb and Haugbølle 2010). Grabher (2004) also claims that if suppliers are replicated, the long-term collaboration can have a reducing impact on the purchasing costs. Thus, if the project network for several successive projects is created at once, it can have a reducing impact on bid prices. Purchasing literature (for example Iloranta and Pajunen-Muhonen 2008, Weele 2010) argue that proactive and strategic purchasing aim to increase the competitiveness of an organisation by not only increasing the bargaining power, but also by improving the suppliers, which can result in long-term competitive advantage. However, if the project network is not standard, and the team dissolves after a project finishes, investment in developing suppliers doesn't benefit the purchasing organisation.

Repetitiveness of projects can be also exploited by copying successful ideas and replicate successful solutions to a certain extent to succeeding projects (4), if the requirements, objectives and site conditions enable the replication and the team wants to replicate the solutions. Replication of solutions can have a reducing effect on the lead time and also total costs if the replicated elements are cost-efficient on the long run. Lajunen (2010) also noted that replication is more challenging in a multi-firm context as the number of stakeholders increases risks if not everyone is committed to the strategy. Thus, by standardising the execution team, also ease of replicating building elements can grow. The solutions can be replicated even though the knowledge concerning the solutions wouldn't be codified, but remain as people's tacit knowledge, if people are kept the same. Galbraith (1990) argues that documentation and knowledge codification, which are prerequisites for replication, also create costs and require time, which can be somewhat undermined in advance. However, as existing knowledge argues people are able to structure and interpret knowledge so that it is applicable for new contexts (Berry and Broadbent 1987). Therefore, by replicating the project team, the solutions created in previous projects can be interpreted to be applicable for the new context. This was also identified in the empirical research.

The empirical research revealed that a principles method is an applicable approach for replication of building elements if the sites or objectives of projects are distinctive because it leaves space for interpretation, but enables that same building elements are

utilised when possible, but better solutions are created if recognised. These elements can be small units like for example doors, windows, materials, furniture, structures and HVAC and electrical systems that have been experienced to be feasible, desirable and viable in earlier projects. Yet, in order to maximise the effect of replicating the team, it is important that all the team members want to utilise same solutions in several projects if the approach generates value instead of creating totally unique outcomes. Utilising the template approach and replicating bigger units like concept rooms or even whole buildings increases the need for collaboration with stakeholders prior to project start because applicable sites and requirements have to be ensured in order to be able to exploit the template solution. Winter and Szulanski (2001) stress the importance of selecting what elements are replicated as only value-adding elements should be multiplied and choosing of the replicated elements has a major influence on the success of replication. Lajunen (2010) noted that creating a design that fits into various environments can become significantly expensive and thus replicated elements should be selected with extra care.

On the grounds of the empirical research, it appears that replication of building elements and design team can reduce waste from a process and therefore shorten the lead time and have a reducing influence on the contractee's costs and design costs. However, it seems that if the contracts are bid to several contractors, the replicated elements don't necessarily result in reduced costs. Because a majority of project costs are accumulated to the contract (Abdul-Kadir and Price 1995, Lindholm 2009), influencing the contract price can significantly reduce the total costs of the project as well. Therefore, it appears the replication strategy should consider the entire project life cycle and include the contractor as well in order to pursue considerable cost advantages.

Also best practices concerning process execution that have been developed in earlier projects can be developed further and utilised in succeeding projects (5) if the team members don't change even though the practices wouldn't be documented explicitly. Even with proper codification of knowledge, the developed best practices can't be developed continuously if the team members change because time is consumed to transferring and capturing the gained knowledge. Waste reduction and development practices are not a quick fix since they can consume resources excessively the first time executed, but produce value in later projects (Womack et al. 1990). Therefore, by minimising the amount of vanguard projects where waste elimination practices are developed, the savings can be achieved faster. Also as a construction process is highly affected by capabilities and decisions of the project team, generated waste can be dependent on the actors and therefore by creating the project network uniquely around every project can result in not being able to utilise the waste elimination practices that have been created in preceding projects. The empirical research revealed that construction projects often include unique challenges and therefore it appears that the process can't be totally standardised but replication of team members eases the

standardisation. Standardising a process for one enables measurement and incremental development (Womack et al. 1990).

