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Factors that Affect Transaction Cost in Different Project Phases

Master's thesis in Project Management
Supervisor: Haavard Haaskjold
September 2020

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Norwegian University of
Science and Technology

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Preface

I am a master student in Project Management at Norwegian University of Science and Technology. The composition of this study was carried out to satisfy the requirements for TPK4920 – Master's Thesis in Project Management, specialization of Production and Quality Engineering, at the department of mechanical and industrial engineering at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway. This study was conducted following a paper that was written for TPK4520 – Project and Quality Management, Specialization Project which formed the basis for this thesis report. Thus, some parts of it especially in the theory section may contain text from the earlier project which can be considered as the basis for this study.

The basis for this research stemmed from my passion to gain a better understanding of the economics of organizations, and to optimize the organizational expenses. The purpose of the thesis is to contribute with more empirical data to the understanding of transaction cost in different phases of construction projects, regardless of the type of contracts. This study is also a response to the call from Li *et al.* (2015) for more research on their framework for determinants of transaction cost in construction projects.

Both statistical analysis and qualitative interviews were used to conduct this report. Thus, this thesis was a great opportunity to practice quantitative and qualitative research methods. Besides, I learned a lot about project management within construction industry in Norway through the interviews with project managers who had years of professional experience. I am grateful for this opportunity.

Hereby, I take the opportunity to thank the individuals that have helped me in the process of conducting this research. I greatly thank my supervisor Haavard Haaskjold, PhD Candidate within the Department of Mechanical and Industrial Engineering at NTNU, for his great inspiration, continuous feedbacks, and invaluable guidance throughout the process of conducting this paper.

Pouria Jalilvand

September 2020, Trondheim, Norway

Abstract

This study is conducted based on a need for more empirical research on transaction cost in construction projects. This study is also a response to the call from Li *et al.* (2015) for more research on their framework for determinants of transaction cost in construction projects.

The purpose of the thesis is to contribute with more empirical data to the understanding of transaction cost in different phases of construction projects, regardless of the type of contracts. The objective is to statistically compare 'the strength of the factors that affect transaction cost' between different phases of construction projects.

To fulfil the purpose and objective of the study, a statistical investigation was conducted on high-quality empirical data from 142 construction projects in Norway. The investigation was conducted to check if there is any statistically significant difference in 'strength of the factors that affect transaction cost' between project phases. The factors that affect transaction cost were selected from Li *et al.*'s (2015) framework that introduce 26 factors that determine transaction cost in projects. Based on the findings of the statistical investigation, 4 qualitative interviews were conducted with project managers with experience in three different types of construction projects. the respondents had on average 18 years of professional experience. The interviews aimed to investigate the reasons for the significant differences found in the statistical investigation. The interviews were conducted to reach a better understanding of the topic.

The findings of the statistical analysis show that there is a statistically significant difference in quality of communication, as a factor that affect transaction cost, between planning and execution phases. More specifically, the statistical findings show that the quality of communication is significantly better in execution than in planning phase of construction projects. The reason for this difference was investigated through the qualitative interviews. Based on the interview findings, communication channel, informal communication, and access to/availability of information ware the reasons for the difference found in the statistical analysis.

This study contributes to the body of knowledge with more empirical data and research on transaction cost in construction project context. There was no research before that compare determinants of transaction cost between different project phases. In addition, no research was found that qualitatively investigate quality of communication between project phases and particularly between planning and execution phases from transaction cost perspective.

The statistical findings of this study identifies the determinants of transaction cost that are significantly stronger or weaker in one phase than in other phases. Project practitioners who want to improve this situation/imbalance, can use the qualitative findings to prioritize their resources based on the reasons/factors that cause the imbalance.

Keywords: Transaction cost economics, Project management

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1 Introduction

There is a need for more empirical research on transaction cost within construction project context (De Schepper, Haezendonck, & Dooms, 2015; Dudkin & Välilä, 2006; Haaskjold, Andersen, Lædre, & Aarseth, 2019; Li, Arditi, Wang, & Management, 2015; Rajeh, Tookey, & Rotimi, 2015). The purpose of this paper is to contribute with more empirical data to the understanding of transaction cost in different phases of construction projects, regardless of the type of contracts. The objective is to make a quantitative comparison of 'the strength of the factors that affect transaction cost' between different project phases.

1.1 Background

The total cost of an enterprise consists of not only the cost of production but also the cost of transactions with external parties (supplier, customer, contractor, etc.). While production costs arise as inputs are transformed into outputs, transaction costs arise as a product or service is transferred across the technologically separable interfaces (O. E. Williamson, 1987). Production costs are clear costs which can be easily measured. However, transaction costs are rather subtle costs that can be easily underestimated in corporate decisions (Dudkin & Välilä, 2006).

Williamson (1981) describe transaction cost as the economic counterpart of friction (Oliver E Williamson, 1981). The general tendency is to minimize transaction costs as they do not add value to an enterprise or an economic system. Lingard *et al* (1998) mention that it is desirable to decrease transaction costs because the value of production increases as a result (Lingard, Hughes, & Chinyio, 1998).

Construction industry is known for high transaction cost due to incompleteness of contracts as well as high level of uncertainty and complexity. A study on 6 infrastructure projects in the USA by Whittington (2008) show that pre-contract transaction costs, on average, can amount up to 2.2 percent in Design-Build contracts and 2.6 percent of the contract value in traditional contracts. Her research also show that post-contract transaction costs in infrastructure projects can amount between 8.9 and 14.7 percent of the contract value which is quite considerable (Whittington, 2008). A study on 55 projects in the UK by Dudkin & Välilä (2006) show that pre-contract transaction costs can amount between 2 and 3 percent of the contract value (Dudkin & Välilä, 2006). According to Torres and Pina (2001), the costs related to monitoring performance (as a post-contract transaction cost) in public-private-Partnership projects in the US can range between 3 to 25 percent of the contract value (Torres & Pina, 2001).

Thus, transaction cost is a useful approach to the economy of construction projects which is adopted in different studies in this respect (Antinori & Sathaye, 2007; Dudkin & Välilä, 2006; Farajian, 2010; Li, Arditi, & Wang, 2014; Li, Arditi, Wang, & Management, 2012; Miller, Packham, & Thomas, 2002; Müller & Turner, 2005; Soliño & Gago de Santos, 2009; A. Walker & Kwong Wing, 1999; G. M. Winch, 2001).

In a classification, transaction costs within construction industry can be categorized to pre-contract and post-contract transaction costs. Pre-contract transaction costs include the cost of gathering information (technical, financial, legal, etc.), finding relevant prices, and bidding. The cost of negotiating and drafting contracts is other example for pre-contract transaction costs. Post-contract transaction costs include the cost of securing agreements and monitoring other party's performance. The costs associated with dispute resolution, agreement renegotiation, contract modification, and enforcement are other examples for post-contract transaction costs (Heide & Stump, 1995; Oliver E Williamson, 1985). Transaction cost can also be in form of hidden costs including the costs related to disputes and conflicts in projects such as degeneration of business relationships, time loss, and emotional costs (I. Gebken, Richard J, Gibson, & Groton, 2005; R. J. Gebken & Gibson, 2006).

To identify sources of transaction cost in construction projects and to make transaction costs quantifiable, few models for 'factors that affect transaction cost' has been introduced by different authors including Dudkin & Välilä (2006), Farajian (2010), and Li *et al.* (2015). A summary of the models and their application is shown in Table 2 in the theory section. Among the existing models, the one by Li *et al.* (2015) found to be the most comprehensive model as it is the only model that entails all types of projects and all project phases. Besides, the existing literature on transaction cost in projects was comprehensively reviewed in the development of the model. Thus, this model was adopted to conduct this study. The framework suggests 26 factors in 4 categories, namely, predictability of owner's behavior and predictability of contractor's behavior (pre-contract transaction cost) as well as transaction environment and project management efficiency (post-contract transaction cost) (Li et al., 2015). Figure 1 on page 3 shows the framework. The scope of this paper is delimited to the factors in project management efficiency category, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency.

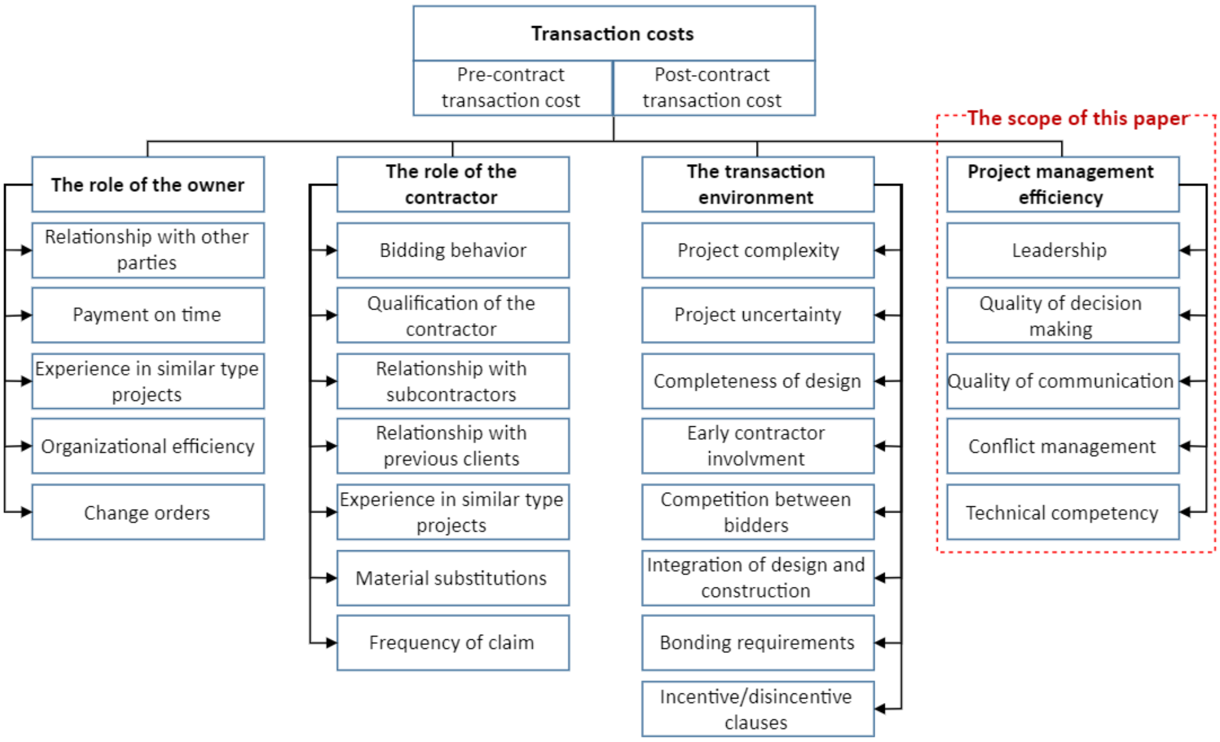

FIGURE 1 MODEL FOR DETERMINANTS OF TRANSACTION COST IN CONSTRUCTION PROJECTS BY LI ET AL. (2015)

Transaction costs cannot be easily measured (Dudkin & Välilä, 2006). It is still difficult to measure and quantify transaction costs despite the availability of frameworks for determinants of transaction cost in construction projects. As a result, there is a **need** for more empirical research on transaction cost in construction project context (De Schepper et al., 2015; Dudkin & Välilä, 2006; Farajian, 2010; Guo, Li, Li, & Zhang, 2016; Haaskjold et al., 2019; Li et al., 2015; Rajeh et al., 2015). The current studies on transaction cost in construction projects are mostly limited to the procurement phase of projects and to the Public-Private-partnership (PPP) arrangements (Li et al., 2015). Therefore, there is a need for more empirical research on transaction cost in construction project context which includes all project phases (not only the procurement phase) and is not limited to a specific type of contractual arrangement (not only Public-Private-Partnership projects). Furthermore, Li *et al.* (2015) call for more empirical research on their model for determinants of transaction cost in construction projects. The research gap is presented in more details in section 2.7 Research gap) at the end of the theory section.

1.2 How this study contributes to the research gap?

There is a need for more empirical research on transaction cost in construction projects (De Schepper et al., 2015; Dudkin & Välilä, 2006; Farajian, 2010; Guo et al., 2016; Haaskjold et al., 2019; Li et al., 2015; Rajeh et al., 2015). To fill the research gap found in the literature on transaction cost, this paper is decided to be a quantitative study on transaction cost in construction project context based on high-quality empirical data from 142 construction projects in Norway provided by CII1010 benchmarking database.

The **purpose** of this study is to contribute with empirical data to the understanding of transaction cost in different phases of construction projects, regardless of the type of contracts. The **objective** is to make a statistical comparison of 'the strength of the factors that affect transaction cost' between different phases of construction projects.

The empirical data for the statistical analysis is obtained from CII1010 which is an internationally recognized benchmarking database for projects. The data on the database is of very high quality and is classified according to phases (Yun, Choi, de Oliveira, & Mulva, 2016) which made the investigation on different phases possible. Since the number of projects registered on the database in the termination phase is very small (3), termination phase is excluded from the comparison in this paper.

In this study, the factors that affect transaction cost are selected based on the framework by Li *et al.* (2015) which introduce 26 factors that affect transaction cost in construction projects. Thus, this study is also a response to the call by Li *et al.* (2015) for more empirical studies on their framework. Based on the scope limits (shown in Figure 1), this paper is limited to the investigation of the factors that affect transaction cost in project management efficiency category, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency.

In summary, this paper, through a statistical analysis, compares the strength of the factors that affect transaction cost between project phases in order to check if there is any difference in the factors between different phases. More specifically, this paper checks if leadership, quality of decision-making, quality of communication, conflict management, and technical competency are better/worse in one phase than other phases. Figure 2 is an illustration of this analysis.

In addition, through the statistical analysis on the data from CII1010 database based on Li *et al.*'s (2015) framework, the author noticed a significant difference in one of the factors, that affect transaction cost, between two phases. The current literature on transaction cost in projects does not quite cover this significant difference. Thus, to obtain a more profound understanding of the subject, 4 qualitative interviews with project managers in Norway was conducted which aimed to find the reasons for the difference found in the statistical analysis. The logical relation of the interviews (the qualitative part of the study) to the statistical investigation (the main part of the study) is illustrated in Figure 3. The interview data is a complementary part to the thesis which answers the second research question.

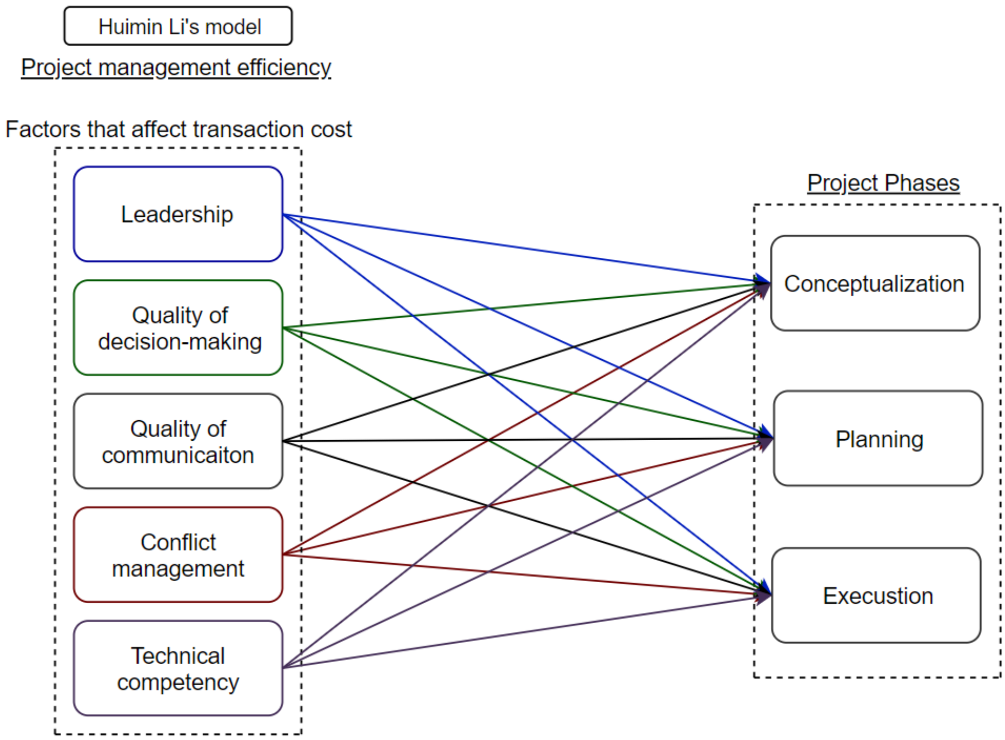

FIGURE 2 STRUCTURE OF THE STATISTICAL ANALYSIS

1.3 Research questions

Before starting a research project, it is quite important to specify the objective of the study and the research questions based on the research gap and the purpose of the study. This research is conducted based on the **need** for more empirical research on transaction cost in construction project context (De Schepper et al., 2015; Dudkin & Välilä, 2006; Farajian, 2010; Guo et al., 2016; Haaskjold et al., 2019; Li et al., 2015; Rajeh et al., 2015). The existing literature does not include all project phases and is mostly restricted to a specific type of contractual arrangement (Li et al., 2015).

The **purpose** of this research is to contribute with more empirical data to the understanding of transaction cost in different phases of construction projects, regardless of the type of contracts. The **objective** is to make a statistical comparison of 'the strength of the factors that affect transaction cost' between different phases of construction projects.

Based on the purpose and objective of the research and considering the scope limits (exclusion of the termination phase), the research questions are formulated as follows:

RQ 1A. Is there a statistically significant difference in factors that affect transaction cost between conceptualization and planning phase?

RQ 1B. Is there a statistically significant difference in factors that affect transaction cost between conceptualization and execution phase?

RQ 1C. Is there a statistically significant difference in factors that affect transaction cost between planning and execution phase?

RQ 2. What is the reason for the found differences if there is any?

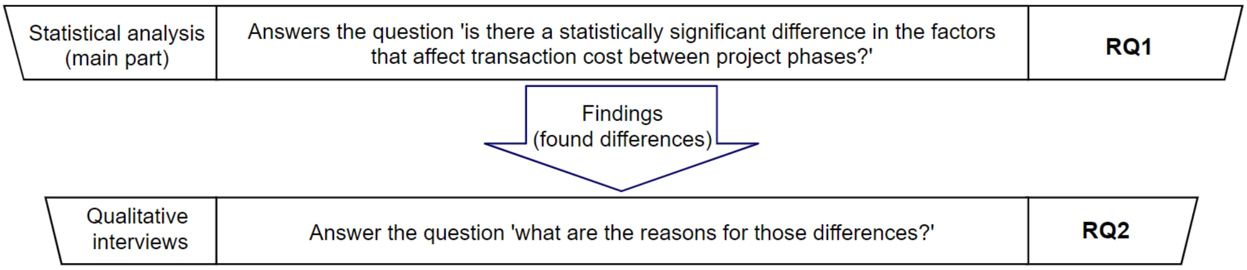

FIGURE 3 THE LOGICAL RELATION OF THE QUALITATIVE INTERVIEWS TO THE STATISTICAL PART OF THE PAPER

The first research question does not cover the termination phase of projects because the termination phase is excluded from the scope of this paper (this is described in the following section). The research questions follow the logical structure of the paper which is shown in Figure 3. The first research question is related to the statistical analysis (main part of the paper) and the second research question is related to the qualitative interviews which is a further investigation on the topic. In first research question, 'statistically significant' refers to the significance level of the measures which is described more in detail in the methodology section.

1.4 Scope limits

The purpose and objective of this paper are to be fulfilled within the following scope:

1. The main part of the paper (the part related to the statistical analysis) is pertaining to quantitative analysis of transaction cost in construction projects and does not include the qualification aspect of research on transaction cost.
2. The scope of this paper is limited to investigation of transaction cost within construction projects in Norway. It includes infrastructure, industrial, and building projects.
3. Within Li's model, determinants of transaction cost are classified under 4 main categories, namely, the role of the owner, the role of the contractor, the transaction environment, and project management efficiency. Due to time limitation, within Li's model, the scope of this study is limited to the determinants of transaction cost in project management efficiency category, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency.

Among the aforementioned categories, project management efficiency was selected because it is in line with author's program of study (Project Management).

4. Li's model only considers transaction cost between a company and outside organizations. Therefore, the internal transaction costs are excluded from the scope of this research.
5. The empirical data for the statistical analysis is obtained from CII1010 benchmarking database. Because the number of projects registered on the database in the termination phase is very small (3), termination phase is excluded from the scope of this paper. Accordingly, the research questions compare the factors that affect transaction cost only between conceptualization, planning, and execution phases.

1.5 Structure of the study

The study comprises 5 main sections, namely, introduction, methodology, findings, discussion, and conclusion. The following is an overview of the sections:

1-Introduction

This part of the paper is meant to cover fundamentals and basis of the research. It contains:

- A brief description of the topic and its importance
- An overview of the research gap within the field
- How this study contributes to filling the research gap, including research purpose and research objective
- The research questions based on the research gap, purpose, and objective
- Limitations of the research (scope limit)
- The structure of the research to address the research questions

2-Theory

The second part of the report covers the literature relevant to the topic. It is important because the foundation of the research is based on the current literature and because the findings are discussed in light of it. The theory section covers:

- A brief history of transaction cost
- An overview of transaction cost theory in general
- The application of transaction cost theory in construction industry
- Models for quantification of transaction cost in construction industry including Li *et al.* (2015)
- Factors that affect transaction cost in projects within the scope
- Project phases
- The research gap within the field

3-Methodology

This section is about description and justification of methods used in the research. It contains 3 parts:

1. Description and justification of the research strategy and research design, and methods used for conducting the literature review.
2. Methods used in the **statistical analysis** (regarding the first research question). The statistical analysis on the empirical data from CII1010 database investigates if there is any distinctive difference in the strength of the factors that affect transaction cost between project phases.
3. Methods used in the **qualitative interviews** which is meant to bring a deeper understanding of the topic (regarding the second research question). The interviews are conducted based on the findings of the statistical analysis. The interviews intend to find the possible reasons for the differences found in first research question.

4-Findings

Based on the order of the research questions, this section contains 2 main parts:

1. In the first part, the findings of the **statistical analysis** on the data from CII1010 database is presented. It is regarding the first research question 'is there any statistically significant difference in the strength of the factors that affect transaction cost between different project phases?'.
2. In the second part, the findings of the **interviews** are presented. This part is pertaining to the second research question 'what are the reasons for the found differences during the statistical investigation?'

5-Discussion

This section contains 2 parts:

1. Discussion of the findings of **statistical analysis**
2. Discussion of the findings of **qualitative interviews**
3. Theoretical contributions and practical implications of the research

Part 1 and 2 answer the following questions:

- What do the findings mean in this context?
- How the findings are related to the current literature mentioned in the theory section?
- How the findings answer the research questions in the introduction section?
- Are the findings for or against the hypotheses made in the methodology section?

6-Conclusion and further research

Conclusion section, as the closing part, covers:

- The achievements of the study pertaining to the problem stated in the introduction
- Suggestions for the readers who are interested in further research on the topic

2 Theory

In this section, the concept and a brief history of transaction cost is outlined first. Then the current state of research on transaction cost is described. Transaction cost is delineated in general as a concept in economy and management. It is also described in construction projects context in particular. Lastly, the literature on transaction cost in different phases of projects is outlined and analyzed.

2.1 What is transaction cost?

The total cost of an organization consists of not only the cost of production but also the cost of transactions with other parties which is known as transaction cost in the study of economic organizations (Coase, 1991; G. Winch, 1989). Production cost occurs as inputs are transformed into outputs in a production process. However, transaction cost happens when goods or services are traded between technologically separable interfaces (O. E. Williamson, 1987). It is not easy to track, measure, and mitigate transaction costs in contractual relationships. That is why they are called *soft costs* by Transportation Research Board (TRB) (AECOM, 2010).

Different authors considered a variety of costs as transaction cost. Williamson (1985) echo that costs associated with contracts such as cost of drafting, negotiating, registering, safeguarding, and renegotiating contracts constitute transaction cost (Oliver E Williamson, 1985). Besides, Joskow (1985) mention legal and organizational costs as well as the cost of information, inefficient production, and pricing behavior as transaction cost too (Joskow, 1985). Rahman & Kumaraswamy (2002) consider the costs associated with deviations from contractual agreements as transaction cost as well (Rahman & Kumaraswamy, 2002). Dudkin *et al.* (2006) consider transaction cost as the cost of establishing and maintaining a partnership including the cost of technical, financial, and legal advisory paid by both parties (Dudkin & Välilä, 2006). Rajeh (2015) considered costs regarding market structure, enforcement, and competitive advantage as transaction cost (Rajeh et al., 2015).

2.2 A brief history of transaction cost

The roots to transaction cost stems from the question stated by Ronal Coase in 1937 about vertical integration of production: what is the efficiency factor for firms to decide between producing and buying a product? He introduced the transaction cost approach which enlightened the understanding of economics of organizations while price mechanism was the predominant approach in this regard at that time. The problem with price mechanism approach was that in its assumptions for defining a firm, it does not consider the industry and market in which the firm is functioning. Thus, transaction cost that is occurred in the exchange of goods, was automatically excluded from the calculations for make-or-buy decisions (Coase, 1991).

Before that, Sir Arthur Salter in 1933 echo that an economic system can be described through price mechanism approach which resources of a firm are directed based on that (Salter, 1933). Based on his statement, resources of a firm would be automatically allocated to products with higher prices. This however may not be applicable to many areas of economy in reality. The impact of external factors (in the market and industry within which a firm is erected) on allocation of resources to different products is inevitable. Price mechanism approach is mostly focused on a firm itself. Coase 1991 mention that resources in a firm are directed by external price movements through a series of exchange transactions on the market (Coase, 1991). This is the fundamental concept of transaction cost economics (TCE).

Transaction cost economy is the key solution to Coase's puzzle (what is the efficiency factor for firms to decide between producing and buying a product?). It can explain the vertical integration in a firm's supply chain. Through Mergers & acquisitions, firms can integrate with their supplier to decrease considerable contract-related costs including the costs of negotiating, administrating, monitoring, insuring, renegotiating, modifying, and closing contracts. Vertical integration has its own downsides as well. The cost of organizing additional transactions increases as an organization grows in size. Consequently, there would be a balance point in the expansion of firms where the cost of outsourcing the certain part of production is approximately equal to the cost of organizing the additional transactions (Coase, 1991). transaction cost acts as the efficiency factor in make-or-buy decisions mentioned in Coase's puzzle. transaction cost is also a critical factor for companies to opt for a long-term or short-term cooperation strategy in their supply chain management because making several short-term contracts adds up to transaction cost (Coase, 1991).

Coase was not the only researcher in the 1930s that emphasized transaction cost economics. Commons (1932) considered transaction cost as the basic unit of analysis in economy (Commons, 1932). The need for transaction cost economics was also mentioned by Mr. Maurice Dobb (1926) when he noted that economists began to realize that the relations of a company with the rest of the economic world is a more important factor than the internal relations of the company (Dobb, 1926). A company's relations with external parties is based on exchange transactions on the market (Coase, 1991).

Transaction cost was not considered as the root cause of the economists' difficulties with markets until almost 70s. In 1969, Arrow introduced transaction cost as a factor that may impede or block development of markets (Arrow, 1969). Afterwards, transaction cost economics was well developed by Oliver Williamson from 1985 to 2010 for which he was awarded a Nobel prize in 2009.

As mentioned before, the internal relation of a firm is not the only factor that affects the direction of resources. The relation of the firm with its contextual market and industry is a significant factor as well (Dobb, 1926). In this respect, transaction cost economics has the advantage of considering **environmental and human factors** that may impact the cost of external trades with the rest of the economic world. For instance, transaction cost economics takes into account bounded rationality and opportunism as two fundamental human features that can increase contractual costs occurred by both parties in a contractual relationship (Li et al., 2012; Oliver E Williamson, 2002).

