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Developing a Data Collection Plan for Pre-tender Cost Estimation in Design Phase

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Pre-tender cost estimation in the Design phase is a crucial step in the plays a crucial role in guiding clients' decisions for long-term financial commitments. It provides a financial roadmap, helps manage risks, supports decision-making, and ensures that projects are executed within budgetary constraints while meeting project objectives. The objective of this study is to understand the pre-tender cost estimation processes in the case company, to develop a Data collection plan for the Pre-tender cost estimation in the Design Phase.

This thesis follows a research design comprising of four stages. The initial stage involves an in-depth literature review focused on discovering existing knowledge and best practices related to the identified improvement areas, forming the basis for a conceptual framework. In the second stage, a current state analysis is undertaken using quantitative and qualitative data, to map the process and identify key improvement areas, and development of data collection plan. In the third stage, initial proposals are collaboratively developed to enhance the specified improvement areas within the tender preparation process, building upon insights gained in previous stages. The fourth stage entails validating and prioritizing the proposals, formation of data collection plan incorporating feedback from executives in the case company.

This thesis concludes with a recommendation to enhance the pre-tender cost estimation process. This includes assigning a dedicated process, producing a structured data collection guideline, and scaling up the plan for diverse projects like tram and railways. Specific target levels for initial improvement, sharing best practices, and setting up a database for recurring questions are suggested. These measures collectively contribute to a more systematic and efficient pre-tender cost estimation approach for the case company's infrastructure projects.

Keywords	Pre-tender cost estimation, accuracy, risk management

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1 Introduction

Although Finland is a sparsely populated country with approximately 5,5 million people, it is densely populated in Southern region (Uusimaa) and Helsinki Metropolitan Area (HMA) region. The City Plan facilitates Helsinki's growth into a densely populated city where several centers are connected by rail transport: metro, trains and light rail and buses. Moreover, new houses are built rapidly and therefore infrastructure is required to cater to the new residents. Finland has a well-developed infrastructure and its continuously developing more mainly in the Southern part.

Nevertheless, financial resources required to be set aside for infrastructure development are usually based on pre-tender cost estimates of construction project cost. Therefore, it is necessary to maintain the accuracy of pre-tender cost estimation since beginning of the project. Preliminary cost estimation is the forecasting of the cost of the project during the planning and design phase (Serpell, 2005, Skitmore 1991).

Infrastructure expenditures are typically contentious and prominent due to their high costs, long durations, and strategic relevance. When commissioning such initiatives, it is critical to reduce the danger of overspending and misusing tax money. As a result, decision-makers are under a lot of pressure to set strict project cost and timeline objectives and monitor adherence to them throughout the project's execution. To tackle this challenge, public infrastructure projects are managed under a control-oriented project management paradigm, with the goal of minimizing change and meeting pre-determined goals. (Pesämaa, Larsson and Eriksson, 2018.)

This thesis investigates how to help the case company to produce more accurate pre-tender estimations via exploring the data, learning from its past projects and expert’s opinion.

1.1 Business Context

The case organization of this thesis is Sweco Oy. It is a leading engineering, design, and consultancy company, which founded back in 1958 as an architecture firm FFNS. In 1996, the company had more than 550 employees working across 20 different locations.

In 1997, FFNS acquired VBB and formed Sweco. In 2019, the Sweco Group's business activities are organized in eight business areas: Sweco Sweden, Sweco Norway, Sweco Finland, Sweco Denmark, Sweco Netherlands, Sweco Belgium, Sweco United Kingdom and Sweco Germany & Central Europe. Sweco works across the following markets: Buildings, Transport, Water, Environment & Health, Energy and Management Consulting.

The Sweco Model is based on four cornerstones: client focus, the best employees, internal efficiency, and a decentralized organization Sweco strategy answers the following questions:

What? Sweco plans and designs the sustainable communities and cities for the future

Where? Securing market leadership in Northern Europe through profitable growth

How? The way we work and how we do business. (The case company website, 2022.)

Sweco recognizes that modern technology is fundamental to forming an accessible and sustainable society. Sweco's experts design transportation systems helping tomorrow's cities manage growing populations and new ways of transport. Sweco's civil engineering specialists plan and design everything from roads and tunnels to bridges and ports. Sweco's project managers are the link between the client's vision and the actual implementation of complex construction projects. This includes Project and design management, Project and development management, and site supervision. (www.sweco.fi, 2022.)

1.2 Business Challenge, Objective and Outcome

In this context, pre-tender cost estimation is very important for the clients to make decisions to invest into financial long term-commitment. Moreover, the accurate pre-tender cost estimation has also an effect on the value proposition, which leads to the value a company promises to deliver the client. It is important to accurately inculcate all the task, resources, and hours in design phase to deliver project successfully. This also leads to the client satisfaction at the end of project completion.

Therefore, a pre-tender cost and resource estimation is an important piece of information when making decisions at the project planning and design stage. These estimations are prone to inaccuracies because they are often prepared within a limited timeframe, and sometimes without finalized project scope. Following an underestimated and overestimated project can lead to project failure.

These bias in the estimation of a project may arise from many sources, but it can be divided into two main sources at the initial stage of research. First, it can be the project itself, the problem will remain in the estimation regardless of the estimator effort. And second, which is the main concern of this thesis, it is the technique used by the estimator as well as the influence of the environment which could be change during the designing phase, which impacts the cost forecast.

The objective of this study is to understand the pre-tender cost estimation processes in the case company, in order *to develop a Data collection plan for the Pre-tender cost estimation in the Design Phase.* This will help improve future pre-tender estimation planning and the method for collecting data systematically from tendered and executed projects. This will also help improve the company's project cost estimation practices and overall project management. As a result, it should lead to more successful projects, satisfied clients, and a stronger position in the industry.

The intended outcome of the thesis is *the Data Collection Plan*. The Data Collection Plan will act as the baseline for managers in future to make more accurate estimations in the Pre-tender cost estimation in the Design Phase.

1.3 Scope of the Study

The scope of the thesis is limited to the pre-tender cost estimation of Infrastructure department, which includes the road, land use planning, bridge design, traffic planning and sewerage system design. Due to large variety of consulting services, this study focuses on the projects carried out by Infrastructure department, inside the cities of Espoo, Helsinki, and Vantaa municipalities.

The scope of this thesis is limited to providing proven practices for accurate pre-tender

cost estimation in the infrastructure department from the managerial perspective and showing how and why it could be deemed significant. The infrastructure department has shown interest in using the Data Collection Plan. Therefore, Infrastructure projects will be in focus to study their pretender cost estimations.

The thesis examines the data of project characteristics and data influencing the accuracy of pre-tender cost estimations. The scope of the thesis will cover the systematic Data Collection Plan from tendered and executed projects. This Data Collection Plan will help project managers and team managers to forecast pre-tender estimation more accurately.

1.4 Thesis Outline

To prepare the Data Collection Plan, this research initially examines the definition, current best practices, and existing technological solutions related to the accuracy of pre-tender cost estimation through literature and best practice reviews. Subsequently, a comprehensive survey/questionnaire is crafted, and interviews are structured specifically for the infrastructure unit of the case company.

Next, the study assesses the current state of pre-tender cost estimation practices in the case company's Infrastructure unit. Following this, the investigation uses the data obtained from surveys and interviews to gain insights into the information and practices that employees within the infrastructure department consider essential in preliminary cost estimation.

After the data analysis, the study identifies what practices and tools are needed to estimate pre-tender cost estimation.

2 Method and Material

This section presents the research methodology and data used in this thesis. To begin, it gives an overview of the research techniques chosen for the thesis. After that, it describes the research strategy and data gathering methods employed in this study.

2.1 Research Approach

It is very important to select the best research approach, because it will determine research methods for data collection, analysis, and will open the for building a solution. Furthermore, the research approach leads to develop research design, or plan to conduct research.

Research is generally divided into two main families Basic and Applied research. Since its primary goal is the advancement of science, basic research is often referred to as fundamental or "pure" research. Basic research's main objective is to simply gather more data to better understand current phenomena, particularly in the realm of natural sciences. Basic research is done to expands current knowledge and it is theoretical and exploratory in nature. Basic research has wider scope and less associated with technology, whereas Applied research is usually used to solves life problems. Applied research is usually practical and descriptive in nature and has more specific scope.

> “The goal of applied research is to learn more about a particular issue in the real world and take action to address it. It focuses on using natural science ideas to solve real problems and advance innovations. These studies are frequently linked to the business, economics, health, and political disciplines”. (Brown, 2018.)

The main research approaches typically used, quantitative, qualitative, and mixed methods. In quantitative research, quantitative data collection and analysis is the primary focus of research, whereas qualitative research focus on analysing qualitative, of soft, data (i.e., non-numerical data such as words and pictures). (Johnson and Christensen, 2014.) *Quantitative* research examines the relationship between variables, typically to test theories. These variables can then be measured using various statistical

instruments, resulting in numbered data that can be examined using statistical processes.(Creswell, 1996.) *Qualitative* research generally emphasizes collecting non-numerical data, and mainly makes conclusions based on descriptive or behavioural data. The primary data collection instrument used for data-collection in qualitative research are in-depth interviews, participant observation, field notes, and open-ended questions, etc. (Creswell, 1994.) A *mixed* methods research is the one that integrates or associates both qualitative and quantitative modes of inquiry. It involves philosophical assumptions, the application of qualitative and quantitative methods, and the combination of the two in a study. As a result, it involves more than just gathering and evaluating both types of data; it also includes combining both methodologies so that a study's overall strength is stronger than either qualitative or quantitative research. (Creswell & Plano Clark, 2007.)

This study uses *applied* research paradigm, as the research focuses on developing a data collection plan, which should help to ensure that data collected during the pre-tender cost estimation period is useful for pre-tender cost estimations and appropriately collected. This thesis uses the *mixed* method research. Both quantitative and qualitative research methods are applied to examine multiple sources for data collection. Qualitative data such as experience, observation, and interviews, are combined with quantitative data. In quantitative data analysis, past and completed project data are used. For qualitative data analysis, project managers are interviewed, and their opinions and experience are utilized.

This thesis was done within the company, as it is the main objective to explore the current state and come up with the Data Collection Plan. The thesis researcher is employed in a Civil engineering consultant company as a Design Engineer.
The result of this research may not present a conclusive solution but rather address the question of whether and how the research subject can be integrated into the company's daily operations.

2.2 Research Design

This section provides details on the research design and explains the rationale behind the chosen research design for the study.

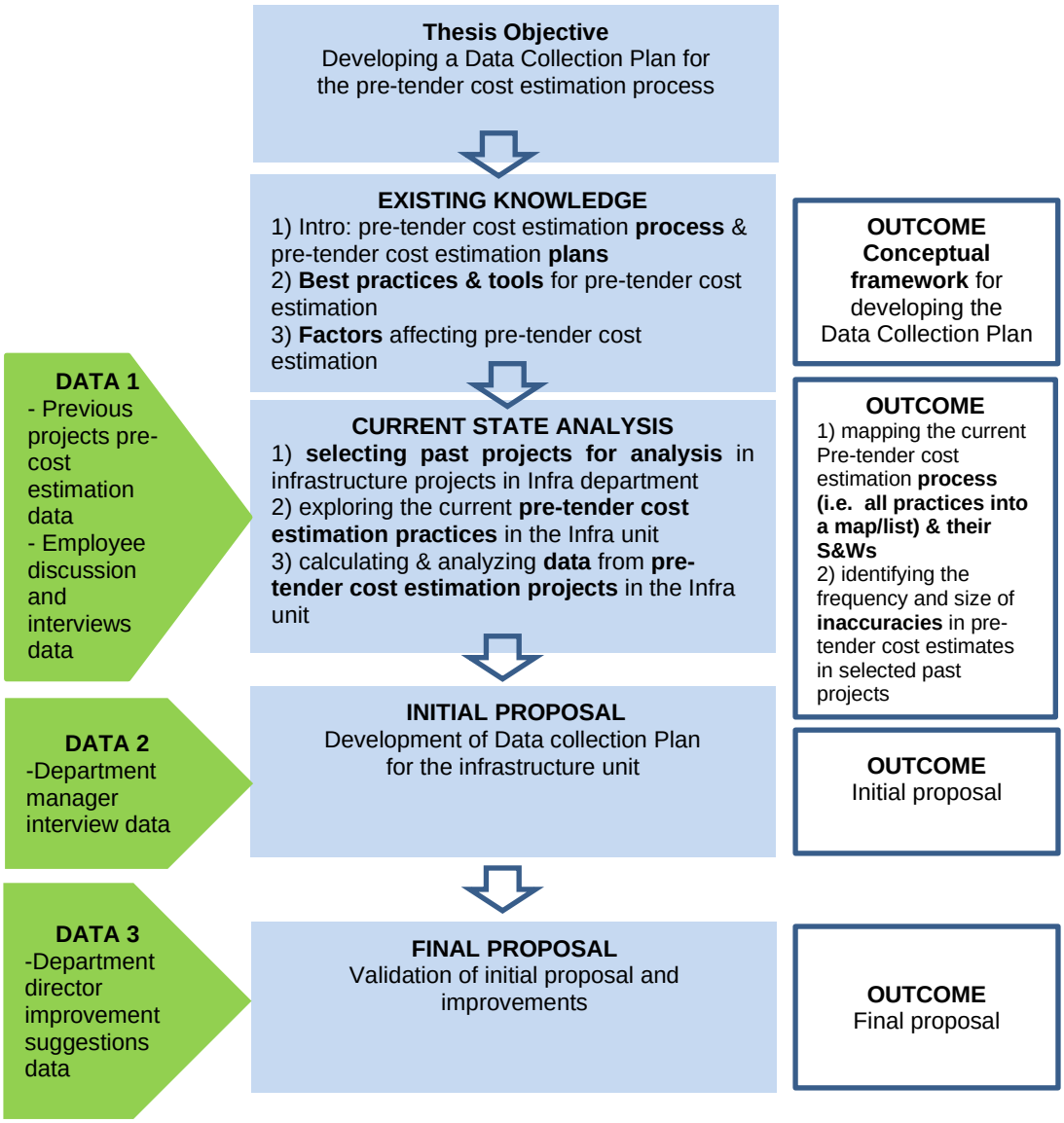

Figure 1. Research design of this study.

As shown in Figure 1, this study was conducted in five steps. The first step was setting the objective. It determines the scope, depth, and the overall direction of the study.

In the next step, existing knowledge and best practices are examined to find suitable guidance for developing the Data Collection Plan later. This section investigates methods and tools, as well as existing best practices for conducting the pre-tender cost estimations. This section explores how existing knowledge and best practices could be utilized for developing the Data collection plan. The outcome of the theoretical part is divided into two parts: a conceptual framework for the proposed estimated accuracy **model**, and a selection of **factors** influencing the pre-tender cost estimation usable for formulating the survey and interview questions. The second part is based on the literature review about project management practices. This will help to gain access to the project personnel responsible for project management implementation throughout project life cycle.

In step 3, the current state analysis is conducted focusing on selected past projects in the case company Infrastructure department and the current practices for doing pre-tender cost estimations. Suggestions from literature and best practices (i.e. the conceptual framework) are compared to the current practices in the Intra unit to judge how well the current strategy, tools and methods are working. The data for the current state analysis was gathered by conducting employee surveys & interviews. The survey & interview questions were formulated based on the inputs from the literature and best practices review. The outcome of the current state analysis gives a clear picture of the current situation and identified pain points, or bottlenecks, in the current pre-tender cost estimation practices in the Intra unit. They give valuable insights that help to ensure project success in the future.

In step 4, the initial proposal is developed for the Data collection plan in the case company´s Infrastructure department. The purpose is to re-design the current practices based on suggestions from the conceptual framework (discussed in Section 3) and based on the results from the completed projects & interview data (discussed in Section 4). The outcome is the Initial proposal for development of the Data collection plan.

In step 5, the final proposal is formulated for the Data collection plan for pre-tender cost estimation in the infrastructure department. The data for developing the final proposal is gathered by validating the initial proposal. The case company's department director and

department manager evaluated the framework, and improvements were proposed to the initial proposal based on the evaluation results. The final proposal can be found in section six of this study.

2.3 Data Collection and Analysis

The study's data gathering, and analysis methodologies are detailed in this section. The data was gathered from a variety of sources, and the analysis was completed in three stages. Table 1 shows details of Data collections 1-3 used in this study.

Table 1 Details of Data collections 1-3 used in this study.

	Content and Target	**Data Sources**	**Participants**	**Timing**	**Outcome**
Data 1 From Current State Analysis	Current state of case company infrastructure department practices Identify +/- of current practices	IU employee questionnaire (8) IU employee 1 to 1 interviews (s) (8)	IU project manager Head of IU department	September (2022)	Summary of case company IU unit's current state of pre-tender cost estimation practices.
Data 2 For initial proposal development	Request for initial proposal development	IU Director (Toimialajohtaja) Interview (1)	IU department director (Toimialajohtaja Siipo Juha)	September (2022)	Initial proposal development request (framework)
Data 3 For final proposal development & validation	Request for final proposal development (framework) Identify +/- of initial proposal (framework)	IU Director (Toimialajohtaja)	IU Director (Toimialajohtaja)	October (2022)	S & W of initial proposal (framework) Final proposal validation

IU* Infrastructure Unit

As seen from Table 1, data for this study was collected in three rounds. In the first round, Data 1 was collected for analyzing the pre-tender cost estimation practices of the case company´s Infrastructure unit (IU) and finding the strengths & weaknesses of these practices. Data for Data 1 comes from the questionnaires / surveys and interviews at the

case company´s Infrastructure unit (IU). The outcome of the current state analysis is a summary of the pre-tender cost estimation practices at the case company´s Infrastructure unit, and the summary of the strengths & weaknesses of these practices.