However, standardising the project network can also generate new challenges concerning e.g. contracting and risk sharing. Outsourcing the design can be problematic because it is considerably common that municipal projects get postponed or even cancelled. Therefore, the approach binds the network to projects that might not happen. Also since the lead time of construction projects can stretch to several years, the team members might change companies and work tasks, which is a challenge for contracting. This must be addressed in advance in order to avoid contractual issues. Also there can be too many projects for one design and implementation team to execute. Grabher (2004) also claims that replication of suppliers can result in decreased amount of fresh ideas. Iloranta and Pajunen-Muhonen (2008) have noted that there are no exact guidelines concerning whether bidding or partnering is a right approach for an organisation or how deeply a supplier should be collaborated with as both bidding and partnering include risks and opportunities. However, Yliherva and Merikallio (2008) claim that in the context of Finnish construction industry too short-term collaboration with suppliers is a major challenge. Standardisation of supplier network is characteristic for Lean thinking (for example Womack et al. 1990, Merikallio and Haapasalo 2009). However, various researches have also noted that Lean practices shouldn't be copied straight without understanding the whole philosophy comprehensively (Iloranta and Pajunen-Muhonen 2008) and then choosing parts that fit the receiving organisation and its culture.

The empirical research revealed that a considerable amount of waste cam stem from inefficient knowledge transfer among projects as similar problems can be tackled distinctively without knowledge of best practices. If a bidding approach is utilised and the project network dissolves after a project finishes, the need for explicit documentation increases because the knowledge gained in a project can mostly remain as team members' tacit knowledge and can be lost if it's not codified explicitly. Hence, in order to ease inter-project learning the documentation concerning the outcome (6) and process (7) should be excessive. Davies and Brady (2000) argue that in order for an organisation to move down the organisational learning curve, there must be efforts to pass on the knowledge to subsequent projects after vanguard project have been executed. Prencipe and Tell (2001) identify that codification of knowledge is highly valuable since knowledge isn't stored into people and created guidelines guarantee that information isn't lost if people change. The empirical research revealed that creating design guidelines including explanation about objectives for projects can accelerate the design process as it is efficient to create a rough understanding about the direction of the project. Also the costs and quality of several outcomes could be made more standard by creating design guidelines. Yet, during the empirical study it was also found out that often the process of a construction project could vary significantly due to unique

features of every construction project and people's distinctive working methods. Therefore it is highly unlikely that the process could be copied exactly. However, the principles for decision-making and responsibilities can be standardised and codified.

Creating a coherent purchasing strategy for an organisation is identified as a source for sustainable competitive advantage by existing literature (for example Iloranta and Pajunen-Muhonen 2008, Weele 2010). During the empirical research it was also recognised that creating a purchasing strategy that intentionally exploits the repetitiveness of projects can increase efficiency and effectiveness of a construction project (8). Iloranta and Pajunen-Muhonen (2008) suggest that an organisation should have a person or department that is responsible for purchases and development of the procurement strategy, but also align the strategy with the overall strategy. It appears that this would also create value in the context of repetitive projects since it enables growing the scope of a purchase, which for one affects bid prices as discussed before, and exploiting established best practices in purchasing (9). Based on empirical research it can be argued that creating framework agreements can accelerate and standardise processes to some extent (10), but framework agreements don't guarantee exploiting repetitiveness to the fullest.

Table 7: Approaches for exploiting repetitive nature of construction projects

1. Replication of team members to subsequent projects, standardisation of project network
2. Creating bids so that suppliers can anticipate moving down the learning curve
3. Increasing scale of purchases
4. Replicating successful ideas and solutions to successive projects
5. Replicating waste elimination practices to successive projects
6. Creating guidelines concerning the outcome
7. Creating guidelines concerning process execution
8. Establishing a coherent purchasing strategy that exploits repetitive nature of projects and that is common for whole organisation
9. Establishing a department or person responsible for all purchases
10. Use of framework agreements

Effect of simultaneous execution on project efficiency

Based on empirical research, it appears that executing the design phase of two projects simultaneously doesn't ensure any major impact on the project efficiency. However, with comprehensive strategic planning there is potential to reduce project costs and lead time. By in advance planning how the cost and time advantages can be achieved, the team can pursue these objectives during the process. For example the team can decide to pursue outcomes that contain so many similarities that same solutions and plans can be utilised to some extent, which reduces the workload of a designer, which can for one shrink the design phase and the expenses.

Also if the construction plans are similar enough to enable a contractor to exploit the learning curve effect, the bid prices can reduce. On the other hand, procuring the contracts to one contractor also increases the amount of required strategic planning and risk management and therefore increases the need for resources especially the first time the approach is utilised. If similar outcomes are pursued, projects that are similar in nature and have common requirements should be combined if same building elements are meant to be utilised. In addition, it is important that the team is willing to pursue similar outcomes and recognise the potential in the approach. Also in order to maximise the learning curve effect the schedule should be planned in advance so that the same team can construct the buildings. However, this can be challenging in the context of municipal decision-making process and determination of budget.