2.3 Transaction cost economics and contracts

Based on transaction cost economics, the nature and governance structure of the transactions should be determined by the interplay between human and environmental factors (Greenwood & Yates, 2006). Transaction cost economics enhances the realistic perception of a contractual relationship as it considers relevant human attributes such as **bounded rationality and opportunism** that may impact contractual relationships

(Rajeh et al., 2015; Oliver E Williamson, 1979, 1981). Contracting parties are human beings. They try to behave rationally while their cognitive abilities, information, and comprehension of contract may be limited. This is a matter of bounded rationality (De Wit & Meyer, 2010).

In addition, in complex contracts (construction contracts are mostly complex), it is almost impossible to anticipate all the future events and remove errors and disturbances due to bounded rationality (Oliver E Williamson, 1979, 1981). As a result, complex contracts are usually incomplete. Within the construction industry, one of the contracting parties (mainly the contractor) can use the incompleteness of contracts in their own favor and exhibit opportunistic behavior by exploiting ambiguities and errors of the contracts. This leads to higher transaction cost as the owners tend to pay more for monitoring contractors' performance by their own engineers/inspectors and for over-specifying the contracts because they are suspicious of the contractors (Kadefors, 2004; Oliver E Williamson, 1979).

2.4 Transaction cost dimensions/general determinants of transaction cost

Frequency, uncertainty, and asset specificity are known as dimensions or general determinants of transaction cost. High frequency of transactions with a stakeholder results in lower transaction cost. However, transaction cost grows as uncertainty and asset specificity increase in contractual relationships (Rajeh et al., 2015; Oliver E Williamson, 1979, 1981, 2010).

Frequency in this context refers to the number of transactions between parties. It is associated with their cooperation history (Oliver E Williamson, 1979). As contractual relationships prolong, the governance efficiency and quality of communication enhance consequently (Dyer, 1996; Oliver E Williamson, 1983). In addition, as contractual parties interact, relational trust arises between them which is based on reciprocal concerns and emotional bonds as well as their reliance on each other's ability to fulfil their promises (Rousseau, Sitkin, Burt, & Camerer, 1998). Consequently, the risk of opportunistic behavior would decrease.

Hellriegel & Slocum (1996) define uncertainty as "the gap between the amount of information needed for a task and the amount of information available" (Hellriegel & Slocum Jr, 1996a). Uncertainty is closely associated with risk. Transactions with high levels of uncertainty are relatively uninteresting (Oliver E Williamson, 1979). To overcome uncertainty, organizations need to have either extra information and better communication or buffer resources (Hellriegel & Slocum Jr, 1996a). As a result of high uncertainty, extra cost of information gathering, communication improvement, contract negotiation, renegotiation, and modification can be imposed to the organizations which in turn leads to higher transaction cost (De Schepper et al., 2015). In fact, uncertainty can be referred to as a key indicator of transaction cost in construction projects (G. Winch, 1989).

Asset specificity is the quotient to which investments are specialized to a particular contract or transaction. In transactions with high degrees of asset specificity, assets cannot be redeployed except at a considerable loss (Oliver E Williamson, 1981, 1996). High level of asset specificity can also open up the possibility of opportunistic behavior because one of the contractual parties cannot easily terminate the contract due to considerable losses regarding contract-specific assets. Vertical integration may be considered when there is bilateral dependency on transaction-specific assets in contracts (Oliver E Williamson, 2010). Kang *et al.* (2009) describes asset specificity as a measure for risk of exchange in tenders. The risk can be measured by the economic loss of losing a tender after investing on contract-specific assets (Kang, Mahoney, & Tan, 2009).

2.5 Transaction cost in construction projects

Construction industry is known for high transaction cost due to **incompleteness of contracts** and high level of **uncertainty**. Despite the high transaction costs in construction industry, the limitations of the current accounting systems have restricted access to transaction costs. Thus, they cannot be easily tracked and quantified (Dudkin & Välilä, 2006). That is why transaction costs are called *soft costs* by Transportation Research Board (TRB) (AECOM, 2010).

Excessive **uncertainty** cannot be tolerated and should be treated. Overcoming or dealing with high uncertainty imposes higher costs of gathering extra information, improving communication, and providing buffer resources which increase transaction cost in turn (Galbraith, 1973). In addition, change orders often happen as customers get a better understanding of their requirements over time in construction projects. Thus, extra transaction costs of contract renegotiation and modification occurs. Uncertainty in soil and weather conditions, and in material prices are other examples of uncertainty in construction projects.

Besides, contracts in construction industry are inevitably **incomplete** because of bounded rationality, complexity of contracts, and the circumstances in the context (e.g. the duration of contract, risk-sharing features, and uncertainty). Transaction costs increase as a result of efforts to treat uncertainty in construction projects and to lower contractual incompleteness (Dudkin & Välilä, 2006; Oliver E Williamson, 1979, 1981).

Li *et al.* (2014) note that in construction projects, transaction costs mostly happen as a result of efforts to 1- mitigate the risk (probability and consequences) of accidents by insurance and other risk reduction measurements, to 2- reduce the risk of contractor default by performance and payment bonds for example, and to 3- obtain transparency in awarding contract in bidding and negotiation stages for instance (Li et al., 2014).

2.5.1 Categories

Transaction costs in construction projects has been categorized variously by different authors. Different categorizations are summarized in Table 1. Williamson (1975) classify transaction costs into *ex-ante* and as *ex-post* categories*. Ex-ante* transaction costs include the cost of tendering, negotiation, and administration of the contract which is occurred before execution phase. However, *ex-post* transaction costs comprise the costs of policing contract and resolving disputes during execution phase (Williamson Oliver, 1975). Dahlman (1979) categorize transaction costs into 3 categories, namely, the cost of 1- search and information, 2- tender bargaining and decision, and 3- contract policing and enforcement (Dahlman, 1979). **Lingard (1998)** classify transaction costs into pre-contract transaction costs and post-contract transaction costs which resembles Williamson's classification (Lingard et al., 1998). Turner and Simister (2001) categorize transaction costs based on the specifications of the product and process into 4 classifications, i.e., the costs regarding 1-specifying product in tender document, 2-specifying the work processes in the tender document, 3- managing deviations from the specifications of the product during execution phase, and 4- managing deviations from specifications of process during execution phase (Turner & Simister, 2001). Hughes (2006) categorize transaction costs based on project phases into pre-tendering, tendering, and post-tendering costs (Hughes, Hillebrandt, Greenwood, & Kwawu, 2006).

The scope of this study is limited to the determinants of transaction cost in Huimin Li's model which is based on Lingard's classification of transaction costs (pre-contract and post-contract transaction costs) (Li, Arditi, & Wang, 2013). Thus, the same classification of transaction cost is adopted here as well.

TABLE 1 DIFFERENT CATEGORIZATIONS OF TRANSACTION COSTS IN CONSTRUCTION PROJECTS

Author	**TC categories**
Williamson (1975)	- Ex-ante - Ex-post
Dahlman (1979)	- Search and information - Tender bargaining and decision - Contract policing and enforcement
Lingard (1998)	- Pre-contract - Post-contract
Turner and Simister (2001)	- Specifying product in tender document - Specifying the work processes in the tender document - Managing deviations from the product specifications - Managing deviations from specifications of process
Hughes (2006)	- Pre-tendering - Tendering - Post-tendering

2.5.1.1 Pre-contract transaction costs

Pre-contract transaction cost is referred to transaction costs that incurred before a contract is signed or a transaction is done. According to Soliño and Gago de Santos (2009), pre-contract transaction costs include the costs regarding project preparation as well as technical, legal, and financial consultations, including the costs related to feasibility study, environmental impact assessment, market research, finding financing party, concept design, tender preparation and negotiation, and daily project management costs before signing the contract (Soliño & Gago de Santos, 2009). Soliño and Gago de Santos (2010) mention that pre-contract transaction costs also include the costs pertaining to gathering information, attending meetings, translating customer and end-users' requirements into product and process specifications, preliminary design, communication, training, and site visits (Soliño & Gago de Santos, 2010).

Pre-contract transaction costs can considerably amount to 2-3 percent of the contract value on average. Dudkin *et al.* 2006 note that pre-contract transaction costs of infrastructure projects is approximately 2-3 percent of the contract value on average based on data collected from public-private partnership (PPP) projects financed by European Investment Bank (Dudkin & Välilä, 2006). Whittington (2008) echo that pre-contract transaction costs can amount to 2.6% (for design/build projects) and 2.2% (for design-bid-build projects) on average (Whittington, 2008).

2.5.1.2 Post-contract transaction costs

Post-contract transaction cost is referred to transaction costs that incurred after signing the contract until handing over the product of the project. Williamson 1985 note that post-contract transaction costs include the costs pertaining to securing the agreed promises and monitoring contractors' performance, as well as referring to and settling disputes, lawyer and courts, and contract renegotiation and modification (Oliver E Williamson, 1985).

Yates (1999) categorized post-contract transaction costs as direct and indirect costs. Direct post-contract transaction costs include the costs of administrating and handling claims, lawyers, court fees, management and employees' time who deal with the case, and the regarding delays in project completion. Indirect transaction costs comprise the costs related to the degeneration of trust, teamwork, and working relationship between the parties because of the disputes and conflicts. They note that disputes and conflicts as post-contract transaction costs impose great costs to the construction industry in the US, the UK, Hong Kong, and Australia (Yates, 1999).

Post-contract transaction costs can be considerably higher than pre-contract transaction costs. Torres and Pina (2001) mention that monitoring contractors' performance (as a post-contract transaction cost) cost between 3 to 25 percent of the contract value in PPP projects in US private sector (Torres & Pina, 2001). Whittington (2008) echo that based on 6 case studies, post-contract transaction costs on average amount 9.5% of the contract value in design/build projects. The regarding percentage for design-bid-build projects is 12.6% (Whittington, 2008).

2.5.2 Determinants of transaction cost in construction projects

Transaction cost is the cost of exchanging goods or services with external parties (O. E. Williamson, 1987). It roots in the inter-relations between human and environmental factors (Greenwood & Yates, 2006). Human factors include bounded rationality and opportunism while environmental factors include the uncertainty/complexity of the context and the number of contractors (monopoly situation) (Blair & Higgins, 1981).

Within the construction project context, transaction cost can increase as a result of contractual issues such as change orders, claims, and disputes (Li et al., 2015). Molenaar (2000) mention 3 factors that directly impact dispute potential, namely, the management ability of the owner, the management ability of the contractor, and project complexity (Molenaar, Washington, & Diekmann, 2000).

Asset specificity, uncertainty, and frequency are 3 general determinants of transaction cost (Oliver E Williamson, 1979, 1981) which are applicable in project context as well

(De Schepper et al., 2015). High frequency of transactions with a stakeholder results in lower transaction cost. However, transaction cost grows as uncertainty and asset specificity increase in projects (Oliver E Williamson, 1979, 1981).

In addition, Dudkin (2006), Farajian (2010), and Li *et al*. (2015) introduced models for determinants of transaction cost in construction projects (Table 2). Dudkin (2006) mention 6 factors as determinants of transaction cost in construction projects, namely, 1-project country, 2-economic sector, 3-project size, 4-length of procurement process, 5-number of bidders, and 6-the year when the project was signed. This model is focused on the procurement phase of the projects and is also limited to Public-Private Partnership (PPP) projects (Dudkin & Välilä, 2006).

Farajian (2010) introduce 4 factors that affect transaction costs, namely, 1-number of bidders, 2-project value, 3-procurement time (PPP complexity), and 4-PPP maturity level. This model is also limited to the procurement phase of PPP projects (Farajian, 2010).

This study is based on the framework by Li *et al.* (2015) because unlike the models by Dudkin (2006) and Farajian (2010), Huimin Li's (2015) model entails all phases of projects and is applicable to all construction projects (it is not restricted to PPP projects). Besides, the existing literature on transaction cost in projects was comprehensively reviewed in the development of this model.

Table 2 summarizes the abovementioned models for determinants of transaction cost in construction projects. Transaction cost can vary in different phases of project as determinants of transaction cost can change in different phases.

TABLE 2 EXISTING MODELS FOR DETERMINANTS OF TRANSACTION COST IN CONSTRUCTION PROJECTS AND THEIR APPLICATION

Study	Determinants of transaction cost in the model	Application
Dudkin and Välilä (2006)	- Project country - Economic sector - Project size - Length of procurement process - Number of bidders - The year of signing the contract	Procurement phase of PPP projects
Farajian (2010)	- Number of bidders - Project value - Procurement time - PPP maturity level	Procurement phase of PPP projects
Li *et al*. (2015)	- The role of the owner - The role of the contractor - The transaction environment - Project management efficiency	All phases of all construction projects

2.5.3 Li's model for determinants of transaction cost in construction projects

Transaction cost economics is based on the interactions between human and environmental factors (Oliver E Williamson, 1979). In the model introduced by Li *et al.* (2015) for determinants of transaction cost in construction projects, human factors appertain to predictability of the contractor's and owner's behavior. The environmental factors are related to the uncertainty of transaction environment and project management efficiency in the model (Li et al., 2013; Li et al., 2015).

The model includes 26 determinants for transaction cost in construction projects. Figure 1 is an illustration of the model. The factors in the model are categorized into four categories, namely, the role of the owner and the role of the contractor (pre-contract transaction cost) as well as the transaction environment and project management efficiency (post-contract transaction cost). The scope of this paper is delimited to the determinants of transaction cost in project management efficiency category, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency (Li et al., 2015). The purpose of this paper is to investigate these factors in different phases of projects to check if they differ between the phases. The factors are described in detail further in this section.

2.5.3.1 The role of the owner

The role of the owner is considered as a major factor in the speed of construction or construction time performance (CTP) (D. H. Walker, 1995). The role of the owner/client impacts transaction cost through CPT because low CPT causes contract renegotiation and modification, changes, longer project duration, and probably disputes and conflicts.

Different authors suggested various factors for the role of the owner. For example, Chan & Kumaraswamy (1997) mentioned on-time payments to contractors, project financing, owner characteristics, owner's variations like change orders, and owner's requirements (Chan & Kumaraswamy, 1997). Songer & Molenaar (1997) also added sufficient owner staffing, well-defined project scoe, and owner's attitude towards risk (Songer & Molenaar, 1997). Owner's experience, knowledge, and project management ability can be considered in this category as well.

In Huimin Li's model, the role of the owner can be measured by 5 factors, namely, relationship with other parties, experience in similar type of projects, on-time payments, organizational efficiency, and change orders (Li et al., 2015). The factors are presented in Figure 1.

2.5.3.2 The role of the contractor

Contracts are not complete. All possible contingencies cannot be covered in contracts. They often contain errors and ambiguities (Chang & Ive, 2007; Kadefors, 2004). This can be due to the complexity of the construction projects and bounded rationality of the people who write the contracts. In addition, in long-term contracts, it is neither desirable nor possible to mention all details and specifications in advance in order to maintain the flexibility and to avoid modification of the specifications in the contract later in project (Shelanski & Klein, 1995).

Considering the incompleteness of the contracts, the monopolistic situation of the contractors after signing the contract may entice them to act opportunistically. They know the ambiguities of contracts better than owners. Thus, they can take advantage of those ambiguities and charge the owner excessively (Kadefors, 2004).

As a result, owners are usually suspicious of contractors and as preventive measure, they tend to over-specify contracts by including as many contingencies as possible. They would also use their own engineers as inspectors to monitor contractors' performance. This mistrust results in a decline in inter-organizational relationships and an increase in transaction cost. This is how the role of contractor impacts the magnitude of transaction cost (Kadefors, 2004; Pinto, Slevin, & English, 2009).

In Huimin Li's model, the role of the contractor is measured by 7 factors, namely, bidding behavior, qualifications of the contractor, relationships with subcontractors, relationships with previous clients, experience in similar type projects, material substitutions, and frequency of claims (Li et al., 2015). The factors are presented in Figure 1.

2.5.3.3 The transaction environment

Transaction cost economics is based on the interactions between human and environmental factors. In this description, environment is not considered as an independent entity. Instead, it is considered as a collection of circumstances with specific impacts on organizations (Shirazi, Langford, & Rowlinson, 1996). The organizations are inevitably affected by their environment as they function in connection with their contextual market and industry (Oliver E Williamson, 1985). Construction projects are also affected by their environment because they function as temporary organizations within their context. Environment impacts the projects both directly and indirectly through contractor's behavior and project management efficiency (Li et al., 2013).

Construction projects are known for high uncertainty and complexity because of which they are subject to greater risks than other business activities (Diekmann & Girard, 1995). Uncertainty and risks raise transaction cost in turn. Owners tend to diminish this transaction cost by avoiding or mitigating risks and disputes. They try to anticipate potential problems and explore different contingencies to elaborate on their contracts. However, the cost of anticipating problems and exploring contingency plans grows considerably with high complexity and uncertainty in construction projects (F. Walker & Pryke, 2009). Thus, as a result of contextual conditions (environment), owners need to decide about the extent to which they are willing to pay for the benefits of having an elaborate contract. This emphasizes the impact of the transaction environment in magnitude of transaction cost in construction industry (Li et al., 2015).

In Huimin Li's model, the effect of the transaction environment on magnitude of transaction cost can be measured by 9 factors, namely, project complexity, project uncertainty, completeness of design, early contractor involvement, competition among bidders, integration of design and construction, bonding requirements, incentive/disincentive clauses, and risk allocation (Li et al., 2015).

2.5.3.4 Project management efficiency

An effective project team is essential for project success. An effective project team can save the project so much trouble. In the absence of effectiveness, small issues or disagreements can potentially grow into serious disputes and conflicts. However, an effective team can minimize the impact of complex issues and prevent or mitigate the resulting transaction costs (Li et al., 2015). In addition, effectiveness of the project management affects transaction cost indirectly through its pertinence to project activities such as planning, coordination, monitoring, and controlling. It also affects projects through its considerable impact on organizational resource allocation decisions (Lewis, Lock, & Sexton, 2009).

Effectiveness of the project team is not limited to their cooperative behavior. An effective team is also featured with effective decision-making procedures, agreement on project goals, and negotiation and problem-solving skills (Mitropoulos & Howell, 2001). Li *et al.* (2015) mention that project management efficiency affects daily costs regarding administration of change orders and claims as well as the resolution of disputes and conflicts (Li et al., 2015).

In Huimin Li's model, the effect of project management efficiency on magnitude of transaction cost can be measured by 5 factors, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency. In addition to the aforementioned factors, other determinants of transaction cost (in other categories) can indirectly affect project management efficiency. For example, predictability of the owner's and contractor's behavior can improve project management efficiency. However, uncertainty in project environment can negatively impact it (Li et al., 2015).

The scope of this paper is limited to determinants of transaction cost under project management efficiency category in Huimin Li's (2015) model. Therefore, unlike the 3 other categories, the factors of project management efficiency will be discussed further in this section as follows.

2.5.3.4.1 LEADERSHIP

Leadership is embedded in human mind. Bass (2009) mention that the patterns of leadership is developed in and merged into human psyche during the childhood period as people need to be nurtured by parents in order to survive (Bass & Bass, 2009). Regardless of culture, leadership happens among all people (H. L. Smith & Krueger, 1933).

Leadership is the art of recognizing and developing capabilities to fulfil goals and objectives. It is essential for managers to have leadership skills to orchestrate the work harmony in the organization. Many studies have emphasized on the critical role of leadership in organizational success (Bass & Bass, 2009; J. E. Smith, Carson, & Alexander, 1984; Sylvia & Hutchison, 1985).

In a project context, it is responsibility of the leader to devise plans and define roles in a project (V. S. Anantatmula, 2010). Leader aligns people with project goals based on their knowledge, skills, and competence (De Meyer, 2011). They should make sure that roles and responsibilities assigned to team-members are unambiguous. To minimize or avoid conflicts, they should also make sure there is a common understanding upon those roles and responsibilities among d team-members (Day, 1998).

It is also a leader’s job to provide structure and motivation to members and to encourage cooperative behavior and team-work despite differences (De Meyer, 2011). They make sure stakeholders are informed about goals, roles and responsibilities, decisions, and other relevant information if they are directly or indirectly affected (Barczak, McDonough, & Athanassiou, 2006). They acknowledge and reward outstanding contributions. This rewarding behavior in turn is one of the factors that determine members’ attitude and performance (T. A. Judge & R. F. Piccolo, 2004; Lowe, Kroeck, & Sivasubramaniam, 1996; Podsakoff, Bommer, Podsakoff, MacKenzie, & Processes, 2006).

In a research by Weinkauf & Hoegl (2002), 15 factors that affect leadership were studies in project phases (the study consider 2 phases for projects). They find out that 6 factors were equally strong in both phases, 6 factors were slightly better in the first phase, and 3 factors were to some extent better in the second phase. All in all, there is not a significant difference in leadership between project phases (Weinkauf & Hoegl, 2002).

The effectiveness of leadership in industrial and business context can be assessed by both objective measures (such as ROI, sales increase, market share, profit margin, and cost per item produced) and more subjective measures (such as employee and customer satisfaction) (Yukl, 1998). In a project context, leadership can be assessed by investigating support facilitation, trust establishment, management outcomes, and the way roles and responsibilities are defined (V. S. Anantatmula, 2010). A decent leadership can considerably reduce transaction cost in projects as it facilitates the flow of work, decreases disputes and conflicts, and delivers the results faster (Li et al., 2015).

2.5.3.4.2 QUALITY OF DECISION MAKING

Construction industry context is known for special circumstances that considerably impact the quality of decision-making, namely, high complexity and uncertainty as well as multiple objectives and stakeholders (Virine & Trumper, 2019). Complexity of construction projects stems from the organizational structure of projects and from the fact that there are several stakeholders involved (Geraldi, 2008; Williams, 2003). Turner and Muller (2003) consider uncertainty as an inherent attribute of projects (Turner & Müller, 2003).

Complexity is a significant factor in understanding project management demands and various situations that PMs encounter in projects (Kähkönen, 2008). Managers in construction industry need to make decisions quickly due to complexity of the context (Elonen & Artto, 2003). Complexity can be in different forms, at different levels, and be caused by different sources based on project objective and context. The level of complexity can change over time (Marques, Gourc, & Lauras, 2011). Williams (2003) mention structural complexity as a form of complexity concerning project organization (Williams, 2003). Geraldi (2008) consider complexity of fact as a form of complexity which is pertaining to great volume of information that project manager has to deal with from different stakeholders.

Despite the limits in terms of time, available information, and cognitive abilities of human beings, managers are expected to make best decisions. Their decisions are in line with realization of the project objectives as well as meeting multiple stakeholders’ requirements (which are usually conflicting) (De Wit & Meyer, 2010). Greiner (1989) note that in order to benefit from practical and direct knowledge of lower level employees in terms of machinery and market, decisions should be made in the lowest level possible in an organization (Greiner, 1989).

To ensure the quality of decisions, decision-making processes are usually defined in organizations. Decisions should be made based on analysis and logic, rather than gut feeling and intuition. Gut feeling- and intuition-based decisions are mostly affected by manager’s mental models and tacit knowledge. Thus, they can be unreliable and biased as they are usually based on few variables that may be interpreted in specific ways (De Wit & Meyer, 2010). Quality of decisions can be measured by the quality of decision-making process and decisions outcome (Keren & De Bruin, 2003).

Sound decisions decrease the amount of rework, potential disagreements and disputes, project duration, and cost overruns. This in turn leads to lower transaction cost (Li et al., 2015).

2.5.3.4.3 QUALITY OF COMMUNICATION

Communication acts as organization blood. Managers depend on communication to perform their basic functions. A considerable amount of management time is dedicated to communication with stakeholders (Juneja).

Quality of communication is considered as a determinant of transaction cost in projects because it directly influences the occurrence of disagreements, disputes, and conflicts (Kumaraswamy, 1997). According to Haaskjold (2019), quality of communication, among the 26 determinants of transaction cost in Huimin Li’s (2015) model, was found to have the biggest impact on collaboration in construction projects (Haaskjold et al., 2019).

Through a proper communication, different parties in a project can develop a decent relationship. In addition to its direct impacts, communication affects transaction cost indirectly through its influence on leadership, conflict management, and technical competency (3 determinants of transaction cost in construction projects) (Li et al., 2015). An efficient and effective communication facilitates leadership as it decreases uncertainties regarding roles, responsibilities, and project goals which results in lower transaction cost (Barczak et al., 2006; De Silva & Ratnadiwakara, 2008). Through a decent communication, participants in a project can effectively share their experience and knowledge within a learning atmosphere and improve technical competency of the team (Li et al., 2015).

Communication is also an important success factor in projects. In an empirical study, based on surveys in Finland, Hyväri (2006) found out that communication is the most important success factor in projects (Hyväri, 2006). Based on her work, the importance of quality of communication as a success factor in projects is the same in planning, execution, and termination phase. However, it is slightly less important in the conceptualization phase. Pinto and Prescott (1988) assume communication to be a significant factor in execution phase. It is not considered as one of the five most important factors in whole project though (Pinto & Prescott, 1988). Finch (2003) also mentioned communication as one of the most important success factors in projects (Finch, 2003).

The importance of communication can be even more significant in projects that are conducted in another country than where they are managed. Issues regarding the differences in country and organization cultures (in terms of work and coordination practices) can negatively affect the whole project which should be overcome by communication (Duarte & Snyder, 2006; Verburg, Bosch-Sijtsema, & Vartiainen, 2013).

To improve the quality of communication with the intention of reducing the occurrence of disputes in construction, behaviors, processes, procedures, and policies should be changed. Merely improving the information flow would not considerably affect the occurrence of disputes (Love, Edwards, Irani, & Walker, 2009). PM and participants agree on means and frequency of communication at the beginning of a project to maintain a decent quality of communication.

By using specific project management software such as Primavera contract management, the quality of communication can be evaluated based on the content and number of phone calls, text messages, and emails between key stakeholders (Li et al., 2015).

2.5.3.4.3.1 FACTORS THAT AFFECT THE QUALITY OF COMMUNICATION

Various factors can impact the quality of communication such as communicational channels, communication openness, and the organization structure which can impede or facilitate the flow of information among stakeholders (Hellriegel & Slocum Jr, 1996b; Housel, 1977). Diallo (2005) mention trust as a significant factor that impacts communication in projects (Diallo & Thuillier, 2005). In addition, in author's Specialization Project, based on data from 98 construction projects, trust was proved to have a significant correlation with quality of communication.

Communication happens both verbally and nonverbally. The importance of nonverbal communication is significant as Wilson (1974) echo that people receive different types of information by verbal and nonverbal communication (Wilson, 1974). Communication channels might afford conveying different amounts of nonverbal communication. Nonverbal communication is greater in face-to-face communication than in phone calls. In the same way, phone calls facilitate nonverbal communication better than written channel like email. (Housel, 1977).

In addition, in a study by Dewhirst (1971), informal face-to-face interaction was found to be more preferable than written channels (Dewhirst, 1971). Face-to-face communication was also considered to be a better channel than phone calls by (Zaidel & Mehrabian, 1969). Wichman (1970) note that Cooperation is better in face-to-face situations (Wichman, 1970). Therefore, it seems reasonable to say that the quality of communication is better in face-to-face meetings than phone calls and it is better in phone calls than emails.

Trust is a factor that affects communication (Diallo & Thuillier, 2005). Haaskjold *et al. (2019)* note that trust is a factor that considerably impact the collaboration in construction projects. In the specialization project conducted by the author, a strong correlation was found between trust and the quality of communication in projects. Different aspects of trust can vary in different project phases which may affect communication in turn. Different authors have introduced different categorizations/aspects for trust. McAllister (1995) categorized trust into affect-based trust and cognition-based trust (McAllister, 1995). Lewicki and Bunker (1995) classify trust into deterrence-based trust, knowledge-based trust, and identification-based trust

(Lewicki & Bunker, 1995). Rousseau *et al.* (1998) introduced calculus-based trust, relational trust, and institution-based trust as 3 categories of trust (Rousseau et al., 1998). And finally, Hartman (2002) introduce competence trust, ethical trust, and intuitive trust as 3 classifications for trust (Hartman, 2002). Table 3 shows a summary of different aspects of trust stated by different authors.