In this thesis, A survey instrument in the form of a questionnaire was used to gather insights from consultants experts regarding their perspectives on tendering process and management. The distribution of the questionnaire was facilitated through direct contact, primarily via email communication with the participants.. The questionnaire was sent to projects and team managers from different teams to understand the current practices in the company. The questionnaire aimed to examine the current Pre-tender cost estimation method used and control with cost estimation. A detailed study of literature review and best practices made the basis for the design of the questionnaire. Questionnaire is attached as an appendix. A questionnaire was developed and sent via email in advance to allow participants to familiarize themselves with the content. The meeting was subsequently conducted either virtually and in-person at the office, depending on the participants' availability. The session was recorded to enable further data extraction and analysis. English served as the primary language for the discussion, although Finnish was also used intermittently. Additionally, quantitative analysis questions were briefly addressed with participants to gather their input. These questions aimed to gather information and insights about department's pre-tender cost estimation process, scope definition, data quality, and risk management practices, with a focus on current project management practices. The questionnaire gathered insights and information related to project management practices, particularly focusing on the challenges and factors that influence project success. The questionnaire asked about the aspects such as project size, risk management, scope changes, realistic timelines, current practices, client expectations, and the importance of client understanding. By analyzing responses, the questionnaire helped to identify key strengths, weaknesses, opportunities, and threats in the organization's project management approach, ultimately facilitating improvements in project planning and execution.

In Data 1, the study also used quantitative data from Source of the Deltek Maconomy database. For this end, project data was exported in the form of Excel files. Deltek Maconomy is an Enterprise Resource Planning (ERP) software solution specifically designed for professional service industries, such as consulting, architecture,

engineering, and other project-based sectors. Deltek Maconomy proves especially beneficial for businesses that rely on project-based work, offering a comprehensive tool to efficiently track and optimize their resources, budgets, and project delivery. Maconomy serves as a valuable tool for businesses looking to simplify project and financial management. It assists in monitoring project costs, revenue generation, and overall profitability. Maconomy ensures that the right personnel are assigned to the correct projects at the appropriate times. It provides user-friendly tools for employees to log their work hours and expenses, which facilitates client billing and cost monitoring. Additionally, it aids in budgeting, invoice generation, expense management, and financial reporting. Therefore, for businesses seeking improved efficiency and financial control, Maconomy proves to be an invaluable resource. The data is presented in the form of Excel sheets, which not only contain cost-related information but also the hours spent on project design tasks. The objective is to establish a baseline for a systematic approach to acquiring data from completed projects. Of particular significance for the current state analysis was the collection of data regarding the hours allocated to each design task.

During the second phase, Data 2 was acquired through the process of conducting interviews with the Infrastructure Director to propose a framework for supporting and improving the currently used cost estimation practices and improving its identified weaknesses. Data for Data 2 come from the interview with the infrastructure department Director. The outcome is the initial proposal for a Data Collection Plan for improving the accuracy pre-tender cost estimation at the case company Infrastructure unit.

In third round, Data 3 was collected from conducting the validation discussion about the proposed Data Collection Plan for improving accuracy in pre-tender cost estimation and improving the current weaknesses in the Intra unit´s pre-tender cost estimation practices. Data for Data 3 came from the project managers and Infrastructure department director's improvement requests to the initial proposal. The outcome is the final proposal for the Data Collection Plan for the pre-tender cost estimation for the case company´s Infrastructure department.

Summing up, this study used a questionnaire and interviews as research techniques, as well as the analysis of internal documents and participant observations of the thesis researcher. The data was gathered from the case company´s Infrastructure employees,

as well as quantitative analysis was performed. The questionnaire was based on a broad literature review of factors affecting pre-tender cost estimation in construction and the company's internal documents and policies. For the qualitative analysis part, 11 semi-structured qualitative interviews with key persons in the tendering process and one observation of a risk meeting were carried out. Finally, the validation discussion was also used to finalize the Data Collection Plan of infrastructural projects. Thus, the main methods of data collection were interviews, quantitative data analysis of project cost estimations from past projects, and a questionnaire. One of the primary strategies of gathering Data 1 in this study was conducting interviews. These interviews took place on the grounds of the case company, face to face interviews. The questions were developed beforehand using the information from the literature review.

3 Existing Knowledge and Best Practice of Pre-Tender Cost Estimation

This section presents three main areas of theoretical research: definitions, best practices, and technical solutions. The result of this section is divided into two outcomes: a conceptual framework for developing effective pre-tender cost estimation plan, and the factors affecting the pre-tender cost estimation usable for formulating the survey and interview questions.

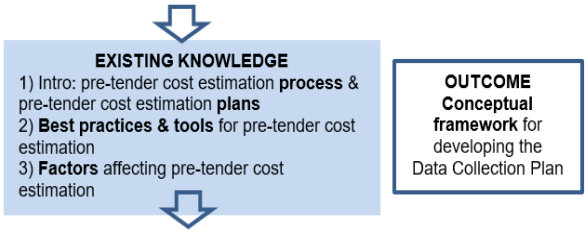

Figure 2. Existing Knowledge section and its outcome.

3.1 Definitions and Key Concepts in Pre-tendering Cost Estimation

This sub-section describes three key definitions to establish the scope of the pre-tender cost estimation framework by clarifying pre-tender cost estimation and accuracy of an estimate, what are the key factors which affect pre-tender cost estimation and current practices in risk management in tendering process.

3.1.1 Definitions

Cost plans are made by cost consultants often quantity surveyors. As additional details and accuracy are added throughout the progression of the project as more data about the nature of the design becomes accessible, actual pricing are then given by suppliers, contractors, and specialty contractors.

Tender documentation is made by consultant or contractor in response to an invitation to tender. It makes an offer for the supply design consultant services. Tender documents are prepared to seek offers.

Pre-tender estimate prepared alongside tender documentation.

Elemental cost plan (ECPs) prepared during the project brief stage and carried through to detailed design.

Contract sum The contract sum is the price agreed with the contractor and entered into the contract.

Outturn cost (OTS) The 'outturn cost' or 'out-turn cost' of a project is its actual construction cost. This usually refers to the final project's actual, total construction cost, but it may also relate to the price of a particular contract or to expenses incurred over a predetermined time. As opposed to this, cost estimates or target costs are computations of the cost that is anticipated or should be attained.

Pre-tender cost estimation Serpell (2005) defines "*Pre-tender cost estimation* as the forecasting of the cost of a project during the planning and design stage. In other words, *Pre-tender cost estimation* (or early-stage cost estimation) means predicting of a project's cost at the planning and design stage is known ".

Proposed tender price, according to Wong, Holt, & Harris (2001), *pre-construction proposed tender price* consists of the actual cost of carrying out the agreed scope of construction works plus a mark-up.

Tendering process is one of the most important tasks in the construction process, and competitive tendering is the most common way for determining who will oversee a project's implementation (Winch, 2010).

Predictive analytics Predictive analytics encompasses a variety of statistical techniques from data mining, predictive modelling, and machine learning that analyse current and historical facts to make predictions about future or otherwise unknown events

3.1.1 Key Concepts in Pre-tendering Cost Estimation

Pre-tender cost estimation is a critical phase in the design consultancy and engineering industry, shaping the foundation of project planning and execution. The primary goal of cost estimation practices, ever since they were integrated into the field of quantity surveying in the early 1950s, has been to establish a foundation for managing project expenses through the development of detailed cost estimates. (Ashworth and Perera, 2015).

Cost estimation at the pre-Tender contract stage is essential. However, construction projects present unique challenges in predicting future work, making it difficult to achieve reliable and accurate estimates, given the uncertainty and complexity of construction projects (Challal and Tkiouat, 2012). Cost overruns are a common issue in the construction industry, particularly in large infrastructure projects. Research in Hong Kong found that cost overruns averaged 32.52% in road projects, 34.83% in rail projects, and 37.48% in bridge and tunnel projects (Huo et al. 2018).

According to a survey by (KPMG NZ ,2017), Infrastructure projects often face extended construction periods, making accurate cost forecasting critical. A survey by KPMG New Zealand noted a decrease in projects delivered within budget, falling from 48% to 29% between 2010 and 2017. In more study Aibinu and Pasco (2008, p. 1260) revealed that that pre-tender building costs are more frequently overestimated than underestimated. Furthermore, the analysis of data suggests that the precision of pre-tender building cost predictions has not shown improvement over time.

A notable proportion of survey respondents express a degree of dissatisfaction with the accuracy of estimates within the industry. Aibinu and Pasco (2008, p. 1260) suggested that to enhance the accuracy of estimates for new projects, several strategies are recommended, including using probability estimation and simulation based on past estimates, reducing turnover in quantity surveying and cost engineering skills, integrating market sentiments into estimates, involving quantity surveyors at an early project briefing stage, and maintaining thorough documentation of experience gained in project estimation.

The researchers have identified multiple factors leading to cost increases in projects, such as alterations in project timelines, inaccurate initial estimates, changes in project scope, execution errors, inconsistent utilization of contingency plans, unexpected events, project complexity, and conflicts within contract documents. (Shane, Molenaar, Anderson, & Schexnayder, 2009). Nonetheless, research suggests that the primary cause of cost overruns is the complexity of projects, as it can trigger a ripple effect across all project elements. (Kaming, Olomolaiye, Holt, & Harris, 1997).

Therefore, (Odusami and Onukwube, 2008) stated that estimating the cost of infrastructure projects before the tender phase demands a high level of expertise and knowledge. Due to the limited design information available during the initial design stages, estimators face considerable challenges in producing precise cost estimates. They identified six key factors that influence the accuracy of pre-tender cost estimates, gaining from the practical experience of quantity surveyors in the construction industry. These factors encompass the consultants' expertise, the quality and availability of information, the project team's familiarity with the specific construction type, the prevailing market conditions and tender period, the level of completion in pre-contract design, and the complexity of both the design and construction.

Sridarran, Keraminiyage, and Herszon (2017) stated that project complexity is a key reason for cost overruns. They suggested that incorporating various dimensions of complexity into cost estimates can lead to more accurate projections. Complex projects typically necessitate the collaboration of professionals from various disciplines, as it is impractical to manage all aspects of the project alone while also capitalizing on specialization (Gray & Hughes, 2001).

Hence, many projects involve organizational complexity, but complexity is a fundamental aspect of a flexible and adaptable industry. Therefore, industry growth depends on improving project management to handle these complexities (Gray & Hughes, 2001).

According to Demirkesen and Ozorhon (2017), the success of an infrastructure project depends on various aspects of project management. Of these, integration management stands out as crucial because effective project management commences with the seamless integration of processes and people involved in the infrastructure project.

Numerous research studies have demonstrated that the key indicators of project success are the safe and timely completion of the work (Khosravi and Afshari, 2011; Chan et al., 2002). Many companies prioritize achieving "client satisfaction" and staying within the "cost" objectives for their projects. The significance of meeting client satisfaction and cost-related goals in determining project success has been underscored in previous research (Shields et al., 2003; Nassar and Abourizk, 2014).

According to (Bryde, 1997) Total Quality Management (TQM) and Project Management (PM) are both fundamental management methodologies adopted by organizations to attain continuous improvement and organisational success.

In a study by Bryde (2003a), the connection between Total Quality Management (TQM) and Project Management (PM) practices was explored through the introduction of the 'Project Management Performance Assessment (PMPA)' model, which is based on the EFQM (European Foundation for Quality Management) model. The PMPA model simplifies the evaluation of high PM performance into five key enablers. These enablers encompass PM leadership, PM staff, PM policy and strategy, PM partnerships and resources, and project life cycle management processes. The final component of the PMPA model is PM Key Performance Indicators (KPIs), which serve as how actual achievements are measured.

Bryde (2003a) elaborates on each of these integral components within the PMPA model. PM Leadership emphasizes the development of awareness regarding projects as vehicles for managing change and ensuring that the PM system supports open, two-way partnerships with customers and suppliers. PM Staff underscores the planning and management of project-related human resources and the incorporation of performance-rewarding methods. PM Policy and Strategy are centered on the systematic introduction of PM across an organization to bridge the gap between strategic and project-level considerations. PM Partnerships and Resources highlight the significance of mutually beneficial partnerships among all stakeholders and their impact on project management strategy. The Project Lifecycle Management Processes encompass the necessary processes for overseeing the entire project life cycle. Lastly, PM Key Performance Indicators (KPIs) concentrate on the use of KPIs to gauge results in relation to meeting project stakeholder requirements and the methods within the PM system designed to

enhance performance in alignment with these KPIs. The PMPA model, as presented by Bryde, serves as a comprehensive framework for assessing and improving project management performance (Bryde, 2003a).

3.2 Best Practices and Tools in Pre-tender Cost Estimation

This section examines the available literature, case studies, articles, and white papers. By understanding the best practices, the framework can be utilized or implemented on current case company.

3.2.1 Historical Data Analysis

Researchers have worked on creating dependable preliminary cost estimates, and they came up with mathematical methods such as stochastic, parametric, and capacity/equipment-factored estimation approaches. These methods all use historical project cost information as a basis. (Lee et al. 2022)

Adafin and Rotimi (2020) studied five researches and discussed plausible solutions for pre-tender cost estimation. They suggested quantity surveyors should only use *one source* of historical cost information from prior projects.

“Major methods of preliminary estimating suggested are superficial and approximate estimating. Other methods such as elemental cost planning can be embraced for better accuracy and consistency. They also suggested quality assurance from the early stages of the project development. “ Adafin and Rotimi (2020)

They recommended a range of measures to improve accuracy of pre-tender cost estimation, such as simulating previous estimates and probability estimation; lowering the rate of skill turnover in cost engineering and quantity surveying; incorporating market feelings into estimates; early participation of the quantity surveyor quantity surveyor at the preliminary stage; appropriate documenting of experience gained in project estimation, which all could aid businesses in improving the accuracy of estimates for subsequent projects. Regression modelling was used to enhance final tender sum

prediction accuracy. (Adafin et al., 2021.) - Could you open it up into 2 pages? This important info, each point can be explained

In addition to studies analyzing generic components affecting cost estimation accuracy, Ahmad et al. (2018), did an earlier study on the organizational variables impacting correct cost estimation. When compared to organizational support systems, human-related factors had the biggest impact on cost accuracy out of the 25 elements in the study that attempted to conceptualize the factors impacting cost estimating accuracy. Several other research (Jitwasinkul & Hadikusumo, 2011; Filho et al., 2012) have made an effort to evaluate the impact of organizational features in various domains, including risk management, crashes during construction, and safety work practices (Adeleke et al., 2018). Following a thorough analysis of research that emphasized the elements that influence cost in the big data era—a higher volume of data produced quickly from various sources—it became imperative to focus on the ways organizational variables might improve conceptual cost estimate accuracy. A comprehensive list of organizational traits that affect the conceptual stage accuracy of cost estimates has been derived from the research studies listed below: (Adeleke et al, 2018; Ahmad et al., 2018; Ji et al., 2014; Jitwasinkul & Hadikusumo, 2011). Using a thorough evaluation approach, the study yielded a comprehensive list of 11 variables that could affect cost estimation. These consist of the following: the capacity to exchange and store cost data; the organizational estimating culture; knowledge and experience; leadership; chances for learning and training; communication; management commitment; IT support (analytical tools and infrastructure); quality benchmarking and standards; the capacity to learn from past mistakes and perform better; and the workforce's attitude.Here is a discussion of the essential elements:

Culture of estimation inside the organization: Almost all experts concur that having a functional estimate system has an impact on producing a high-quality cost estimate. Of them, the construction sector regularly employs Denison's Organizational Culture Model (DOCM), which is well known for analysing organisational culture and has been widely applied in construction (Cheung et al., 2011; Denison & Mishra, 1995). The first definition of "adaptability" is the capacity of an organization to recognize and react to its surroundings, which includes bringing about change and organizational learning. Second, "mission" considers how much an organization's mission statement explains to

its staff why and how the services it provides advance a larger objective. This represents vision and strategic direction. Thirdly, "consistency" enables organizations establish a set of mechanisms that produce an internal framework of governance based on consenting support by offering a central source of acceptance, coordination, and control. Fourth, "involvement," which refers to fostering a sense of accountability and ownership in order to foster dedication to the organization.

Management commitment: The cost-estimating process is cognizant of how management decisions may impact estimates, particularly in terms of precision. Employees have expressed dissatisfaction with low-quality estimates generated from rushed meetings or inadequate evaluations. The biases of estimators surely also affect accuracy (Ashworth & Perera, 2015). However, prior experience with related projects helps reduce weaknesses in this regard.