Even if the outcomes are not similar, the collaboration of the team becomes more efficient as they can discuss the solutions and challenges of two projects as once and information doesn't have to be transferred and captured by double amount of people. However, this increased efficiency of collaboration doesn't necessarily assure any cost or lead time advantage for the project owner if they don't manage the project in a manner that the effect could be exploited. If the outcomes are similar in nature and include same building elements, furniture and structures, a contractor can gain economies of scale if they construct both buildings and thus bid with a lower price. Also the owner can gain benefit of the added buying power when the team is procured if external team members are allured by the chance to implement several projects and therefore reduce their bid prices. Added buying power was recognised in the empirical research as well as by existing literature (for example Weele 2010, Gottlieb and Haugbølle 2010).

On the other hand, the simultaneous execution can also have hindering effects on the process. The lead time can be lengthened if the other project gets postponed and the other can't proceed. Especially the first time the approach is utilised the need for upfront strategic planning and risk management increases, which consequently has an adding effect on the required resources. Also the need for replication knowledge is higher than in a single approach. In addition, management has to be excessive during the project in order to guarantee that the cost and lead time advantages are going to be reached and that risks aren't realised. Therefore, projects that are executed simultaneously should be seen as a development project when the approach is utilised for the first times and enough resources should be guaranteed for developing the approach. Later when the approach has been utilised repeatedly there is a chance that an organisation can move down the organisational learning cycle and begin to gain larger benefit. Therefore, an organisation should evaluate whether they want to invest in developing the approach, because it is likely that the approach will produce more value in succeeding projects.

It seems that parallel execution doesn't enable that both projects would be executed by same team members as the workload would be too big for one principal designer and a construction team can't be at two sites at once. Thus, it appears that implementing projects successively rather than simultaneously enables utilising the same principal designer. This is a value-adding approach for the process as the principal designer has a major influence on the process and outcome. Implementing projects successively also enables exploiting the learning curve effect and diffusing success that has been established formerly into new projects. The results are consistent with existing knowledge as Lajunen (2010) argues that time between projects is important in order to enable reflection on the process and identify what elements ought to be replicated to subsequent projects. Davies and Brady (2000) have also argued that in project-based production, repetition of projects results in more significant benefit than increasing scale or scope.

5 CONCLUSION

In this chapter the most important findings are summarised. The chapter also introduces recommendations for the case organisation. Finally, the study is evaluated and further research recommendations are presented.

5.1 Summary and comparison to existing knowledge

This thesis examines the execution process of similar recurrent construction projects focusing in the pre-construction phase. The objective of the study was to understand how the construction projects could be executed efficiently and effectively and how the repetitiveness of projects could be exploited in the process. Also the goal was to understand how simultaneous execution affects the efficiency of the projects. The research focused in operations before actual construction begins. Waste elimination in the context of construction projects has been researched previously as well as exploiting economies of repetition in the construction phase of projects. However, the context of this study differs from previous research because the research emphasises decisions and activities that are executed in the pre-construction phase and the context is projects owned by a municipal contractee. Based on the conducted literature review and empirical research approaches to increase efficiency and effectiveness of the pre-construction process were concluded into table 6 whereas approaches to exploit repetitive nature of similar projects were concluded into table 7. The findings of the empirical research were mostly consistent with existing knowledge.

Several factors that increase the amount of waste in construction projects and correspondingly the lead time and total costs were recognised during the study. It can be concluded that waste can be reduced from a process with effective collaboration with stakeholders and project team members. Especially the work in the beginning of a project is important because it can be concluded that a basis for reducing lead times of individual projects is formed by establishing a common long-term vision with stakeholders about the development of needs and upcoming projects so that projects can proceed smoothly without changes in requirements. However, the study also concludes that there are no easy fixes for increasing the efficiency and effectiveness of a process. Instead in order to be able to significantly eliminate waste, the project network and stakeholders must invest in development activities and share an objective of creating cost-efficient and user-friendly buildings. The team and stakeholders should be motivated to continuously recognise and eliminate occurring waste and ideate on practices how to maximise the value generated for end-users. However, the hands-on

development practices consume time and other resources and therefore it can in the beginning increase the project costs and lead time temporarily, but produce value in the long-run. On the other hand, in the context of buildings that are constructed fairly often, like nursery schools, the savings can be major after the process has been repeated many times and has become efficient, even though the projects are rather small in scope and therefore process development activities should be invested in. Yet, existing knowledge notes that often activities that ensure project completion are emphasised over activities that are implemented to reflect on a project and transfer the learnt lessons (Brady et al 2002).