TABLE 3 DIFFERENT ASPECTS OF TRUST STATED BY DIFFERENT AUTHORS

Author	Trust categories	Description
McAllister (1995)	Affect-based trust	It is based on the mutual concerns and emotional attachments between people. It enhances the mutual understanding between people and improves the connection of their values.
	Cognition-based trust	It is based on the ability and competence of the trustee in trustor's eyes to fulfil their promises based on contractual agreements.
Lewicki and Bunker (1995)	Deterrence-based trust	It is the lowest level of trust. It is based on fear of legal or financial punishments and termination of collaboration.
	Knowledge-based trust	It is based on the extent to which stakeholders know one another, so they can predict each other's behavior.
	Identification-based trust	It is based on stakeholders' mutual understanding. It is related to the extent to which parties have internalized each other's preferences and requirements to achieve an effective collaboration.
Rousseau (1998)	Calculus-based trust	It is based on trustee's willingness and competency to fulfil their promises and take care of trustor's interest.
	Relational trust	It grows as the parties spend time, interact, and get information about each other. It involves personal attachments and feelings.
	Institution-based trust	It related to stakeholders' perception of each other's trustworthiness which is based on the role of legal system, cultural rules, and social norms.
Hartman (2002)	Competence trust	Same as cognition-based trust, it is based on the stakeholders' perception of one another's competence and ability to perform their job.
	Ethical trust	It is the extent to which trustor believes that trustee takes care of their interest and is loyal to them.
	Intuitive trust	It is based on the gut feelings. It is the response to the question 'does it feel write?'. It can be considered as the starting point for decisions. Then the decisions can be analyzed logically.

Furthermore, Lloyd and Varey (2003) mention directly and implicitly some factors that impact communication, namely, personality clashes between managers, lack of employees' understanding about each other's roles and responsibilities, communication channel (face-to-face is considered to be the most preferred communication channel), ease of access to information, staff changes in projects, and manager's interest in improving communication. They also note that informal ways of communication are considered to be the best if possible because "it ensures a continuous positive influence and support which helps to expose and solve problems as a team amicably, sensibly, and democratically" (Lloyd & Varey, 2003). About informal communication, Christensen (2008) state that it is an effective way of discussing and finding solutions (Christensen, 2008). On the contrary, an employee survey by Foehrenbach and Goldfarb (1990) show that the respondents preferred formal communication channels for receiving information (Foehrenbach & Goldfarb, 1990). A balance between formal and informal communication would lead to best results (Turner & Müller, 2004). Any of these factors may vary in different project phases due to phase nature and requirements as well as contextual factors.

In addition, uncertainty can also be a factor that affects the quality of communication. Hellriegel & Slocum (1996) define uncertainty as "the gap between the amount of information needed for a task and the amount of information available". To overcome uncertainty, organizations need to have either extra information and better communication (vertical information systems and lateral relations) or buffer resources (Hellriegel & Slocum Jr, 1996a). Thus, to deal with uncertainty, project team members may choose to use better communication channels like face-to-face or video call meetings instead of email (as a one-way communication means) which increases the quality of communication as a result. Furthermore, uncertainty is a determinant of transaction cost that has a great impact on the quality of client-contractor collaboration in construction projects (Haaskjold et al., 2019).

The difference of aforementioned factors in project phases can lead to a difference in quality of communication between the phases.

2.5.3.4.4 CONFLICT MANAGEMENT

Conflict is inherent in human relationships. As mentioned earlier in this section, transaction cost economics takes into account human and environmental factors such as conflicts. Thus, conflict management is considered as a determinant of transaction cost in construction projects.

A project is meant to satisfy requirements of different stakeholders which are usually conflicting within construction industry. A project manager needs to prioritize requirements of some key stakeholders over the others due to limited resources which can cause conflict. There are other factors that also contribute to high amount of conflicts in construction industry (a competitive multiparty environment) such as complexity, inadequate planning, size of work, financial issues, poor contract preparation, and site-related issues (Harmon, 2003).

Conflict management is a negotiation-based process that continuously responds to identified conflicts (Curcija, Breakey, & Driml, 2019). It is a major component of project management in construction industry (Gardiner & Simmons, 1995). The purpose of the process is to resolve the conflicts between stakeholders that have different interests regarding something serious and important (Jones, 1994). An effective conflict management requires a structured process which is introduced and utilized in the beginning of a project.

In a project, valuable resources can be wasted on conflicts and their associated transaction costs. Therefore, conflict management can have a considerable effect on efficiency of project management as it helps to avoid many conflicts in the first place (Jergeas & Hartman, 1994). Transaction costs regarding conflicts include the cost of conflict and litigation such as the cost of claim advisor, lawyer, fines for delay in project completion, and management time. It also includes the costs of filing claims as well as renegotiation and modification of contracts (Oliver E Williamson, 1985; Yates, 1999). The extent to which a company monitors their contractual conflict resolution methods is a measurement to assess their conflict management capabilities (Li et al., 2015).

TABLE 4 FIVE DETERMINANTS OF TRANSACTION COST UNDER PROJECT MANAGEMENT EFFICIENCY CATEGORY IN LI ET AL. (2015) MODEL

Category	Factors	Description
Project management efficiency	Leadership	Leadership is the art of recognizing and developing capabilities to fulfil goal and objectives. Leaders align people with project goals based on their knowledge, skills, and competence. They develop an environment of trust, cooperation, support, and learning. A decent leadership can considerably reduce transaction cost in projects as it contributes to a decent flow of work, fewer disputes and conflicts, and on-schedule or ahead of schedule delivery of results. (V. S. Anantatmula, 2010; Bass & Bass, 2009; De Meyer, 2011; Li et al., 2015)
	Quality of decision-making	High complexity and uncertainty as well as multiple objectives and stakeholders impact the quality of decision-making in construction industry. Managers should follow decision-making processes to make informed unbiased decision based on logic and analysis than intuition and gut feelings. Sound decisions lead to lower transaction cost as they decrease the amount of rework, potential disagreements and disputes, project duration, and cost overruns. (De Wit & Meyer, 2010; Li et al., 2015; Virine & Trumper, 2019)
	Quality of communication	Communication acts as organization blood. Project manager and participants agree on means and frequency of communication at the beginning of a project. A decent communication decreases transaction cost as it affects the occurrence of conflicts. In addition, it affects leadership, quality of decision-making, and conflict management which also leads to lower transaction cost. (Juneja; Kumaraswamy, 1997; Li et al., 2015)
	Conflict management	In a project, conflicts can arise a result of conflicting interests of different stakeholders. A decent conflict management reduces transaction cost as it saves costs regarding lawyer, filing claims, litigation, project delay, management time, and renegotiation and modification of contracts. (Li et al., 2015; Oliver E Williamson, 1985; Yates, 1999)
	Technical competency	Technical competency is about company's knowhow as well as equipment and machinery to conduct the physical realization of project. It is also about the eligibility and experience of technical staff. Adequate technical competency contributes to fewer reworks, smooth operation, speedy decisions, and easy communication which results in lower transaction cost. (Carey, Subramaniam, & Ching, 2006; Isik et al., 2010; Li et al., 2015)

2.5.3.4.5 TECHNICAL COMPETENCY

Technical competency is pertaining to both equipment and skills. Isik *et al.* (2010) relates technical competency to 2 items, 1- the company's machinery and equipment to physical realization of the project and 2- the company's technical knowhow to conduct their projects such as technological expertise, system design, industry specialization, and risk management skills (Isik, Arditi, Dilmen, Talat Birgonul, & Management, 2010). Adequate technical competency contributes to fewer reworks, smooth operation, speedy decisions, and easy communication which results in lower transaction cost (Carey, Subramaniam, & Ching, 2006).

Warszawski (1996) mention quality of the product, the speed and productivity of construction activities, experience of technical staff, preferred construction methods as measurements to assess technical competency of a company (Warszawski, 1996). To evaluate a project team's technical competency, their routine guidelines regarding the qualification process of bidding processes can be analyzed (Li et al., 2015). A summary of the 5 aforementioned determinants of transaction cost is presented in Table 4.

2.6 Project phases

A project can be divided into different phases. Different phases represent different stages in development of a project which is referred to as project life cycle. It is important to consider a project as different phases that together form project lifecycle in order to understand the contribution of each stage to project logic and goal. It facilitates planning for projects based on requirements and circumstances of each phase. For instance, it helps scheduling resource allocation in planning process. It also helps to visualize the challenges and required activities in a project (Pinto, 2013).

Dividing project lifecycle to phases also helps governance of projects. For example, a project manager would know better how to evaluate progress in each stage which makes the monitoring process easier. Project team can consider phases as viewpoints based on which the actual performance and work is compared with planned work to check project status in terms of cost, schedule, and quality. Necessary, correction, rework, and over-time work would be conducted if needed (Pinto, 2013).

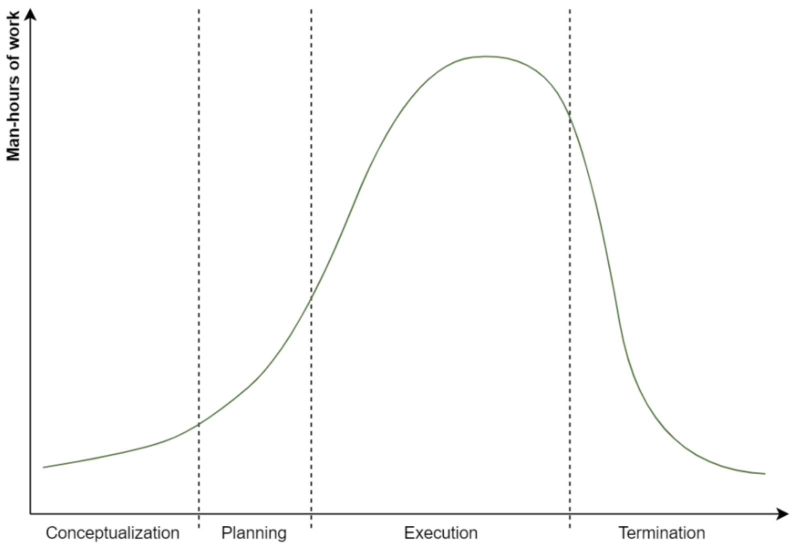

FIGURE 4 DIFFERENT PHASES OF PROJECT BY PINTO (2013)

Based on Figure 4, Pinto considers 4 phases for a project, namely, conceptualization, planning, execution, and termination. Table 5 provides a description of different project phases. Different authors considered different number of and names for phases in a project. For example, in PMBOK, 5 phases/process groups are mentioned for projects, namely, initiating, planning, execution, monitoring and controlling, and closing (Rose, 2013). However, Bassam Hussein considered starting, planning, execution and control, and handover as different phases/stages in a project life cycle (Hussein, 2018). In CII1010 database, 5 phases are mentioned for projects, namely, front-end planning/Programming, engineering/design, procurement, construction, commissioning/start-up (Yun et al., 2016). Here, front-end planning/programming is equivalent to the conceptualization phase, engineering/design is equivalent to the planning phase, procurement together with construction is equivalent to the execution phase, and commissioning/start-up is equivalent to the termination phase. This is shown in Table 8 methodology section.

TABLE 5 DESCRIPTION OF DIFFERENT PROJECT PHASES BY PINTO (2013)

Phase	Description
Conceptualization	In this phase, initial goal and specifications are developed, scope and resources (including human resource, machine, material, and money) are determined, and stakeholders are identified and contacted.
Planning	In this phase, detailed plans, schedules, schematics, and specifications are developed, project management assisting tools such as work break-down structure (WBS), critical path method (CPM), and Program Evaluation Review Technique (PERT) are developed, individuals' responsibilities are defined, and all necessary process for project completion are mentioned.
Execution	During this phase, the physical realization of the project is performed, and the product/result of the project is produced. The spent man-hour reaches a pick in this phase of project (Figure 4).
Termination	In this phase, the output of the project is handed to the customer, resources are allocated for other purposes, and the project is formally closed out. As a result, resource consumption drops drastically in this phase.

Different factors and features such as uncertainty, importance of decisions, available information, flexibility, resource consumption, and client interest in a project can be assessed with regards to different phases. As a project progress over time from conceptualization to termination phase, the operational uncertainty reduces gradually. The contextual uncertainty is almost the same throughout the project though (N. Olsson, 2006; Pinto, 2013; Samset, 2014). The importance of decisions is also decreased over time in a project since the initial decisions about project and product specifications can basically change the results (Samset, 2014). However, the amount of available information increases over time in projects (N. O. Olsson, 2006; Samset, 2014). Resource consumption grows over time and has a pick in execution phase and then decreases in termination phase The abovementioned factors and features throughout project are depicted in Figure 5.

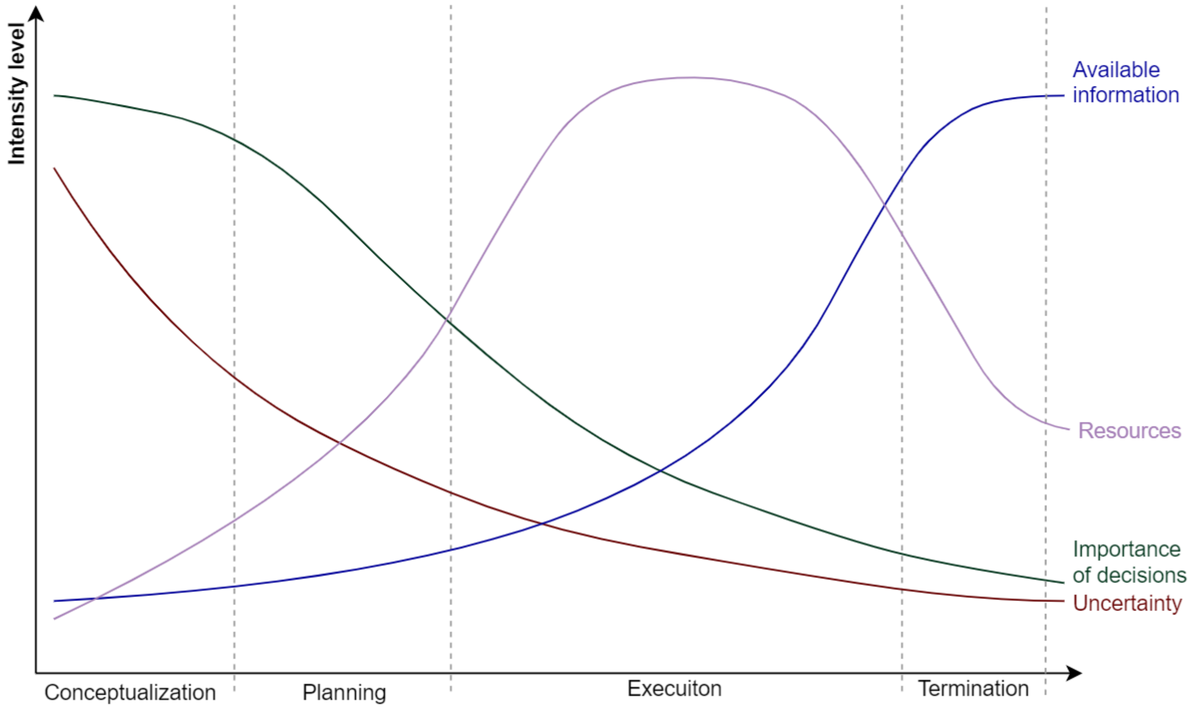

FIGURE 5 DIFFERENT FACTORS AND FEATURES THROUGHOUT PROJECT

Many features and factors can vary in different phases. Consequently, determinants of transaction cost, i.e., leadership, quality of decision-making, quality of communication, conflict management, and technical competency (based on the scope of this paper), might also vary in different phases. This is the topic of this paper.

2.7 Research gap

Although the roots of research on transaction cost goes back to 1930's, this field of study started to be taken seriously in the study of economy and management since 1980's specially through Oliver E. Williamson's work on transaction cost. In fact, he received a Nobel prize in 2009 for his work regarding using transaction cost lens for the study of complex economic phenomena. Research on the application of transaction cost theory to construction projects started almost in 2000. Thus, the subject is relatively new and needs more research on.

Transportation Research Board (TRB) considers transaction costs as 'soft costs' because transaction costs are subtle costs that cannot be easily measured and quantified. Dudkin & Välilä (2006) mention a lack of empirical studies on quantification of transaction cost because the available empirical data on transaction cost is limited and the data is usually confidential (Dudkin & Välilä, 2006). Li *et al.* (2015) echo that there have been only a few quantitative studies on transaction cost in construction industry and most of studies are limited to the Public-Private-partnership (PPP) type of projects. The existing literature also mostly limited to the procurement phase of projects although transaction costs are usually higher in the execution phase (Li et al., 2015).

In addition to Dudkin & Välilä (2006), Haaskjold *et al.* (2019), Guo *et al.* (2016), Li *et al.* (2015), Rajeh *et al.* (2015), De Schepper *et al.* (2015), and Farajian (2010) also mention a need for more empirical research on transaction cost in construction projects (De Schepper et al., 2015; Dudkin & Välilä, 2006; Guo et al., 2016; Haaskjold et al., 2019; Li et al., 2015; Rajeh et al., 2015). Furthermore, Li *et al.* (2015) call for more empirical research on their model for determinants of transaction cost in construction projects.

In conclusion, there is a need for more empirical research on transaction cost in construction project context which includes all project phases (not only the procurement phase) and is not limited to a specific type of contractual arrangement (not only Public-Private-Partnership projects).

3 Methodology

In the first place, this paper was conducted to fill the research gap regarding a lack of empirical research on transaction cost in construction projects which mentioned by different authors such as Dudkin *et al.* (2006), Farajian (2010), Rajeh *et al.* (2015), Li *et al.* (2015), Guo *et al.* (2016), and Haaskjold *et al.* (2019). This research is also a response to a call by Li *et al.* (2015) for more empirical research on his model for determinants of transaction cost in construction projects.

It is quite significant to adopt an appropriate method to conduct a research based on the field of study, research objective, available data, tools, and resources. In this section, different steps for conducting the paper is described including reasoning, advantages, and limitations of the choices that are made where needed.

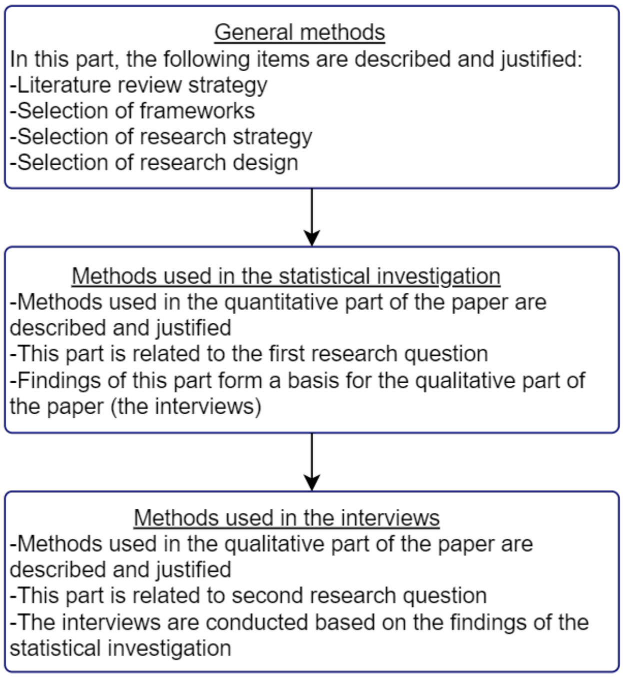

Figure 6 The structure of the methodology section

This paper consists of 2 parts, i.e., 1-the main part which is a quantitative investigation and 2-qualitative investigation. 1-In the main part, a statistical investigation is conducted on data for 142 projects in CII1010 benchmarking database. The purpose is to investigate the first research question, i.e., to check if there is a statistically significant **difference** in factors that affect transaction cost between project phases. In other words, in the first part of the paper, the data from CII1010 database is statistically checked to see which factors (that affect transaction cost) are distinctively different between which phases. Thus, the first part of the paper is quantitative. The findings of the first part of the paper form the basis for the second part.

2-In the second part, the reasons for the **differences** (found in the first part) is investigated through interviews with project managers within construction industry. Thus, the second part of the paper is qualitative and related to the second research question. It is meant to bring a deeper understanding of the topic to the readers.

Based on the logical order of the investigation in this paper (shown in Figure 3), this section is categorized into 3 main parts. 1- In the first part, general methods regarding literature review strategy as well as selection of frameworks, research strategy, and research design are described and justified. 2- In the second part, methods used in the statistical investigation related to the first research question are described and justified. 3- In the third part, methods used in the qualitative part of the study (interviews) is described and justified. This part is pertaining to the second research question. Finally, criticisms to the research method is presented at the end of this section.

Figure 6 illustrates the structure of this section which is structured in accordance with the logical relation between quantitative and qualitative parts of the paper depicted in Figure 3.

3.1 General methods

3.1.1 Literature review

To conduct this study, papers and books in addition to prior knowledge of the author about the transaction cost were studied. The studied literature includes vey first studies on transaction cost economics by Coase 1973 to the recent studies on transaction cost such as transaction cost theory and approach, transaction cost in construction industry, and quantification of transaction cost. In addition, based on the topic and research objective, literature about CII1010 database and different frameworks for project characteristics were studied. The literature study process was carried out intensively in the beginning and also during the whole process of conducting the paper.

The literature was gathered from two main databases, namely ntnu.oria.no and scholar.google.no. There was an emphasis on Oria to assure the validity of results. In addition, some of the literature was suggested by the supervisor. Literature that was found on online databases was filtered first, based on the relevance of their topic, and second, by the relevance of their content. The data on CII1010 database was provided by supervisor having access to the database. The statistical investigation and interpretation of results was mainly based on the book Social Research Methods by Alan Bryman.

3.1.2 Frameworks

After literature study, finding the research gap, and defining the research objective, it is needed to specify frameworks through which the research objective is to be investigated.

To fulfil the research objective, a framework must be selected for determinants of transaction cost in construction projects. Dudkin and Välilä (2006), Farajian (2010), and Li *et al.* (2015) introduced models for this purpose. **Dudkin and Välilä (2006)** mention 6 factors as determinants of transaction cost in construction projects, namely, project country, economic sector, project size, length of procurement process, number of bidders, the year when the project was signed. This model is focused on the procurement phase of the projects and is also limited to Public-Private Partnership (PPP) projects (Dudkin & Välilä, 2006). **Farajian (2010)** note 4 factors that affect transaction costs, namely, number of bidders, project value, procurement time (PPP complexity), and PPP maturity level. This model is also limited to the procurement phase of PPP projects (Farajian, 2010). **Li *et al.*'s (2015)** model was selected as a framework for determinants of transaction cost in construction projects in this study because it entails all phases of project (in line with the research objective) and because it is applicable to all types of construction projects (not only PPP projects). A summary of this information is shown in Table 2 in theory section. Huimin Li's model for determinants of transaction cost in construction projects is shown in Figure 1 in introduction section.

In this paper, factors that affect transaction cost are compared in different phases of projects. Projects can be divided into different phases such as conceptualization, planning, execution, and termination (Pinto, 2013). In fact, different authors considered different number of and names for project phases. For example, in PMBOK, 5 phases/process groups are considered for projects, namely, initiating, planning, execution, monitoring and controlling, and closing (Rose, 2013). However, Bassam Hussein mentioned starting, planning, execution and control, and handover as different phases/stages in a project life cycle (Hussein, 2018). In this study, Pinto's naming for project phases is selected as it is more in line with the project phases in CII1010 database as it does not comprise controlling process. This is shown in Figure 4 in theory section.

3.1.3 Research strategy

Basically, social research can be done either quantitatively or qualitatively. A combination of the methods is possible as well. In a quantitative research, the relationship between 2 or more factors is investigated by collecting numerical data and then running statistical tests on them. On the other hand, qualitative research strategy usually consists of words rather than numerical data and statistical calculations (Bryman, 2016).

Based on the research gap (which mention a lack of quantitative research in the area of study), the main part of this paper is decided to be conducted quantitatively. Besides, the main part of this paper is related to the first research question in which the relation between 'factors that affect transaction cost' and 'project phases', as 2 factors, is investigated. Based on the description of quantitative research strategy by Bryman (2016), this strategy is suitable for this type of investigation.

The second part of the paper is related to the second research question in which the reasons for the findings of the first part is investigated. Based on the description of qualitative research strategy by Bryman (2016), this strategy is found to be suitable for the second part of this paper.

3.1.4 Research design

In this paper, a cross-sectional/survey design is applied. There are different research designs as frameworks for collecting and analyzing data. Bryman 2016 consider 5 research designs i.e. experimental design, cross-sectional/survey design, longitudinal design, case study design, and comparative design (Bryman, 2016).

<u>Experimental design</u> within the context of social science is not very usual and is mostly used to assess the impact of a change like a new policy or a reform on organizations.

Cross-sectional/survey design includes the collection of data on 2 or more cases at a single point of time, regarding 2 or more variables, in order to investigate patterns of association. It can be conducted in the form of survey, questionnaire, interview, structured observation, content analysis, official statistics, and diaries.

Longitudinal design is not quite common because it is costly and time consuming. It can be considered as an extended form survey design which is usually used for topics such as human geography, sociology, and social policy within social science context.

Case study design comprises detailed and intensive analysis of a case in a specific setting. The case can be of a critical, extreme or unique, representative or typical, revelatory, and longitudinal type (Yin, 2009).

Comparative design includes studying 2 very different cases using same methods. It is mainly used to gain a better understanding of social phenomena by comparing them in meaningfully different cases.

Among the presented research designs, cross-sectional/survey design is found to be the most relevant to the topic and research objective because in order to see how transaction cost can vary in different phases of projects, different case companies should be studied within construction industry in terms of patterns of association between transaction cost and project phase variables.

3.2 Methods used in the statistical analysis

The statistical analysis on data from CII1010 database constitutes the main part of the paper which is related to the first research question. Here, the methods used in the statistical investigation are described and justified.

3.2.1 Data collection

The main part of this paper is conducted using secondary analysis method of data collection which basically means that the author runs analysis on data which is collected by others rather than collecting data himself. CII1010 is selected as a database for this purpose.

To conduct a research, one may use questionnaire, interviews, structured observation. This can be considerably costly and time consuming. Therefore, instead, they may choose to analyze the data that is collected by governments, social scientists, and organization that work in this area. Using secondary analysis would be cheaper and less time consuming. In addition, it can provide the research with high quality data that is collected in a time span by organization and scientists that are specialist at designing surveys and collecting data (Bryman, 2016). To benefit from these advantages, secondary analysis of data is applied in this paper.

In this study, the data that is provided by CII1010 is of a high quality because first, the sampling process is quite comprehensive and accurate (Yun et al., 2016), and second, it entails data related to 142 national projects in Norway by both public and private sector which is a decent sample size.

3.2.2 CII1010 benchmarking database

To collect data for this paper, CII1010 was selected as a database. Dudkin2006 mention that the reason for inadequate research on quantification of transaction cost in construction industry is that there is limited data available for transaction cost and often, the data is confidential (Dudkin & Välilä, 2006). To overcome the 2 obstacles, CII1010 database is found to be a decent solution that entails data regarding performance of 142 construction projects in Norway. The data is collected in form of survey. It is phase-wise, in great details, and with high quality (Yun et al., 2016). Therefore, CII1010 was selected to provide data for statistical investigation in this paper because it is in line with the research objective and choice of research design and data collection (secondary analysis). Using CII1010 database as a secondary analysis also has some potential drawbacks which is mentioned in section 3.4 Criticism to the method).