Communication: In any area of an organization, communication is a vital tool. When communication is seen as a two-way process, it fosters the mutual trust and comprehension that are necessary to enable the production of estimates. Adeleke et al. (2018), for instance, came to the conclusion that effective communication fosters beneficial relationships inside the organization and that a lack of it will only exacerbate conflict and perhaps compromise the accuracy of estimations generated (Ahmad et al., 2018; Carrillo et al, 2011).

IT support (infrastructure and analytic capabilities): Information technology (IT) is being rapidly adopted in the construction industry, moving past the phase of piecemeal application to enhance the efficiency and effectiveness of discrete operations on a daily basis inside specific organizations. Big data emerged as a result of this development, the expansion of the Internet of Things (IoT), and the development of more reasonably priced data processing and storage technologies (Ngo et al.,, 2020).

Capacity development: One respondent said, "Capacity building means a lot to every professional," in their introductory statement. Since training and real-world experience are necessary for producing cost estimates, their accuracy can be increased. All of the respondents concur that training for quantity surveyors, especially in fields linked to estimating, is still applicable in the construction industry. Therefore, management's

investment in staff development will undoubtedly result in a high-quality estimate. The ability—or lack thereof—to do accurate estimation plays a major role in the achievement or otherwise of the majority of consulting organizations (Adepoju & Aigbaboa, 2020).

Database and sharing capabilities for cost information: One crucial element that permeates every aspect of quantity surveying practice is the significance of maintaining an updated cost information database (Ashworth & Perera, 2015). It is thought that the technology element that was previously examined will advance quantity surveying practices in the present day. Because it enhances the cost information in its libraries, the usage of building information modeling (BIM) has been promoted to become a crucial component of estimating activities.

Elmousalami (2020) developed practical cost prediction models, studied cost drivers that the past literature has classified into two main categories: qualitative and quantitative procedures.

Furthermore, Elmousalami (2020) suggested using both qualitative and quantitative methods to identify the most reliable cost drivers. Such a process for identifying cost drivers can be referred to as a hybrid method. The hybrid approach's drawback is the requirement for both expert judgment and historical cases are required. Their study suggests creating a database for each project and making those projects open source so that they can be used for research and development. Elmousalami (2020) also reviewed various computational intelligence (CI) techniques and methods conducted to develop practical cost prediction models. His study highlights the critical significance of computational intelligence and machine learning in effectively improving and automating cost modeling forecasts.

3.2.2 Cost Estimating Methods

The two primary approaches to the cost estimate, according to estimating methods, are top-down and bottom-up approaches. On the one hand, the top-down method uses historical cost data from previous projects to estimate the present project, and it is used at the conceptual stage. Contrarily, the bottom-up strategy necessitates comprehensive data regarding the project under study. (Elmousalami, 2020)

The common approach used by the estimator in the early phase of design is parametric method which is mostly depends on the cost data of similar previous projects. However, as the design proceeds estimator break down the total scope of the project into quantifiable elements i.e. bill of quantity BOQ. (Himansu Bhaumik, 2010).

All projects are first broken down into individual parts to establish a cost breakdown framework (CBS). The quantity of resources (workers, equipment, materials, and subcontractors) determines the primary components of a CBS. The cost of each damaged item must then be determined, and the overall building cost must be added (AACE 2004)

Single-unit rate techniques determine the project's overall cost based on a unit, such the road's length, or a meter approach, like the price per meter. Another method utilizes parametric cost modeling to develop a statistical model that is built upon the fundamental factors acquired through qualitative research techniques (Elmousalami et al. 2018a). Elemental cost analysis implies breaking the project down into its constituent parts and calculating the cost of each component based on historical data.

> "These traditional methods of estimates are used to determine the single point quantities, unit rates, and unit costs of separate components, and they are combined to determine the projected total cost of the project. These figures are merely projections of future values based on the data available during design phases, however, as it is extremely challenging to calculate accurate prices at this stage of the design process". (Bhaumik, 2010).

Hence, construction cost estimation employs top-down and bottom-up approaches, with parametric methods initially used in early design phases. These techniques rely on historical data and resource breakdowns to project component costs and overall project expenses. However, it's important to note that these estimates are preliminary and subject to refinement as the project progresses through design phases.

3.2.3 Use of Collaborative Project Management Methods

Collaborative project management is an approach to managing projects that emphasizes teamwork, cooperation, and open communication among project team members and stakeholders. It involves the use of collaborative tools, technology, and methodologies to facilitate effective project planning, execution, monitoring, and completion.

Utilization of collaborative project management methods are often use for collaboration among project participants but also used in Enterprise Resource Planning, Document Management or Design and cost Estimating within construction organizations.

ERP systems significantly impact pre-tender cost estimation in construction projects through several key mechanisms. These systems centralize project-related data, ensuring estimators have access to accurate and current information. Real-time updates enable immediate adjustments to estimates based on changing project parameters, and standardized processes reduce the risk of errors. Integration with other construction software tools enhances data flow and provides a holistic project view. ERP systems also support cost control, budget tracking, and robust reporting and analytics, collectively improving the accuracy and competitiveness of cost estimates in construction pre-tender processes. (Kirmizi and Kocaoglu, 2022).

Based on these multiple benefits discussed above, it can be concluded the use of collaborative project management methods are important component of the cost estimation process. Without this process i.e. team or collectivist approaches are essential to solve the problems related to the project management. Such collaboration is necessary for enterprises management to reduce the chances of errors regarding all the difficult procedures.

3.2.4 Cost Control Methods

Cost control is the practice of identifying and reducing business expenses to increase profits, budgeting is the first step in cost control. When a business owner compares actual results to budget expectations, management acts if actual expenditures are higher than anticipated. The objective of cost control is to manage the delivery of the project

within the approved budget (Wong, 2015). The basic goal of cost control is to maximize benefits for all involved parties and to optimize resource use over the whole project life cycle.

3.2.1 Objectives of Cost Control

Regular cost reporting will provide the most accurate estimation of the project's current cost, projected end cost, and future cash flow. The following can be used to identify the general objectives or goals of cost control (Wong, 2015):

• To optimize the investment's return within the allotted time frame and financial constraints.

• To make the most of the project's resources during the design and construction phases to maximize return on investment.

• To keep the final project cost within the range set by the clients and estimated by the cost estimator/quantity surveyor during the various design stages. Additionally, instill a feeling of accountability among all stakeholders for firm cost control throughout all design phases and implementation to guarantee that the agreed-upon cost estimate, tender amount, and final account balance are all within the predetermined range.

• To put into practice controlling measures from the planning to the execution phases to make sure the total cost of the project or the total sum does not go beyond the client's approved budget.

• To mandate the examination of a project's total costs, considering the project's life cycle costs.

• To make sure that the project's cost is a key consideration during the design and construction phases to achieve adequately balanced costs across all of the project's components. (Ahmad et al., 2018).

These goals and objectives of the cost control serve many purposes i.e. returning of investment within time framework, estimation of the cost during projects, to keep up appearances before, during and after the project, assurance of cost accountability and management practices and strategies etc. All these steps are necessary for maintenances of cost control during a project.

3.2.2 Significance of Cost Control

Cost control is always a crucial component of the design and construction phases is However, in recent years, the importance of cost control has multiplied. All project stakeholders have had a dire need to comprehend construction economics and cost control, especially throughout the design stage of projects. The importance of cost control is explained below.

- A dynamic and more efficient system for cost control is therefore needed from the start of the project through its completion, as well as during the operational phase.

- If the quotations received for the required works are excessively costly, the client and end users are unlikely to bear any delays brought on by redesigning the project.

- Due to mismanagement and poor cost control, the reputations of the clients (big enterprises and financial institutions) are at risk.

- Project costs should be managed not just in terms of initial costs but also in terms of life cycle costs, often known as total-cost appraisal, which takes operational costs into account. (Ji et al., 2014)

One of the most crucial factors that can make or damage a project is cost control. A project will be made by cost management in the form of cost control since it requires precise budgetary allocation. The management's commitment to cost containment is based on a solid core value system and a long-held awareness of these concepts. In the construction industry, there is widespread recognition of the impact of management's dedication to cost control inside an organization.

3.2.3 Reasons for Cost Overruns

It is a common notion that cost overruns are more common in mega projects than in normal projects, considering common factors like long projects lifetime and opportunistic or justified firm-initiated renegotiation. Flyvbjerg et al. (2004) studied sample of 258 mega rail, bridge, tunnel, and road projects worth 90 billion dollars. They considered the factors on which cost escalation mostly dependent such as i) the length of the projects implementation phase, ii) the size of the project, iii) the type of project ownership.

Similarly, mega projects have greater chances of under cost estimation during pre-tender cost estimation phase. Some of the reasons for cost overruns during the pre-contract stage (design stage) are listed as below:

> "Design flaws have been cited as one of the main causes of cost overruns in most projects. Insufficient field inquiry, design and specification flaws, plan errors, design changes, etc. are the main causes of design faults in most projects. Project designs are often drawn out properly to represent the technical and financial needs of the client. Therefore, any design mistakes effectively translate to inaccurate or insufficient portrayal of project deliverables. Inadequate design could also result in inaccurate project estimates and misrepresentation of project work, which would result in excess and unnecessary work, change orders, and other issues that would cause a delay and cost overrun". (Olawale and Sun, 2010).

Hence, it can be anticipated by the above-mentioned paragraph that the cost overruns usually occur in the bigger and lengthy i.e. mega projects like construction of railways and bridges etc. Project designing issue is among one of the reasons behind this. This malady needs urgent repair to manage effective cost control during mega projects.

3.3 Factors Affecting Pre-tender Cost Estimation

There are factors affecting the accuracy of cost estimation in the pre-tender stage. Cost estimates at preliminary stages of any project play a significant role in construction projects (Ayed, 1999).

The European Public Procurement Directives (Directives 2014/24/EC and 2014/25/EC) state that contracting authorities may award contracts based on either the lowest price or the economically best tender to economically most advantageous tender (EMAT). A simplistic interpretation would be that, when quality is unimportant, the authority should select the option with the lowest price, while an authority that values quality highly would rely on EMAT and give it a lot of weight. (Lundberg and Bergman, 2017).

Accuracy of cost estimation is the essential feature of any project. If the contractors are endowed with the rewards on the basis of cost and quality management, it will increase their passion for the future projects. This will enhance the accuracy of a project at pre-tender stage.

3.3.1 Accuracy of Pre-cost Estimation

The accuracy of early stage estimating, according to Skitmore (1991), is “comprised of two aspects: bias and consistency of the estimate when compared to the contract or accepted tender price. The average of disparities between the actual tender price and the forecast is known as bias, and the degree of variation around the average is known as consistency of forecasts”.

The accuracy of early-stage estimation is normally compromised of two aspects, biasing and consistency of the estimate affected from the defined scope and accepted tender price. (Skitmore 1991). Azman (2012) studied 83 projects according to three estimating targets revealed that a project’s size, number of bidders, location are the most important factors that affect the accuracy of cost estimates. Another study by Alghonamy (2015), in which 43 questionnaire surveys were analysed, which determined 34 causes of cost overrun. The study revealed that the most important factors are bid award for the lowest price, frequent design changes, payment delay, improper planning and long period between design and implementation.

Serpell (2010) stated in his paper “Towards a knowledge-based assessment of conceptual cost estimates” that with the use of expert knowledge, it is likely to get an appropriate preliminary assessment of the expected accuracy and reliability of an estimate which should be later supplemented with historical and empirical information.

Serpell (2010) made an accuracy causal model, it was based on the factors identified on his several other papers. He identified those factors through analysis of three sources of data. Firstly, they performed comprehensive analysis of the factors that affect the accuracy of conceptual estimates was performed. Accuracy is the closeness of estimates to the actual reference cost of a project. Estimating error is calculated with the difference between the estimate and reference values. (Serpell, 1990). Later (Ashley and Serpell, 1988) collected answers from a survey from group of estimators on conceptual estimating practices. They also conducted direct interviews from experienced estimators for the discussion of additional accuracy factors.

According to Serpell (2010), Scope quality has very huge impact on project pre-tender cost estimation and in sub-divided into two variations: completeness and stability of the scope. The completeness of scope varies when unidentified scope items are not added into the scope ate the conceptual stage. It is mostly due to these two factors:

- The more experience, the company's team has in design and estimating more complete scope would be.

- The consistency of project 's demand in the scope. Project needs should be stated clearly in the scope, to make scope complete (Serpell, 2010).

- *Scope stability* represents the possibility for the project scope to alter because of modifications in the owner's project demands or adjustments prompted by project characteristics, three crucial subfactors come into play:

• Owner commitment: the fewer the number of expected adjustments, the more committed the owner organization is to the stated scope.

• Project complexity: the more complicated a project is in terms of size, workspace, and other criteria, the more likely it is to change its scope.

• Project technology: the higher the project's technological level, the more likely it is that changes may be required in the future (Serpell, 2010).

According to Serpell (2010), *Information quality* can be assessed into two factors: historical and current. Two types of historical data have been incorporated into the model (Figure 3). The applicability of this data tries to determine how reliable past data is for estimating the current project. The confidence that may be attributed to historical data because of earlier collection attempts, probable errors, and inaccuracies is measured by its reliability. The availability of updated information from vendors, designers, and other sources determines its quality. In the case of historical data, the same qualities are considered.

Serpell (2010) included two primary sources of uncertainty shown in Figure 3: *environment* and *project* related.

> "Environmental uncertainty covers unknowns related to changes in market conditions such as a reduction of supply, financial uncertainty, and other effects. On the other hand, project uncertainty is related to sources of uncertainty present during the project's management and construction. Labour productivity is considered an important and uncertain factor. Project technology and complexity are also determinants of this uncertainty". Serpell (2010)

Serpell (2010) determined performance of an estimator by three factors: the estimator's experience, the amount of effort put forward, and the estimator's personal traits. Field construction and estimate experience are among the estimator's qualifications. The amount of work put in is largely driven by the estimator's view of the estimate's relevance to him and his firm (Adams and Swanson, 1976). Finally, the estimator's common sense and self-assurance are the most significant personal attributes (Skitmore, 1985).

According to Serpell (2010), The key elements influencing the quality of the estimating process include the anticipated level of errors and omissions, along with the time allocated for conducting the estimate. Serpell (2010), presented the complete estimating accuracy model in Figure 3.

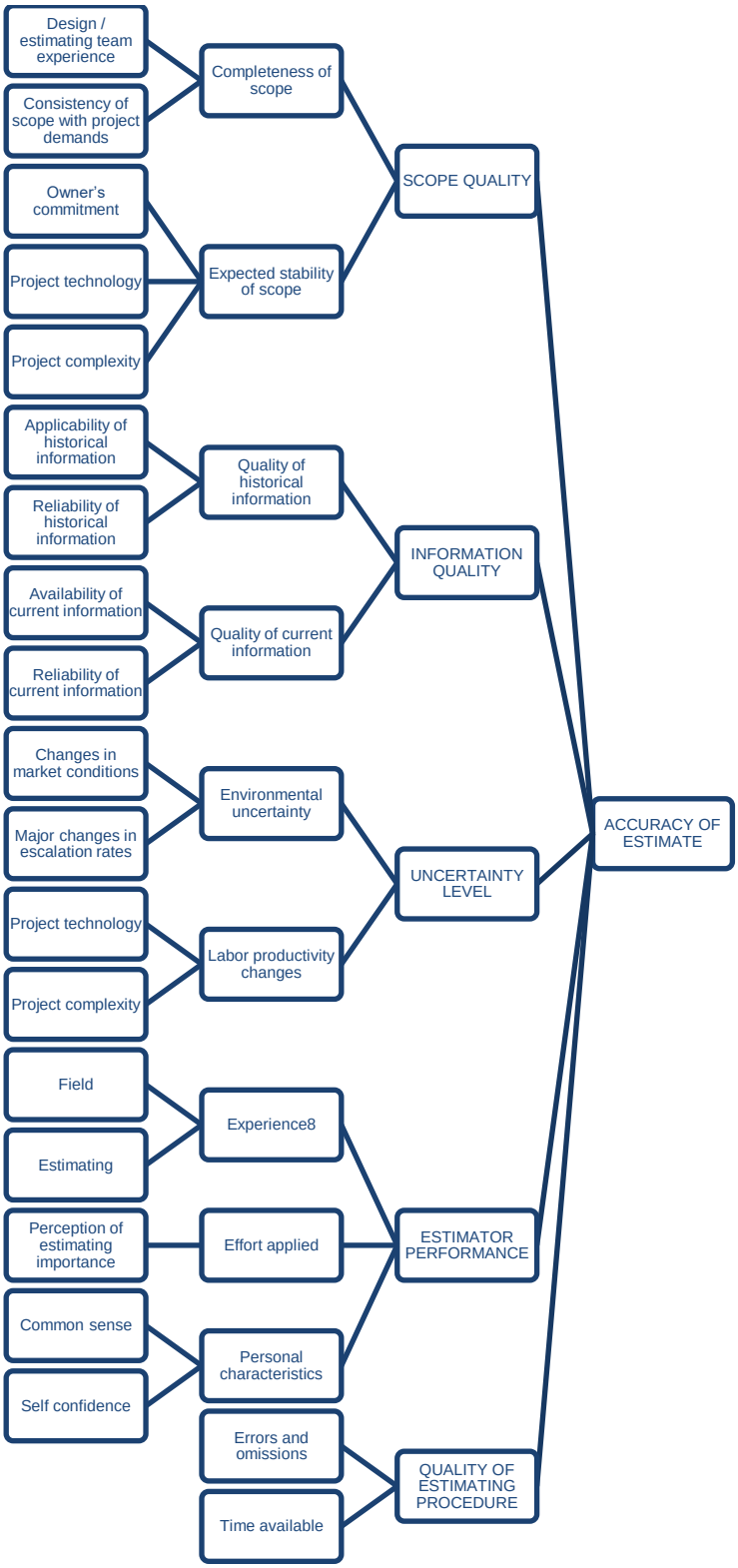

Figure 3. Proposed estimating accuracy model (Serpell, 2010, page 23).