The existing research acknowledges that a rather significant share of an organisation's costs are formed of purchases and therefore development of purchasing strategy can results in considerable advantage (Iloranta and Pajunen-Muhonen 2008, Yliherva and Merikallio 2008, Weele 2010). This study also concluded that in the context of construction projects, the project network has a significant influence on the process and thus purchasing is a relevant contributor to project success. Also major share of project costs accumulate to purchasing. Therefore, by developing purchasing strategy the efficiency and effectiveness of a process can be majorly affected as well. Yliherva and Merikallio (2008) argue that a significant current challenge for Finnish construction industry is developing purchasing practices so that the whole supply chain is encouraged to create innovations.

The study also examined exploiting recurrent nature of projects. Both existing knowledge and empirical research resulted into the notion that replication of team members can have a positive impact on the process because project-based production is highly dependent on the actions of people. Because construction projects often include unique features, exact replication of building features or process is challenging and not necessarily value-adding. Winter and Szulanski (2001) have also noted that replication can become expensive and challenging if the receiving environments differ much from each other.

Simultaneous execution of the pre-construction phase hasn't been discussed previously by researchers. On the grounds of the empirical research it can be concluded that simultaneous execution can ease collaboration between team members if the members are included in both projects and the team members want to utilise same solutions as much as possible. The more similar the projects are in terms of requirements and sites, the more same plans can be used, which correspondingly has a shrinking effect on the lead time. Cost advantages can be gained also by the added buying power resulting from increased scale, which is also acknowledged by the existing literature (Gottlieb and Haugbølle 2010, Weele 2010). However, simultaneous execution requires increased amount of strategic planning in order to realise how lead time and cost advantages can be achieved. The approach can also create new challenges and therefore increased risk

management practices are necessary. Based on the empirical research it can be deduced that successive rather than simultaneous execution can generate more value for a construction project if both approaches include same team members. The result is consistent with existing literature because it is suggested that in project-based production the economies result more from amount of executed succeeding projects rather than scope or scale advantages (Davies and Brady 2000) and that in the context of multi-firm projects, inter-project learning requires time between projects in order to be able to reflect on the experience (Lajunen 2010). In addition, by executing projects successively the whole project team can be kept the same, which has potential to result in lead time advantage as the learning curve effect recognised by existing knowledge can be exploited.

5.2 Next steps for the case organisation

This chapter presents recommendations for the case organisation about how they could begin the development activities required to create an efficient and effective process.

As concluded, in order to create an efficient and effective process, all stakeholders and members of project team should be motivated to pursue the goal and be involved in the development practices. Thus, in addition to the case organisation, stakeholders such as the user departments, site resources department, land use department and geotechnical department should establish a common plan how to develop the process so that waste can be eliminated from the process and projects can proceed quickly and the total costs of projects can be reduced. In the development important is that the stakeholders analyse the issue comprehensively and pursue a solution that minimises the total costs rather than sub-optimises their own objectives. The case organisation should decide how in practice they could organise the increased collaboration with stakeholders. One approach could be having a person responsible for the collaboration but it should be assured that the person has enough resources to fully be involved in the development.

In the case organisations' projects expensive surprises regarding foundation work were common. Hence, collaboration with the geotechnical department is especially important. There could be a development project with them in order to establish a common understanding about how the status quo could be changed and what actions could be undertaken to minimise the amount of surprises.

During the study it was spotted that in general the design-bid-build procurement method is perceived as an easy approach and therefore applicable for small projects like nursery schools. Also because using more innovative procurement methods requires increased resources for planning and management in the beginning it can be alluring to use the old methods especially when the resources are already somewhat limited. Yet, the design-bid-build procurement method doesn't enable radical development. Neither will

development happen if it is not invested in. In addition, because nursery schools are contracted fairly often, developing the approach can result in significant benefit on the long-term. Therefore, it is important that team members would invest in developing the contracting process of nursery schools. The case organisation could launch a pilot project in which few nursery school projects are executed by the same team, but an important objective in addition to creating the building would be also to develop the process with a hands-on approach. Development activities should emphasise continuous waste recognition and developing methods to eliminate waste in succeeding projects. In order to enable a good result the team should include people who have experience and enthusiasm towards process development, waste elimination and maximising value generated for end-users. Also highly important is that the project is seen as a development activity and therefore increased resources are invested in the project. Management should also acknowledge that development projects include a risk of failures. Therefore, risk management practices should be included in the project. Also in case a failure happens it is that the reasons behind the failure would be recognised and actions taken to assure that the failure wouldn't happen again. Whether the pilot project generates value for the organisation, the approach can be taken further and guide the execution of other upcoming nursery schools as well. Also the best practices could be interpreted to other kind of projects than nursery schools.