3.2.2.1 How CII1010 works?

CII1010 is an online benchmarking program that is designed to assess project performance. It includes two sets of KPIs, one regarding leading performance measurements (input measures) and one related to lagging performance measurements (output measures). Input and output measures are presented in Table 6. The results of each leading and lagging KPI is depicted in a box plot. Each box plot is divided to 4 quartiles representing different performance levels from worst to best performance. Performance level of the ongoing project is indicated with a dot in the box plot in relation to other similar projects (Yun et al., 2016) (CII1010 user manual). A sample of the box plots regarding the input measures are presented in Appendix D (Yun et al., 2016).

Table 6 Input and output measures in CII1010 database

10 Input measures	10 Output measures
Planning	Total Project Cost / Capacity
Organizing	Total Project Schedule / Capacity
Leading	Phase Cost / Capacity
Controlling	Phase Schedule / Capacity
Design Efficiency	Phase Cost Growth
Human Resources	Phase Schedule Growth
Quality	Capacity Efficiency
Sustainability	FTE / Total Project cost
Partnering and Supply Chain	FTE / Cost (includes Complexity)
Safety	Phase Cost / Phase Schedule

Surveys at CII1010 are to be filled out at the end of each phase, during the course of a project. This would be beneficial to the respondents (project team) because they can compare their performance in each phase with other projects of the same type. Therefore, they would have the opportunity to compensate their poor performance by developing proactive strategies for the following phases projects (Yun et al., 2016).

The data at CII1010 is categorized based on project phases and is collected in the form of surveys (Yun et al., 2016). A trained representative of CII1010 participates in the program at the companies for training purposes in order to increase the accuracy of the data by increasing the understanding of the respondents of the survey. The data is also categorized for 3 different types of construction projects, namely, infrastructure, industrial, and building (Yun et al., 2016) (CII1010 user manual).

3.2.3 Using CII1010 database to conduct this paper

Finally, after literature study, defining research objective, selecting needed frameworks, and determining the attributes of the research method, it is time to use the database for statistical investigation.

According to the scope of the paper, the desired determinants of transaction cost for investigation are leadership, quality of decision-making, quality of communication, conflict management, and technical competency (the factors related to project management efficiency category). To find transaction cost-related questions/variables in CII1010 database, each question in the database was analyzed to see if they can measure one of the desired factors. Subsequently, the variables are selected and grouped together in the form of constructs. Table 9 contains the variables of each construct and the supporting references found in the literature.

During the statistical analysis, the mean score of each construct (each construct measures a determinant of transaction cost within the scope) is measured with regards to each phase of projects. As a result, factors that affect transaction cost can be investigated in different project phases. In other words, the objective of the paper would be fulfilled.

It is significant to mention that the data on CII1010 is categorized to 5 phases. Number of projects registered in each phase is different. The phases and the number of projects in each phase are available in Table 7. Pinto however, introduces 4 phases for projects which are presented in Figure 4 (Pinto, 2013). To maintain the precision of the results of the statistical investigation, the number of phases in Pinto (2013) and in CII1010 database should be the same. Project phases in both Pinto's book and CII1010 database are similar in terms of definition, except from procurement which is an extra phase in CII1010. In this paper, procurement phase together with construction phase in CII1010 is considered as one single phase, 'construction', which would be equivalent to the execution phase by Pinto. Consequently, the number of projects for construction phase in statistical calculations is 7+49=56. This phase would be equivalent to execution in Pinto's model. This is shown in Table 8.

TABLE 7 PROJECT PHASES AND THE NUMBER OF PROJECTS REGISTERED IN EACH PHASE IN CII1010 DATABASE

The project phases in CII1010	The number of projects registered in CII1010 in each phase
1- Front-end planning/Programming	29
2- Engineering/Design	54
3- Procurement	7
4- Construction	49
5- Commissioning/Start-up	3

Table 8 Equivalent project phases in CII1010 and Pinto (2013) together with the number of projects registered for each phase in CII1010

Project phases in CII1010 database + sample size	Equivalent project phases by Pinto
1- Front-end planning/Programming (29)	1- Conceptualization (29)
2- Engineering/Design (54)	2- Planning (54)
3- Procurement+ Construction (56)	3- Execution (56)
4- Commissioning/Start-up (3)	4- Termination (3)

Table 9 The variables of each construct and the supporting references found in the literature. Source: The specialization project of the author.

Construct	Questions	References
Leadership	102. The project's Startup objectives were appropriately communicated to the relevant project team members.	(Barczak et al., 2006; Li et al., 2015)
	106. Project leaders were open to hearing bad news, and they wanted input from project team members.	(Housel, 1977; Li et al., 2015)
	109. Project management team members were clear about their roles and how to work with others on the project.	(Barczak et al., 2006; Bennett & Jayes, 1995; Stephenson, 1996)
	110. People on this project worked effectively as a team.	(Bennett & Jayes, 1995; Li et al., 2015; Stephenson, 1996)
	112. The Procurement strategy and plan were developed and communicated to the project team during Programming.	(V. S. J. E. M. J. Anantatmula, 2010; Barczak et al., 2006; De Meyer, 2011; Li et al., 2012)
	114. Key project team members understood the owner's goals and objectives of this project.	(V. S. J. E. M. J. Anantatmula, 2010; Barczak et al., 2006; Bennett & Jayes, 1995)
	115. All the necessary, relevant project team members were involved in an effective risk identification and management process for design.	(V. S. J. E. M. J. Anantatmula, 2010; Li et al., 2015)
	116. Project team members had the information that they needed to do their jobs effectively.	(Barczak et al., 2006; Li et al., 2015)
	120. The owner level of involvement was appropriate.	(Li et al., 2015)
	126. Leadership effectively communicated business objectives, priorities, and project goals.	(Barczak et al., 2006; Li et al., 2015)
	130. Project leaders recognized and rewarded outstanding personnel and results.	(T. A. Judge & R. F. J. J. o. a. p. Piccolo, 2004; Lowe et al., 1996; Podsakoff et al., 2006)
	152. The key stakeholders (owner, designers, vendors, and suppliers) were fully aligned during design and construction.	(De Meyer, 2011; Kotter, 2000; Li et al., 2012)

Quality of decision making	007b. Decisions were co-operative and inclusive.	(Abe et al., 2006) (Zaraté, 2013)
	007c. Decisions were made at the lowest possible level in the organization.	(Greiner, 1989)
	007e. Decisions were made effectively and timely.	(Elonen & Artto, 2003)
	007f. Decisions were in line with delegated authority.	(Greiner, 1989)
Quality of communication	102. The project's Startup objectives were appropriately communicated to the relevant project team members.	(De Silva & Ratnadiwakara, 2008) (Li et al., 2015)
	106. Project leaders were open to hearing bad news, and they wanted input from project team members.	(Housel, 1977) (Li et al., 2015)
	112. The Procurement strategy and plan were developed and communicated to the project team during Programming.	(Barczak et al., 2006; De Silva & Ratnadiwakara, 2008; Li et al., 2015)
	126. Leadership effectively communicated business objectives, priorities, and project goals.	(Barczak et al., 2006; De Silva & Ratnadiwakara, 2008; Housel, 1977)
	131. Plan and progress including changes were communicated clearly and frequently amongst project stakeholders.	(Barczak et al., 2006; De Silva & Ratnadiwakara, 2008; Housel, 1977)
Conflict management	117. When issues arose, there were effective mechanisms to ensure they were resolved	(Assael, 1969; Jones, 1994)
Technical competency	122. The project's work processes and systems (e.g., document management, project controls, business, and financial systems) supported project success.	(Carey, Subramaniam, Ching, & Finance, 2006; Li et al., 2015)
	123. The project team including project manager(s) had skills and experiences with similar projects/processes.	(Carey, Subramaniam, Ching, et al., 2006; Isik et al., 2010; Li et al., 2015)

3.2.4 Hypothesis

The following is the null hypotheses (H0) formulated based on the first research question:

1A: There is no statistically significant difference in factors that affect transaction cost between conceptualization and planning phase.

1B: There is no statistically significant difference in factors that affect transaction cost between conceptualization and execution phase.

1C: There is no statistically significant difference in factors that affect transaction cost between planning and execution phase.

3.2.5 Data analysis

This section is about the statistical analysis of the data which is conducted mostly based on the book Social Research Methods by Alan Bryman. The first step in data analysis is to determine the type of the variables in the database. It is known as variable level. Other statistical investigations can be conducted based on the variable level (Bryman, 2016). In addition, sample size, normality, reliability, and validity of the data is investigated in this section. Finally, to fulfill the purpose of the paper, t-test and Mann-Whitney U test are conducted on the data regarding transaction cost in different phases of the projects.

3.2.5.1 Variables

The tools for data analysis can vary based on the type of variables in surveys. Thus, it is of high importance to determine the type of the variables (variable levels) in very first stages of the statistical assessment. Basically, there are 4 types of variables that are described in Table 10 (Bryman, 2016).

TABLE 10 DESCRIPTION OF DIFFERENT TYPES OF VARIABLES. SOURCE: BRYMAN (2016).

Variable	**Feature**
Interval/ratio variables	The values for these variables are defined in categories with 2 attributes: 1- the distance between categories is meaningful and 2-the distances between categories are identical. The only difference between interval and ratio variables is that for ratio variables, a fixed zero point is defined.
Ordinal variables	Possible values for these variables are ordered and can be ranked above or below each other.
Nominal/categorical variables	These variables include categories like different colures that are not in order and cannot be ranked over or below each other.
Dichotomous variables	The value categories for these variables are twofold, like gender and yes/no questions. They can be treated as any of the abovementioned variables based on the circumstances. In this paper, the dichotomous variables are treated as interval variables.

In this paper, data is provided by CII1010 database. There are 2 types of questions/variables in CII1010:

1- Q001 to Q040 are yes/no questions or dichotomous variables. These variables are used in the quality of decision-making construct which is shown in Table 9. On CII1010 database, the dichotomous variables are not aimed to be considered and interpreted solely based on the 0-1 answers to the questionnaire. Instead the mean of the values given by team members of each project is considered as the value of the variable on the database (CII1010 manual). Thus, the values for each variable are practically a number between 0 and 1 with 2 decimals. As a result, the grounds are provided to treat these variables effectively as interval variables (Bryman, 2016).

2- Q101 to Q188 (used in leadership, quality of communication, conflict management, and technical competency constructs) are based on a 1-5 Likert scale in which 1 indicates strongly disagree and 5 indicates strongly agree; the questions are considered as interval variables. Joshi *et al.* (2015) state that a variable with Likert scale values can be considered as an interval variable because the values can be rank ordered and because the intervals between the values are equal (Joshi, Kale, Chandel, & Pal, 2015). Furthermore, some studies like Baggaley & Hull, 1983; Maurer & Pierce, 1998; and Vickers, 1999 support the idea of treating Likert scale variables as interval variables. James brown mention that to treat the Likert scale variables as interval variables effectively, the scale values should cover at least 5 and preferably 7 classifications (Baggaley & Hull, 1983). This condition is satisfied in this paper as the questionnaire is formulated based on a 1-5 Likert scale.

In conclusion, all variables in this study are to be treated as interval variables.

3.2.5.2 Sample size

The impact of sample size on statistical analysis is substantial. Large sample size decreases the impact of sampling errors and increases statistical power. When the sample size is large, the difference of a sample data from normal distribution and its effect on results can be considered less important or even negligible. Hair *et al.* (1998) state that considerable departure from normality can have a significant effect on the results when the sample size is smaller than 50 and specially 30 (Hair, Black, Babin, Anderson, & Tatham, 1998). The sample size smaller than 50 is considered as small and smaller than 30 is considered as very small.

The sample sizes of different constructs in this paper are shown in Table 8. As shown in the table, based on Hair *et al.* (1998), the sample size of the constructs in this study is either in the very small range (29) or very close to the small range (54 and 56). Thus, departures from normality should be treated carefully. The sample size for the termination phase is 3 which is quite few. This can negatively impact the precision of the results. Therefore, this phase shall be excluded from the further analysis in this section.

Resources are considerably tighter in the beginning (conceptualization phase) and at the end (termination phase) of projects (Pinto, 2013; Sohmen, 2002). Thus, these 2 phases apparently do not receive as much attention as the other 2 phases. This can be a reason that the number of projects registered on CII1010 in the termination phase is only 3, Which led to the exclusion of this phase from statistical investigation in this paper.

3.2.5.3 Normality

Since the variables are considered as interval, normality of the data can be investigated. Based on the normality results, it can be decided to use either parametric or nonparametric tests on the data. Parametric tests can be applied to normal data. Nonparametric tests can be used for both normal and non-normal data (Bryman, 2016; Hair et al., 1998). Further in the paper, the internal consistency of the constructs will be investigated, and a T-test will be conducted. Normality of the data impacts these 2 assessments.

3.2.5.3.1 SKEWNESS AND KURTOSIS

To investigate normality, the data should be examined in terms of the extent to which it resembles a normal distribution. There are 2 factors for that purpose, namely, skewness and kurtosis. In a distribution, skewness is a measure of lack of symmetry. In order for a distribution to be considered as normal, the Z value for skewness ($Z_{skewness}$) must be between +/-2.58 at significance level of .01 (Hair et al., 1998).

$Z_{skewness}$=skewness/standard error

Kurtosis is the extent to which the distribution is heavy tailed compared to the normal distribution. In other words, kurtosis is about density of the data around the average. For a distribution to be considered approximately as normal, Z value for kurtosis ($Z_{kurtosis}$) must be between +/-1.96 at significance level of .05 (Hair et al., 1998). The acceptable normal range of $Z_{skewness}$ and $Z_{kurtosis}$ are presented in Table 11.

$Z_{kurtosis}$=kurtosis/standard error

Table 11 The acceptable normal range of Z(skewness) and Z(kurtosis)

		Minimum acceptable Z value	Maximum acceptable Z value	Significance level
Criteria for normal distribution	Skewness	-2.58	+2.58	0.01
	Kurtosis	-1.96	+1.96	0.05

In this study, the aforementioned factors should be measured for the constructs (dependent variables) in different phases (independent variables) because the mean score of each construct is to be assessed in each phase. To investigate normality, skewness and kurtosis for each construct was measured using *IBM SPSS 26.0.* results are presented in Table 12.

There are also two statistical tests for normality, Shapiro-Wilks test and Kolmogorov-Smirnov test, which measure the level of significance for the differences from a normal distribution. These tests are not quite useful for small sample size especially smaller than 30 (Hair, Black, Babin, Anderson, & Tatham, 2006). In this paper, sample sizes are 29, 54, and 56 for different phases. The sample size for one phase is too small. Therefore, the aforementioned tests are not conducted in this study. Instead, deviations from skewness and kurtosis of a normal distribution is assessed very carefully. The nonparametric tests are conducted for constructs with high skewness or kurtosis even when the measures are within the acceptable range but close to the limits.

3.2.5.3.2 RED HIGHLIGHTS IN TABLE 12

The red highlights indicate unacceptable divergence from normality in constructs. Nonparametric test must be used for these constructs. Leadership construct in conceptualization phase and quality of decision-making construct in planning phase are considered non-normal. The next two paragraphs describe it in more details.

The skewness measure for the leadership construct in conceptualization phase, marked in the table, is slightly (.03) out of acceptable range. According to Figure 9 and also based on the dataset, the reason can be that two projects have considerably low performance in their conceptualization phase which skewed the distribution to the left in this construct. In fact, the data set was examined excluding the two projects and the resulting skewness found to be within the acceptable range. The divergence from the limit is very small (.03), but to ensure the accuracy of the results, both parametric and nonparametric tests are conducted for comparing transaction cost in different phases. Thus, leadership in conceptualization phase is considered **non-normal**.

Kurtosis for quality of decision-making construct in planning phase is unacceptable. This is because the concentration of the data in the middle of distribution is high compared to normal distribution. Therefore, it is **not approximately normal**.

3.2.5.3.3 NORMALITY AND SAMPLE SIZE

Although skewness and kurtosis are helpful measures for normality, they may not be enough to consider a construct approximately normal. Hair *et al.* (2006) mentioned that departure from normality can have detrimental impacts on the precision of results depending on the sample size. Large sample sizes can decrease the detrimental effects of departure from normality. When the sample size is smaller than **50** and especially smaller than **30**, the effect of considerable departure from normality can be crucial on the results (Hair et al., 2006).

The sample size for conceptualization, planning, and execution phases is 29, 54, and 56 respectively. The sample sizes are either very small or very close to the small range mentioned by Hair *et al.* (2006). Thus, the normality of the constructs should be investigated with more scrutiny. In this study, the results of nonparametric tests would be prioritized over parametric test results specially when $Z_{skewness}$ and $Z_{kurtosis}$ are close to the acceptable range. Acceptable normal ranges for $Z_{skewness}$ and $Z_{kurtosis}$ are available in Table 11.

3.2.5.3.4 PINK HIGHLIGHTS IN TABLE 12

Six spots are highlighted pink in Table 12 which means the skewness/kurtosis measure was within the normality range, but considering the small sample sizes, the measures are too high to be considered normal. This condition applies to quality of decision-making construct in conceptualization phase, to quality of communication construct in conceptualization, and execution phases, and to conflict management construct in conceptualization phase.

The distribution of the regarding constructs in those phases are considered non-normal. Consequently, the results of nonparametric test would be preferred for them when findings of parametric and nonparametric test do not match.

In addition to phase-wise assessment of normality, it is needed to investigate normality of the constructs regardless of different phases of the projects. This investigation must be carried out because in the next section, reliability of the constructs is tested by Cronbach alpha that assumes normality of the constructs regardless of the different phases. Table 13 denotes the regarding results extracted from *IBM SPSS 26.0.* Based on which all the constructs found to be approximately normal.

In the table, the skewness of leadership and quality of communication constructs is close to the limit of acceptance rage (+/-2.58). This would not have detrimental effect on the precision of the results because the sample size for the whole constructs (regardless of different phases) is 142 which is not small.

TABLE 12 Z(SKEWNESS) AND Z(KURTOSIS) OF CONSTRUCTS IN EACH PHASE

Construct	Phase	Zskewness	Zkurtosis	Interpretation
Leadership	Conceptualization	-2.61	1.51	The construct is considered non-normal.
	Planning	-0.94	-0.41	The construct is approximately normal.
	Execution	-0.79	0.21	The construct is approximately normal.
Quality of decision-making	Conceptualization	-1.62	0.38	The construct is considered non-normal.
	Planning	1.66	2.24	The construct is considered non-normal.
	Execution	-0.29	-0.87	The construct is approximately normal.
Quality of communication	Conceptualization	-1.71	0.52	The construct is considered non-normal.
	Planning	-0.09	-0.33	The construct is approximately normal.
	Execution	-1.86	1.68	The construct is considered non-normal.
Conflict management	Conceptualization	-2.25	1.82	The construct is considered non-normal.
	Planning	0.29	-0.83	The construct is approximately normal.
	Execution	-1.48	-0.56	The construct is approximately normal.
Technical competency	Conceptualization	-0.77	0.44	The construct is approximately normal.
	Planning	-0.96	-0.08	The construct is approximately normal.
	Execution	-1.34	0.1	The construct is approximately normal.

TABLE 13 Z(SKEWNESS) AND Z(KURTOSIS) OF CONSTRUCTS REGARDLESS OF PHASES

Construct	Zskewness	Zkurtosis	Interpretation
Leadership	-2.33	0.41	The construct is approximately normal.
Quality of decision-making	-0.05	0.37	The construct is approximately normal.
Quality of communication	-2.38	1.16	The construct is approximately normal.
Conflict management	-1.95	0.04	The construct is approximately normal.
Technical competency	-1.78	0.03	The construct is approximately normal.

3.2.5.4 Reliability

Reliability is a measure of the extent to which different variables in a group or construct are measuring coherently the same factor. In other words, it is a measure of internal consistency of variables in a construct (Huberly & Morris, 1989). Thus, it is not meaningful to investigate reliability for constructs that consist of one variable like the conflict management construct in this paper.

In this paper, reliability can be measured for 4 constructs, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency. These constructs will be investigated to see to what extent the variables of a construct are measuring the same attribute of the data. It is important to mention that for this purpose, the investigation does not need to be run on different phases of each phase. Instead, it shall be conducted on the whole 142 projects regardless of their phases (Hair et al., 1998).

TABLE 14 DESIRABILITY OF DIFFERENT LEVELS OF ALPHA

Alpha (α)	**Desirability**
$0.9 < \alpha < 1$	Excellent
$0.8 < \alpha < 0.9$	Good
$0.7 < \alpha < 0.8$	Acceptable
$0.6 < \alpha < 0.7$	Questionable
$0 < \alpha < 0.6$	Unacceptable

3.2.5.4.1 CRONBACH ALPHA

Cronbach alpha is the most common test for assessing the internal consistency of constructs/group of variables. The result of the test is a number between 0 (representing no internal consistency) and 1 (representing perfect internal consistency) (Bryman, 2016). Table 14 shows the desirability of different levels of alpha (George & Mallery, 2003).

3.2.5.4.2 CRONBACH ALPHA AND NORMALITY

Normality used to be not considered as an assumption for Cronbach alpha (Bay, 1973; Zimmerman, 1997). It is still not quite common to consider normality as a factor that affects the results of Cronbach alpha test. However, recent research suggests that "coefficient alpha is not robust to the violation of the normal assumption" (Sheng & Sheng, 2012). Measuring Cronbach alpha under non-normal circumstances may lead to additional bias or error (Sheng & Sheng, 2012).

To ensure the precision of the results in terms of reliability, normality of the constructs regardless of different phases are investigated in section 3.2.5.3 Normality. The results are denoted in Table 13. All the constructs found to be approximately normal.

The results of Cronbach alpha test on the 4 constructs in the paper are presented in Table 15.

Table 15 The results of Cronbach alpha test on the 4 constructs in the paper

Construct	Number of items	Cronbach alpha (α)	Desirability
Leadership	12	0.933	Excellent
Quality of decision-making	4	0.691	Questionable
Quality of communication	5	0.836	Good
Technical competency	2	0.649	Questionable

Cronbach alpha for quality of decision-making and technical competency constructs are questionable. It means the internal consistency of the two constructs may not be good or quite acceptable. Thus, it may need more precise assessment. The number of variables/questions in the constructs (fewer than 10 variables) can be a reason for this which is explained in the next paragraph. The number of items/variables in each construct is available in Table 15 which is simply measured by counting the number of questions of each construct presented in Table 9.

Pallant (2011) echo that Cronbach alpha test results are sensitive to the number of items in the construct. It is quite common to get low alpha values from the test when the number of items in the constructs is fewer than **10**. In this case, 'mean inter-item correlation' can produce more accurate results for reliability of the constructs (Harvey, 2009). An optimal range for inter-item correlation is between 0.2 and 0.4 (Briggs & Cheek, 1986).

Since the number of items for the two of the constructs with questionable Cronbach alpha is fewer than 10, the 'mean inter-item correlation' test is also conducted on them to get more precise results for reliability analysis. The test results are shown in Table 16.

Based on the results in Table 15 and Table 16, the reliability of all construct can be considered acceptable.

Table 16 The results of 'mean inter-item correlation' test

Construct	Mean inter-item correlation	Desirability
Quality of decision-making	0.306	Acceptable
Technical competency	0.303	Acceptable

3.2.5.5 Validity

Validity is about whether the variable (or a set of variables) really measure a concept that they intended to (Bryman, 2016). In this paper, validity can be assessed in the constructs that aim to measure the determinants of transaction cost within the scope. In other words, the variables of each constructs can be checked to see if they really measure the determinant of transaction cost that they are intend to. To assure the validity in this respect, in addition to personal assessment based on the knowledge of the author about the subject, supporting references that found in the literature are shown in Table 9.

In addition, Joshi *et al.* (2015) introduce a 4-question test for validity of constructs which is shown in Table 17. If the answer to all questions is yes, validity of the construct would be acceptable.

TABLE 17 TEST BY JOSHI ET AL. (2015) FOR VALIDITY OF CONSTRUCTS

Number	Question
1	Whether the items are arranged in a logical sequence?
2	Whether the items are closely interrelated but provide some independent information as well?
3	Whether there is some element of coherence/expectedness between responses (whether next response can be predicted up to some extent based upon previous one)?
4	Whether each item measures a distinct element of the issue?

In this paper, 4 different constructs are defined to measure leadership, quality of decision-making, quality of communication, and technical competency. The answer for all 4 questions in Table regarding the constructs was YES which assures the validity of constructs.

Validity can be also discussed in terms of the determinants of transaction cost in Huimin Li's model under project management efficiency category, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency. Validity in this respect means the extent to which these factors measure project management efficiency. Li *et al.* (2012) measured this validity by average variance extracted and composite reliability which is proven to be acceptable (Li et al., 2012).

Furthermore, to ensure the validity of the research in terms of the method that is used to investigate transaction cost in different phases of projects, it is decided to exclude the termination phase from the statistical investigation. The sample size of Termination phase in CII1010 database is only 3, which may negatively affect the accuracy of the results.

3.2.5.6 T-test

So far in the data analysis section, the basic necessary statistical items were investigated including variable type, sample size, normality, validity, and reliability. Now, appropriate statistical tests should be determined to fulfil the research objective.

The objective of this research is to make a quantitative comparison of 'the strength of the factors that affect transaction cost' between different phases of construction projects. To measure transaction cost, Huimin Li's model inFigure 1 was used that introduce the determinants of transaction cost in construction projects (Li et al., 2015). In CII1010 database, relevant variables were grouped together in form of constructs each of which measure an aspect of transaction cost based on the determinants of transaction cost in Li's model. These constructs will measure the average score of projects for each determinant of transaction cost in different phases.

Therefore, to fulfil the research objective, a statistical test is needed that compares the mean value for transaction cost of projects in different phases. The desired test is found to be t-test which is used for investigating **statistically significant differences** between the mean values of a variable/attribute (constructs here) when data values are divided into groups (project phases here) (Hair et al., 1998).

There are two types of t-test, namely, paired-samples t-test and independent-samples t-test. The former is conducted for comparing different variables in same sample. The latter is carried out for comparing same variables but for different group of cases (Briggs & Cheek, 1986). In this paper, the aim is to compare same variables/group of variables (constructs) related to determinants of transaction cost, in different groups of project phases which have different samples. Thus, independent-samples t-test can be conducted here.

Independent-samples t-test can also be categorized based on the null hypothesis to 1-tailed/directional and 2-tailed/non-directional t-test. In 1-tailed/directional t-test, the null hypothesis is that one sample has an attribute higher or better than the other. In 2-tailed/non-directional t-test, the null hypothesis does not include one sample having higher/better attributes. Instead, the null hypothesis is about the 2 samples having approximately equal attributes (Ruxton & Neuhäuser, 2010). Based on the null hypothesis in this research, 2-tailed independent-samples t-test is considered to be suitable for the data analysis.

So far, t-test found to be suitable for the purpose of the paper, but it also has 2 basic assumptions that should be considered: 1- t-test can be conducted only on interval/ratio variables and 2- it can be conducted only on normally distributed data (Pallant, 2013). The variables are interval in this study, but the normality of the data for leadership in conceptualization phase and for quality of decision-making in planning phase is found to be questionable in Table 12. Thus, it would be safe to run also a nonparametric alternative for independent-samples t-test. Mann-Whitney U test is the most famous test in this respect which is described further in this section.

3.2.5.6.1 INDEPENDENT-SAMPLES T-TEST

Independent-samples t-test assumes that the two data samples have approximately equal variances (it is called homogeneity of variance). Therefore, as a prerequirement to independent-sample t-test, equality of the variances should be checked with **Levene's test**. In Levene's test, the significance level lower than 0.05 shows a significant difference between the variance of the samples. Thus, significance level higher than 0.05 is acceptable (Pallant, 2013). Tables in Appendix C include the results of Levene's test which show that the assumption regarding the homogeneity of variances is satisfied in in all the investigations.

The size of the 2 samples in an independent-samples t-test, should not be very different. In this paper, this can be an issue when it comes to termination phase because the sample size for termination phase is 3, while the sample size is 29, 54, and 56 for conceptualization, planning, and execution phases respectively. This may affect the precision of the results related to the termination phase although the variances are homogeneous (Hair et al., 2006). This is another reason for excluding the termination phase from the investigation.