Many tasks and procedures in complex projects are exceedingly complicated and non-routine, requiring a different project management style centred on flexibility, collaboration, adaptability, and exploration of new information and technology (Geraldi, 2009; Hobday, 1998, 2000).

Pre-tender cost estimation is therefore influenced by several variables. Among them, consistency and bias are the most crucial. It is also greatly impacted by other issues, such as the lowest bid being awarded, numerous design modifications, payment delays, inadequate planning, and a lengthy time lag between design and implementation. The other factors influencing the pre-tender cost estimating process are scope stability and completeness. To ensure that the pre-tender cost estimation process is accurate, it is imperative to elaborate on these elements.

3.3.2 Risk management during tendering process

It is important to understand and manage risks during the pre- tendering cost estimation process for large scale infrastructural projects. The section will focus on risk management in the tendering process from a consultant's perspective.

The client defines a price on their commitment to the consultant at the cost estimation phase of the tendering process.

> "The cost estimate must be low enough to win a project while also being high enough to achieve the needed rate of return. As a result, the estimate is a balance between the two extremes, and it will be critical to the company's survival. The tendering phase, where risks are considered and added to the tender price, is where a large part of the cost estimation is done". (Kim et al. (2008))

This leads to the estimation and management of contingency funds. Most organizations lack clear criteria for the contingency fund's plans. (Lam and Siwingwa, 2017) identified the construction phase risk factors that are linked to project cost overruns and to build a trustworthy approach for the estimate of contingency sum. Contingency is the

percentage of a construction budget set aside to account for unforeseen circumstances and project-related uncertainty.

Demkin and AIA (2004) state that the contingency fund is utilized in construction projects as leverage against errors and omissions in contract papers, changes in the scope of projects, and cost increases owing to unforeseen events that arise during the designing phase. However, if risks and uncertainties have not been adequately analysed and addressed, an estimate cannot be reliable (Mislick & Nussbaum, 2015). This is true because the budget for contingency amounts that must be set aside to reduce the anticipated risks and uncertainties depends on the risk that has been identified. Contingency reserves, specifically identified hazards, are utilized to reduce known risks, (Mulcahy, 2013), while management reserves are used to address unknown risks. Inadequate risk and uncertainty analysis causes activity estimates to be amplified, which leads to inflated contingency reserves. As a result, an incomplete risk analysis by any estimator could lead to an incorrect pre-tender cost estimate.

Therefore, it is important to consider significant risk factors in the beginning of design-phase cost estimation. (Adafin, Rotimi, Wilkinson, 2021) identified top-five risk factors from the questionnaire survey analysis conducted from 64 practising project managers (PMs) in New Zealand. These are changes in project owner/stakeholder requirements, experience of project team, site condition information, competency of consultants and information flow and quality.

Examining differences between ECPs (elemental cost plans) and OTS (outturn tender sums) can reveal important information about how commercial projects behave economically. (Adafin, Rotimi and Wilkinson (2020). According to the study conducted by Adafin et al. (2021),

> “The industry might gain from implementing cutting-edge technologies to enhance performance, particularly productivity and efficiency. The adaption of "local best practices" from case studies, which would include stories of successful inventions that may inspire confidence in future innovation, was one of the main forces behind the adoption of innovative methods. Additionally, it was determined that industry and government

> should foster innovation through joint agreements, rules, and laws. Furthermore, it was emphasized that to foster capabilities and skills among the workers in the industry, a culture of innovation needed to be created" Adafin et al. (2021).

It is widely acknowledged that the construction sector needs to change from its conservative old methods to more creative ones to increase sector production and efficiency. This implies to designing consultant companies as well.

According to Tang et al. (2008), there are three types of tenderers. Risk-averse tenderers believe that the likelihood of unreliable hidden cost factors is greater than the likelihood of unreliable latent profit elements. Risk-taking bidders believe the reverse to be true. The two probabilities are viewed as being equal by risk-neutral tenderers. This study concluded that risk-seeking tenderers typically offer a lower price, risk-averse tenderers a higher price, and risk-neutral tenderers a price in the middle. Risk-taking tenderers are therefore more likely to be awarded contracts. (Tang et al. 2008).

But for risk-taking tenderers the potential for project's cost overrun is very high. It is therefore challenging to quantify how each of other factors such as project size etc., affects cost overruns because they vary depending on the project's characteristics and management environment. Common practice done by consultant companies is to add a fixed value such as 10% to the estimated cost. Companies defend this strategy by pointing out how similar their projects are (for instance, a transit agency would primarily construct urban rail projects), and how the ownership and management structures are consistent from one project to the next. It goes without saying that this method is at best arbitrary and that it offers no assurance against cost overrun. (Touran, 2003)

As per Adafin and Rotimi (2020), the study identified the top five risk factors affecting the variability between design-phase Estimated Construction Prices (ECPs) and Outturn Costs (OTS) in traditionally procured commercial projects. This identification was achieved through mean scoring analysis based on the collected data parameters. Table 2 below summarizes the Key Factors Affecting Project Success and Risk Mitigation Strategies.

Table 2 Key Factors Affecting Project Success and Risk Mitigation Strategies.

(1) Changes in project owner/stakeholder requirements. Changes in project owner or stakeholder requirements involve adjustments in expectations, specifications, or criteria. These changes, which can occur at any project stage, include scope modifications, budget adjustments, timeline revisions, and quality standard adaptations. Managing these changes effectively is crucial in project management, requiring clear communication and strategic decision-making to ensure successful project delivery while meeting evolving demands. Adafin and Rotimi (2020)
(2) Experience of project team. Experienced project teams bring expertise but risk complacency and higher costs. Less experienced teams may lack expertise and efficient resource allocation, potentially leading to errors and delays. Structured mentoring and clear communication are essential to balance both teams and ensure project success. (Adafin and Rotimi 2020)
(3) Site condition information. Incomplete or inaccurate site condition information poses various risks. These include design errors, construction delays, cost overruns, safety hazards, environmental issues, resource inefficiencies, legal complications, reputation damage, operational problems, and financial losses. To mitigate these risks, comprehensive site investigations and precise data collection are crucial, enabling informed decisions that consider site-specific conditions, ensuring project success and minimizing associated risks. (Akintoye and Fitzgerald 2000)
(4) The competency of consultants Consultant competency, while critical for project success, can introduce various risks, including design errors, conflicts of interest, miscommunication, inflexibility, budget overruns, compromised quality, legal issues, client dissatisfaction, schedule delays, and missed innovation opportunities. Mitigating these risks necessitates careful consultant selection, clear expectations, effective communication, and ongoing performance monitoring to ensure collaboration and project success. (Odusami and Onukwube 2008)
(5) information flow and quality. "Information" relates to the quantity and quality of design-related details and cost-related data accessible for a project (Odusami and Onukwube 2008). Adequate and accurate data are essential for informed decisions, innovation, risk assessment, resource allocation, client satisfaction, quality control, regulatory compliance, and timely decision-making. In essence, information quality and flow shape design outcomes and project success by enabling effective decision-making and fostering

innovation while mitigating risks and ensuring compliance with standards. (Ling and Boo 2001)

In order to do risk management there is a dire need of the low cost estimate that is enough to win a project while also being high enough to achieve the needed rate of return. On the other hand, for a reliable estimate the risks and uncertainties should be adequately analysed and addressed. This may cause any estimator to do an insufficient risk analysis, which would then lead to an inaccurate pre-tender cost estimate. Changes in project owner/stakeholder requirements, project team experience, site condition information, consultant competency, and information flow and quality are other aspects that impact it. Thus, it is imperative that the industry's workforce should be given the tools and abilities they need, and that an innovative culture should be established. It is often known that in order to boost industry output and efficiency, the construction industry must abandon its traditional, conservative practices and adopt new, innovative ones.

3.4 Conceptual Framework of This Thesis

The conceptual framework of this thesis is visualized in Figure 7.

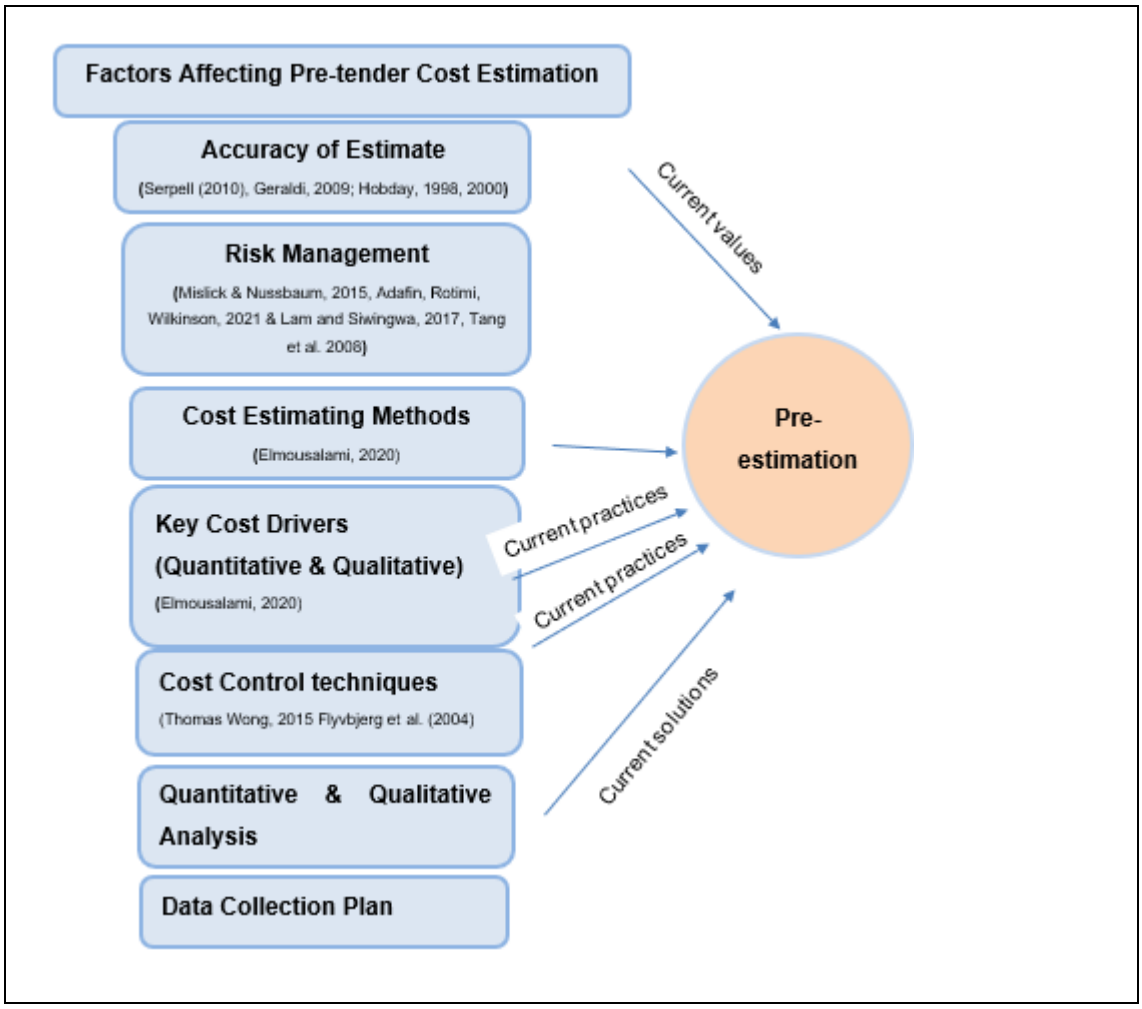

Figure 4. The conceptual framework for building a Pre-estimate in the design phase.

4 Current State Analysis of Pre-tender Cost Estimation Practices and Data in the Intra Unit´s Projects

This section discusses the current state of the case company´s Infrastructure department practices, based on answers to the questionnaire and interviews. This section starts with the overview of the present planning, execution, and conclusion practices. Following the overview, the IT unit's present self-direction procedures are described with three keys values, best practices, and technology solutions are the main subjects. A list of the present self-direction practices' strengths and flaws follows an examination of the important findings from the current state study.

4.1 Overview of the Current State Analysis

The objective of the current state analysis was to obtain an overview of the case company's Infrastructure department, current pre-tender cost estimation practices from the individual employee’s perspective, and historical data. In this thesis, selected company is Engineering consultant company, and it provides design services for many sectors as discussed in introduction.

Cost estimation is mainly done based on hours consumed by designers and secondly size of the projects. For example, in the case of Infrastructure department, where streets and related infrastructure (water utilities, landscape, Geotechnical) are designed. Pre-tender cost estimation are calculated based on hours used to design this infrastructure and size of the projects e.g., length and number of streets, etc. Therefore, a mixed research approach was applied, quantitative and qualitative. During quantitate data collection, pre-tender cost estimation and outturn cost (actual cost) was compared. Disparities between the two cost and percentage difference were calculated. For this purpose, five similar projects were chosen as sample, in terms of size and type.

The knowledge acquisition for qualitative analysis is conducted through semi structured interviewing process. The current state analysis would be conducted in the following way:

First, it describes the current pre-tender process and pre-tender cost estimation procedures. This description helps to understand the current practices in pre-tender cost estimation as well as tender process in general. It also helps to understand the current

procedures in the company and roles of the managers and project engineers within the project and department.

Second, the current cost-estimation techniques and tools used are described in accordance with their characteristics, also analyzing the pros. and cons of these tools during the pre-tender cost estimation within the case company.

Third, based on the results from qualitative data collection round, the strengths and weaknesses of the current pre-tender cost estimation procedures and tools are identified. Finally, the key findings from the current state analysis are summarized.

Qualitative data was collected through interviews with project managers which was conducted with four different team's managers of Infrastructure Municipal departments. Questionnaire is formed and send to Managers beforehand, so they can go through the questions. Primary language for this discussion was English, but Finnish language was used in between if necessary.

Quantitative data was collected through project hourly task data fed into the Maconomy system for everyday hours spent on task. This quantitative data was collected from three different sizes of projects that is small, medium, and large projects. Both successful and unsuccessful projects were analyzed to study what went wrong during the project and what did well to complete the project within the budget. The data was extracted from Maconomy for the projects from the last two years, when the project started and when the project is finished, hours from the first budget and hours from the completed of the project were compared.

4.2 Selection of the Part Projects from the Intra Unit for Analysis

A comprehensive data collection plan for pre-tender cost estimation based on past infrastructure projects is prepared through a detailed and systematic approach. The first step of data collection is to choose the data collection methods. In this study mixed approach is uses as discussed in the above research approach chapter. This step involves the encompassing the analysis of past project documentation, interviews with key stakeholders including project managers and engineers, and a thorough study of

quantitative data, number of hours allocated and number of hours used. The second step is to state the criteria for selecting past projects, considering factors such as size, complexity, and similarity of the project. Moreover, both successful and unsuccessful projects are also used for the analysis, to study the reason behind success and failure of the project.

The third step is very important, which is Integrating standardized instrument for the data collection. This generally includes interview guides, and checklists for reviewing project documentation, to maintain consistency and structure in the data collection process. For this study, standardized questionnaire was formed, by studying the best practices used for the pre-tender cost estimation in the previous chapter.

All the important topics were covered in the questions to get the complete insight of the current practices in the case company. In this process it is important to clearly understand the role of everyone involved in the interview process. This includes those collecting data, project managers overseeing the process, and experts who know about technical and financial details.

Table 3 presents information on different projects, including their names and project details. The case company has provided data for a total of eight projects, but only five of them have complete data that can be analyzed for research purposes, those are Project 1,5, 6, 7 and 8. The data should include information on road design tasks to analyze the hours spent and costs incurred in road design activities. Therefore, Project 2 has been excluded because it only involves electrical and lighting design tasks only.

Table 3 Selected projects.

Project No.	Project Information
Project 1	No information
Project 2	yleis- ja rakennussuunnitelmat, kuivatussuunnitelma,jäädytysjärjestelmä, sähkö- ja valaistussuunnittelu

Project 3	No information
Project 4	No information
Project 5	Rakennussuunnitelmat
Project 6	Katusuunnitelma, Rakennussuunnitelmat, Vesihuolto
Project 7	Maastomallin mittaus- ja pohjatutkimusohjelmat, Yleissuunnitelmat, Katusuunnitelmat, Rakennussuunnitelmat
Project 8	Katusuunnitelmat, Rakennussuunnitelmat, Vesihuolto

Moreover, project information contains different phases of the project, which needs to be designed. In Table 3, project information column shows planning phase of the projects.