The study concluded that an organisation's procurement strategy influences the efficiency and effectiveness of a contracting process. During the empirical study it was recognised that the case organisation doesn't have a totally coherent procurement strategy as the procurement of project teams differs from project to project. Also the context for making purchases is one of the most challenging as the made purchases are consulting services in a project environment made by a public organisation. The case organisation should decide how they want to develop their procurement strategy so that it is ensured that the collaboration among project team members is efficient, the team members' capabilities are exploited to the fullest and that the team members have common objectives in all projects and that the repetitive nature of projects can be benefitted from. Also the team should be formed so that the events occurring during the building's life cycle are considered. Creating a coherent procurement strategy could be eased by establishing a department or person who is responsible for all made project purchases and development of procurement strategy so that it is aligned with the overall strategy. The people involved in strategy creation should also be familiar with process development and Lean thinking if the case organisation wants to evolve their approach so that more effort will be invested in process development and waste elimination. The case organisation should also analyse the effects of the simultaneous execution of the two studied projects after the projects have finished in order to keep developing the procurement approach since the approach had potential for value creation, but the potential wasn't fully realised.

The project managers of the pre-construction phase are currently responsible for collecting feedback from the design team of construction projects, as there isn't a standard system collecting feedback from the designers. However, the designers can have valuable development suggestions and therefore their thoughts should be harvested and the process developed constantly if the ideas of the team members have potential to eliminate waste from the process or generate more value for end-users or results in a more cost-efficient outcome. Also after a project finishes especially the successes and challenges of the project should be discussed and reasons behind them should be identified with the whole team in order to find means to repeat the success or avoid the same mistakes in succeeding projects. Also a project process could be analysed after a project has ended in order to understand where waste was generated. For example the value stream map tool can be exploited in the process. The ideas generated by feedback collection and post-project analysis should also be documented in order to enable inter-project learning. In addition, the end-users' experiences should be collected after they have been using the premises in order to enable development of the outcome.

The nursery school design manual and the space requirement cards should be updated and all the designers who have been involved in the projects that have used the manual should be motivated to give feedback and development suggestions about the content. Currently there are some contradictions between the guidelines and these should be eliminated. Also the case organisation should establish a common policy about what requirements introduced in the manual must be fulfilled and what requirements can be interpreted if a better solution is realised. When the requirements are updated the total costs that occur during a building's life cycle should be taken into account as well as the value generated for the end-users.

Currently a rather large share of information remains as employees' tacit knowledge, which makes inter-project learning challenging. Enough resources should be invested in knowledge codification to ensure that several projects can benefit of the ideas developed in other projects. Also the person doing the knowledge codification can learn in the process as they reflect on the project. The case organisation should also decide what platforms are utilised to store information and establish a common understanding about what documents are stored there and assure that all employees can access the information in order to ease finding valuable information

If the case organisation wishes to pursue a Lean process, the employees should begin the transition by familiarising with the philosophy thoroughly in order to create a comprehensive understanding about process development and introduced changes. Also by training the staff to recognise waste that occurs due to their actions, incremental development of the contracting process can begin. However, the employees should be given enough time to invest in the training.

5.3 Evaluation of the study and further research suggestions

The study succeeded in answering the set research questions and can therefore be seen as successful. However, as the emphasis of the empirical study laid on examining only one case organisation, the external validity of the study is relatively low as the results aren't necessarily generalizable for other similar contexts. On the other hand, the construct validity and reliability of the study are fairly high because several sources of evidence were utilised and it was assured that the data collection means were relevant for the objectives and the empirical research process was documented well.

Even though assumptions about costs occurring in the construction phase were made based on the data gained from interviews and existing literature, the study excluded interviewing contractors. Thus, the construction phase should be examined in terms of how bidding of several projects to one contractor affects total costs and lead times of a project. Also the influence of simultaneous and successive execution in the construction phase should be compared. The study also excluded investigating comprehensively how the public procurement law that changes in 2016 will affect the bidding practices. Therefore, further research about how the change influences the development of a purchasing strategy, should be conducted.

Whether various succeeding projects are executed by the same project team, including also the contractor, there should be further research on how the approach affects the efficiency and effectiveness of the process and what other impacts does the approach have because this study excluded examining case projects like that. Also the studied projects of this study were implemented with a design-bid-build method, but assumptions were made about the effectiveness of other procurement methods. Hence, the impact of procurement methods like Integrated Project Delivery and design-and-build on project efficiency and effectiveness should be examined. Also waste elimination practices as well as methods to maximise value for end-users should be examined thoroughly in order to establish new best practices.

The research concluded that purchasing has a relatively high influence on the efficiency and effectiveness of construction projects. Further research should address the suggested procurement of several team members or whole team at once and investigate does it produce value for the collaboration. Also further investigation is required in order to understand how total costs of ownership thinking could be applied in practice when external consulting services are acquired and what kind of invitation for tenders would be applicable. In addition, further research should address more explicitly how purchasing strategy can be developed in practice so that the benefit gained from repetitive nature of projects can be maximised. Further research should also compare the effects of competitive bidding and partnering in the construction industry and

analyse how they affect waste elimination and exploiting repetitiveness because the case projects of this study only included projects that were bid.