‘Critical t-value’ can be used to interpret the results of t-test. Critical t-value indicates a critical range for t-value that is calculated based on the degree of freedom. Critical t-values for different degrees of freedom is already available in tables on the internet. Any t-value outside of this range (-/+ critical t-value) indicates a significant difference between the samples in terms of the factor being investigated. Critical t-value can be found in t-test distribution table (Hair et al., 1998).

If the t-value is outside the critical t-value range, a significant difference between the mean value of the 2 samples can be indicated. Now, the question is that to what extent this statistical conclusion can be reliable in reality. This can be investigated by **significance level**. In independent-samples t-test the significance level higher than 0.05 means that there is a considerable chance that the results can show a difference (either low or high) in the mean value of 2 samples (here, different transaction cost in different phases of the projects) although there is not a significant difference in reality (Pallant, 2013).

To ensure the precision of the results in this study, both parametric test (regarding normal data) and nonparametric test (for the data that is not normally distributed) were conducted for comparing the mean value of constructs in different phases. Mann-Whitney U test is used as a nonparametric test for this purpose in this study.

3.2.5.7 Mann-Whitney U test

Mann-Whitney U test is a nonparametric alternative for independent-samples t-test which uses median to check if there is a **statistically significant difference** in an attribute between 2 samples. It can be also used for normal distributions though. As a nonparametric test, Mann-Whitney U test is useful for very small sample size as well (Pallant, 2013).

To interpret the results of the test, it is important that the distribution shape of 2 samples are not very different. Otherwise, the test results only compare the mean ranks of medians (Lund, 2013). This can be the most important assumption of the test that need to be considered in this paper because of the termination phase. The distribution shape of the termination phase (available in Appendix A) is quite different from the other phases. therefore, the interpretation of the results for **termination phase** based on this test may not be considered quite reliable. Therefore, this phase is excluded from further investigation in this paper.

To interpret the results of the test, significance level should be checked. **Significance level values lower than 0.05** indicate a significant difference between the 2 samples.

3.2.5.8 Conflicting results of t-test and Mann-Whitney U test

In some cases, the results of t-test and Mann-Whitney U test may be different. Thus, it is important to know how to decide about the final result when it comes to this situation. T-test is only applicable to the datasets that are approximately normally distributed. However, Mann-Whitney U test is applicable to both normal and non-normal datasets. Therefore, normality of the constructs in each phase is an important point in valuing the results of a test over the other one when results are conflicting.

It is not quite common to have a perfectly normal dataset. It is important to know the extent to which difference from normality can be acceptable (can be considered as approximately normal). Hair *et al.* (1998) state that sample size is an important factor in this respect because the statistical power of large sample size can reduce sampling errors. Therefore, detrimental impact of nonnormality can be decreased by large sample size. A considerable difference from normality can have a very detrimental impact on the precision of results when the size of sample is smaller than **50** and specially when the sample size is smaller than **30**. The same effect may be negligible for sample size larger than 200 (Hair et al., 1998).

Therefore, when the results of t-test and Mann-Whitney U test are conflicting, it is crucial to check the departure of the construct from normality considering the sample size. When the condition of normality or approximate normality is met (which is not quite often), t-test can be slightly more powerful than Mann-Whitney U test. In case of violation of normality (which is relative depending on the sample size), Mann-Whitney U test is 3 or 4 times more powerful than t-test (Blair & Higgins, 1981; Blair & Higgins, 1980a, 1980b; Blair, Higgins, & Smitley, 1980; Sawilowsky, 2005; Sawilowsky & Blair, 1992).

In conclusion, when results of t-test and Mann-Whitney U test are conflicting, to a high probability, the result of Mann-Whitney U test is more reliable and precise. However, normality and sample size should be investigated to have highly accurate results.

The tests are carried out on the data from CII1010 database using *IBM SPSS 26.0* software. The results are available in the 4 **Findings** section. The investigation is done on each pair of phases in each construct. Therefore, 15 results are presented that compare transaction cost related to the 5 constructs in each phase of projects (except for termination phase).

3.3 Methods used in the interviews

To explore the second research question, semi-structured interviews were conducted. The second research question is about the reasons for the difference in quality of communication between project phases which is based on the findings for the first part of the paper. Thus, the second research question is qualitative which needs to be explored deeply through a proper research method. Interview is a suitable method for this purpose (Cassell, 2009).

Interview is a highly effective method to collect qualitative data. It is widely used in qualitative research (Bryman, 2016). To answer the second research question, qualitative interview was employed instead of qualitative survey or interview because it gives a deeper understanding of the respondents' reasons for their answers. A semi-structured interview with open questions also allows respondent to mention factors that does not exist in the literature or the author has not thought about. The follow-up questions in an interview, based on the interviewee's response, also help to get rich details about their answers. Furthermore, as it applies to the requirements of research method here, there is more interest in respondent's answer in interviews than in quantitative research strategies (Bryman, 2016).

3.3.1 Sampling

In this paper, interview respondents were selected using purposive sampling. Purposive sampling is a common type of sampling in qualitative research in which interviewees have a reference to the research question (Bryman, 2016). Here, the research question is about the reasons for difference in factors that affect transaction cost between different phases of construction projects. To ensure the relevance and validity of the collected data, purposive sampling was used. More specifically, project manager within construction industry were selected as respondent.

In addition, to find relevant respondents, elements of snowball sampling (Bryman, 2016) were used in one case. In other words, one of the interviewees suggested a potential respondent with knowledge and experience that they claimed to be relevant to the study. The problem with snowballing is that the sample may not represent the whole population and as a result, the findings cannot be generalized (Bryman, 2016). To avoid this issue as much as possible, the suggested potential respondent were carefully chosen, i.e., the chosen respondent had experience as project manager, but their experience of project types and field of work was different enough to make sure they do not give similar responses.

Four project managers participated in this research as interviewees. They had 18 years of experience on average. They are currently working in Norway. %75 of the respondents have had international job experiences in their field. Also, all respondents work in companies that work in international market or perform activities in the market. %25 of the interviewees has the role of a client in contractual agreements and %75 of them work in contractor companies. %50 of the respondents work on industrial (oil and gas) projects, %25 on infrastructure, and %25 on infrastructure and building projects. Thus, project experience of respondents covers all construction project types on CII1010 database that was used for the statistical analysis.

3.3.2 Theoretical saturation

How many interviews are enough? The answer to this question is in the idea of theoretical saturation introduced by Glaser and Strauss (1967). Based on theoretical saturation, interviews should be performed to a point at which the new data does not provide any important new information or theme (Bryman, 2016). Guest *et al.* (2006) note that theoretical saturation happened within only 12 interviews in study on a sample of 60 women in West Africa. The basic elements of metathemes were collected within 6 interviews though (Guest, Bunce, & Johnson, 2006). The sufficient number of interviews can vary in different studies though. In a study by Crouch and McKenzie (2006), the adequate number of interviews was found to be less than 20 (Crouch & McKenzie, 2006). In a study on 38 respondents by Haaskjold *et al.* (2019), theoretical saturation was reached within 30 interviews (Haaskjold et al., 2019). In this study however, due to time limit, 4 in-depth interviews were conducted.

3.3.3 Interview method

To increase the quality of interviews, an interview guide was written that include important topics. The interview guide includes some general open-ended questions about communication in project phases as well as some questions about the factors that may affect the quality of communication in projects. The effort was to avoid asking questions in a way that may lead the respondents to specific answers.

The interview guide was revised after the first interview to cover the regarding research question more precisely and more completely. In order not to lose any data from the first respondent, a quick follow-up interview was also conducted with them which covered the revised interview guide. The approach to the interview guide was dynamic. After each interview, minor/small adjustments were applied to the questions of the interview guide to improve the quality of the finding data. The revised interview guide is presented in Appendix E. It can help those who may want to conduct further research on the topic and may want to repeat (to some extent) the investigation in order to cover the termination phase for example which is excluded from the scope of this paper. This is also mentioned in chapter 6 Conclusion and further research.

Because of the safety considerations due to Corona virus pandemic at the time of interviews, the interviews were done through video calls. Phone calls and videos call are preferred interview methods when face-to-face interview is too costly or time-consuming, in case of great geographical distances for example, or when safety is a consideration (Bryman, 2016). Different authors mention different statements about phone call and video call interviews. Shuy (2002) note that face-to-face interview is more effective in complex issues than phone call. It also results in more accurate responses. Furthermore, the interactive power is more balanced in face-to-face interview (Shuy, 2002). However, Sturges and Hanrahan (2004) found no considerable difference between the two interview methods in terms of depth, nature, and quantity of responses (Sturges & Hanrahan, 2004).

Interviews lasted between 45 to 90 minutes (71 minutes in average). They were performed by the same person (the author) in the time period between June 28th, 2020 and August 16th, 2020. The interviews were not recorded with any recording device. Instead, handwritten notes were taken during the interviews. Afterwards, a summary of the interview was written and sent to the interviewee to be verified or corrected.

Audio-recording and transcribing interviews is common in qualitative research. It increases the accuracy of data and allows the researcher to examine the responses repetitively. It also decreases the likelihood of biasedness as it permits other researchers to scrutinize the analysis (in secondary analysis research) (Bryman, 2016). However, the interviewees may be less willing to share all the information knowing that their voice is being recorded (Warren, 2002). In this study, it was decided not to record the interviews to let the respondents feel more comfortable to share information. In addition, based on the research regulations in Norway, researchers need to get permission from NSD (Norwegian Center for Research Data) to audio-record the interviews. This was not quite convenient because the process of getting permission can take time and there was time limit when the interviews were being conducted in the summer since many employees go on holiday in that time of the year.

3.3.4 Privacy and ethical considerations

Research should not cause any likely harm to participants (Bryman, 2016). In this research, ethical considerations and privacy of the respondents were taken into account based on the guidelines at NSD. To protect the privacy of the interviewees, the author anonymized their identity and the name of the company that they are working in. In addition, any specific name of customers and partners was anonymized too. Furthermore, the summaries of the interviews were used for the purpose of analysis and no direct quotes were used that might identify the respondent. Quotes were generalized and anonymized. Prior to the interviews, a one-page document was sent to the respondents including the aforementioned considerations as well as other relevant information such as the interview method and the purpose of the interview.

NSD is the Norwegian Center for Research Data that provides equal access to data for researchers and protects privacy of research participant based on Norwegian laws. Studies that are to use directly or indirectly identifiable personal data need to register on the website and ask for permission. In this paper, no directly or indirectly identifiable personal data was used. Thus, the paper was not registered on NSD. In fact, there is a test on the website to know if the project must be notified to the agency or not (the notification test). The notification test was done, and the result was 'not subject to notification'. The regarding official document from NSD.no is presented in Appendix F.

3.4 Criticism to the method

The data for the first part of this paper (the statistical part) was collected from CII1010 database in which only Norwegian projects are registered. This may affect the validity of the findings for external use. However, this may increase the accuracy and applicability of the findings to be used within the country.

The interviews for the second part of the paper were conducted with companies in Norway. This may affect the external validity of the findings. However, %75 of the respondents had international experience. In addition, the companies that %75 of the respondents work for are active in international market as well.

To conduct the statistical part of the study, secondary analysis was used as the data collection method. In other words, author chose to use the data from CII1010 database instead of designing a questionnaire and collecting data by himself. Secondary analysis has several benefits that were mentioned in 3.2.1 Data collection section. There are also some potential drawbacks associated with secondary analysis. For example, the author may not be well familiar with organization of the data in the database, some of the key variables may not be included in the database, and the data can be complex due to high number of variables and respondents (Bryman, 2016). This may impact the precision of the findings. To minimize the drawbacks of secondary analysis, the author studied the database and its user manual to obtain a decent understanding of the organization of its data. In addition, the data from CII1010 was analyzed and investigated using *IBM SPSS 26.0* software which helps to deal with the complexity of data. The reason for choosing CII1010 as a source of data was because the questions are formulated by professionals and a great number of projects are registered there.

The questions on CII1010 were selected and assigned to the constructs based on their relevance to the literature on that topic. This is a subjective process which may have been impacted by author's bias and mental map. As a result, the validity of the constructs may have been affected. To mitigate this effect, a 4-question test regarding the validity of construct by Joshi *et al.* (2015) in Table 17 was taken. Based on the test result, the validity of the construct was not affected in this respect, but again the answer to the test is subjective and may be subject to criticism.

The data on CII1010 benchmarking database was provided by companies that volunteered to take part in the survey. Poorly functioning firms may not have knowledge or willingness to take part in the program because to participate in a benchmarking program, companies should usually have a decent level of maturity. In addition, only 142 projects were registered on CII1010 database at the time of analysis which does not include all the construction projects in Norway. This may affect the precision or generalization of the findings as they may not reflect what happens in all companies.

Generally speaking, the efficiency and productivity of people's work may be affected as they know that they are being observed or measured. This might be the case for participance of CII1010 survey because they knew the questions and they knew the way they were going to be measured. Therefore, the data may not be an accurate reflection of their work. This may slightly impact the precision of the findings.

For the statistical part of the paper, questions/variables (from CII1010) that measure each factor in project management efficiency were grouped together in form of constructs shown in Table 9. Hair *et al.* (2006) recommend to include at least 3 to 5 questions in a group to make constructs (Hair et al., 2006). In this paper, conflict management and technical competency constructs include 1 and 2 questions respectively. This may increase the level of uncertainty of findings.

To decide that there is a distinctive difference in quality of communication between planning and execution phase, 2 tests were conducted. The results of the tests were conflicting. The result of Mann-Whitney U test (a nonparametric test) was preferred because the execution phase in quality of communication is not normally distributed. The execution phase was considered non-normal in the first place in (Table 12) because the sample size was very close to small and the skewness and kurtosis were relatively high. This choice was subjective to some extent. Therefore, it can be subject to criticism. To mitigate the risk of poor choice in this critical situation, the literature on conflicting results of t-test and Mann-Whitney U test were studied. It was decided to prefer the results of Mann-Whitney U test because many authors stress the higher power of Mann-Whitney U test or t-test in this situation.

To collect data for the second research question, semi-structured qualitative interviews with open questions were conducted. General questions regarding the topic were mostly asked during the interviews instead of specific questions. The answers afterwards were interpreted with regards to the key factors in the topic. This subjective interpretation may be subject to criticism due to the risk of misinterpretation based on the author's mental maps. In this paper, open question in semi-structured qualitative interviews were chosen because it opens up the opportunity to explore the factors that did not exist in the literature before (like in the case of respondent 1 who mentioned availability of the stakeholder as a factor that was not found in the literature before). To minimize the risk of misinterpretation, a copy of the conversation notes was sent to the respondents to be approved or corrected by them. Another option for interview questions is specific questions in a Likert scale for example. This may direct the respondents' answers (Bryman, 2016) and constrain them to the factors found in the literature. Thus, specific question was not chosen for the interviews.

No audio-recording device was used in the interviews. This may negatively affect the preciseness of the findings because of author's potential misinterpretation and biasedness. To minimize the risk of this potential drawback, a summary of the meeting was sent to the respondents after interviews to be verified or corrected if there was any mistake.

The theoretical saturation in the interviews is point in which no new data is revealed by the respondents. Theoretical saturation may be achieved somewhere between 12 (Guest et al., 2006) to 30 (Haaskjold et al., 2019) interviews. In this study however, due to the time limits and limitation on other resources, 4 interviews were conducted. This can cause 2 issues: 1-the sample may not represent the population and 2-the data may not be complete. To minimize these detrimental effects, respondents with different experiences were selected. In addition, %75 of the respondents had several years of experience in different projects which helps to have complete data. The average experience of the respondents was 18 years.

4 Findings

In this section the findings of statistical analysis and qualitative interviews are presented. The structure of the section is based on the order of research questions. In the first part, the findings of statistical analysis on 142 projects at CII1010 database is presented which is related to the first research question. The findings of the interviews (related to the second research question) are presented in the second part of this section. The findings of statistical investigation and qualitative interviews are summarized in Figure 28. A summary of the statistical findings is shown separately in Table 18 and in more details in Table 76. A summary of findings for interviews is presented in Table 77.

4.1 Statistical investigation (quantitative findings)

In this part, findings of statistical investigation are presented. These findings are pertaining to the first research question. During the statistical analysis, the data from CII1010, which is assigned to 5 determinants of transaction cost in Huimin Li's model (Figure 1), is investigated in different project phases. The objective was to check whether there is a statistically significant difference in the strength of each determinant of transaction cost between different phases. For example, leadership, as a determinant of transaction cost, was tested to see if there is a statistically significant difference in leadership scores between different phases. T-test (parametric test) and Mann-Whitney U test (nonparametric test) were used for this comparison. The tests can compare 2 phases at a time.

This part is divided into 5 subsets associated with the 5 determinants of transaction cost (the constructs) in Li's model shown in Figure 1 (Li et al., 2015). In each subset, a description about the distribution of data in the construct (regardless of phases) is presented first. Afterwards, distribution of the constructs is shown by histograms both generally (regardless of phases) and specifically in different phases. Then, the construct is tested by independent-samples t-test and Mann-Whitney U test in 3 pairs of phases, namely, conceptualization-planning, conceptualization-execution, and planning execution. Figure 7 depict the structure of this section in each subset/construct (determinant of transaction cost).

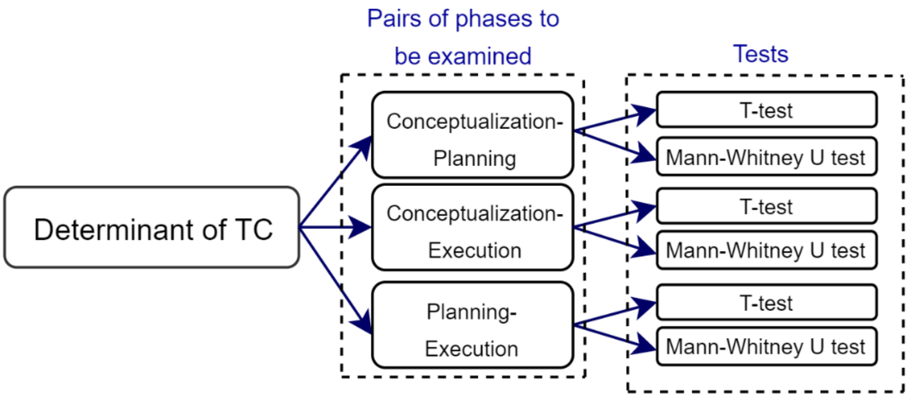

FIGURE 7 THE STRUCTURE OF THE FINDINGS OF STATISTICAL ANALYSIS IN EACH CONSTRUCT/DETERMINANT OF TRANSACTION COST

Findings suggest that there was a significant difference in quality of communication between planning and execution phases of projects which in turn can contribute to different transaction cost associated with the phases. More specifically, quality of communication was found to be significantly better in execution than in planning phase. A simple summary of the findings is presented in Table 18. Findings are summarized in detail in Table 74 and Table 76.

TABLE 18 A SIMPLE SUMMARY OF THE FINDINGS OF THE STATISTICAL ANALYSIS

Determinant of transaction cost (construct)	**There is a significant difference between phases**
Leadership	NO
Quality of decision-making	NO
Quality of communication	YES
Conflict management	NO
Technical competency	NO

Independent-samples t-test is based on a normality assumption (Hair et al., 1998; Pallant, 2013). Thus, the normality of each construct is investigated in conceptualization, planning, and execution phases separately.

In addition to normality, t-test assumes that the data in the 2 samples (related to the 2 phases being tested here) have approximately equal variance (Pallant, 2013). Thus, the tables regarding t-test include data regarding Levene's test which is a test for variances. The tables also include a second row that includes the data for a t-test that does not take the equality-of-variances assumption.

This section includes 20 figures and 67 tables that illustrate or present the main structure of the section, distributions histogram, results of the statistical investigations, findings, descriptives, and summary of the results. It is decided to include almost all the related tables and figures in this section (rather than placing them in the appendix) in order to facilitate reading and understanding the data and statistical procedures for the readers who are interested in them.

It should also be mentioned that the language of CII1010 database is Norwegian. Therefore, in the graphs, sometimes, the names of phases are presented as Tidligfase, Prosjektering, and bygging which are equivalent to conceptualization, planning, and execution phases respectively.

4.1.1 Leadership

The leadership construct includes 12 questions/variables shown in Table 9. The sample size for the whole construct (regardless of phases) is 142 including all projects in the database. The data is normally distributed based on the histogram shape Figure 8 and also based on the skewness and kurtosis Table 13. The internal consistency/reliability of the construct is excellent Table 15. Descriptives of leadership construct are shown in Table 19 below.

As mentioned before, for t-test, the normality of the leadership construct should be tested in each phase, namely, conceptualization, planning, and execution. This investigation is already done in the methodology section using skewness and kurtosis which is presented in Table 12. The table suggest that leadership construct in conceptualization phase is **not normal**. The distribution histograms of the phases are shown in Figure 9, Figure 10, and Figure 11.

TABLE 19 DESCRIPTIVES OF LEADERSHIP CONSTRUCT

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Leadership	142	2.81	2.11	4.91	3.7593	.52497	.276
Valid N (listwise)	142						

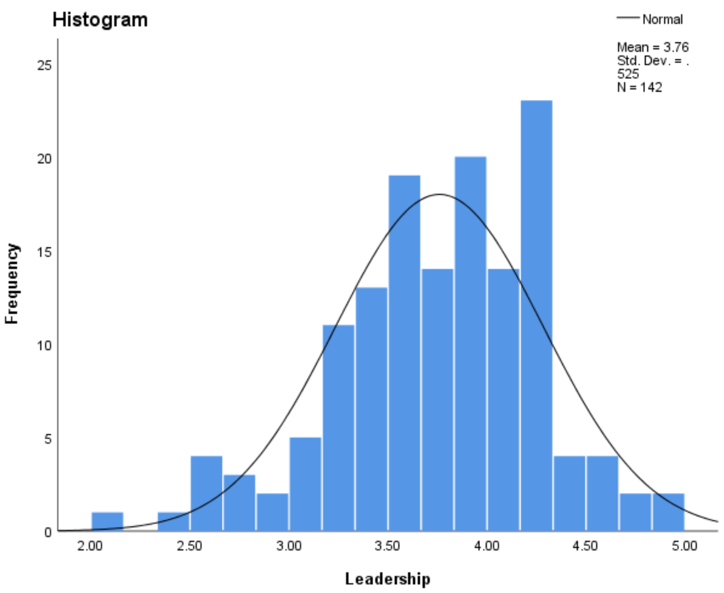

FIGURE 8 DISTRIBUTION HISTOGRAM OF LEADERSHIP CONSTRUCT REGARDLESS OF DIFFERENT PHASES

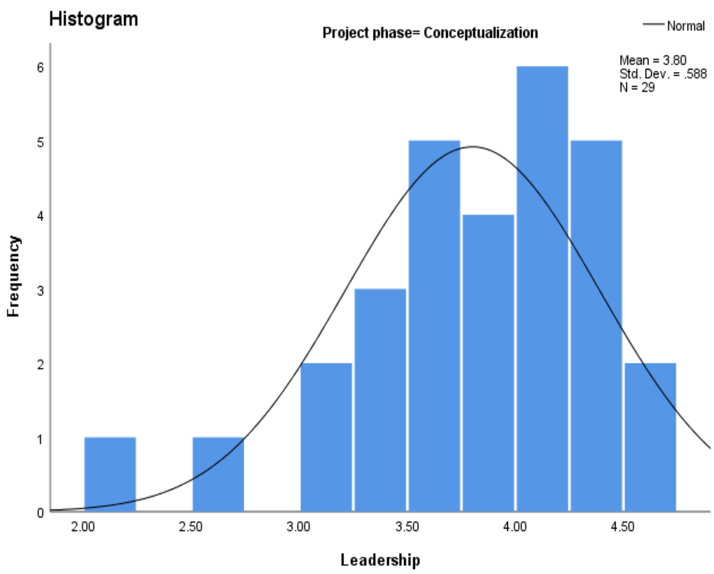

FIGURE 9 DISTRIBUTION HISTOGRAM OF LEADERSHIP CONSTRUCT IN CONCEPTUALIZATION PHASE

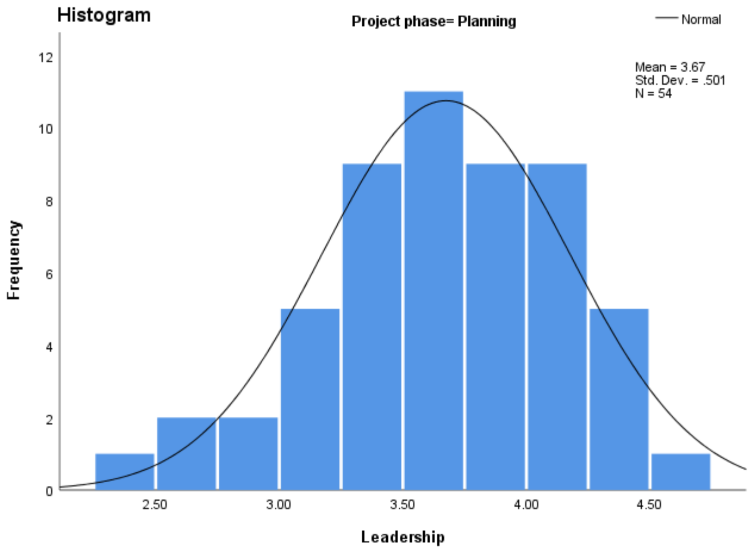

FIGURE 10 DISTRIBUTION HISTOGRAM OF LEADERSHIP CONSTRUCT IN PLANNING PHASE

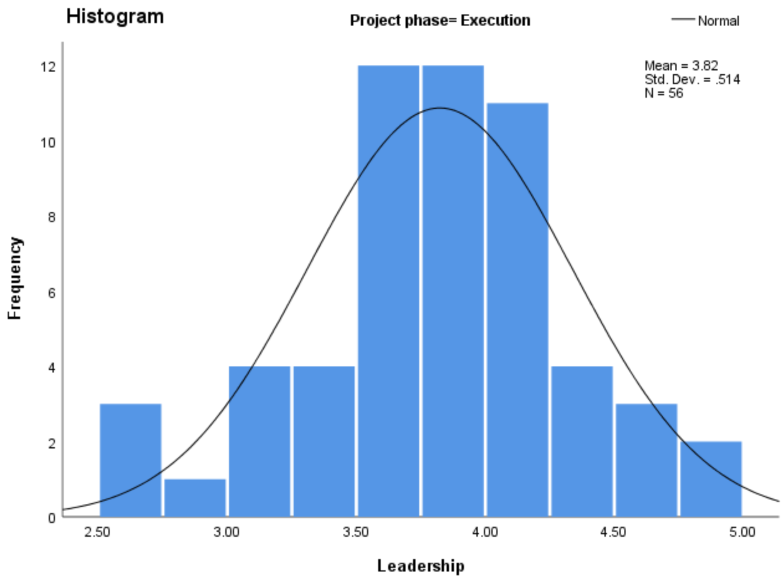

FIGURE 11 DISTRIBUTION HISTOGRAM OF LEADERSHIP CONSTRUCT IN EXECUTION PHASE

Descriptives of leadership construct in different phases are available in Table 20 including sample size, mean, standard deviation, and standard error mean.

TABLE 20 DESCRIPTIVES OF LEADERSHIP CONSTRUCT IN DIFFERENT PHASES

Group Statistics					
	Project phase	N	Mean	Std. Deviation	Std. Error Mean
Leadership	Conceptualization	29	3.8007	.58843	.10927
	Planning	54	3.6743	.50124	.06821
	Execution	56	3.8235	.51376	.06865

The results of independent-samples t-test and Mann-Whitney U test are presented in 3 categories as follows.

4.1.1.1 Conceptualization and planning

Descriptives of the 2 phases are shown in Table 20 including sample size, mean, standard deviation, and standard error mean.