Complete street planning involves three main phases: the general plan (Yleissuunnitelma), the street plan (Katusuunnitelma), and the construction plan (Rakennussuunnitelmaa). The master plan is created based on site plans and zoning. In the general planning phase, general things are planed like street types and speeds. The master plan needs to consider future land use and traffic needs. After figuring out these needs, the next phase is street plan phase. (Finnish Transport Agency 30, 2013)

The next phase is the street plan, should displays the street area, used for various purposes and how the street adapts to the environment. It considers the impact on the environmental appearance, especially if it's necessary due to the area's nature or construction measures. The street plan needs to show traffic management principles, drainage and rainwater management, the street's elevation, and paving material. Additionally, it should include details about plantings and permanent structures and equipment if needed. (Finnish Transport Agency 30, 2013)

Whereas, the Construction phase is the final phase, after which drawing are send to customer and landxml files to the contractors on the site construction. The construction plan is directed by a variety of design instructions. It includes technical drawings and

explanations to ensure precise implementation of structures, allowing the construction of the street to proceed based on them. Fundamentally, the building plan doesn't outline measures to determine the street's direction, except to a limited extent. Instead, it functions as a guide for implementing and coordinating structures tailored to the terrain. This ensures that the vertical and horizontal geometry of the street forms a technically functional structure and environment, complementing the dimensions and features outlined in the street plan. (Finnish Transport Agency 30, 2013.)

4.3 Analysis of the Current Pre-tender Cost Estimation Practices

This section provides the results from a general-level description for both quantitative and qualitative analyses related to selected projects. These analyses are performed to assess the pre-tender cost estimation process of the case company in its current state, utilizing the collected data. This analysis included seven completed projects, analyzing the difference between hours allocated, actual hours spent, allocated costs, and actual costs incurred.

4.3.1 Pre-Tender Cost Estimation Process in the Case Company, Description

The current practice of the case company of pre-tender cost estimation was summarized based on inputs by Interviewee 1 and Interviewee 2, and also participant observations by the thesis researcher.

Table 4 Current practice of the case company of pre-tender cost estimation.

The pre-tender cost estimation, steps.
1. The procurement unit must ask the consultants to submit their offers by the deadline in the procurement notice or invitation for tenders (Tarjouspyyntö). 2. Receive Tarjouspyyntö (Request for Proposal): Start when your team gets a project request from a potential client. 3. Decide who's responsible for this proposal, usually a manager or team lead.

4. The department manager or team manager selects the project to pursue.
5. Internal Documentation Initiation: Access the CRM system via the internal network and create the necessary documentation.
6. Department Manager Communication: The project or team manager reaches out to all department managers.
7. Resource Allocation Planning: Begin resource allocation by assigning designers and determining the required hours. Typically, experienced team managers or designers provide input on the hours needed for specific disciplines like Road, Water and Sewer, Geo, and Landscape departments.
8. Proposal Preparation: Use the info and cost estimates to create the proposal.
9. Quality Check: Ensure the proposal is accurate and well-structured.
10. Submission: Send the proposal to the client within the given timeframe.
11. Follow-Up: Keep track of the proposal's progress and respond to client questions or needs as necessary

The pre-tender cost estimation process involves above-described steps. Firstly, in Step 1, the procurement unit initiates the procedure by inviting consultants to submit their offers by a specified deadline outlined in the procurement notice or invitation for tenders (Tarjouspyyntö). During Stage 2, the reception of the Request for Proposal (Tarjouspyyntö) when a project request is received from a potential client. Moving on to Step 3, there's an important decision to be made regarding the individual responsible for the proposal, typically a manager or team lead. In Step 4, the department manager or team manager selects the specific project to pursue, considering various factors. Following this, Step 5 involves the initiation of internal documentation by accessing the CRM system via the internal network. Step 6 consists of communication with all department managers to gather input and ensure coordination. Step 7 focuses on resource allocation planning, where designers are assigned, and required hours are determined with input from experienced team members. Step 8 involves the actual preparation of the proposal, utilizing gathered information and cost estimates. The subsequent Step 9 emphasizes a quality check to ensure the accuracy and structure of the proposal. Step 10 is the submission phase, where the completed proposal is sent to the client within the stipulated timeframe. Finally, Step 11 emphasizes the importance of follow-up, requiring the team to monitor the proposal's progress and respond to client

questions or needs as necessary. This comprehensive process ensures a systematic and well-coordinated approach to pre-tender cost estimation.

One of the interviewees described *Tarjouspyyntö* process as follow:

> We choose who gets which tarjouspyntja after receiving all of them. Manager or team decisions are made. The team supervisor or project leader will then begin to prepare tarjous. Within our network, you first pass through CRM. You start gathering all the documents and information in the file. They create written plans, after that, we begin to get into greater detail about the scope of the project. *(Interviewee 3)*

4.3.2 Effectiveness of Project Scope Definition in the Pre-Tender Cost Estimation Process

In this study, all the participants shared similar views about how the project scope changes during the pre-tender cost estimation process. They believe that the project's scope can shift, and this was expected based on what the study participants said. For example, Interviewee 1 mentioned:

> The second client wants to proceed differently from the conclusion we reached with the first client. Scope can change at times. When conducting this tarjous, you must rule out a lot of possibilities. For instance, a client may request 10 alternative layouts, but we may have previously stated that we would only create 3. If you request more than 3, we must create a new proposal. Rule out the possibilities is a good idea since if an issue arises later, you already stated in the beginning that it is not covered by the offer. Additionally, you can make fresh offers, but if you don't rule anything out, it will only expand. *(Interviewee 1)*

But in some cases, for example in project 8, Interviewee 1 said that:

> The extent of detailed planning required for the project turned out to be significantly larger than what was initially anticipated during the bidding stage. This was primarily due to the presence of numerous private structures that extended into the street area, which needed to be considered in the design. *(Interviewee 1)*

This crucial information only became apparent during the design phase and was not discussed at the beginning of the project.

Interviewee 3 also emphasized that it's a good practice to specify what is not covered in the offer to avoid misunderstandings later. On the other hand, Interviewee 3 stated that:

> It is importance to organize data in a way that can be used for various projects. They look for common measurements, like how much time it takes to design a specific type of road for a certain length. This helps them create a structured approach for handling data and planning projects effectively. *(Interviewee 3)*

4.3.3 Quality of Information from Client

In this study, participants shared their thoughts on the quality of information provided by the client. Their opinions were quite similar, as evident from their comments on this specific question. Interviewee 1 pointed out,

> Clients often have high expectations. If the project manager lacks the necessary expertise, they might say, 'Sure, we can complete it in a month.' However, it's important to be realistic. It's not a good approach to simply aim to please the client. Instead, after preparing plans, you should inform the client that they aren't ready yet, and the situation has become more challenging compared to a month ago due to the tight timeframe. More time is needed, and constant communication with the client is crucial. Sometimes, clients may not even realize their own lack of knowledge. *(Interviewee 3)*

For example, in one project, Interviewee 1 mentioned that the client provided insufficient planning guidance:

> The client was very particular about details, and at times, their attention was directed towards less important matters. The water supply client was absent from the meetings, leading to a lack of adequate planning guidance. The design principles of the water supply changed in the middle of the project and the water supply had to be modeled again. This absence and misinformation contributed to the project's schedule longer when things had to be replanned. *(Interviewee 1)*

Another participant Interviewee 2 emphasized the importance of connecting project progress with client satisfaction, saying,

> It's a bit challenging to assess success solely based on hours spent, design costs, and client happiness. It would be helpful to conduct a quantitative analysis to determine how customers are responding to our most recent service. While we do have some responses, it's possible that not every client with a project has provided feedback, as observed during our analysis. Therefore, it might not be entirely representative. Our information mainly comes from client surveys. *(Interviewee 2)*

4.3.4 Environmental Changes During the Design Phase

Moreover, all five participants provided nearly identical insights regarding the frequency of changes in project circumstances during the design phase. They acknowledged that

the situation could shift rapidly, depending on the client's requirements. Typically, during the design phase, time tends to vary in different ways. Interviewee 1 highlighted this by stating,

> One of the most significant factors contributing to these changes is often personnel adjustments and mid-project departures of team members. Clients may change, new clients ask the same questions, and certain tasks may require revisions. For instance, decisions made with the first client may not align with the preferences of the second client. *(Interviewee 1)*

Interviewee 3, another respondent, explained,

> Yes, I agree. To effectively collect data, we must establish a project breakdown structure. Otherwise, we end up with a large lump sum of hours. We need to define how our project tasks should be organized in the Maconomy system. *(Interviewee 3)*

Interviewee 2, the second participant, repeated,

> One of the major reasons behind these fluctuations is typically personnel changes, with some individuals leaving the project prematurely. There's also the aspect of client turnover, where new clients pose the same questions. Sometimes, designs need to be revised, as decisions made with the first client may not align with the second client's preferences. *(Interviewee 3)*

Interviewee 1 indicated how environment change during one project, she stated:

> During the project, most of the team changed, except for the street designers. New people joined the project, who weren't familiar with the clients' instructions. One designer got a new job in the middle of the project, and another was absent for a long time, when we were planning the most important things. This made things difficult. Also, we had to completely change the water supply design because the rules for it changed in the middle of the project. This made the project more complicated and added to the problems. *(Interviewee 1)*

This collective perspective features the dynamic nature of environmental changes during the Design phase.

4.3.5 Role of Management in Pre-Tender Cost Estimation

Everyone in the group expressed their opinions about how management sees things in the process of pre-tender cost estimation. Like the responses mentioned earlier, most of them expressed similar opinions on this matter. Interviewee 1 shared her perspective as follows:

> Our initial step in engaging with the client involved inquiring about their willingness to proceed and the expected timeline for measurements. We deliberated whether to take immediate action or defer it, much like the approach in Tarjousplaveri. For example, if all the planning is completed within two months but no tests are conducted, how can we proceed with design when measurements cannot be obtained during the winter? It's simply not feasible; we need to communicate this to the client and help them understand

> the limitations. We must wait until the snow melts before we can commence measurement collection and planning. *(Interviewee 1)*

A similar response was provided by another participant, interviewee 2, stated,

> While they initially mentioned 'Monitorable engineering projects,' once your thesis is completed—and we've been conducting tests this week—you can expand that to encompass railroads, environmental consultancy, the water sector, and other areas. Therefore, when constructing the breakdown structure, it becomes somewhat universal. However, for various disciplines, this level of detail is not obligatory. Instead, you outline the general procedure. Our approach to addressing this issue will shape our subsequent actions, following the same methodology you are currently studying. *(Interviewee 2)*

Interviewee 3 raised very important aspect of project management practice related to sharing project information and data utilization. It raises concerns about how information is shared within the project team and whether the project manager has control over this data. This can impact the project in various ways, including decision-making, collaboration, and trust among team members. He stated it as:

> One question that comes to my mind is whether we are transparently sharing information with the individuals involved in the projects, such as our estimates and consumption data. Do we maintain transparency in utilizing project data, or does the project manager retain control of this information? (*Interviewee 3)*

4.3.6 Current project management practices

During the study, all participants shared their insights regarding current management practices. Each participants provided their perspective based on their experience to the current management practices. Interviewee 1 emphasized the importance of initiating a dialogue with the client from the outset, discussing feasibility and establishing clear timelines and project requirements in the beginning of the project. For example, in one of the project, Interviewee 1 said that:

> Project experienced series of challenges leading to cost overruns because This happened because the project team wasn’t well familiar with the client's design instructions, and they didn't have all the information they needed from the customer, like where to connect the water supply etc. for the houses, so these had to be guessed. When changes had to be made to the project team (people leaving the firm and people on long absence), all the new people didn’t have the experience needed for such a challenging project. The tight timeline and long absences/inexperienced project team made it necessary to take extra new people to help with the project, so everything got ready in time (*Interviewee 1)*

She highlighted the issue of unrealistic expectations, noting that inexperienced managers might make over commitments to please clients. Interviewee 1 stressed the significance of being realistic and avoiding conflict avoidance. She pointed out that it's better to communicate early with the client, even if it means admitting that the initially proposed timeline is too short. This proactive communication prevents situations from deteriorating. Interviewee 1 also acknowledged that clients themselves can lack experience, leading to misunderstandings. Sometimes, managers had to select less experienced designers for challenging projects due to the unavailability of experienced designers. For instance, in the case of one project, Interviewee 1 noted,

> The designers lacked the necessary experience for the project's demands. This led to that we had to take extra, more experienced people, to help these younger designers. This of course led to more hours used and this hadn't been considered in the cost estimation. (*Interviewee 1)*

4.3.7 Risk Factors Affecting the Accuracy of Pre-tender Cost Estimations

Accurate pre-tender cost estimations in construction projects can be influenced by various key risk factors, as discussed above. These factors encompass incomplete project information, alterations in project scope, the involvement of inexperienced estimators, market fluctuations, unclear project requirements, unexpected risks, insufficient historical data, project complexity and size, external influences, and the possibility of inexperience designer.

Moreover, all participants provided their insights regarding the key risk factors influencing the accuracy of pre-tender cost estimation, and their responses were largely consistent. Interviewee 1 gave her perspective, stating,

> Without measurements and only two months for planning, it becomes challenging to answer to the client's needs, when the weather is unsuitable for measurements. It is impossible; we need to communicate this to the client and convince them that it's not feasible. We must wait until the snow melts before we can gather measurements and initiate the planning process. (*Interviewee 1)*

Interviewee 1 also emphasized,

> Larger projects, with a big project group, inherently come with more significant risks. Smaller projects, with a smaller project group, tend to have a higher success rate and carry fewer risks. It is verry important that you know the client and understand the scope.

> One of the most significant challenges often arises from personnel changes and departures in the middle of a project. Additionally, clients can change, and new clients may raise similar questions that has been tackled before. Some tasks may involve a two-step process, where decisions made with the first client may not align with the preferences of the second client, causing shifts in scope. In nearly every project, certain factors must be accounted for and addressed. (*Interviewee 1)*

4.3.8 Key cost drivers

All the respondents elaborated on the key cost drivers from their respective perspectives. Interviewee 1 stated,

> Yes, I do believe that because it can be completed in a matter of hours. Make a calculation equation using the typical payment we receive. Since it's related to the class, it's a broader measure than just hours. It's likely to change in the future, hopefully at a higher rate than it currently does, much like hourly salaries. Hours will continue to be a widely used unit of measurement. (*Interviewee 1)*

Another respondent, Interviewee 3 shared a similar perspective, saying,

> Yes, I do think so since it can be finished in a few hours. Create an equation for calculations using the typical payment we receive. It's a more general measure than hours because it pertains to the class. Like hourly wages, it will certainly fluctuate in the future, hopefully more than it does now. Many people will still use hours as a unit of measurement. (*Interviewee 3)*

4.3.9 Managing Risk and Developing Risk Contingency Plans

The participants shared their insights on risk management and risk contingency plans. Among them, Interviewee 1 expressed,

> Large, diverse projects carry greater hazards, while smaller ventures typically involve less risk. One of the most significant challenges arises from personnel changes and mid-project departures of some individuals. Projects must also adapt to changing clients, including new clients who pose similar questions. One project also can have more than one client and need a lot of coordination between different clients. Certain tasks may involve multiple steps, and decisions made with one client may not align with the preferences of a different client. Therefore, project scopes can occasionally shift. In nearly every project, certain aspects must be ruled out. For example, a client may request ten different layouts, even though we initially agreed in a meeting to provide only three. If the client requests more than three, we must create a new proposal. (*Interviewee 1)*

4.4 Results from the Quantitative Analysis of Past Projects Data

Data was collected from different sizes of project, small, medium, and big projects, and successful and failed projects. During the quantitative analysis, these data were studied from different teams in road department. The focus was placed to analyze: How all the teams are dividing their work task, what are their differences, what practices they are using; how teams manage the projects; how each team define the work breakdown structure (WBS). The purpose of this data analysis was to look deeper how designers are utilizing hours, do they have just one project number in Maconomy for all the disciplines that they just enter the hours.

> The purpose of the quantitative data collection is to understand hours spent. To understand how many of those hours has been spent in making drawings, how many hours spent in designing one section of the street. How many hours spent in establishing the project in Nova point or some other design software. *(Interviewee 3)*

For example, it is crucial to record the hours required for road design and delineate the specific tasks integrated into the Maconomy system. Interviewee 3 had the following opinion about the difference in allocated and actual hours spent:

> There is another viewpoint that we need to comprehend and attempt to comprehend in this situation because I believe there are differences in how we manage the project and how we define the Work breakdown structure. *(Interviewee 3)*

4.4.1 Task Allocation

The analysis aimed to understand how time was allocated for different tasks in the project, especially before starting the actual design work. For instance, out of 100 hours spent on street design, only 20 hours were dedicated to actual design, while the rest were used for analyzing initial data and meetings. This breakdown helped to gain insights into task distribution and the current project situation. Table 5 shows the task number, assigned to the task and used in Maconomy software, so that employee can put hours into it.