This study concluded that benefit can be gained by replicating some elements of the outcome and process of construction projects. Further research should investigate what these elements are explicitly and how does the replication affect the process and outcome. Also further research should consider what external factors either ease or hinder the replication process. The research should also include the total cost of ownership angle and study what building elements, design solutions or systems would be recommended to be used in for example all nursery schools to minimise the costs that occur during the building's life cycle but maximise the value created for the children and other users. In order to execute the study also the costs occurring during a building's life cycle should be modelled to be able to analyse how the costs could be reduced.

Further research is also required to understand how stakeholders could collaborate efficiently when establishing a common long-term vision about the development of service needs. In addition, the effect of creating a coherent long-term plan for the upcoming projects with stakeholders should be examined more thoroughly.

Finally, further investigation concerning change management is required. The conclusion of this study includes several suggestions about process development. It should be examined, how in practice an organisation can motivate employees to participate in development activities and continuously develop the contracting processes well as how they can create objectives that are shared by all project team members. Also the desirable characteristics and capabilities of team members that are included waste elimination and process development should be investigated more in depth.

REFERENCES

Abdul-Kadir, M. R. and Price, A. D. F. 1995. Conceptual phase of construction projects. International Journal of Project Management, 13(6), 387-393.

Ahola, T. 2009. Efficiency in project networks: the role of inter-organizational relationships in project implementation.

Argote, L., Ingram, P., Levine, J. M. and Moreland, R. L. 2000. Knowledge transfer in organizations: Learning from the experience of others. Organizational behavior and human decision processes. 82(1), 1-8.

Artto, K and Kujala, J. 2008. Project business as a research field. International Journal of Managing Projects in Business, 1(4), 469-497.

Baden-Fuller, C. and Winter, S. G. 2005. Replicating organizational knowledge: principles or templates?. Available at SSRN 1118013.

Ballard, G. 2008. The lean project delivery system: An update. Lean Construction Journal, 2008, 1-19.

Bartezzaghi, E., Corso, M. and Verganti, R. 1997. Continuous improvement and inter-project learning in new product development. International Journal of Technology Management. 14(1), 116-138.

Belayutham, S. and Gonzalez, V.A. 2014. Process Complexity at the Pre-construction Stage: A Lean Based Solution. Proceedings of the 4th New Zealand Built Environment Research Symposium (NZBERS). Auckland, New Zealand. 14 November. ISSN 2324-1829

Berry, D. C. and Broadbent, D. E. 1987. The combination of explicit and implicit learning processes in task control. Psychological research, 49(1), 7-15.

Bhasin, S. and Burcher, P. 2006. Lean viewed as a philosophy. Journal of Manufacturing Technology Management, 17 (1), 56-72.

Brady, T., Marshall, N., Prencipe, A. and Tell, F. 2002. Making sense of learning landscapes in project-based organisations. In Third European Conference on Organizational Knowledge, Learning and Capabilities, Athens, Greece.

Brady, T. and Davies, A. 2004. Building project capabilities: from exploratory to exploitative learning. Organization studies. 25(9), 1601-1621.

Cox, A. 2001. Understanding buyer and supplier power: a framework for procurement and supply competence. Journal of Supply Chain Management, 37(1), 8-15.

Davies, A. and Brady, T. 2000. Organisational capabilities and learning in complex product systems: towards repeatable solutions. Research Policy, 29(7), 931-953.

Dvir, D., Raz, T. and Shenhar, A. J.2003. An empirical analysis of the relationship between project planning and project success. International Journal of Project Management, 21(2), 89-95.

Eisenhardt, K. M. 1989. Building theories from case study research. Academy of management review. 14(4), 532-550.

Ellram, L. M. 1995a. Total cost of ownership: an analysis approach for purchasing. International Journal of Physical Distribution & Logistics Management. 25(8), 4-23.

Ellram, L. M. 1995b. A managerial guideline for the development and implementation of purchasing partnerships. International journal of purchasing and materials management, 31(1), 9-16.

Ellram, L. M. and Siferd, P. S. 1993. Purchasing: The cornerstone of the total cost of ownership concept. Journal of Business Logistics. 14, 163-163.

Eloranta K., Kujala J. and Artto K. 2006. Subcontractors' inter-organizational relationships as risk sources in project networks. Proceedings of the Seventh International Conference of the International Research Network on Organising by Projects IRNOP VII, Xi'an, China, October 11-13, 2006, pp. 302-317

Espoo. 2015 a. "Technical and Environment Services". Accessed June 22, 2015. http://www.espoo.fi/en-US/City_of_Espoo/Organization/Technical_and_Environment_Services

Fisk, R. P., Grove, S. J. and John, J. 2012. Services marketing self-portraits: introspections, reflections, and glimpses from the experts. Marketing Classics Press.