Based on Table 12, the leadership construct in conceptualization phase is **not normal** because its skewness is slightly (0.03) out of the acceptable range. Therefore, it is necessary to conduct both parametric and nonparametric tests here, i.e., independent-samples t-test and Mann-Whitney U test.

Table 21 presents the results of **independent-samples t-test** (the parametric test) which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in leadership between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** (the nonparametric test) together with its descriptives are presented in Table 22 and Table 23. Based on Table 23, there is **no significant difference** in leadership between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

TABLE 21 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR LEADERSHIP IN CONCEPTUALIZATION-PLANNING COMPARISON

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Leadership	Equal variances assumed	.731	.395	1.030	81	.306	.12639	.12271	-.11775	.37054
	Equal variances not assumed			.981	50.06	.331	.12639	.12881	-.13232	.38511

TABLE 22 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR LEADERSHIP IN CONCEPTUALIZATION-PLANNING COMPARISON

Ranks

	Project phase	N	Mean Rank	Sum of Ranks
Leadership	Conceptualization	29	47.03	1364.00
	Planning	54	39.30	2122.00
	Total	83		

TABLE 23 THE RESULTS OF MANN-WHITNEY U TEST FOR LEADERSHIP IN CONCEPTUALIZATION-PLANNING COMPARISON

Test Statistics

	Leadership
Mann-Whitney U	637.000
Z	-1.394
Sig. (2-tailed)	.163

a. Grouping Variable: Project phase

4.1.1.2 Conceptualization and execution

Descriptives of the 2 phases are shown in Table 20 including sample size, mean, standard deviation, and standard error mean.

Based on Table 12, the data regarding the conceptualization phase of leadership construct is **not normal**. Thus, it is necessary to conduct a Mann-Whitney U test in addition to the t-test.

Table 24 presents the results of **independent-samples t-test.** It also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in leadership between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 25 and Table 26. Based on Table 26, there is **no significant difference** in leadership between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

TABLE 24 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR LEADERSHIP IN CONCEPTUALIZATION-EXECUTION COMPARISON

Independent Samples Test											
		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Leadership	Equal variances assumed	.766	.384	-.184	83	.854	-.02277	.12357	-.26853	.22300
	Equal variances not assumed			-.176	50.4	.861	-.02277	.12905	-.28191	.23637

TABLE 25 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR LEADERSHIP IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Leadership	Conceptualization	29	44.34	1286.00
	Execution	56	42.30	2369.00
	Total	85		

TABLE 26 THE RESULTS OF MANN-WHITNEY U TEST FOR LEADERSHIP IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Test Statistics	
	Leadership
Mann-Whitney U	773.000
Z	-.362
Sig. (2-tailed)	.718
a. Grouping Variable: Project phase	

4.1.1.2.3 Planning and execution

Descriptives of the 2 phases are presented in Table 20 including sample size, mean, standard deviation, and standard error mean.

Table 27 presents the results of **independent-samples t-test.** It also comprises the results of Levene's test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in leadership between planning and execution phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 28 and Table 29. Based on Table 29, there is **no significant difference** in leadership between planning and execution phases of the projects because the significance level is greater than 0.05.

TABLE 27 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR LEADERSHIP IN PLANNING-EXECUTION COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Leader ship	Equal variances assumed	.006	.941	-1.54	108	.126	-.149	.0968	-.341	.043
	Equal variances not assumed			-1.54	107.98	.126	-.14916	.09678	-.341	.04267

TABLE 28 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR LEADERSHIP IN PLANNING-EXECUTION PHASE COMPARISON

Test Statistics	
	Leadership
Mann-Whitney U	1261.000
Z	-1.501
Sig. (2-tailed)	.133
a. Grouping Variable: Project phase	

TABLE 29 THE RESULTS OF MANN-WHITNEY U TEST FOR LEADERSHIP IN PLANNING-EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Leadership	Planning	54	50.85	2746.00
	Execution	56	59.98	3359.00
	Total	110		

4.1.2 Quality of decision-making

The quality of decision-making construct consists of 4 variables/questions shown in Table 9. The sample for the whole construct includes all 142 projects. The data of the construct is normally distributed based on the histogram in Figure 12 and also based on Table 13 regarding skewness and kurtosis of constructs. The internal consistency/reliability of the construct is acceptable according to Table 13.

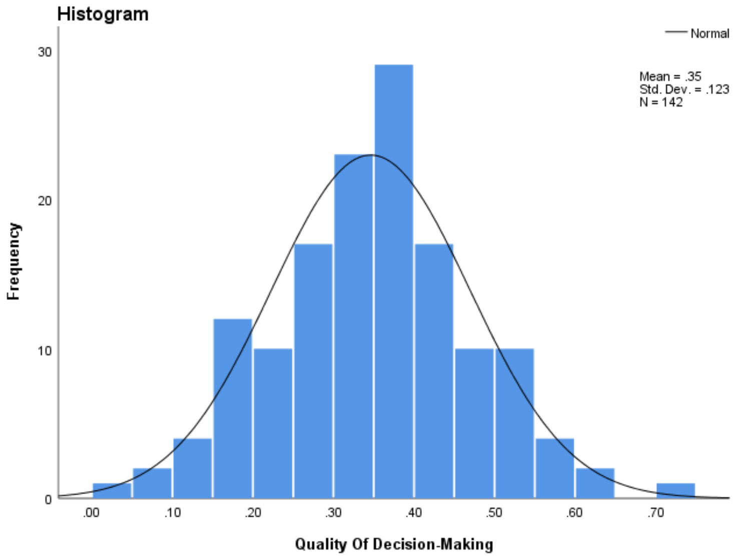

Figure 12 Distribution histogram of quality of decision-making construct regardless of phases

Table 30 shows the statistical descriptives of quality of decision-making construct.

Table 30 Descriptives of quality of decision-making construct

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Quality of Decision-making	142	.71	.00	.71	.3462	.12334	.015
Valid N (listwise)	142						

In order to compare transaction cost in different phases of projects, parametric and nonparametric tests are conducted on the construct in different phases. The tests can compare 2 phases at a time, i.e., conceptualization and planning, conceptualization and execution, and planning and execution.

As a prerequirement to the parametric test/independent-samples t-test, the normality of the construct in each phase is investigated in Table 12 in methodology section. Based on the table, quality of decision-making is **not normal** in planning phase. Figure 13, Figure 14, and Figure 15, depict the distribution histograms of the construct in 3 phases, namely, conceptualization, planning, and execution.

According to Table 12, the skewness of the conceptualization phase is within the acceptable range but high. Since the sample size of conceptualization phase is very small (29), this departure from normality can detrimentally impact the accuracy of results. Thus, this phase is considered nonnormal (Hair et al., 1998). The results of the Mann-Whitney U test would be preferred to the results of t-test in case that the results of the tests did not match.

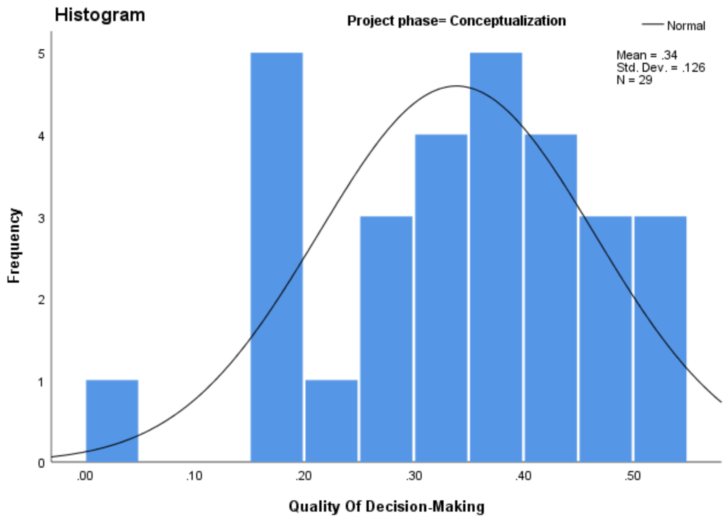

Figure 13 Distribution histogram of quality of decision-making construct in conceptualization phase

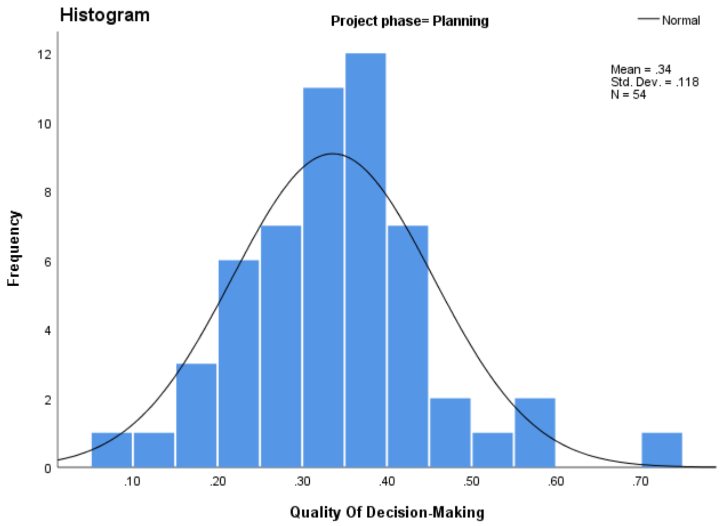

Figure 14 Distribution histogram of quality of decision-making construct in planning phase

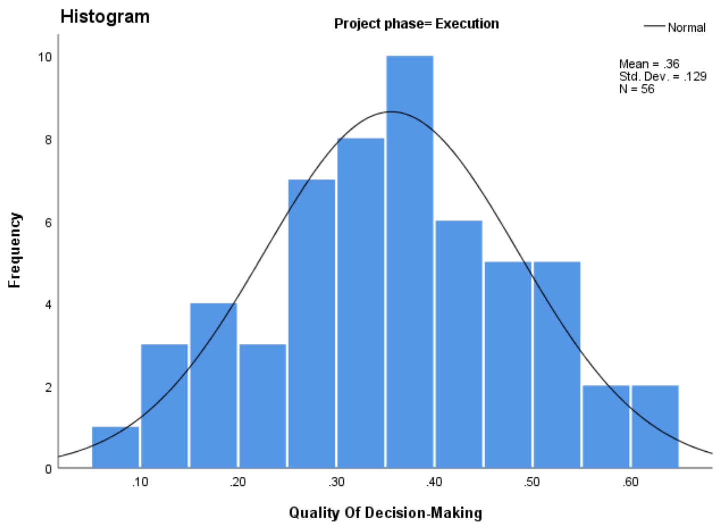

Figure 15 Distribution histogram of quality of decision-making construct in execution phase

TABLE 31 DESCRIPTIVES OF QUALITY OF DECISION-MAKING CONSTRUCT IN DIFFERENT PHASES

Group Statistics						
	Project phase	N	Mean	Std. Deviation	Std. Error Mean
Quality of Decision-making	conceptualization	29	.3389	.12594	.02339
	Planning	54	.3362	.11849	.01612
	Execution	56	.3561	.12925	.01727

The results of the independent-samples t-test and Mann-Whitney U test are presented under the 3 following headlines.

4.1.2.1 Conceptualization and planning

Descriptives of the 2 phases are shown in table 31 including sample size, mean, standard deviation, and standard error mean.

According to Table 12, quality of decision-making construct in planning phase is considered **not normal** because its kurtosis is higher than the acceptable upper limit. In addition, the distribution of the conceptualization phase is considered nonnormal because the skewness is high while the sample size is small. This emphasizes the necessity of a nonparametric test. Therefore, in addition to the t-test, Mann-Whitney U test is considered essential in all comparisons concerning this construct.

Table 32 presents the results of **independent-samples t-test** (the parametric test) which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in quality of decision-making between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

TABLE 32 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR QUALITY OF DECISION-MAKING IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Quality of Decision-making	Equal variances assumed	.373	.543	.098	81	.922	.00274	.0279	-.053	.0582
	Equal variances not assumed			.096	54.449	.924	.00274	.02841	-.05420	.05968

The results of **Mann-Whitney U test** (the nonparametric test) together with its descriptives are presented in Table 33 and Table 34. Based on Table 34, there is **no significant difference** in quality of decision-making between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

Table 33 The descriptives of Mann-Whitney U test for quality of decision-making in conceptualization-planning phase comparison

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Quality of Decision-making	conceptualization	29	44.26	1283.50
	Planning	54	40.79	2202.50
	Total	83		

Table 34 The results of Mann-Whitney U test for quality of decision-making in conceptualization-planning phase comparison

Test Statistics	
	Quality of Decision-making
Mann-Whitney U	717.500
Z	-.626
Sig. (2-tailed)	.532
a. Grouping Variable: Project phase	

4.1.2.2 Conceptualization and execution

Descriptives of the 2 phases are shown in table 31 including sample size, mean, standard deviation, and standard error mean.

As mentioned before, the conceptualization phase of quality of decision-making construct is not considered normal. Thus, the result of Mann-Whitney U test would be preferred to the result of t-test if the findings did not match. Table 35 presents the results of **independent-samples t-test** that also comprises the results of Levene's test for equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in quality of decision-making between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

Table 35 The results of independent-samples t-test for quality of decision-making in conceptualization-execution phase comparison

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Quality of Decision-making	Equal variances assumed	.059	.808	-.586	83	.560	-.01717	.02932	-.07548	.04113
	Equal variances not assumed			-.591	58.1	.557	-.01717	.02907	-.07537	.041

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 36 and Table 37. Based on Table 37, there is **no significant difference** in quality of decision-making between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

Table 36 The descriptives of Mann-Whitney U test for quality of decision-making in conceptualization-execution phase comparison

Ranks					
	Project phase	N	Mean Rank	Sum of Ranks
Quality of Decision-making	Conceptualization	29	41.53	1204.50
	Execution	56	43.76	2450.50
	Total	85		

Table 37 The results of Mann-Whitney U test for quality of decision-making in conceptualization-execution phase comparison

Test Statistics	
	Quality of Decision-making
Mann-Whitney U	769.500
Z	-.394
Sig. (2-tailed)	.694
a. Grouping Variable: Project phase	

4.1.2.3 Planning and execution

Descriptives of the 2 phases are presented in table 31 including sample size, mean, standard deviation, and standard error mean.

Since the planning phase of quality of decision-making construct is considered **non-normal**, the result of Mann-Whitney U test would be preferred to the result of t-test in case of conflicting results.

Table 38 presents the results of **independent-samples t-test** which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in quality of decision-making between planning and execution phases of the projects because the significance level is greater than 0.05.

Table 38 The results of independent-samples t-test for quality of decision-making in planning-execution phase comparison

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Quality of Decision-making	Equal variances assumed	1.05	.31	-.841	108	.402	-.0199	.0237	-.0668	.027
	Equal variances not assumed			-.843	107.73	.401	-.0199	.0236	-.0667	.0269

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 39 and Table 40. Based on Table 40, there is **no significant difference** in quality of decision-making between planning and execution phases of the projects because the significance level is greater than 0.05.

TABLE 39 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR QUALITY OF DECISION-MAKING IN PLANNING-EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Quality of Decision-making	Planning	54	52.08	2812.50
	Execution	56	58.79	3292.50
	Total	110		

TABLE 40 THE RESULTS OF MANN-WHITNEY U TEST FOR QUALITY OF DECISION-MAKING IN PLANNING-EXECUTION PHASE COMPARISON

Test Statistics	
	Quality of Decision-making
Mann-Whitney U	1327.500
Z	-1.103
Sig. (2-tailed)	.270
a. Grouping Variable: Project phase	

4.1.3 Quality of communication

Quality of communication construct consists of 5 questions/variables shown in Table 9. The data of the construct is normally distributed based on the histogram shape Figure 16 and based on the skewness and kurtosis Table 13. The internal consistency/reliability of the construct is good based on Table 15.

Descriptives regarding the construct are shown in Table 41 below.

TABLE 41 DESCRIPTIVES OF QUALITY OF COMMUNICATION CONSTRUCT

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Quality of Communication	142	2.75	2.20	4.95	3.857	.52348	.274
Valid N (listwise)	142						

Due to the normality assumption of t-tests, it is necessary to investigate normality of the data in different phases. The information regarding the normality of the construct in different phases is shown in Table 12. The skewness of the **conceptualization** phase is high. Since the sample size is small, the great skewness can negatively impact the precision of the results of t-test. Thus, this phase is considered **not normal**. The results of Mann-Whitney U test would be preferred if the results of the 2 tests did not match.

The skewness and kurtosis of the **execution** phase is high. Although it is within the acceptable range, but it can have detrimental effect on the precision of results of t-test because the sample size is not big. The sample size is 56. It is only a little bigger than 50 (50 is the 'small sample size' mentioned by Hair *et al.* (1998)). Therefore, the execution phase is considered **not normal**. The results of Mann-Whitney U test would be preferred if the results of the 2 tests did not match.

Figure 17, Figure 18, and Figure 19 illustrate distribution of the 3 phases regarding quality of communication construct.

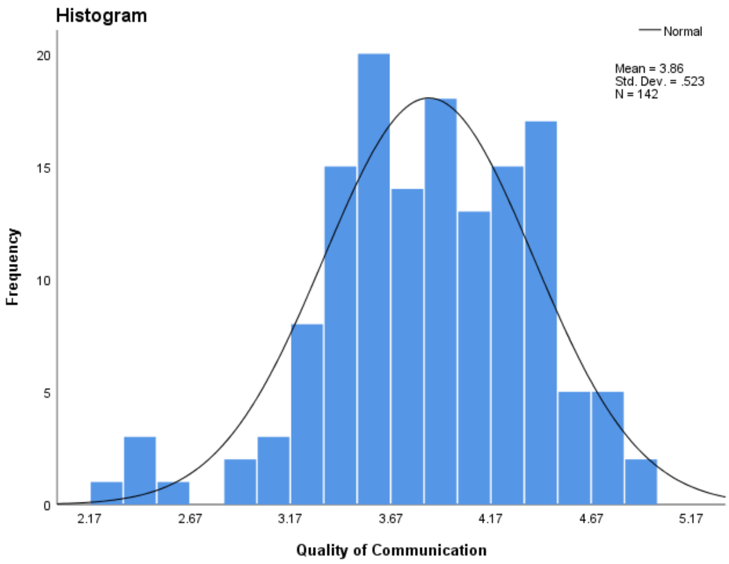

FIGURE 16 DISTRIBUTION HISTOGRAM OF QUALITY OF COMMUNICATION CONSTRUCT REGARDLESS OF PHASES

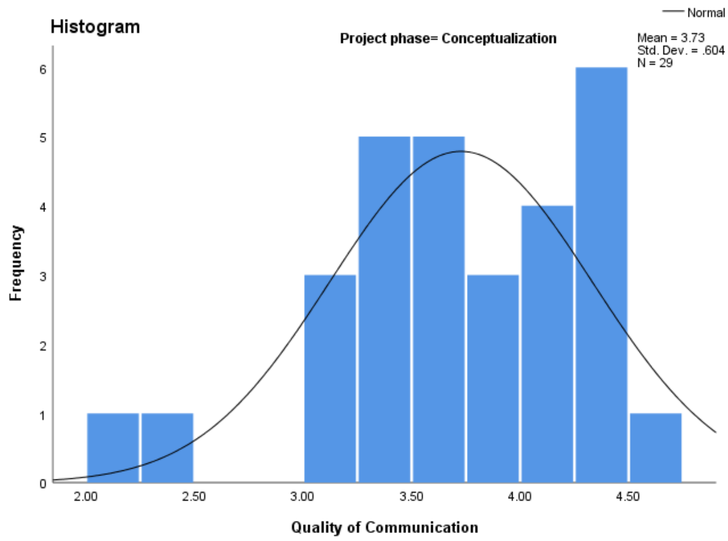

FIGURE 17 DISTRIBUTION HISTOGRAM OF QUALITY OF COMMUNICATION CONSTRUCT IN CONCEPTUALIZATION PHASE

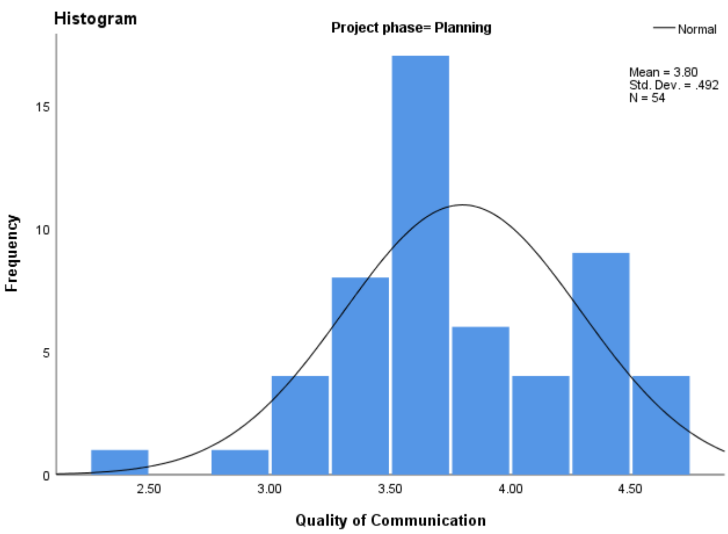

FIGURE 18 DISTRIBUTION HISTOGRAM OF QUALITY OF COMMUNICATION CONSTRUCT IN PLANNING PHASE

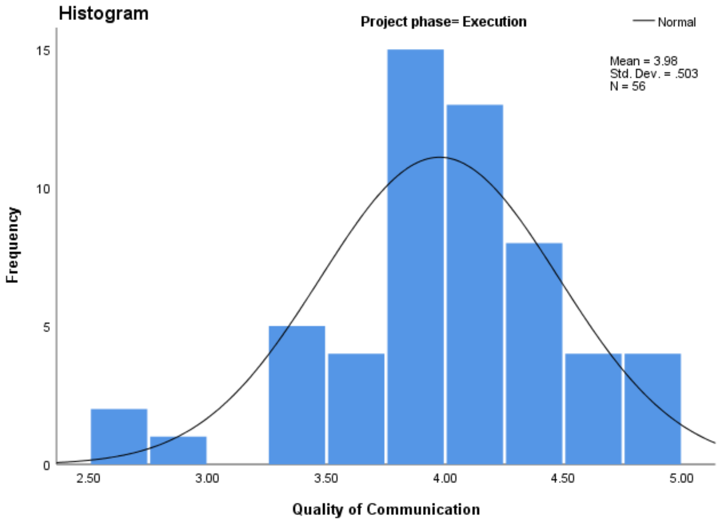

FIGURE 19 DISTRIBUTION HISTOGRAM OF QUALITY OF COMMUNICATION CONSTRUCT IN EXECUTION PHASE

Descriptives of quality of communication construct in different phases are available in Table 42 including sample size, mean, standard deviation, and standard error mean.

TABLE 42 DESCRIPTIVES OF QUALITY OF COMMUNICATION CONSTRUCT IN DIFFERENT PHASES

Group Statistics					
	Project phase	N	Mean	Std. Deviation	Std. Error Mean
Quality of Communication	Conceptualization	29	3.7272	.60428	.11221
	Planning	54	3.7991	.49193	.06694
	Execution	56	3.976	.50302	.06722

The results of independent-samples t-test and Mann-Whitney U test are presented in 3 categories as follows.

4.1.3.1 Conceptualization and planning

Descriptives of the 2 phases are shown in Table 42 including sample size, mean, standard deviation, and standard error mean.

Table 43 presents the results of **independent-samples t-test** (the parametric test) which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in quality of communication between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

Since the conceptualization phase might be too different from a normal distribution, a Mann-Whitney U test is considered to be essential for accuracy of the results. The results of **Mann-Whitney U test** (the nonparametric test) together with its descriptives are presented in table 44 and table 45. Based on Table 45, there is **no significant difference** in quality of communication between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

TABLE 43 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR QUALITY OF COMMUNICATION IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Quality of Communication	Equal variances assumed	1.43	.23	-.58	81	.560	-.07190	.12281	-.3163	.17245
	Equal variances not assumed			-.55	48.3	.585	-.07190	.13066	-.334	.19078

TABLE 44 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR QUALITY OF COMMUNICATION IN CONCEPTUALIZATION-PLANNING PHASE OMPARISON

Test Statistics	
	Quality of Communication
Mann-Whitney U	737.500
Z	-.435
Sig. (2-tailed)	.664
a. Grouping Variable: Project phase	

TABLE 45 THE RESULTS OF MANN-WHITNEY U TEST FOR QUALITY OF COMMUNICATION IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Quality of Communication	Conceptualization	29	40.43	1172.5
	Planning	54	42.84	2313.5
	Total	83		

4.1.3.2 Conceptualization and execution

Descriptives of the 2 phases are shown in Table 42 including sample size, mean, standard deviation, and standard error mean.
Table 46 presents the results of **independent-samples t-test** that also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and **<u>there is a significant difference</u>** in quality of communication between conceptualization and execution phases because the significance level is lower than 0.05.

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 47 and Table 48. Based on Table 48, there is **<u>no significant difference</u>** in quality of communication between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

This can overrule the result of the t-test about a significant difference between the phases because conceptualization phase is **not normal** (because of high skewness and small sample size). Mann-Whitney U test is a test designed for comparing 2 sets of data that are either normally or not normally distributed. T-test results can be valid only for normal distribution. Therefore, the conclusion is that there is **<u>no significant difference</u>**

in quality of communication between conceptualization and execution phases of the projects.

TABLE 46 THE RESULTS OF T-TEST FOR QUALITY OF COMMUNICATION IN CONCEPTUALIZATION-EXECUTION PHASES

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Quality of Communication	Equal variances assumed	2.133	.148	-2.02	83	.047	-.2491	.123	-.494	-.004
	Equal variances not assumed			-1.90	48.5	.063	-.2491	.131	-.512	.014

TABLE 47 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR QUALITY OF COMMUNICATION IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Quality of Communication	Conceptualization	29	36.59	1061.00
	Execution	56	46.32	2594.00
	Total	85		

TABLE 48 THE RESULTS OF MANN-WHITNEY U TEST FOR QUALITY OF COMMUNICATION IN CONCEPTUALIZATION-EXECUTION COMPARISON

Test Statistics	
	Quality of Communication
Mann-Whitney U	626.000
Z	-1.724
Sig. (2-tailed)	.085
a. Grouping Variable: Project phase	

4.1.3.3 Planning and execution

Descriptives of the 2 phases are presented in Table 42 including sample size, mean, standard deviation, and standard error mean.

As mentioned before, the execution phase is considered **not normal** because the skewness and kurtosis are high, and the sample size is not large. Thus, the result the Mann-Whitney U test would be preferred if it does not match t-test results.

Table 49 presents the results of **independent-samples t-test** which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in quality of communication between planning and execution phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 50 and Table 51. Based on Table 51, **there is a significant difference** in quality of communication between planning and execution phases of the projects because the significance level is lower than 0.05. More specifically, quality of communication is better in execution phase than in planning phase based on 'mean ranks' in Table 50.

This can overrule the result of the t-test about no significant difference between the phases because execution phase is not normal. Mann-Whitney U test is a test designed for comparing 2 sets of data that are either normally or non-normally distributed. T-test results can be valid only for normal distributions. Therefore, the conclusion is that **there is a significant difference** in quality of communication between planning and execution phases of the projects.

TABLE 49 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR QUALITY OF COMMUNICATION IN PLANNING-EXECUTION PHASE COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Quality of Communication	Equal variances assumed	.251	.617	-1.87	108	.065	-.17722	.09491	-.3653	.01090
	Equal variances not assumed			-1.87	107.98	.064	-.17722	.09487	-.3653	.01082

TABLE 50 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR QUALITY OFCOMMUNICATION IN PLANNING-EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Quality of Communication	Planning	54	48.82	2636.50
	Execution	56	61.94	3468.50
	Total	110		

TABLE 51 THE RESULTS OF MANN-WHITNEY U TEST FOR QUALITY OF COMMUNICATION IN PLANNING-EXECUTION PHASE COMPARISON

Test Statistics	
	Quality of Communication
Mann-Whitney U	1151.500
Z	-2.156
Sig. (2-tailed)	.031
a. Grouping Variable: Project phase	

4.1.4 Conflict management

This construct consists of 1 variable shown in Table 9. The construct regardless of phases includes 142 projects in the CII1010 database. The distribution of the data is normal based on the skewness and kurtosis measures Table 13 and based on the distribution shape Figure 20. The distribution is considered normal although its skewness is high because the sample size is large enough. The internal consistency/reliability measure cannot be defined for this construct because it comprises only 1 variable.