Table 5 Maconomy Task Description.

Task number	Task Description
10	Projektin johto
100	Valaistussuunnittelu
110	Kadun rakennussuunnittelu
20	Kokoukset (Meeting)
30	Katusuunnitelma
40	Liikennesuunn. ja liikenteenohjaussuunn.
50	Vesihuolto
60	Hulevesisuunnittelu
70	Rakennesuunnittelu
80	Geosuunnittelu
90	Maisemasuunnittelu

In Table 5, it is especially interesting to look at Task number 30 (Katusuunnitelma) and 110 (Kadun rakennussuunnittelu). This task has several sub tasks, and we analyzed the number of hours spent on designing and other tasks which are not directly related to designing. For example, initial data collection, scheduling managing. But these sub tasks are put into the road designing task and are not actually design work.

There are eight completed projects of different sizes are used to perform quantitative analysis. Total number of hours used in task 30 (Katusuunnitelma) and 110 (Kadun rakennussuunnittelu) is extracted from given data. A pivot table is made from the provided data to perform analysis. Data from all the 8 projects are appended and combined. Data was in correct and organized format.

For performing the analysis on completed projects, data is filtered and categories in terms of task description. All the hours are put in road design task (30 and 110), but hours are filtered according to the task performed under the task description categories.

Below is the information extracted from eight projects. The quantitative data was extracted from an Excel sheet exported from Maconomy. A pivot table has been created to efficiently summarize this extensive dataset. This quantitative analysis provides a breakdown of the number of hours and the percentage of each task category in the project. Hours spent on actual design work are marked with red color and the hours spent

on other tasks, under the road design task. Below, Table 6 shows the information analyzed from the gives data.

Table 6 Total Hours Allocated to Tasks.

Katusuunnitelma (30) & Kadun rakennussuunnittelu (110)	**1456,50**	**100 %**
Initial Data (Aineiston)	27,50	1,89
Actual Design work	**244,00**	**16,75**
Comments	30,00	2,06
Meetings	19,50	1,34
Checking (Tarkastelu)	132,00	9,06
Geotechnical design matters	56,00	3,84
Water and Sewerage (Vesihuolto)	77,50	5,32
Wire transfer drawings and cables (Johtosiirtopiirustus)	108,50	7,45
Documentation (Asiakirjat)	49,00	3,36
Pohja asiat	29,00	2
Other Structural elements (eg. Retaining wall)	49,50	3,4
Sähkö asiat (Fortum	44,00	3,0
Cost Estimation and counting of lights, cables	38,00	2,6
Miscellaneous Task	552	37,90

The quantitative analysis of the provided data revealed several insights. The task "Katusuunnitelma (30) & Kadun rakennussuunnittelu (110)" accounts for most of the hours spent, representing 100% of the total. This shows that this task is clearly the most time-consuming and critical aspect of the project.

Among the other tasks, "Checking (Tarkastelu)" also need a significant amount of time, with percentages of 9.06% and 7.45%, respectively. These tasks are essential for quality control and intermediate checking of the design. On the other hand, tasks such as "Initial Data (Aineiston)" and "Pohja asiat" have relatively low percentages, indicating that they

are less time intensive. These tasks may involve preliminary data collection and soil investigation work.

The "Meetings" task stands out with a percentage of 7.99%. While meetings are essential for communication and project coordination, it's crucial to manage them efficiently to ensure they do not consume an excessive amount of project hours. There are two types of meeting, inside (sisainen palaveri) meetings and meetings with customer. It depends on project manager, normally there is one inside meeting for 1 hour every week to check the project status. It is important to conduct those meeting to coordinate between different teams involved.

Moreover, in the last row it is evident that a significant number of hours are used to small or miscellaneous tasks. These tasks, while not directly related to street design, but seems like needed for the completion of various activities within the broader context of street designing. These tasks needed to be checked thoroughly when collecting data for data collection plan.

4.4.2 Cost based Analysis

Additionally, cost-based analysis has been conducted on a few projects to gather additional information for building proposals which is given in the table below. This data provides information about two successful projects. The data includes allocated hours, completed hours and their difference. Additionally, it presents the contract price for the project, which includes the "succeed price," "ceiling price," and the difference between them. These datasets offer understandings into the allocation of resources and the financial aspects of these projects.

Table 5 below shows information on two projects, "Kustaantie street and construction design, City of Vantaa" and "Street and construction design of Sörnäistenkatu, City of Helsinki," as well as details on various technical disciplines within these projects. It shows the allocated hours, actual hours used, the difference between them, and the contract, succeed, and ceiling prices for each technical discipline and the overall project.

Project	**Technical discipline**	**Hours offered**	**Hours completed**	**Difference**	Contract price:	succeed price:	ceiling price:
	Project management	110	61	49			
Project 9 street and construction design	Meetings	74	52	22	**87 440 €**	**76 310 €**	**11 130 €**
	Street design	420	649,5	-229,5			
	Water supply planning	225	149,5	75,5			
	Construction design	160	18,5	141,5			
	Landscape design	105	112,5	-7,5			
	Geoplanning	95	15	80			
	IN TOTAL:	**1189**	**1058**	**131**			
	Technical discipline	**Hours offered**	**Hours completed**	**Difference**			
Street and construction design of Project 10	Project management	76	47	29	42 212,15 €	42 002,75 €	**209,40 €**
	Meetings	24	16,5	7,5			
	Street design	360	386,5	-26,5			
	Landscape design	85	85	0			
	Geoplanning	25	9	16			
	IN TOTAL:	**570**	**544**	**26**			

Table 7 Project Cost Calculation.

As seen from Table 7, these are the two successful projects, and quantitative data will be analyzed based on two sets of data, each detailing the hours offered, hours completed, and the differences observed for various technical disciplines.

The "Difference" column in the provided data provides as a reflection of the differences between the hours initially allocated and the hours expended for each technical discipline. When the difference is positive, it indicates that a surplus of hours was initially allocated compared to the actual hours expended. Conversely, when the difference is negative, it indicates that the hours spent on a task exceeded the originally designated allocation.

It can be seen in the data that during the street planning phase, a substantial number of hours has been used, indicating thorough and effective design work. Conversely, during the construction phase, fewer hours were utilized, suggesting that design has done properly in street design phase.

In the data, Table 7 shows that for Street Design more hours were used than planned. This means that they completed more work than expected. Subsequently, in Geotechnical, they had more hours planned than what they used. This means they had some extra hours that they didn't use, which made the project profitable. Reflections on the above projects are provided by the project manager stated as:

> Throughout the project, there was a consistent small design team, including an experienced structural designer who handled street design instead of a less-experienced designer. The project manager handled required reports, and the same designer took on significant responsibilities for both street and water supply planning, which were conducted concurrently. They conducted regular meetings and had site visits with the customer. Additionally, on-site planning was part of the project, although it wasn't included in the initially estimated hours. The project's schedule was effectively streamlined by the planners through regular meetings and ongoing communication with the customer. *(Interviewee 1)*

Therefore, the analysis of the two successful projects reveals the critical role of efficient project management and team expertise in achieving positive outcomes. The success of these projects can be attributed to factors such as a consistent and experienced design team, thorough planning, regular customer engagement, and effective project scheduling. These findings underscore the importance of sound project management

practices and experienced personnel in achieving project goals and optimizing resource utilization.

4.5 Findings from Data current state analysis

The current state analysis collectively emphasizes the dynamic and complex nature of pre-tender cost estimation process. The analysis also showed that effective communication, clarity, and adaptability are essential for successful project outcomes. Addressing client expectations, managing scope changes, and applying data-driven approaches occur as key findings for improving the accuracy and efficiency of pre-tender cost estimation in design phase.

The results from the current state analysis is presented in this section. The quantitative data provided information on the number of hours among different project tasks. It shows that a substantial portion of hours is dedicated to critical design and planning activities, this shows that it's important to manage resources well in these parts of the project. Additionally, it is important to improve time management and simplification of tasks like meetings could further enhance project efficiency and resource allocation.

Furthermore, the current state analysis has emphasized the significance of handling project bidding. This involves understanding each project, accordingly, setting realistic deadlines, and creating a record of past projects for reference. Properly allocating resources, which means having experienced designers and making accurate time estimates, is crucial for making projects successful and improving the quality of project data.

The current state analysis also revealed the requirement for improving project management practices. This includes training less-experienced managers to get better at their jobs, improving communication within the team, and making better decisions. When project circumstances change, it's important to define the scope clearly that what is included and what is excluded from the beginning, request comprehensive information upfront, and limit the available project options. Lastly, the importance of identifying potential risks early and implementing a management plan should be applied. This

approach helps prevent mistakes when there's prior knowledge of the risks, ensuring project success.

Table 8 illustrates challenges and improvement needs in project management and data collection using CSA.

Table 8. Challenges in the project management practices of the case company.

Aspect	Challenges/Issues	Improvement needs
Project Size	- Cost overrun - Complexity - Large-scale - Involvement of multiple public and private stakeholders - Intrinsic risks - Long-term planning - Managers with deep domain experience	- Clear risk assessment - Comprehensive long-term planning - Utilizing experienced managers
Current Tendering Practices	- Unclear project scope - Unrealistic project timelines - Lack of past project database	- Defining clear boundaries - Setting realistic timelines from the start - Establishing a database from past projects
Resources (Time, Designers, Initial Data, Project Information)	- Less experienced designers assigned - Insufficient hours allocated - Quality of initial data from clients	- Realistic time estimation - Recruitment of experienced managers and designers - Enhancing initial data quality
Current Project Management Practices	- Less-experienced project managers - Poor communication skills - Manager's judgment - Poor decision-making	- Skills development and leadership training - Improved communication within the team
Change in Internal and External Environment	- Client representative changes - Designers leaving or changing during the design phase - Client requirements changing during the design phase - Highly critical and punctilious clients	- Scope limitation and agreement on limited options at the project's outset - Requesting comprehensive initial data at the project's start and during its progress if necessary
Risk Factors	- Identifying risk factors in the beginning - Mismeasurement of known risks	- Implementing a risk management plan for early identification and mitigation

Firstly, CSA revealed the aspect of "Project Size," which involves challenges such as cost overruns, complexity, and the involvement of multiple stakeholders. To address

these challenges, it is suggested to conduct clear risk assessment, comprehensive long-term planning, and the use of experienced managers.

Current Tendering Practices, highlighted issues like unclear project scope and unrealistic timelines. The suggested improvement strategies include defining clear project boundaries, setting realistic timelines from the beginning, and establishing a database of past projects to inform future tenders.

The third aspect, "Resources (Time, Designers, Initial Data, Project Information)," points out problems like less experienced designers, insufficient time allocation, and poor initial data quality. To tackle these issues, it is recommended realistic time estimation, recruiting experienced managers and designers, and enhancing the quality of initial data.

The "Current Project Management Practices" section identifies challenges related to less-experienced project managers, poor communication skills, and decision-making. Improvement strategies involve skills development and leadership training for project managers and enhancing communication within the project team.

During CSA, various interviewees emphasized to considers changes in the "Internal and External Environment," such as client representative changes, designers leaving or changing during the design phase, and evolving client requirements. To address these changes, it is suggested to limit the project scope, agreeing on limited options at the project's outset, and requesting comprehensive initial data at the project's start and during its progress.

Finally, the current state analysis revealed and emphasizes the importance of identifying risks early and avoiding the mismeasurement of known risks. It is recommended to implement a risk management plan to ensure early identification and mitigation.

The department has a lot of experience in managing projects, which shows in how well it handles estimating costs before bidding on projects and planning them. Additionally, the department has a carefully structured process for estimating costs before bidding, which involves efficiently gathering all the necessary information and optimizing resources. Furthermore, the department understands how important it is to understand what clients need and expect, which is good for making projects better.

However, the department faces some challenges. The biggest one is managing risks, especially in large-scale projects. The department is also vulnerable to changes in teams' members which made in the start of project. Sometimes, changes in client requirements, also cause hurdle in the design phase. Furthermore, the procedure for overseeing changes in project scope and client interactions appears to lack clear explanations, indicating possible concerns with how modifications and communication are being managed.

> To begin with, we need to improve our speed in deciding whether to pursue a tender opportunity. If someone mentions that we lack the necessary resources, it's crucial to make this decision promptly. For instance, if the tender deadline is three weeks away, we can't afford to wait until the last moment. We should aim to make this decision well before the deadline, ensuring we have adequate time for preparation. Otherwise, we might find ourselves rushing and compromising on the quality of our tender submission. *(Interviewee 5)*

Sometimes client may be extremely detailed and precise offering comments on every detail and actively participating in the planning process, expecting things to be done a certain way. If the client's precision is considered, a more accurate estimation of the required time can be made. Being well-informed about the client involves comprehending their expectations. Therefore, this often sets unrealistic project timelines, which can lead to rushed planning and incomplete data collection, ultimately affecting project success.

Despite these challenges, there are many opportunities for improvement. The department can continuously get better, making project management processes more refined and effective. Building better relationships with clients through good communication and aligning with their expectations can lead to more successful projects. As the department becomes known for its skill in project management, it can attract more projects from clients.

However, the department also faces threats. The competitive landscape is always challenging, with other organizations competing for similar projects and increasing competitive pressure. Unrealistic client expectations can make it hard to meet project requirements and timelines, potentially making clients unhappy. Lastly, resource limitations, like not having enough or experienced designers or time, cause challenges for the department's ability to manage projects effectively. More important, quality of information is also very important as Interviewee 1 stated below:

> If all the planning is completed within two months, but there are no measurements available, it poses a challenge for the design process. It's impossible to conduct measurements during the winter season. We need to engage in a conversation with the client to make them aware of this situation. Regarding the timeline, we must wait for the snow to melt away before we can start taking measurements, and only then can we proceed with the planning. *(Interviewee 1)*

In summary, this SWOT analysis highlights the department's experience, processes, and understanding of clients as strengths. It also points out weaknesses in risk management, handling scope changes, internal and external changes in teams' members and setting unrealistic project timelines. There are opportunities to improve project management processes and client relationships, but the organization needs to be mindful of threats like competition, client expectations, and resource constraints.

> Especially the team manager and department manager must possess a good understanding of the team's work situation. They should be aware, particularly the team manager, of who will be available for assignments in March. This aspect of resourcing is of very importance. (*Interviewee 5*)

By using these insights, the organization can create strategies to build on its strengths, address weaknesses, seize opportunities, and protect itself from potential threats, ultimately making project management better and more successful.

4.5.1 Summary of the Current Practices in the Pre-tender Cost Estimation

The quantitative analysis highlights the allocation of hours across various project tasks. Most hours are allocated to critical design and planning activities, emphasizing the importance of efficient resource management in these areas. It also suggests that effective time management and streamlining of tasks, such as meetings, could further optimize project efficiency and resource allocation.

Furthermore, the quantitative analysis of successful projects revealed that having a small project with an experienced design team significantly increased the likelihood of project success. The project manager handled report requirements, while one designer took on significant responsibilities for both street and water supply planning, which were conducted simultaneously. The team ensured regular meetings and customer site visits, and on-site planning, although not initially estimated, was efficiently incorporated into the project schedule through effective communication and coordination with the customer.

The numbers show that most hours in the project are spent on important design and planning tasks. This means that managing resources efficiently in these areas is important. It also suggests that better time management, especially in meetings, can make the project run smoother and use resources better.

Table 9 Key Practices and Insights.

Category	Key Practices and Insights
Project Scope Definition	- Project scope can change during pre-tender estimation.
	- Rule out possibilities to avoid scope expansion later.
	- Specify what is not covered in the offer to prevent misunderstandings.
Quality of Information from Client	- Clients often have high expectations; be realistic.
	- Continuous communication with the client is crucial.
	- Client's lack of expertise can lead to challenges.
Environmental Changes During Design Phase	- Rapid shifts in project circumstances are common.
	- Personnel adjustments and client turnover can impact projects.
	- Establish a project breakdown structure for data management.
Role of Management in Pre-Tender Estimation	- Engage with the client early to discuss feasibility.
	- Be transparent about limitations and realistic timelines.
	- Share project information transparently within the team.
Current Project Management Practices	- Communicate early with the client to manage expectations.
	- Avoid overcommitting to please clients; be realistic.
	- Address client inexperience and provide guidance.
Risk Factors Affecting Estimation Accuracy	- Incomplete project information can affect accuracy.
	- Personnel changes, client shifts, and scope changes pose risks.
	- Larger projects inherently carry more significant risks.
Improving Pre-Tender Estimation Process	- Early client communication and managing expectations are crucial.
	- Data-driven decision-making and data analysis improve accuracy.

Key Cost Drivers	- Use broader measures than hours for cost estimation.
	- Expect fluctuations in cost drivers in the future.
Managing Risk and Risk Contingency Plans	- Large projects involve greater hazards and risks.
	- Adapt to changing clients and shifting project scopes.
	- Rule out certain aspects in project proposals.

Another important finding is that the successful projects having a small team of experienced designers makes the project more likely to succeed. The project manager focused on reports, while one designer handled both street and water supply planning at the same time. They had regular meetings and visits with the customer, and they even added on-site planning to the schedule. This was all possible because they communicated well and worked together effectively with the customer. Key findings are summarised above in Table 10.