Freeman, M and Beale, P. 1992. Measuring project success. Project Management Journal 1. 8–17.

Galbraith, C. S. 1990. Transferring core manufacturing technologies in high technology firms. California Management Review, 32(4), 56-70.

GoLeanSixSigma. 2015. "The 8 wastes". Accessed June 22, 2015. https://goleansixsigma.com/8-wastes/

Gottlieb, S. C. and Haugbølle, K. 2010. The repetition effect in building and construction works: A literature review. SBI forlag.

Grabher, G. 2004. Temporary architectures of learning: knowledge governance in project ecologies. Organization studies, 25(9), 1491-1514.

Green, S.D. 1999. The dark side of lean construction: exploitation and ideology. The 7th Conference of the International Group for Lean Construction. University of California. Berkeley, USA.

Green, S.D. 2001. Towards a critical research agenda in construction management. CIB World Building Congress, 2-6 April 2001, Wellington, New Zealand.

Haahtela, Y. and Kiiras, J. 2013. Talonrakennuksen kustannustieto. Haahtela-kehitys Oy. Tampere.

Hankinnat. 2013. "Hankintalain uudistaminen alkaa." Accessed April 6, 2015. http://www.hankinnat.fi/fi/malleja-ja-lainsaadantoa/hankintauutisia/lainsaadanto/hankintalaki/Sivut/default.aspx

Hellgren B. and Stjernberg T. 1995. Design and implementation in major investments – a project network approach. Scandinavian Journal of Management. (11)4: 377-394.

Hines, P., Holweg, M. and Rich, N. 2004. Learning to evolve: a review of contemporary lean thinking. International Journal of Operations & Production Management. 24(10), 994-1011.

Hines, P., Found, P., Griffiths, G. and Harrison, R. 2011. Staying Lean: Thriving, Not Just Surviving. Lean Enterprise Research Centre, Cardiff University.

Hobday, M. 1998. Product complexity, innovation and industrial organisation. Research Policy 26, 689–710.

Hobday, M. 2000. The project-based organisation: an ideal form for managing complex products and systems?. Research policy, 29(7), 871-893.

Horman, M. and Kenley, R. 1996. The application of lean production to project management. In Fourth International Workshop on Lean Construction.

Iloranta, K. and Pajunen-Muhonen, H. 2008. Hankintojen johtaminen: ostamisesta toimittajamarkkinoiden hallintaan. Tietosanoma.

Johansen, E. and Walter, L. 2007. Lean construction: Prospects for the German construction industry. Lean Construction Journal, 3(1), 19-32.

Kankainen, J. and Junnonen J-M. 2001. Rakennuttaminen. Helsinki: Rakennustieto Oy

Kolltveit, B. J. and Grønhaug, K. 2004. The importance of the early phase: the case of construction and building projects. International Journal of Project Management, 22(7), 545-551.

Lajunen, E. 2010. Replication in Large Multi-Firm Investment Projects. Master of Science Thesis. Aalto University School of Science.

Larson, E. 1995. Project partnering: results of study of 280 construction projects. Journal of management in engineering. 11(2), 30-35.

Lean Construction Institute Finland. n.d. "WHAT LCI-Finland". Accessed March 28, 2015. http://www.lci.fi/en/content/what-lci-finland

Lindholm, M. 2009. Kustannushallinta Rakennushankkeessa. Suomen Rakennusmedia Oy. Helsinki.

Liker, J. K. 2008. Toyotan tapaan. 2. edition. Gummerus Kirjapaino Oy. Jyväskylä.

Love, P. E. D., Gunasekaran, A. and Li, H. 1998. Concurrent engineering: a strategy for procuring construction projects. International Journal of Project Management, 16(6), 375-383.

Masterman, J. 2003. An introduction to building procurement systems. Routledge.

Mauger, C. 2012. Method for the conceptual phase of an Integrated Product and Service Design applied to Construction Project. In REFSQ.Vol. 2, pp. 365-372.

Merikallio, L. and Haapasalo, H. 2009. Projektituotantojärjestelmän strategiset kehittämiskohteet kiinteistö- ja rakennusalalla. Espoo. Rakennusteollisuus RT ry and Lean Construction Institute Finland.

Milosevic, D. and Patanakul, P. 2005. Standardized project management may increase development projects success. International Journal of Project Management, 23(3), 181-192.

Montonen, M. 2014. Competitive Bidding of Building Design Services of the Local Government Sector in Finland. Bachelor of Science Thesis. University of Applied Sciences of Kymenlaakso.