Descriptives regarding conflict management construct is shown in Table 52 below.

Table 52 Descriptives of Conflict management construct

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Conflict Management	142	3.50	1.50	5.00	3.6484	.67370	.454
Valid N (listwise)	142						

As an assumption to t-test, normality of the construct is investigated in all phases in Table 12. According to the table, the data in conceptualization phase of conflict management construct is not normally distributed. Therefore, in addition to the t-test, a nonparametric test such as Mann-Whitney U test is essential. Planning and execution phases are normal though.

Figure 21, Figure 22, and Figure 23 depict distribution of the data regarding conflict management construct in different phases. The skewness and kurtosis of the conceptualization phase is high. It can negatively affect the precision of the results of t-test because the sample size is small (29). Thus, conceptualization phase is considered non-normal. Consequently, the result of Mann-Whitney U test would be preferred over t-test result if the results did not match.

Descriptives of conflict management construct in different phases are available in Table 53 including sample size, mean, standard deviation, and standard error mean.

Table 53 Descriptives of Conflict management construct in different phases

Group Statistics					
	Project phase	N	Mean	Std. Deviation	Std. Error Mean
Conflict Management	Conceptualization	29	3.5534	.71000	.13184
	Planning	54	3.6033	.63834	.08687
	Execution	56	3.7377	.70482	.09419

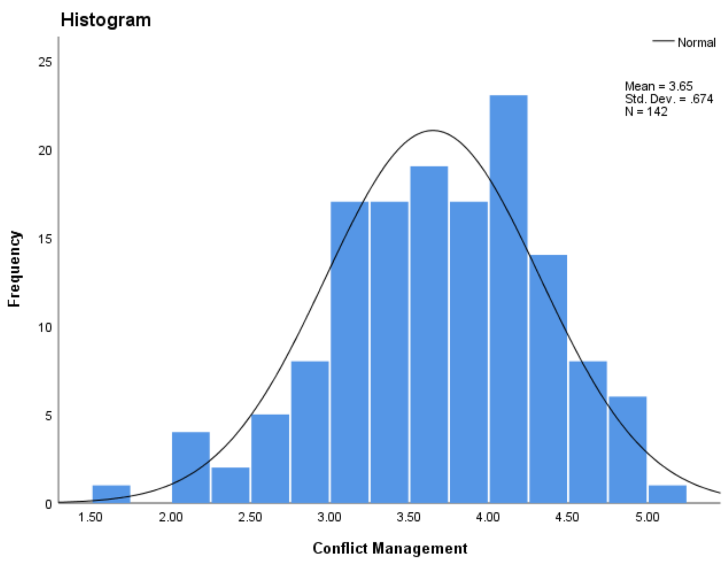

Figure 20 Distribution histogram of Conflict management construct regardless of different phases

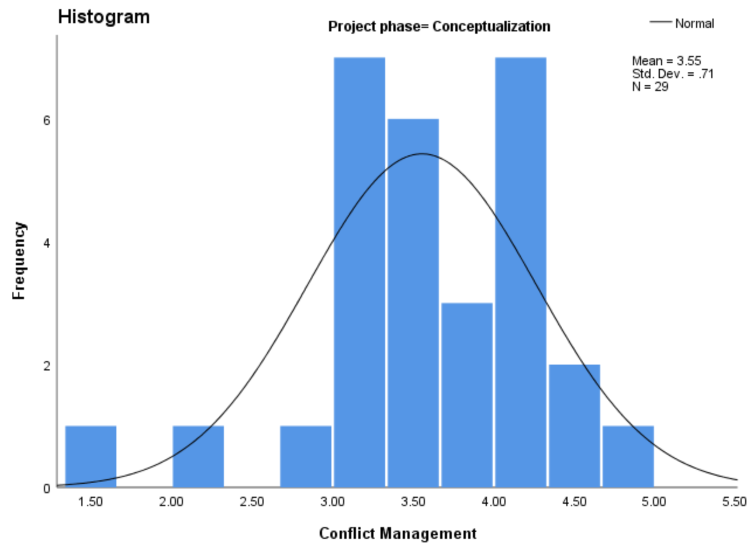

FIGURE 21 DISTRIBUTION HISTOGRAM OF CONFLICT MANAGEMENT CONSTRUCT IN CONCEPTUALIZATION PHASE

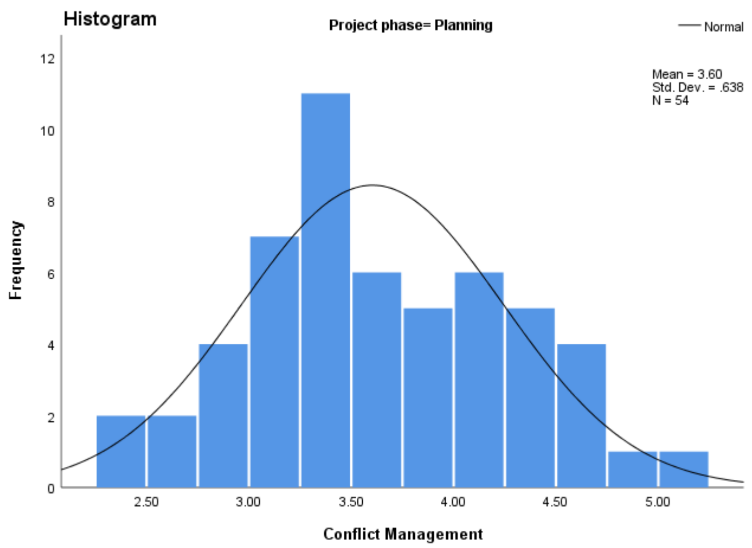

FIGURE 22 DISTRIBUTION HISTOGRAM OF CONFLICT MANAGEMENT CONSTRUCT IN PLANNING PHASE

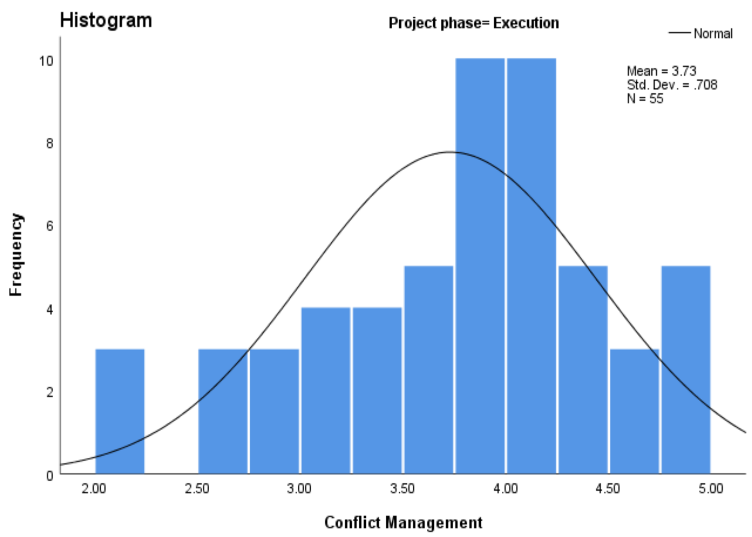

FIGURE 23 DISTRIBUTION HISTOGRAM OF CONFLICT MANAGEMENT CONSTRUCT IN EXECUTION PHASE

The results of independent-samples t-test and Mann-Whitney U test are presented in 3 categories as follows.

4.1.4.1 Conceptualization and planning

Descriptives of the 2 phases are shown in Table 53 including sample size, mean, standard deviation, and standard error mean.

Table 54 presents the results of **independent-samples t-test** (the parametric test) which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in conflict management between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** (the nonparametric test) together with its descriptives are presented in Table 55 and Table 56. Based on Table 56, there is **no significant difference** in conflict management between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

TABLE 54 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR CONFLICT MANAGEMENT IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Conflict Management	Equal variances assumed	.020	.888	-.326	81	.745	-.04989	.15286	-.35403	.25426
	Equal variances not assumed			-.316	52.372	.753	-.04989	.15789	-.36666	.26689

TABLE 55 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR CONFLICT MANAGEMENT IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Ranks

	Project phase	N	Mean Rank	Sum of Ranks
Conflict Management	Conceptualization	29	42.07	1220.0
	Planning	54	41.96	2266.0
	Total	83		

TABLE 56 THE RESULTS OF MANN-WHITNEY U TEST FOR CONFLICT MANAGEMENT IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Test Statistics

	Conflict Management
Mann-Whitney U	781.000
Z	-.019
Sig. (2-tailed)	.985

4.1.4.2 Conceptualization and execution

Descriptives of the 2 phases are shown in Table 53 including sample size, mean, standard deviation, and standard error mean.

Table 57 presents the results of **independent-samples t-test** that also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **<u>no significant difference</u>** in conflict management between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

Since the conceptualization phase is considered to be not normal, Mann-Whitney U test is necessary for the comparison of the 2 phases. The results of **Mann-Whitney U test** together with its descriptives are presented in Table 58 and Table 59. Based on Table 59, there is **<u>no significant difference</u>** in conflict management between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

TABLE 57 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR CONFLICT MANAGEMENT IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Conflict Management	Equal variances assumed	.114	.737	-1.140	83	.258	-.18423	.16165	-.5057	.13728
	Equal variances not assumed			-1.14	56.39	.260	-.18423	.16203	-.5088	.14030

TABLE 58 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR CONFLICT MANAGEMENT IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Ranks

	Project phase	N	Mean Rank	Sum of Ranks
Conflict Management	Conceptualization	29	38.97	1130.00
	Execution	56	45.09	2525.00
	Total	85		

TABLE 59 THE RESULTS OF MANN-WHITNEY U TEST FOR CONFLICT MANAGEMENT IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Test Statistics

	Conflict Management
Mann-Whitney U	695.000
Z	-1.085
Sig. (2-tailed)	.278

a. Grouping Variable: Project phase

4.1.4.3 Planning and execution

Descriptives of the 2 phases are presented in Table 53 including sample size, mean, standard deviation, and standard error mean.

Table 60 presents the results of **independent-samples t-test** which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in conflict management between planning and execution phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 61 and Table 62. Based on Table 62, there is **no significant difference** in conflict management between planning and execution phases of the projects because the significance level is greater than 0.05.

TABLE 60 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR CONFLICT MANAGEMENT IN PLANNING-EXECUTION PHASE COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper
Conflict Management	Equal variances assumed	.384	.537	-1.05	108	.298	-.1343	.12836	-.3888	.12009
	Equal variances not assumed			-1.05	107.58	.297	-.1343	.12813	-.3883	.11964

TABLE 61 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR CONFLICT MANAGEMENT IN PLANNING EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Conflict Management	Planning	54	51.34	2772.50
	Execution	56	59.51	3332.50
	Total	110		

TABLE 62 THE RESULTS OF MANN-WHITNEY U TEST FOR CONFLICT MANAGEMENT IN PLANNING-EXECUTION PHASE COMPARISON

Test Statistics	
	Conflict Management
Mann-Whitney U	1287.500
Z	-1.343
Sig. (2-tailed)	.179
a. Grouping Variable: Project phase	

4.1.5 Technical competency

This construct consists of 2 variables/questions. The sample size for the whole construct (regardless of phases) is 142 including all projects in the database. The construct data is normally distributed based on the histogram shape Figure 24 and also based on the skewness and kurtosis in Table 13. The internal consistency/reliability of the construct is acceptable Table 16. Descriptives regarding the construct are shown in Table 63 below.

For the t-test, the normality of the construct must be tested in terms of normality in each phase, namely, conceptualization, planning, and execution. This investigation is already done in the methodology section Table 12 based on which the data is found to be normally distributed in all phases. The regarding distribution histograms are provided in Figure 25, Figure 26, and Figure 27.

TABLE 63 DESCRIPTIVES OF TECHNICAL COMPETENCY CONSTRUCT

Descriptive Statistics							
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Technical Competency	142	2.80	2.20	5.00	3.7977	.59750	.357
Valid N (listwise)	142						

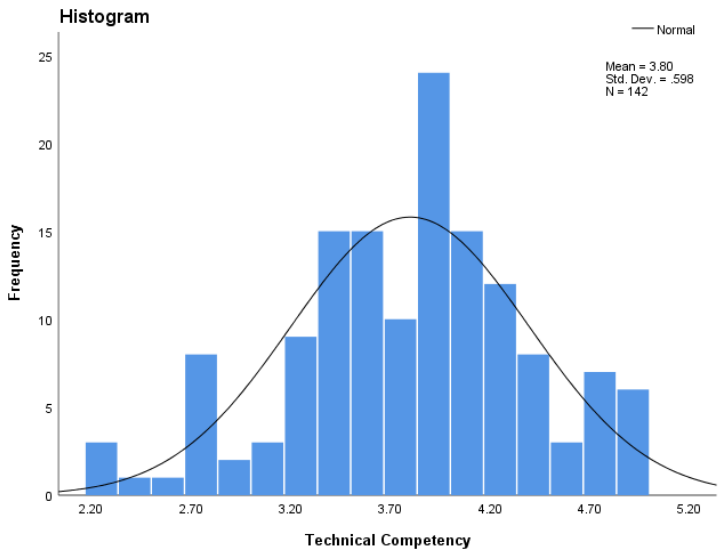

FIGURE 24 DISTRIBUTION HISTOGRAM OF TECHNICAL COMPETENCY CONSTRUCT REGARDLESS OF DIFFERENT PHASES

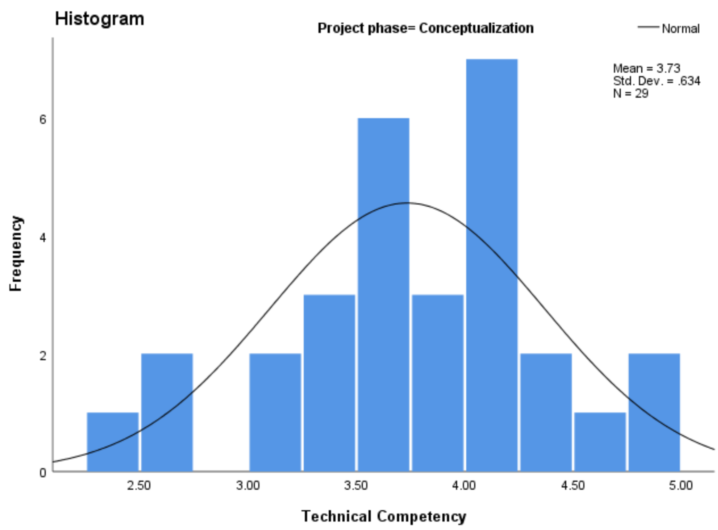

FIGURE 25 DISTRIBUTION HISTOGRAM OF TECHNICAL COMPETENCY CONSTRUCT IN CONCEPTUALIZATION PHASE

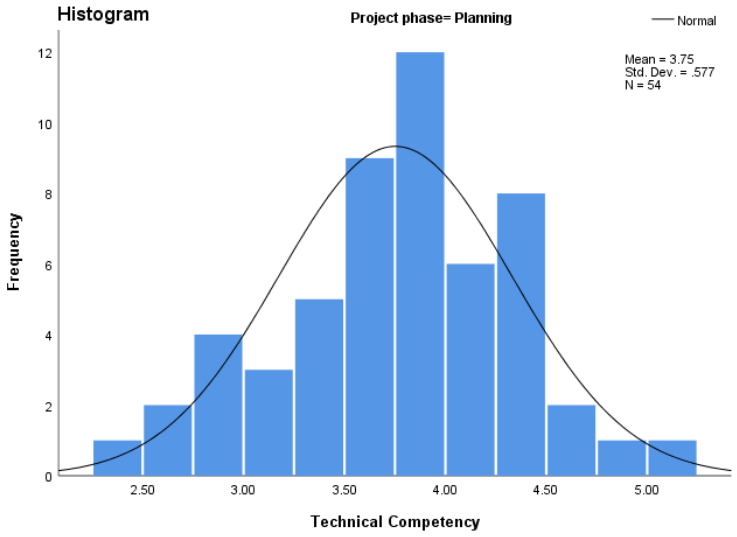

Figure 26 Distribution histogram of Technical competency construct in planning phase

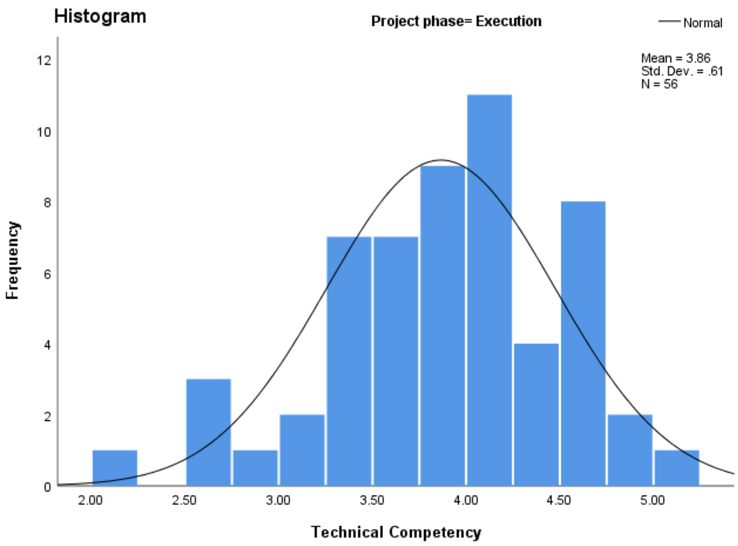

Figure 27 Distribution histogram of Technical competency construct in execution phase

Descriptives of technical competency construct in different phases are available in Table 64 including sample size, mean, standard deviation, and standard error mean.

Table 64 Descriptives of Technical competency construct in different phases

Group Statistics					
	Project phase	N	Mean	Std. Deviation	Std. Error Mean
Technical Competency	Conceptualization	29	3.7336	.63450	.11782
	Planning	54	3.7518	.57706	.07853
	Execution	56	3.8648	.60956	.08146

The results of independent-samples t-test and Mann-Whitney U test are presented in 3 categories as follows.

4.1.5.1 Conceptualization and planning

Descriptives of the 2 phases are shown in Table 64 including sample size, mean, standard deviation, and standard error mean.

Table 65 presents the results of **independent-samples t-test** (the parametric test) which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in technical competency between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** (the nonparametric test) together with its descriptives are presented in Table 66 and Table 67. Based on Table 67, there is **no significant difference** in technical competency between conceptualization and planning phases of the projects because the significance level is greater than 0.05.

TABLE 65 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR TECHNICAL COMPETENCY IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Technical Competency	Equal variances assumed	.182	.671	-.132	81	.895	-.01814	.13757	-.2918	.25558
	Equal variances not assumed			-.128	52.89	.899	-.01814	.14159	-.3022	.26588

TABLE 66 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR TECHNICAL COMPETENCY IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Technical Competency	Conceptualization	29	41.62	1207.0
	Planning	54	42.20	2279.0
	Total	83		

TABLE 67 THE RESULTS OF MANN-WHITNEY U TEST FOR TECHNICAL COMPETENCY IN CONCEPTUALIZATION-PLANNING PHASE COMPARISON

Test Statistics	
	Technical Competency
Mann-Whitney U	772.000
Z	-.105
Sig. (2-tailed)	.916
a. Grouping Variable: Project phase	

4.1.5.2 Conceptualization and execution

Descriptives of the 2 phases are shown in Table 64 including sample size, mean, standard deviation, and standard error mean.

Table 68 presents the results of **independent-samples t-test** that also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in technical competency between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** together with its descriptives are presented in Table 69 and Table 70. Based on Table 70, there is **no significant difference** in technical competency between conceptualization and execution phases of the projects because the significance level is greater than 0.05.

TABLE 68 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR TECHNICAL COMPETENCY IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Technical Competency	Equal variances assumed	.015	.902	-.928	83	.356	-.1312	.14140	-.41245	.15005
	Equal variances not assumed			-.916	54.789	.364	-.1312	.14324	-.41828	.15588

TABLE 69 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR TECHNICAL COMPETENCY IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Technical Competency	Conceptualization	29	39.45	1144.0
	Execution	56	44.84	2511.0
	Total	85		

TABLE 70 THE RESULTS OF MANN-WHITNEY U TEST FOR TECHNICAL COMPETENCY IN CONCEPTUALIZATION-EXECUTION PHASE COMPARISON

Test Statistics	
	Technical Competency
Mann-Whitney U	709.000
Z	-.955
Sig. (2-tailed)	.340
a. Grouping Variable: Project phase	

4.1.5.3 Planning and execution

Descriptives of the 2 phases are presented in Table 64 including sample size, mean, standard deviation, and standard error mean.

Table 71 presents the results of **independent-samples t-test** which also comprises the results of Levene's Test for Equality of Variances. According to the table, the variances of the phases is approximately equal and there is **no significant difference** in technical competency between planning and execution phases of the projects because the significance level is greater than 0.05.

The results of **Mann-Whitney U test** together with its descriptives are presented inTable 72 and Table 73. Based on Table 73, there is **no significant difference** in technical competency between planning and execution phases of the projects because the significance level is greater than 0.05.

TABLE 71 THE RESULTS OF INDEPENDENT-SAMPLES T-TEST FOR TECHNICAL COMPETENCY IN PLANNING-EXECUTION PHASE COMPARISON

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Technical Competency	Equal variances assumed	.134	.715	-.998	108	.320	-.11306	.11326	-.33756	.11144
	Equal variances not assumed			-.999	107.965	.320	-.11306	.11314	-.33734	.11121

TABLE 72 THE DESCRIPTIVES OF MANN-WHITNEY U TEST FOR TECHNICAL COMPETENCY IN PLANNING-EXECUTION PHASE COMPARISON

Ranks				
	Project phase	N	Mean Rank	Sum of Ranks
Technical Competency	Planning	54	52.30	2824.00
	Execution	56	58.59	3281.00
	Total	110		

TABLE 73 THE RESULTS OF MANN-WHITNEY U TEST FOR TECHNICAL COMPETENCY IN PLANNING-EXECUTION PHASE COMPARISON

Test Statistics	
	Technical Competency
Mann-Whitney U	1339.000
Z	-1.035
Sig. (2-tailed)	.301
a. Grouping Variable: Project phase	

4.1.6 Summary of the statistical findings

A simple summary of statistical findings is presented in Table 18. Summary of the findings is presented in more detail in Table 74 and Table 76 which are related to the findings of the independent-samples t-test and Mann-Whitney U test respectively. Based on the findings, there is a statistically significant difference in quality of communication (as a factor that affect transaction cost) between planning and execution phase. More specifically, quality of communication is better in execution phase than in planning phase. Furthermore, based on the mean rank value, quality of communication was better in planning phase than in conceptualization phase. This difference however was not statistically significant based on the results of Mann-Whitney U test.

4.1.6.1 Independent-samples t-test

A summary of the findings of independent-samples t-tests is presented in Table 74. Based on the table, there is a significant difference in quality of communication between conceptualization and execution phases of projects because the significance level is lower than 0.05. This finding, however, can be scrutinized because based on Figure 17 and Table 12, the conceptualization phase in this comparison is not normally distributed while t-test has normality as an assumption. Thus, results of the Mann-Whitney U test can overrule this finding.

In addition, according to the table, there is no significant difference in quality of communication between planning and execution phases although the significance level is 0.065 which is slightly higher than the critical range limit (0.05). The execution phase in this comparison is not normally distributed. Therefore, the finding may be overruled by the result of the Mann-Whitney U test.

Table 74 The summary of the findings of independent-samples t-tests

Construct	Phase	Assumption of equal variance of samples	Critical range for t-value	T-value	Significance level (2-tailed)	significant difference between phases (significance level <0.05)
Leadership	1-2	Valid	+/-1.99	1.030	.306	NO
	1-3	Valid	+/-1.99	-.184	.854	NO
	2-3	Valid	+/-1.98	-1.541	.126	NO
Quality of decision-making	1-2	Valid	+/-1.99	.098	.922	NO
	1-3	Valid	+/-1.99	-.586	.560	NO
	2-3	Valid	+/-1.98	-.841	.402	NO
Quality of communication	1-2	Valid	+/-1.99	-.585	.560	NO
	1-3	Valid	+/-1.99	-2.019	.047	YES
	2-3	Valid	+/-1.98	-1.867	.065	NO
Conflict management	1-2	Valid	+/-1.99	-.326	.745	NO
	1-3	Valid	+/-1.99	-1.140	.258	NO
	2-3	Valid	+/-1.98	-1.047	.298	NO
Technical competency	1-2	Valid	+/-1.99	-.132	.895	NO
	1-3	Valid	+/-1.99	-.928	.356	NO
	2-3	Valid	+/-1.98	-.998	.320	NO

In Table 74 and Table 76, the phases are shown by numbers because of space limit. Table 75 shows the numbers assigned to each phase.

Table 75 Numbers assigned to each phase

Phase	Number
Conceptualization	1
planning	2
Execution	3

4.1.6.2 Mann-Whitney U test

A summary of the findings for Mann-Whitney U tests is presented in Table 76. Based on the table, **there is no significant difference** in quality of communication between conceptualization and execution phases. Since the conceptualization phase is not normally distributed, this result can overrule the regarding t-test result about a significant difference between the 2 phases.

Furthermore, the table shows **a significant difference in quality of communication between planning and execution phases**. Since the execution phase is not normally distributed, this result can overrule the regarding t-test result about a significant difference between the 2 phases.

TABLE 76 THE SUMMARY OF THE FINDINGS OF MANN-WHITNEY U TESTS

Construct	Phase	Z-value	Significance level	significant difference between phases (significance level <0.05)
Leadership	1-2	-1.394	.163	NO
	1-3	-.362	.718	NO
	2-3	-1.501	.133	NO
Quality of decision-making	1-2	-.626	.532	NO
	1-3	-.394	.694	NO
	2-3	-1.103	.270	NO
Quality of communication	1-2	-.435	.664	NO
	1-3	-1.724	.085	NO
	2-3	-2.156	.031	YES
Conflict management	1-2	-.019	.985	NO
	1-3	-1.085	.278	NO
	2-3	-1.343	.179	NO
Technical competency	1-2	-.105	.916	NO
	1-3	-.955	.340	NO
	2-3	-1.035	.301	NO

In conclusion, quality of communication is the only construct that was proven to have a significant difference between its phases. More specifically, there is a statistically significant difference in quality of communication between planning and execution phases. All the other 4 constructs (or determinants of transaction cost) did not show any significant difference between different phases of projects.

4.2 Interviews (Qualitative findings)

In this part, the findings of qualitative interviews are presented. These findings are related to the second research question. In the previous part, findings of the statistical analysis (the main part of the research) were presented which show a statistically significant difference in the quality of communication between planning and execution phases of construction projects. In this part, the findings of the interviews with industry practitioners (project managers in Norway) are presented which intend to find the reasons for the difference found in the statistical analysis. This organization of findings is in line with the order of research questions. The logical relation of the interviews (the qualitative part of the study) to the statistical investigation (the quantitative part of the study) is illustrated in Figure 3.

There are different factors that impact the quality of communication in projects. The strength of these factors can be different in different phases of projects which may lead to a difference in the quality of communication between project phases. This section starts with a summary of the findings (factors found in the interviews) which is shown in Table 77. It is followed by a detailed description of the factors.