4.5.2 Summary of the Current Data Collection Plan

In the pre-tender cost estimation process within the department, a notable challenge arises in the category of "Risk Factors Affecting Estimation Accuracy." The problem centers around the potential for incomplete project information, posing a risk to the accuracy of cost estimations. The department faces uncertainties related to personnel changes, shifts in client requirements, and alterations to the project scope, all of which can impact the precision of the estimation process. The inherent complexity and scale of larger projects introduce additional risks. In the department's context, these uncertainties emphasize the critical need for comprehensive and accurate information during the pre-tender stage. Addressing these challenges becomes important for the department to enhance the reliability of cost projections and ensure that the estimation process aligns effectively with the actual demands and complexities of the projects at hand.

Table 10 Problems identified from the current state analysis.

(1) Incomplete Project Information: The text mentions that incomplete project information can affect estimation accuracy. This could be a drawback, as it highlights a potential challenge in acquiring

comprehensive data, which may lead to uncertainties and inaccuracies in cost estimations.
(2) Personnel Changes, Client Shifts, and Scope Changes: The text identifies these factors as risk factors affecting estimation accuracy. These changes can introduce volatility and unpredictability, posing challenges to effective project management. Sudden shifts in personnel or client requirements may disrupt established plans
(3) Larger Projects Inherently Carry Significant Risks: The acknowledgment that larger projects inherently carry more significant risks implies that managing and mitigating these risks can be more complex. Larger projects often involve more variables, increasing the potential for unforeseen challenges.
(4) Fluctuations in Cost Drivers: While it's advised to expect fluctuations in cost drivers, this recognition suggests a potential drawback. Unpredictable changes in cost drivers may make it challenging to maintain a stable and predictable budget, potentially leading to financial uncertainties.Top of Form
(5) Client's Lack of Expertise: While communication is emphasized as crucial, the text notes that a client's lack of expertise can lead to challenges. This could be a drawback, as it introduces the need for additional efforts to bridge the knowledge gap and ensure effective collaboration.
(6) Avoiding Overcommitting: While advising against overcommitting is a positive practice, it also highlights a potential drawback if not carefully managed. Striking a balance between meeting client expectations and setting realistic goals is crucial, as overly conservative estimates may affect competitiveness.
(7) Addressing Client Inexperience: While providing guidance to address client inexperience is positive, it also signals a potential drawback in terms of the additional support and resources required to bring less-experienced clients up to speed. This could increase the workload and project complexity.
(8) Data-Driven Decision-Making:

While the text advocates for data-driven decision-making, the drawback may lie in the need for sophisticated data analysis capabilities. Implementing such practices requires adequate resources and expertise, and smaller organizations or teams may face challenges in this regard.

Table 10 outlined the Data collection plans, its objectives, data to collect and method of data collection. It was important to identify the main goal or purpose of each task. It clarifies why the task is being undertaken and what insights or information are required.

It was also important to clearly the data to collect, the specific data points or information to be gathered during the task are listed. It includes details about the sources of data and the methods used for data collection.

Lastly, the techniques or approaches used to collect the required data were also listed. They may include the methods such as document review, interviews, or any other means employed to obtain the necessary information. This table shows how the infrastructure unit conducts various analyses within the street projects, outlining the objectives, data collection points, and methods for each task. It illustrates the current practices. This current approach ensures that the project's management and performance are comprehensively evaluated, providing valuable insights for improvement and decision-making.

Table 11 shows a step-by-step method to check and suggestion for data collection plan and how the data should be collected and managed. It will help to understand things about the project to make it work even better. Task number one focuses on initial data collection, seeking to understand its impact on project efficiency.

This involves detailing the sources and methods of data collection, with data to be collected through document reviews and interviews, along with the measurement of time spent on this initial data gathering. Subsequent tasks, such as analyzing the time and effort allocated to actual design work, assessing the role and effectiveness of meetings, understanding the importance of checking processes for design quality, and evaluating the significance of specific design components (e.g., geotechnical, water and sewerage, wire transfer drawings, and cables), follow a similar methodology. Each task outlines

specific objectives, data to be collected, and the methods employed, encompassing document review, interviews, and time allocation assessments.

The primary objective is to gain a comprehensive understanding of various elements within the project, ranging from specific design components to documentation processes and cost estimation methods. This detailed analysis allows for targeted improvements and optimizations in each component, ultimately contributing to enhanced project efficiency and quality. The complete and systematic nature of the solution ensures a holistic evaluation of the project's design and management, providing a foundation for informed decision-making and process refinement.

Table 11 Current Data Plan.

Task Number & Task Description	Objective	Data to Collect	Method
1. Initial Data (Aineiston)	Understand initial data collection impact on project efficiency.	- Details on sources and methods of data collection - Time spent on initial data gathering.	Document review, interviews
2. Actual Design Work	Analyze time and effort allocated to actual design work.	- Breakdown of design tasks. - Time spent on each design sub-task.	Document review, interviews
3. Meetings	Assess the role and effectiveness of meetings in project management.	- Frequency and duration of meetings. - Meeting agendas and outcomes.	Document review, interviews
4. Checking (Tarkastelu)	Understand the importance of checking processes in ensuring design quality.	- Types of checks performed. - Time spent on checking activities.	Document review, interviews
5. Geotechnical Design Matters	Evaluate the significance of geotechnical design in the project.	- Specific geotechnical tasks. - Time allocation for geotechnical work.	Document review, interviews
6. Water and Sewerage (Vesihuolto)	Examine the role of water and sewerage planning in the project.	- Tasks related to water and sewerage planning. - Time spent on these tasks.	Document review, interviews
7. Wire Transfer Drawings and Cables (Johtosiirtopiirustus)	Assess the importance of electrical design components.	- Details of wire transfer and cable design. - Time allocation for electrical design.	Document review, interviews
8. Documentation (Asiakirjat)	Understand the role of documentation in project management.	- Types of documents produced. - Time spent on documentation.	Document review, interviews
9. Groundand soil (Pohja Asiat)	Examine any specific tasks related to "Pohja Asiat."	- Description of "Pohja Asiat" tasks. - Time allocation for these tasks.	Interviews
10. Other Structural Elements (e.g., Retaining Wall, Bridges)	Investigate the significance of other structural elements.	- Specific structural tasks. - Time allocation for these tasks.	Document review, interviews
11. Sähkö Asiat (Fortum)	Assess the role of electrical components.	- Description of "Sähkö Asiat" tasks. - Time allocation for these tasks.	Document review, interviews
12. Cost Estimation and Counting of Lights, Cables	Analyze cost estimation processes and the role of lights and cables.	- Details of cost estimation methods. - Time spent on cost estimation and counting.	Document review, interviews
13. Miscellaneous Task	Examine thoroughly all the tasks related to " Miscellaneous Task ."	-Description of "Miscellaneous tasks - Time allocation for these tasks.	Document review, interviews

5 Building Proposal for the Data Collection Plan for the Pre-tenser Cost estimation in the Design Phase for the Case Company

This section is dedicated to making an Initial proposal for improving the pre-tender cost estimation and project management practices within the Infrastructure department. This section starts with an outline of the planning, execution, and implementation process of building the initial proposal. The overview is followed by the description of pre-tender process, which is utilized in building the initial proposal. The descriptions are followed by development of baseline for the pre-tender cost estimation process. The section ends with the initial proposal for the Data collection plan for the case company's Infrastructure unit. This will help the assessment and improvements made in the final proposal detailed in Section 6 of this study.

5.1 Overview of the Proposal Building Stage

The Proposal is based on the findings from the literature review presented in Section 3, as well as insights gathered from interviews and surveys conducted for the current state analysis, and also Data 2 gathered in Section 5.

After conducting the current state analysis, two critical areas were identified that needed improvement. They were chosen as the primary focus of this study, and literature review examined the availbale knowledge that would help to address the shortcomings associated with these key areas in the studied process. Consequently, relevant findings from the literature were used to establish the conceptual framework for this thesis. Developing the initial improvement suggestions leveraged the insights gathered in the two previous stages of this thesis, and also gathered new date as inputs from stakeholders to develop the Proposal.

The initial improvement proposal was developed collaboratively with two stakeholders, both of whom had previously participated in the current state analysis stage. These stakeholders were identified as Interviewees 2 and 3. Two workshops were conducted for building these proposals, with the participation of two stakeholders in each. Additional information on the collection of Data 2 can be found in Table 3, Section 2.3.

The proposal development comprised three steps. To begin, in Step 1, a preliminary set of ideas for addressing each key improvement areas was prepared, inspired by the conceptual framework. Afterwards, in Step 2, the workshop, participants received a recap of the current state analysis and an overview of the conceptual framework. Thirdly, in Step 3, the ideas were exchanged with the participants, and participants were encouraged to share their comments and feedback, leading to the co-creation of the improvement proposals through open discussion and brainstorming. During these stages, Data 2 was gathered as audio recordings and field notes during the first proposal building workshop.

Both key improvement areas were addressed in the proposal building workshops. The workshop provided insights and input for the Key Improvement Area related to development of Data collection plan. The following subsections provide details of the Improvement Proposals co-created during the proposal building workshops.

5.2 Initial Improvement Proposals for Data collection Plan

This section presents the Initial improvement proposal for the Data collection plan in the Pre-tender cost estimation process. Each proposal is followed by brief descriptions. The logic and concrete measures for implementation will be covered in the next subsection in a more detailed manner, along with the workshop findings. Figure 5 visualizes the Initial Improvement Proposals for the Data Collection Plan in the Pre-Tender Cost Estimation Process.

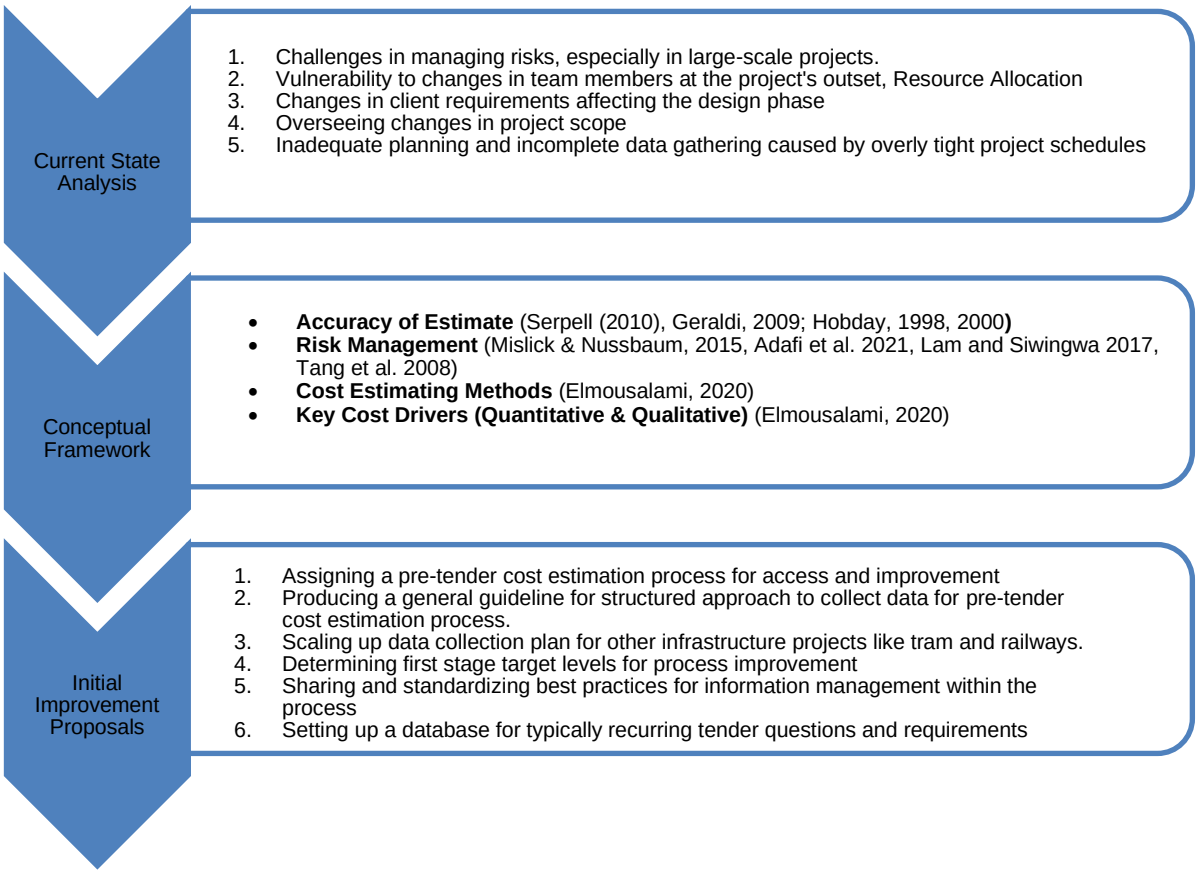

Figure 5. Summary of steps in the Initial Improvement Proposal building for the Data Collection Plan.

As shown in Figure 5, six Initial Improvement Proposals for developing data collection plans were co-created from the current state analysis and interviews. The numbers given for each proposal indicate their priorities. The first proposal suggests assigning a process of pre-tender cost estimation for improving and for making things better and easier to access. the tender preparation process of the case company.

To simplify and enhance project management practices, it is important to establish a systematic pre-tender cost estimation process specifically designed for access and improvement projects. The assignment of this process will involve assembling a dedicated team of experts with a deep understanding of cost estimation methodologies, project complexities, and relevant industry standards. Their primary responsibility will be to develop and oversee the cost estimation process, ensuring accuracy, consistency, and alignment with project objectives. This approach will minimize cost overruns and improve overall project financial management.

In Proposal 1, Improving the Pre-tender Cost Estimation Process, all the participants provided suggestions for improving the pre-tender cost estimation process from their own perspectives, and all their suggestions were positive. Interviewee 1 remarked,

> In the beginning, talk with the client, ask if we can do things, when we can get the measurements, talk with the client from the start. Like in the meeting in the bid face (tarjouspalaveri), discuss with the client about the realistic timeline. Clients often have unrealistic expectations and if the manager lacks experience, they might agree to an unrealistic one- or two-month deadline. We need to be realistic and avoid merely pleasing the client to avoid conflicts. It's better to inform the client well in advance if the timeline is too short; this prevents greater problems later. Continuous communication with the client is essential. Sometimes, clients can be inexperienced and need guidance. Knowing the client well is crucial because if you don't understand their expectations, you won't know how much time is needed. Understanding the client is as important as understanding the project. (*Interviewee 1)*

Interviewee 3 added,

> Yes, and when we realize how many hours are spent on specific design tasks or components of the technical design, such as 100 meters of street or pathways, we can better estimate our work under various soil conditions or environmental factors. Collecting and analyzing data from multiple projects over time can make us wiser and potentially improve our productivity. (*Interviewee 3)*

Thus, the participants provided insightful suggestions for enhancing the pre-tender cost estimation process, emphasizing early client communication, managing expectations, and data-driven decision-making as essential factors.

Proposal 2 and 5 are related to best practices and sharing of information, producing General Guidelines for a Structured Approach to Data Collection. It is important that everyone involved in this phase of a project understands and follows proven and efficient methods for gathering, organizing, and handling cost-related information. By creating a common framework and guidelines, we ensure that information management becomes more straightforward, efficient, and consistent during the process.

To facilitate the accurate and efficient collection of data for pre-tender cost estimation, it is essential to create comprehensive guidelines outlining a structured approach. These guidelines will serve as a reference point for project teams, ensuring that data collection is standardized across all projects. This will include the type of data collected for example number of hours, length of the street from the CRM system.

> The purpose of the quantitative data collection is to understand hours spent. To understand how many of those hours has been spent in making drawings, how many hours spent in designing one section of the street. How many hours were spent in establishing the project in Novapoint or some other design software. Yes, and when we realize how many hours are spent on specific design tasks or components of the technical design, such as 100 meters of street or pathways, we can better estimate our work under various soil conditions or environmental factors. Collecting and analyzing data from multiple projects over time can make us wiser and potentially improve our productivity. (*Interviewee 3)*

It is important to provide clear instructions, so that project teams will be better equipped to gather and analyze the necessary information, resulting in more precise cost estimates and reduced uncertainty in project planning and execution.

Proposal 3 is given by interviewee 3 for the scaling up data collection for other infrastructure projects. Recognizing the potential for increased efficiency and cost savings in the pre-tender cost estimation process, scaling up the data collection plan for other infrastructure big projects, such as tram and railway projects. This expansion will leverage the knowledge and expertise gained from the initial implementation and apply it to a broader range of projects. The benefits of consistency in data collection and estimation methodologies will extend to these related endeavors, promoting uniformity and comparability across all infrastructure projects and later on for other departments.

Proposal 4 and 6. propose the First-Stage Target levels for process improvement:

To continually enhance project management practices, first-stage target levels for process improvement should be established. Through careful analysis of historical data and industry benchmarks, realistic and attainable goals will be set. Achieving these targets will signify progress in our commitment to process improvement and risk reduction, ultimately leading to better project outcomes and client satisfaction. The feedback process in the pre-tender cost estimation process is a critical element that facilitates ongoing improvement and refinement. It involves systematically collecting input, insights, and assessments from various stakeholders, both internal and external, to assess the effectiveness and accuracy of cost estimates and associated practices.