Morgan, J. M. and Liker, J. K. 2006. The Toyota product development system. New York.

Morledge, R. and Smith, A. 2013. Building procurement. John Wiley & Sons.

Nelson, R.R. and Winter, S.G. 1985. An Evolutionary Theory of Economic Change. Belknap Press of Harvard University Press.

Pearson, J.N. and Wisner, J.D. 1993. Using volume and economies of scale to benefit long-term productivity, Industrial Management. 35 (6), 13-16.

Pelin, R. 2004. Projektihallinnan käsikirja. Projektijohtaminen Oy Risto Pelin. Jyväskylä.

Perttilä, H. and Sätilä H. 1992. Rakentamistalous 2. Rakennuttaminen. Rakentajain kustannus. Helsinki.

Pitkänen, J. 2009. Asuinkerrostalojen rakentamisen ohjauksen kustannustarkasteluja.

Helsingin kapungin talous- ja suunnittelukeskus. Talous- ja suunnittelukeskuksen julkaisuja 6/2009. Helsinki.

Porter, M. E. 1980. Competitive Strategy: Techniques for Analyzing Industries and Competitors. Free Press.

Porter, M. E. 1985. Competitive advantage: creating and sustaining superior performance. New York.

Pekuri, A., Herrala, M., Aapaoja, A. and Haapasalo, H. 2012. Applying Lean in construction–cornerstones for implementation. In Proceedings of the 20th Annual Conference of the International Group for Lean Construction (pp. 18-20).

Prencipe, A. and Tell, F. 2001. Inter-project learning: processes and outcomes of knowledge codification in project-based firms. Research policy, 30(9), 1373-1394.

Rakennustieto. 2013. RT 10-11107, Hankkeen johtamisen ja rakennuttamisen tehtäväluettelo HJR12.

Reynolds, R. L. 1983. Policy Choices and Economies of Scale. Journal of Economic Issues. 17(4), 1067-1074.

Rissanen, A. 2013. Julkisen Rakennuttajan Uudisrakennushankkeiden Kustannusarviointi ja -ohjaus. Master of Science Thesis. Aalto University School of Engineering.

Rust, R. 1998. What is the domain of service research?. Journal of Service Research, 1(2), 107-107.

Sarhan, S. and Fox, A. 2012. Trends and challenges to the development of a lean culture among UK construction organisations'. In Proceedings for the 20th Annual Conference of the IGLC (pp. 1151-1160).

Szulanski, G. and Winter, S. 2002. Getting it right the second time. Harvard business review, 80(1), 62-9.

Tzortzopoulos, P. and Formoso, C. T. 1999. Considerations on application of lean construction principles to design management. 7th Annual Conference of the International Group for Lean Construction, Berkeley, California, USA.

Weele, Van, A. J. 2010. Purchasing & supply chain management: analysis, strategy, planning and practice. Andover. Cengage Learning.

Vuorela, K., Urpola, J. and Kankainen, J. 1998. Johdatus Rakentamistalouteen. Espoo.

Williams, T. and Samset, K. 2010. Issues in front-end decision making on projects. Project Management Journal, 41(2), 38-49.

Winch, G. M. 1997. Thirty years of project management. What have we learned? Presented at British Academy of Management, Aston 1996, revised March.

Winch, G. M. 2002. Managing construction projects. Blackwell Publishing.

Winter, S. G. and Szulanski, G. 2001. Replication as strategy. Organization science, 12(6), 730-743.

Womack, J.P., Jones D.T. and Roos, D. 1990. The Machine That Changed The World. New York. Free Press.

Womack J.P. 2006. Value stream mapping. Manufacturing Engineering 136 (5): 145-156.

Wood, H. L. 2010. Modelling project complexity at the pre-construction stage. Unpublished doctoral dissertation, The University of Brighton, Brighton, United Kingdom.

Yin, R. K. 2003. Case studies research: design and methods. Thousand Oaks, Sage.

Yliherva, J. and Merikallio, L. 2008. Infra-alan tuottavuushanke TUKEFIN. Unpublished resource.

Zollo, M. and Winter, S. G. 2002. Deliberate learning and the evolution of dynamic capabilities. Organization science, 13(3), 339-351.

Singleton, R.A.J. and Straits, B.C. 2005. Approaches to Social Research 4th ed. New York: Oxford University Press.

Case organisation's internal resources

Espoo. 2013. Strategy of Espoo.

Espoo. 2014. Organisational guidelines for contracting commercial premises.

Espoo. 2015 b. Developing the service network. 14.4.2015

Piirainen, A. and Saarinen, J. 2013. Espoo - procurement workshop 18.1.2013. Unpublished resource.