> Engaging relevant stakeholders from the beginning of the project and during the design phase is very important. But not every client is interested in feedback during the design phase, sometimes the client gives overall feedback which includes all the department's performance, and it's not reflecting the actual feedback for a particular department. It will

> be beneficial to develop some systematic procedure to collect feedback from the clients during the design phase and after the completion of the project. (*Interviewee 1)*

It's important to prioritize these insights based on how much they affect the accuracy of cost estimation and the efficiency of the process. Some insights might lead to immediate changes, while others may require more comprehensive adjustments or additional training.

Making changes based on the feedback is crucial. This might involve updating how we estimate costs, improving our project documentation, offering more training, or enhancing how we communicate. Regularly checking how effective these changes are is very important. The feedback process should be ongoing and not just a one-time thing. Continuously asking for feedback and making improvements over time helps to improve, maintain industry standards, and understanding of stakeholder's expectations.

In conclusion, this proposal outlines a strategic approach to address critical aspects of pre-tender cost estimation and data collection processes. By assigning dedicated teams, developing structured guidelines, scaling up data collection efforts, and establishing measurable process improvement targets, improved project management practices, reduce risks, will affect the overall time and cost of the projects.

6 Validation of the Proposal

This section focuses on confirming the initial proposal for a Pre-tender cost estimation data collection plan designed for the infrastructure department of the case company. It begins by outlining how the validation stage was planned, executed, and put into action. Following this, a managerial evaluation of the change enablement framework is presented. The section ends by presenting the final suggestion for creating a data collection plan in the infrastructure department of the case company, accompanied by the author's recommendations for a successful implementation. It also concludes with a strategy for carrying out the Final Improvement Proposals, providing an initial timeline for implementing the suggested actions to improve the studied process.

6.1 Overview of the Proposal Building Stage

The aim of this phase was to validate the initial proposal introduced in Section 5. To accomplish this, stakeholders provided their expert perspectives on the proposal outlined in Section 5. The proposal was enhanced based on the suggestions provided by the stakeholders.

There were validation meetings took place within the case company. The initial meeting involved the Director of the Infrastructure division of business unit, where the summary, key points, and the initial proposal were presented. Recommendations and insights from this meeting were documented through field notes and incorporated into the final proposal. This session held particular significance as it provided a professional viewpoint on the thesis's objectives and outcomes.

The second validation session involved with the Director, project development in the infrastructure and transportation business unit. Like the initial validation meeting, it represented the format of the first meeting, presenting an overview of the study, essential section highlights, and an initial recommendation. Opinions and comments about the study emerged during this second meeting, and these insights were documented through field notes.

6.2 Developments to the Proposal (based on Data Collection 3)

The development of the final proposal for pre-tender cost estimation data collection plan was influenced by the findings obtained during the third round of data collection. Data collection 3 comprises stakeholders' responses to the initial data collection plan proposal and additional insights gathered throughout the validation phase. Given that the conceptual framework, along with the identified weaknesses and initial recommendations, all revolved around the same critical areas, the approach employed in analyzing Data 3 results paralleled that of preceding phases. The subsequent section details the validation outcomes and specifies the requirements for further refinement in the pre-tender data collection plan.

6.2.1 Developments to Element 1 of the Initial Proposal

Developing a comprehensive data collection plan for street design involves a structured approach to gather information related to various aspects of the project. Establishing a data collection plan for implementing a pre-tender cost estimation process for access and improvement involves a systematic approach, drawing inspiration from the structured method outlined for street design data collection.

According to experts' input, engaging key stakeholders is a very important aspect of implementing an effective pre-tender cost estimation data collection process. Involving project managers, financial experts, and department heads provides a diverse range of perspectives, expertise, and insights. Collaborative input from these stakeholders ensures a comprehensive understanding of project requirements and contributes to the development of a well-rounded cost estimation data collection plan.

Furthermore, documenting successful practices and lessons learned from each estimation process is essential. This documentation serves as a valuable repository of best practices, offering insights for continuous improvement and future reference. Learning from past experiences and refining approaches based on documented lessons contributes to the evolution and optimization of the pre-tender cost estimation process over time.

The business director of Infrastructure department highly recommends for developing method related to implementing a customer-specific data collection approach. It is required in the context of pre-tender cost estimation for access and improvement, as reflected in the comprehensive street design data collection plan. Like the strategy used for street design, this approach is instrumental in adapting cost estimations according to the unique demands of each project. The gathering and organization of data, exemplified by the pricing of street design per kilometer in the street design plan, serve as a benchmark for upcoming tender projects. This customer-specific data not only heightens the precision of cost estimations but also guarantees that forthcoming projects benefit from a more personalized and well-informed methodology.

6.2.2 Developments to Elements 2 of the Initial Proposal

In general, the primary stakeholders expressed unanimous satisfaction upon being informed about the results, findings that were mirrored in the preliminary proposal. According to most of the feedback, emphasis on street design data collection plan identify the importance of a structured approach to pre-tender cost estimation. The utilization of historical data, engagement of key stakeholders, establishment of a database, and provision of training collectively contribute to the development of a effective methodology, aligning with the main goals of accuracy, reliability, and continuous improvement.

6.2.3 Developments to Elements 3 of the Initial Proposal

Furthermore, the experts are keenly interested in expanding the data collection plan to encompass other types of infrastructure projects after successfully implementing it in the street projects. This scaling up the data collection plan will includes diverse infrastructure projects, such as tram and railways, involves documenting successful practices and lessons learned. The key steps include tailoring the cost estimation process to address specific goals, establishing a feedback loop for continuous improvement through regular reviews and refinements, and implementing measures to ensure consistency in data collection methodologies across various infrastructure projects.

6.3 Final Proposal

This section outlines the Final proposal, an outcome derived from combining Section 5 (Initial proposal) and Section 6 (Developments to the Initial proposal). The data collection plan for street designing task and revised Initial proposal for further development of data collection plan is presented in Table 11and 12 subsequently.

As mentioned earlier, primary stakeholders suggested developing a comprehensive data collection plan for street design requires a structured approach to gather information on various project aspects. Further, experts suggested engaging key stakeholders, including project managers, financial experts, and department heads, is crucial in ensuring diverse perspectives and insights, contributing to a well-rounded cost estimation data collection plan. Documenting successful practices and lessons learned is essential for continuous improvement and serves as a repository of best practices for future reference.

The recommendation from the business director of the infrastructure department emphasizes the importance of a customer-specific data collection approach. This approach, exemplified in the street design data collection plan, adapts cost estimations to the unique demands of each project. The gathered data, such as the pricing of street design per kilometer, becomes a benchmark for future tender projects, ensuring precision and a well-informed methodology.

Regarding the developments to Elements 2 of the Initial Proposal, stakeholders express unanimous satisfaction, validating the structured approach to pre-tender cost estimation. Utilizing historical data, engaging stakeholders, establishing a database, and providing training collectively contribute to an effective methodology, aligning with goals of accuracy, reliability, and continuous improvement.

Expanding the data collection plan to include diverse infrastructure projects, as outlined in Elements 3 of the Initial Proposal, reflects experts' keen interest. Scaling up involves documenting successful practices and lessons learned, tailoring the cost estimation process, establishing a feedback loop, and ensuring consistency in data collection methodologies across various infrastructure projects. This approach ensures a comprehensive and adaptable framework for future endeavors.

Table 12 Data Collection Plan

Task Number & Task Description	Objective	Data to Collect	Method
1. Initial Data (Aineiston)	Understand initial data collection impact on project efficiency.	- Details on sources and methods of data collection - Time spent on initial data gathering.	Document review, interviews
2. Actual Design Work	Analyze time and effort allocated to actual design work.	- Breakdown of design tasks. - Time spent on each design sub-task.	Document review, interviews
3. Meetings	Assess the role and effectiveness of meetings in project management.	- Frequency and duration of meetings. - Meeting agendas and outcomes.	Document review, interviews
4. Checking (Tarkastelu)	Understand the importance of checking processes in ensuring design quality.	- Types of checks performed. - Time spent on checking activities.	Document review, interviews
5. Geotechnical Design Matters	Evaluate the significance of geotechnical design in the project.	- Specific geotechnical tasks. - Time allocation for geotechnical work.	Document review, interviews
6. Water and Sewerage (Vesihuolto)	Examine the role of water and sewerage planning in the project.	- Tasks related to water and sewerage planning. - Time spent on these tasks.	Document review, interviews
7. Wire Transfer Drawings and Cables (Johtosiirtopiirustus)	Assess the importance of electrical design components.	- Details of wire transfer and cable design. - Time allocation for electrical design.	Document review, interviews
8. Documentation (Asiakirjat)	Understand the role of documentation in project management.	- Types of documents produced. - Time spent on documentation.	Document review, interviews
9. Groundand soil (Pohja Asiat)	Examine any specific tasks related to "Pohja Asiat."	- Description of "Pohja Asiat" tasks. - Time allocation for these tasks.	Interviews
10. Other Structural Elements (e.g., Retaining Wall, Bridges)	Investigate the significance of other structural elements.	- Specific structural tasks. - Time allocation for these tasks.	Document review, interviews
11. Sähkö Asiat (Fortum)	Assess the role of electrical components.	- Description of "Sähkö Asiat" tasks. - Time allocation for these tasks.	Document review, interviews
12. Cost Estimation and Counting of Lights, Cables	Analyze cost estimation processes and the role of lights and cables.	- Details of cost estimation methods. - Time spent on cost estimation and counting.	Document review, interviews
13. Miscellaneous Task	Examine thoroughly all the tasks related to " Miscellaneous Task ."	-Description of "Miscellaneous tasks - Time allocation for these tasks.	Document review, interviews

Table 13 Final Proposal for improvement of Data collection Plan for Pre-Tender Cost Estimation

Proposal Element	Proposal Contents	Actions
Assigning a pre-tender cost estimation process for access and improvement	Re-establishing and developing structured method for a pre-tender cost estimation process a Document successful practices and lessons Focus on access and improvement aspects.	➢ Define clear objectives for the pre-tender cost estimation process, emphasizing access and improvement goals. ➢ Engage key stakeholders, including project managers, financial experts, and department heads, for diverse perspectives. ➢ Document successful and lesson learned from each estimation process, creating a repository of best practices for future reference and improvement. ➢ Customer-specific data is collected and tabulated as a reference for future tender projects e.g., price of street design/km
Producing a general guideline for structured approach to collect data for pre-tender cost estimation process.	Develop a systematic and structured method Sharing and standardizing best practices for information Incorporate industry best practices in cost estimation to align with standards.	➢ Utilize historical data and past project cost information to enhance accuracy and reliability. ➢ Engage key stakeholders, including project managers, financial experts, and department heads, for diverse perspectives. ➢ Setting up a database for typically recurring tender questions and requirements ➢ Provide training for individuals involved in the estimation process to ensure necessary skills and knowledge.
Scaling up data collection plan for other infrastructure projects like tram and railways.	Document successful practices and lessons learned for other type of infrastructure projects and improvement. Identify common data elements and requirements across different infrastructure projects to streamline the scaling-up process.	➢ Tailor the cost estimation process to specifically address goals of improving access and making enhancements. ➢ Establish a feedback loop for continuous improvement, regularly reviewing and refining the estimation process. ➢ Implement measures to maintain consistency in data collection methodologies across various infrastructure projects.

7 Conclusion

This section presents a summary of the study. The executive summary sums up the primary processes and results of the study. Consequently, the subsequent stages planned for implementation are detailed. Lastly, the thesis evaluation is presented.

7.1 Executive Summary

Finland, with a population of around 5.5 million, has concentrated density in the Southern region, particularly the Helsinki Metropolitan Area (HMA). The City Plan envisions Helsinki as a densely populated city connected by various transport options. Being a big city, the City of Helsinki conducts a lot of large construction projects. In infrastructure projects, pre-tender cost estimation is important for client decisions on long-term commitments, directly influencing a company's value proposition and client satisfaction. This study focuses on understanding pre-tender cost estimation processes within the infrastructure department, specifically in Espoo, Helsinki, and Vantaa municipalities. The aim is to develop a Data Collection Plan for street design tasks in the Design Phase, enhancing planning practices and accuracy.

The data used in this study includes qualitative and quantitative data. The qualitative data was gathered from semi-structured interviews. Whereas, quantitative data was collected from Maconomy system entries, detailing hours spent on tasks for small, medium, and large projects over the past two years. In preparation for qualitative analysis, interview questions were crafted by drawing insights from availbale literature and best practices. The current state analysis (CSA) encompasses describing the existing pre-tender process, cost estimation procedures, and tools, shedding light on current practices and roles. The CSA identified key challenges in project size, current tendering practices, resource allocation, and project management practices. Changes in the internal and external environment call for limiting the thesis scope, agreeing on limited options, and requesting comprehensive initial data.

The development of the initial proposal resulted in six Improvement Proposals for creating data collection plans, developed with the help of current state analysis and interviews. Proposal 1 emphasizes the assignment of a pre-tender cost estimation process to enhance accessibility and streamline the tender preparation process. This involves forming a dedicated team of experts to oversee the cost estimation process, ensuring accuracy and consistency while minimizing cost overruns.

Proposals 2 and 5 focus on best practices and information sharing, proposing the creation of General Guidelines for a Structured Approach to Data Collection. The goal is to establish a common framework and guidelines to facilitate efficient information management during project phases. Proposal 2 underscores the importance of everyone involved in the project understanding and adhering to proven methods for handling cost-related information.

Proposal 5 emphasizes the need for comprehensive guidelines outlining a structured approach for accurate and efficient data collection, serving as a reference point for standardized practices across all projects. The third proposal aims to scale up the data collection plan for diverse infrastructure projects, tailoring cost estimation, implementing a feedback loop for improvement, and ensuring consistency in data collection methodologies.

The Final proposal presents the result of the validation of the Initial proposal (Section 5) and its subsequent developments (Section 6) and feedback from the stakeholders. The primary focus is on the data collection plan for street design tasks. The business director recommends a customer-specific data collection approach, illustrated in the street design plan, customizing cost estimations to match project-specific requirements. Developments of the final proposal gathered stakeholder feedback, confirming the effectiveness of a structured approach. Moreover, utilizing historical data, engaging stakeholders, establishing a database, and providing training contribute to a precise, reliable, and continually improving methodology.

The study zeroes?? in on enhancing pre-tender cost estimation processes within the infrastructure department, with a specific focus on developing a Data Collection Plan for street design tasks. The envisioned outcome, the Data Collection Plan, is positioned as

a fundamental tool for managerial decision-making, playing an important role in achieving project success and bolstering the company's standing in the industry.

7.2 Thesis Evaluation

The objective of this master's thesis was to develop a data collection plan for the improvement of pre-tender cost estimation process in the case company. During the research, a proposal was developed, providing a framework for the case company to improve pre-tender cost estimation process and data collection plan based on past completed projects. This challenge is driven by the significance of pre-tender cost estimates for clients making decisions on long-term financial commitments. Additionally, the challenge is compounded by the inherent inaccuracies of estimations, frequently prepared within limited timeframes and occasionally without a finalized project scope.

While exploring the current scenario of the case company, insights were provided into the different project tasks, emphasizing the need for efficient resource management, especially in critical design and planning activities. The analysis also highlighted the significance of efficient resource management in critical design and planning activities, revealing that these tasks consume a substantial portion of project hours. The research design and data collection ensured the accuracy and reliability of pre-tender cost estimations in the case company. All relevant topics were comprehensively addressed to analyze the current situation of the case company. Further investigation is required, utilizing project data to scrutinize miscellaneous tasks that account for a significant number of hours. To achieve this, a greater number of projects need to be examined in detail. Further, the adoption of a customer-specific data collection approach tailors cost estimations to the unique demands of each project, incorporating specific data points like length of road.

7.3 Closing Words

In conclusion, the pursuit of excellence in pre-tender cost estimation is vital for company's success. By embracing the proposed improvements and diligently implementing the outlined roadmap, it will lay the groundwork for a more accurate,

reliable, and efficient pre-tender cost estimation process. This will not only increase ability to meet the diverse needs of clients but also solidifies company's position as an industry leader. Executing the enhancements recommended in this thesis, establishes the foundation for continual future process development. This approach also sets the stage for addressing the identified issues that fall beyond the scope of the current study.

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Appendix 1. Interview Questions for Data 1, Current State Analysis

Interview questions:

1. Could you briefly describe the pre-tender cost estimation process in our department?
2. How good the project scope defines during the pre-tender cost estimation process?
3. What do you think about Information quality from client?
4. What techniques used by the estimator?
5. How many times environment changes during design phase?
6. How you view the Role of management perspective in the process of pre-tender cost estimation?
7. What are the Current project management practices?
8. What data influencing the accuracy of pre-tender cost estimations?
9. Suggestion for making pre-tender cost estimation process better:
10. What are the key cost drivers?
11. What are the main risk factors that influence the accuracy of pre-tender cost estimation?
12. How to manage risk? What is the risk contingency plans?