TABLE 77 FINDINGS OF INTERVIEWS (RQ2)

Respondents		**Factors found in the interviews**					
		Factors that cause a better quality of communication in execution than in planning phase			Factors that affect the quality of communication in general		
Respondents ID	Respondents Project Type	Communication channel	Informal ways of communication	Access to information	Trust	Uncertainty	Availability of the stakeholder
1	Industrial (Oil and Gas)	✓	✓	✓	✓		
2	Industrial (Oil and Gas)	✓	✓		✓	✓	
3	Building and Infrastructure	✓	✓		✓	✓	✓
4	Infrastructure	✓	✓	✓	✓		✓

4.2.1 Factors found in the interviews

The interviews aimed to find the reasons for the difference in the quality of communication between planning and execution phase of projects. Thus, during the interviews, the effort was to find factors that cause the difference. The following factors were found to be the potential reasons for a difference in quality of communication between planning and execution phases:

1. Communication channel

Members of a project team can communicate through different channels which may impact the quality of communication (Hellriegel & Slocum Jr, 1996b; Housel, 1977; Lloyd & Varey, 2003). Face-to-face communication, video call, phone call, email, and online portals and databases are examples for communication channels.

All respondents note that the choice of communication channel can impact the quality of communication. %75 of the respondents considered face-to-face communication as the best and most preferred channel. %25 of the respondents mentioned phone calls as the preferred communication channel “because it is more convenient and faster” but also mentioned that some misunderstandings can happen in phone calls. Other respondents also state that they more often use video calls and phone calls because of their lower cost and higher convenience.

All respondents mentioned a difference between the portion of communication channels used in planning and execution phases. They all stated that phone calls, video calls and face-to-face meetings are more common in the execution phase of projects. In addition, respondent 2 echoed that "Communication is more regular/orderly in execution phase. The meetings are scheduled every week, every other week, or once a month depending on the project". %50 of the respondents said that communication in planning phase is mostly done through emails and shared databases.

%50 of the respondents noted that the quality of communication can change over time in projects due to the nature of different phases. Respondent 2 stated that communication becomes better in a project over time as a project progress. She/he also mentioned that "as projects proceed, things become clearer and the need for communication may decrease as a result. Therefore, communication channel may change back to email after a while in execution phase and later in project. It can be done through an intranet interface as well." Respondent 4 also mentioned that communication is mostly done through email in the planning phase. Face-to-face communication was identified to be mostly during the execution phase. He/she also note that the communication in the termination phase is not at the same level as planning and execution phase. there are some rest points at this phase to be done, but it does not need as much communication. Quality of communication drops especially after you pay the contractor.

All respondents agree that a certain amount of communication has to be done through email to provide documents which can be used later in the project or even after project completion for documentation and knowledge transfer purposes. It is especially important in the initiation and planning phase where the need for documentation of agreements, legal documents, drawings, and plans is high. Emails are needed in execution phase as well for reporting for example, but phone calls, video calls, and meetings constitute a bigger portion of communication channel in the execution phase compared to the planning phase according to the respondents.

2. Informal ways of communication

Lloyd and Varey (2003) mention that informal communication is a factor that can improve the quality of communication. It is considered to be the best if possible (Lloyd & Varey, 2003). Respondent 1 mentioned that informal communication can be a success factor. He/she said that "A lot of informal communication in a flat structure can make a sharing and helping environment".

%75 of the respondents reported that informal communication is more common in the execution phase than in the planning phase while %25 considered it to be equal in both phases. respondent 3 noted that informal communication is more common in the execution phase because of the nature of the work in this phase. "In the planning phase, documentation is more necessary which requires written communication channels like email and digital databases". The workload is lower in the planning phase. She/he also mentioned that communication with the execution teams that do the physical work in the field is mostly in form of informal phone calls.

%75 of the respondents considered informal communication as a factor that positively affects the quality of communication. %25 believed that it can negatively impact traceability and comprehensiveness of information. "Some important data may be missed during informal communication" he/she said.

3. Access to/availability of information

Lloyd and Varey (2003) note that ease of access to information can affect communication. %50 of the respondents considered 'access to information' as a factor that positively affect the quality of communication. Respondent 2 echoed that "as the project proceeds, things become clearer (available information increases) and the need for communication decreases". It is especially significant in the planning phase of offshore projects in oil-and-gas industry. "Sometimes, some important information is not provided to the project-team in the beginning and in the planning phase. After the execution phase, when it comes to analysis and delivery of the deliverables, they realize that something is missing because the project-team was not informed about some significant information in the beginning" as respondent 1 reported. It results in reworks, longer duration, and cost overrun in some cases. This specially happens when they do not communicate directly to the end-user. Some important information may miss when they do not have direct communication with end-user. This can be a communication barrier especially in the planning phase.

Generally, availability of/access to information was reported to be better in the execution phase.

4. Uncertainty

Hellriegel & Slocum (1996) define uncertainty as "the gap between the amount of information needed for a task and the amount of information available" (Hellriegel & Slocum Jr, 1996a). Uncertainty is also one of the three general determinants of transaction cost. High levels of uncertainty give rise to transaction cost (Oliver E Williamson, 1979, 1981, 2010). To overcome uncertainty, organizations need to have either extra information and better communication or buffer resources (Hellriegel & Slocum Jr, 1996a). Thus, project team members may choose to use better communication channels like face-to-face or video call meetings instead of email (as a one-way communication means) which increases the quality of communication as a result.

Uncertainty was identified in %50 of the interviews as a factor that can positively affect the quality of communication. Respondent 3 stated that uncertainty can affect the quality of communication as more and better communication is needed to clarify things and to reduce the uncertainty. However, respondent 4 mentioned that uncertainty would result in more communication in the planning phase, but it does not necessarily mean that the quality of communication is affected by uncertainty in the phase. "It is only more frequent". %75 of the interviewees specifically reported that uncertainty is higher in the planning phase. Respondent 2 echoed that "as the project proceeds, things become clearer and the need for communication decreases". Communication becomes better over time in projects. Respondent 1 mentioned that uncertainty is considerably high in offshore projects because there is a lot of change in schedules due to weather condition for example.

5. Trust

Diallo (2005) mention trust as a significant factor that impacts communication in projects (Diallo & Thuillier, 2005). Different aspects of trust can vary in different project phases which may affect communication in turn. The most relevant aspects of trust that can be related to the findings of interviews are Cognition-based trust (McAllister, 1995) and Knowledge-based trust (Lewicki & Bunker, 1995) which refer to trust based on the competency of the stakeholder in fulfilling their job and trust based on the previews work with the stakeholder respectively.

All respondents noted that trust in the meaning of not lying is not an issue in the work relationships in Norway because "work relations are trust-based to an acceptable degree". However, for offshore projects in oil-and-gas industry, this can be an issue when it comes to working with low-budget companies in other countries, as respondent 1 said. Respondent 4 also mentioned that competency and more specifically experience of the contractors can affect the quality of communication. This would impact communication equally in planning and execution though.

All respondents stated that frequency of work with a party can positively affect the quality of communication. %50 considered the effect to be equal in the planning and execution phase. One of these respondents mentioned that the impact of this factor is greater in the planning phase in offshore oil-and-gas projects. %25 mentioned that the impact is more considerable in the execution phase as most of the workload of a building or infrastructure project is in the execution phase.

Respondent 1 also mentioned 'cultural differences' as a factor that can affect the quality of communication especially when it comes to the low-budget companies in Asia. They may also underbid to get the job but deliver lower quality product in the end. This factor can also affect trust between the parties. The effect of cultural difference on the quality of communication is more in the planning phase in offshore projects. "It affects all phases equally in onshore projects though".

6. Availability of the stakeholder

This factor did not exist in the literature, but it was mentioned by %50 of the respondents that work on infrastructure projects as a factor that affects the quality of communication with contractors who may not respond quickly. "The project manager of the contractor is sometimes hard to find" as responded 4 described. They reported that availability of a contractor can be more of an issue for communication in the execution phase. It does not lead to huge consequences though. This issue was mostly with big-size contractor companies because project managers in big companies may handle many projects at the same time. The availability of the other party was better in the planning phase.

In addition to the aforementioned factors, respondent 2 and 4 noted that regular and routine communication can positively impact the quality and effectiveness of communication is more orderly and regular in the execution phase

4.3 Summary of the findings for statistical analysis and qualitative interviews

The summary of the findings for the statistical analysis is presented in Figure 28. The statistical findings are related to research question 1 (main part of the research) and interview findings are related to research question 2 (for deeper understanding of the topic). The scope is limited to the factors that affect transaction cost based on Li *et al*. (2015) model for determinants of transaction cost in construction projects. The scope is also limited to the factors in project management efficiency category in the model, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency (Figure 1). The summary of the statistical and interview findings are presented in more details in Table 76 and Table 77 respectively. The summary of the findings for the interviews are presented in more detail in Table 77.

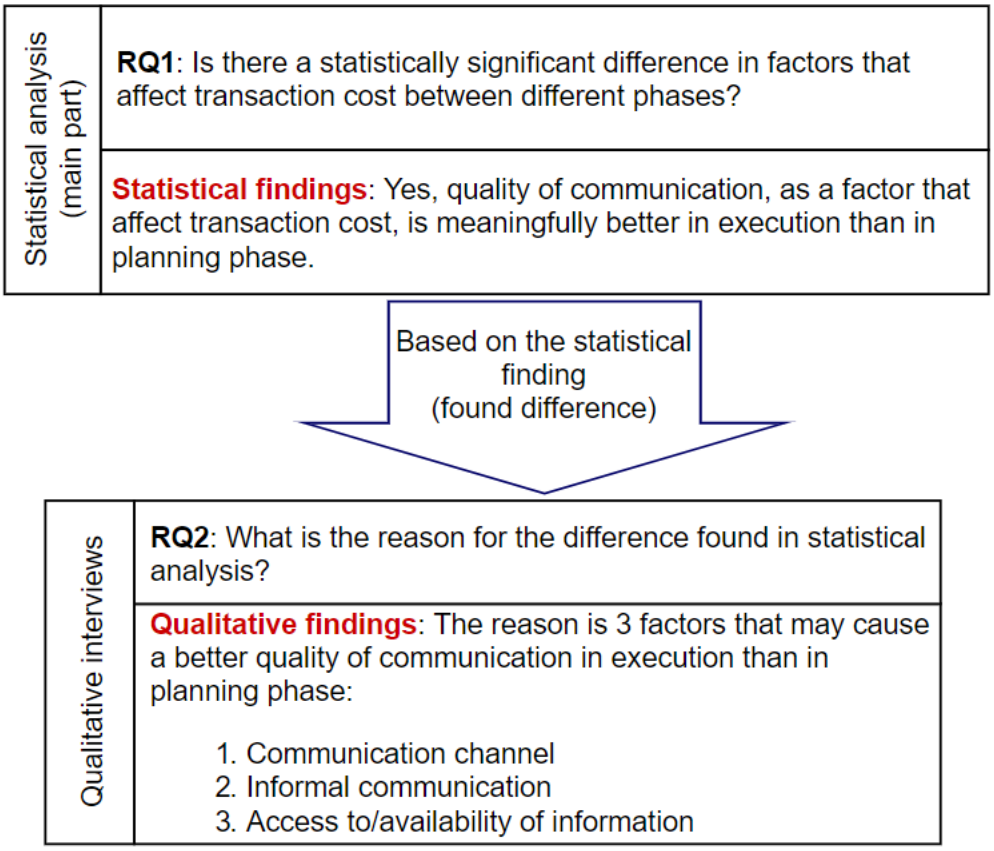

FIGURE 28 SUMMARY OF THE FINDINGS FOR STATISTICAL ANALYSIS AND QUALITATIVE INTERVIEWS

5 Discussion

In this section, the findings of the research are discussed in light of the current literature on transaction cost in projects. The structure of this section follows the order of the research question. First, the findings of the statistical analysis on the data from 142 projects (on CII1010 database) are discussed. The first part is related to the RQ1. Then, the findings for the qualitative interviews are discussed which meant to bring a deeper understanding of the subject. The second part is related to RQ2. At the end of the section, theoretical contributions and practical implications of the research are presented.

This paper compares factors that determine transaction cost in different phases based on Li *et al.*'s (2015) model for determinants of transaction cost. The scope of this paper is limited to the factors in project management efficiency category, namely, leadership, quality of decision-making, quality of communication, conflict management, and technical competency. This is shown in Figure 1.

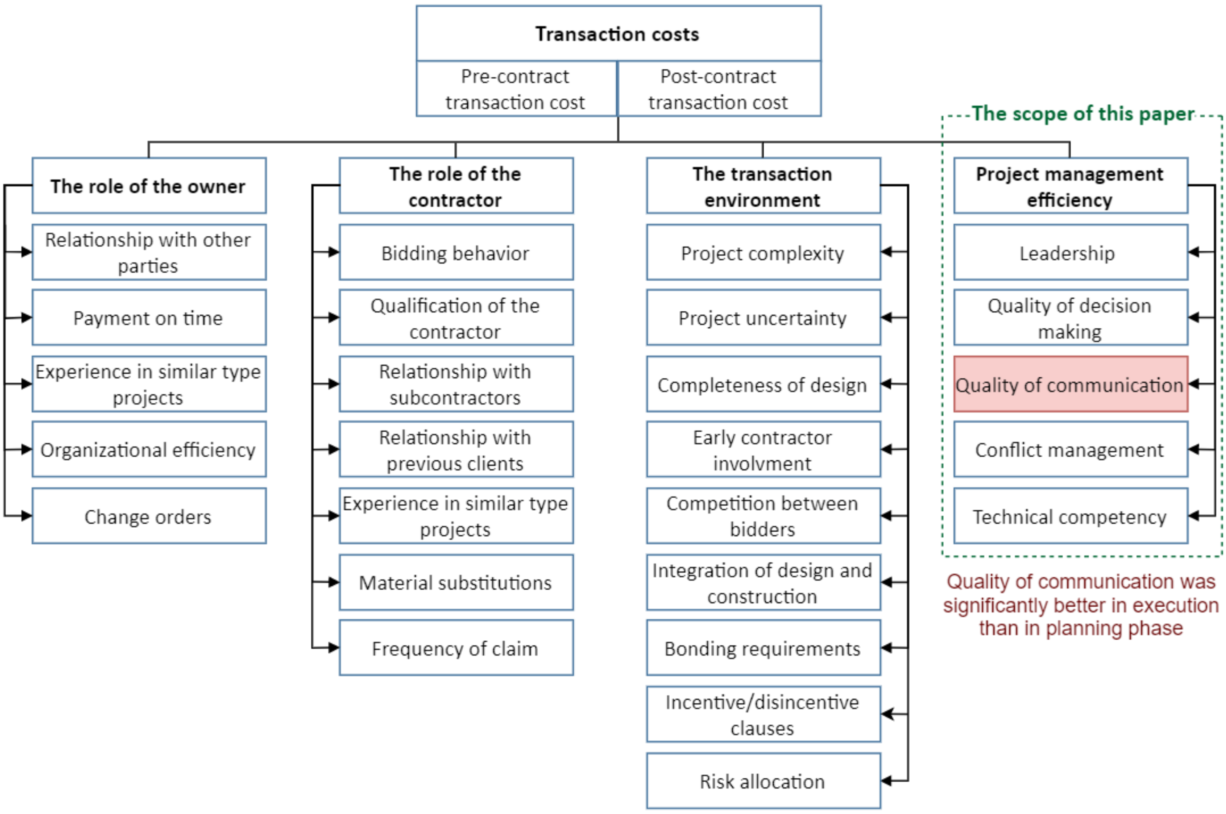

FIGURE 29 DETERMINANT OF TRANSACTION COST FROM LI ET AL.'S (2015) THAT WAS SIGNIFICANTLY DIFFERENCT BETWEEN PROJECT PHASES

During a statistical analysis on the data from CII1010 database based on Li *et al.*'s (2015) framework, the author noticed a significant difference in quality of communication, as a factor that affect transaction cost, between planning and execution phases. This is shown in Figure 29. In fact, quality of communication was significantly better in execution than in planning phase. The current literature on transaction cost in projects does not quite cover this significant difference between the phases. Thus, to obtain a more profound understanding of the subject, qualitative interviews with 4 project managers was conducted which aimed to find the reasons for the differences found in the statistical analysis. The logical relation of the interviews (the qualitative part of the study) to the statistical investigation (the quantitative part of the study) is illustrated in Figure 3. Based on this logical relation, the summary of findings is presented in Figure 28.

It is important to mention that the existing empirical studies on transaction cost in projects are mostly limited to the procurement phase of projects and to Public-Private-Partnership arrangement. This paper is one of the few studies that is not limited to a specific phase or contractual arrangement.

5.1 Discussion of the finings for the statistical analysis

The purpose of the statistical analysis was to identify which factors, that affect transaction cost, are significantly different between project phases. The factors were selected from Li *et al.*'s (2015) framework for determinants of transaction cost in projects. High-quality data for 142 construction projects in Norway was analyzed to check if the factors that affect transaction cost are significantly stronger or weaker between different phases. During the literature search for this paper, no research was found that study determinants of transaction cost specifically in different project phases. The literature in this area may not be rich enough. Furthermore, as it is important for statistical analyses, validity and reliability of the data was examined in this research which found to be good enough to support the precision of the findings.

Further in this part of discussion section, the findings of the statistical analysis are discussed based on the order of the 5 determinants of transaction cost in Li *et al.'s* (2015) model in project management efficiency category shown in Figure 29. Subsequently, the findings are discussed based on the order of the first research question which includes 3 sub-questions pertaining to the 3 pairs of phases between which determinants of transaction cost are compared.

1. Leadership is the first determinant of transaction cost in Li *et al.'s* (2015) model. Based on the findings, there was no statistically meaningful difference in leadership between project phases.

The finding is in line with the findings of the research by Weinkauf & Hoegl (2002) as they found that 12 out of 15 fearures of leadership have almost same strength in different pahses and 3 fearures were slightly better in the second phases (Weinkauf & Hoegl, 2002). Unlike this research, 2 phases were considered for projects in their study. It is not surprizing to see that leadership is not different between project phases considering the significance of leadership patterns in human psyche since childhood (Bass & Bass, 2009) and also considering the importance of leadership activities in whole project such as motivating members towards cooperative behavior (De Meyer, 2011), informing stakeholders of important information and decisoins (Barczak et al., 2006), and acknowledging outstanding contributions (T. A. Judge & R. F. Piccolo, 2004; Lowe et al., 1996).

Considering the role of leadership as a factor that determine transaction cost in projects (Li et al., 2015), it can be concluded that leadership may not cause a meaningful difference in transaction cost between project phases.

2. Quality of decision-making is the second determinant of transaction cost in the scope of this paper. Based on the findings, there was no statistically meaningful difference in quality of decision-making between different project phases.

Uncertainty is one of the factors that affect quality of decision-making (Virine & Trumper, 2019). It is surprising that findings show no difference in quality of decision-making in project phases because the level of uncertainty, as a factor that affect quality of decision-making, changes from high to low in projects (N. O. Olsson, 2006; Pinto, 2013) and also because the importance of decisions in a project decreases as project progress over time (Samset, 2014). It can be surprising also because the level of complexity, as a factor that affect quality of decision-making (Virine & Trumper, 2019), can change over time (Marques et al., 2011). There are pre-defined decision-making processes in organizations which project managers should follow when they make decisions because they should make sure that the decisions are made based on analysis and logic, rather than gut feeling and intuition (De Wit & Meyer, 2010). Therefore, the stability of the quality of decision-making (which is the finding of this paper) can probably mean that decent decision-making processes are defined for the projects in the survey and they have decently followed the decision-making processes throughout the project lifecycle. This can make sense because organizations should usually reach a decent maturity level to participate in benchmarking surveys like CII1010 program that the data for this paper is provided by.

Considering the role of quality of decision-making as a factor that determine transaction cost in projects (Li et al., 2015), it can be concluded that quality of decision-making may not cause a meaningful difference in transaction cost between project phases.

3. Quality of communication is the third determinant of transaction cost in the scope of this paper that is compared between project phases. Based on the statistical findings, quality of communication was significantly better in execution than in planning phase. Based on the statistical results, quality of communication was also better in execution than in conceptualization phase. The difference was not great enough to reach the acceptable statistical significance level (between 0 and 0.05) but it was close to it (0.85). This can mean that in many of the projects in the survey, the quality of communication was better in planning than in conceptualization phase, but it cannot be considered statistically significant. The mean ranks of the aswers to the survey show that quality of communication was better in planning than in conceptualization and it was better in execusion than in conceptualization phase.

The found difference in quality of communication between planning and execution phases can be surprizing because the importance of communicaiton as a success factor was the same in planning and execution phases based on a research by Hyväri (2006). However, the small difference in quality of communicaiton between conceptualization and execution phases, that was found in the statistical analysis, was in line with her findings as she found out that the importance of the factor was slightly less in the conceptualization phase (Hyväri, 2006). Pinto and Prescott (1988) assume communication to be a significant factor in execution phase which can explain why this factor was found to be better in this phase (Pinto & Prescott, 1988). There are different factors that affect the quality of communication in project phases. changes in those factors can cause a difference in quality of communication in project phases. This is discussed in the next part of discussion which is related to the findings for qualitative interviews.

Based on the statistical findings, the changes in quality of communication are roughly illustrated in Figure 30. This illustrasion is conceptual and is not based on accurate number. Quality of communication in termination phase, on Figure 30, is based on the findings for interviews presented in the next part of this section. Termination phase was excluded from the scope of statistical analysis.

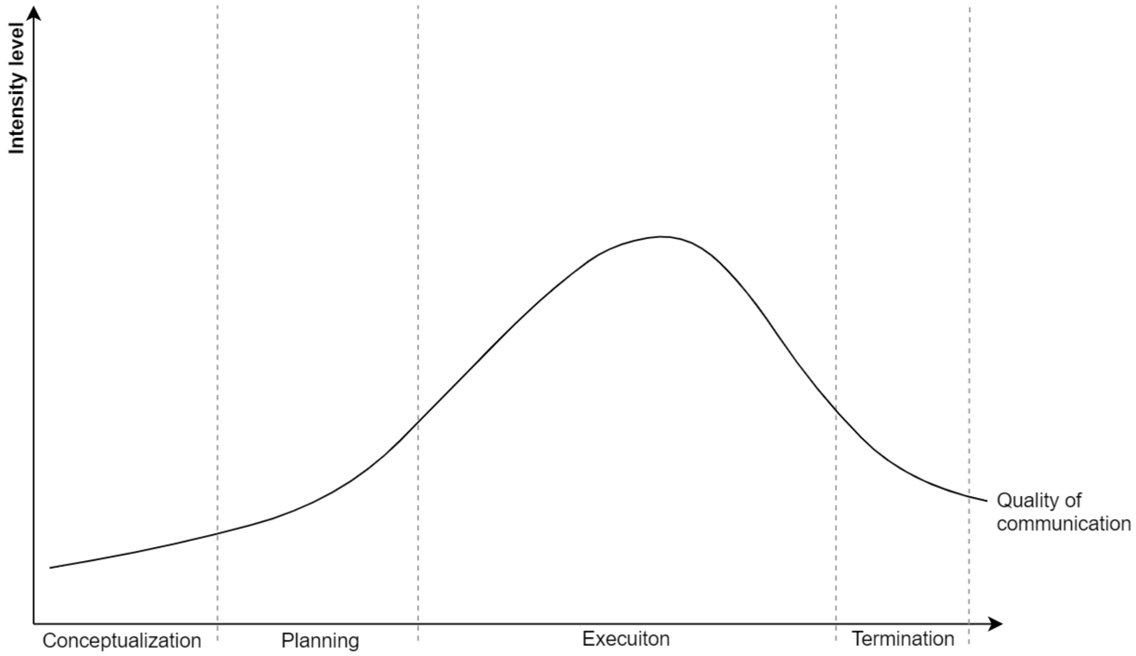

FIGURE 30 QUALITY OF COMMUNICATION IN PROJECT PHASES BASED ON THE FINDINGS OF THIS STUDY

Considering the role of quality of communication as a factor that determine transaction cost in projects (Li et al., 2015), it can be concluded that quality of communication may cause a meaningful difference in transaction cost between project phases.

4. Conflict management is the forth determinant of transaction cost in the scope of this paper. Based on the findings, there was no statistically meaningful difference in conflict management between different project phases.

The impact of conflict management on transaction cost is based on the fact that transaction cost economics takes into account human and environmental factors such as conflicts (Oliver E Williamson, 1981). Conflicts are inherent in human relationships including relationship between project team and various stakeholders with usually conflicting expectations (Harmon, 2003). Thus, it is expectable that conflicts may happen in all project phases. To cope with the conflicts, conflict management processes are considered to be a major component of project management in construction industry (Gardiner & Simmons, 1995) which continuously respond to identified conflicts in whole project (Curcija et al., 2019). Project management processes are usually introduced in the beginning of projects and used when a conflict rises. This may explain why no difference was found in conflict management between project phases, because basically, conflicts can happen in all phases and conflict management systems continuously respond them. Besides, since conflict management has a considerable impact on project management efficiency and transaction cost (Jergeas & Hartman, 1994), project managers may continuously employ project management process throughout the project to avoid consequences of conflicts which results in no difference in conflict management between project phases.

Considering the role of conflict management as a factor that determine transaction cost in projects (Li et al., 2015), it can be concluded that this factor may not cause a meaningful difference in transaction cost between project phases.

5. Technical competency is the fifth determinant of transaction cost in the scope of this paper. Based on the findings, there was no statistically meaningful difference in technical competency between different project phases.

Technical competency in this context is related to not only the machinery and physical realization of the project in execution phase but also to technological expertise, system design, industry specialization, and risk management skills (Isik et al., 2010) which may affect whole project. This may to some extent explain why no difference was found in technical competency between project phases. Besides, the variables from CII1010 database that are assigned to the technical competency construct are mainly about the general work processes and team-members' skills and experience which imapact the whole project. Vairables are presented in Table 9. The fact that machinary aspect of the work is not included in the variable construct might have affected the results.

Considering the role of technical competency as a factor that determine transaction cost in projects (Li et al., 2015), it can be concluded that this factor may not cause a meaningful difference in transaction cost between project phases.

Following is the discussion of the statistical findings based on the order of the first research question which includes 3 sub-questions pertaining to the 3 pairs of phases between which determinants of transaction cost are compared.

5.1.1 Comparison between conceptualization and planning phases

Based on the results of the statistical investigation, there was no significant difference in the factors between conceptualization and planning phases. More specifically, leadership, quality of decision-making, quality of communication, conflict management, and technical competency as determinants of transaction cost were not significantly different between conceptualization and planning phases. Thus, the hypothesis that 'there is no statistically significant difference in factors that affect transaction cost between conceptualization and planning phases' is verified.

According to the findings, leadership, quality of decision-making, quality of communication, conflict management, and technical competency were not better or worse in one of conceptualization and planning phases. Since the factors affect transaction cost in projects, it can be concluded that none of them cause a significant difference in transaction cost between the two phases.

5.1.2 Comparison between conceptualization and execution phases

Based on the results of the statistical investigation, there was no significant difference in the factors between conceptualization and execution phases. More specifically, leadership, quality of decision-making, quality of communication, conflict management, and technical competency as determinants of transaction cost were not significantly different between conceptualization and execution phases. Thus, the hypothesis that 'there is no statistically significant difference in factors that affect transaction cost between conceptualization and execution phases' is verified.

According to the findings, leadership, quality of decision-making, quality of communication, conflict management, and technical competency were not better or worse in one of conceptualization and execution phases. Since the factors affect transaction cost in projects, it can be concluded that none of them cause a meaningful difference in transaction cost between the two phases.

5.1.1 Comparison between planning and execution phases

Based on the results of the statistical investigation, there was a significant difference in quality of communication between planning and execution phases. More specifically, quality of communication was significantly better in execution than in planning phase of the projects. Thus, the hypothesis that 'there is no statistically significant difference in factors that affect transaction cost between planning and execution phases' is not verified.

Quality of communication is a factor that determine transaction cost in projects. Better communication in execution phase means that currently in projects, this factor reduces transaction cost more significantly in execution than in planning phase.

The first part of the discussion was regarding the statistical findings. In the second part, the reasons for the differences found in the statistical findings will be discussed.

5.2 Discussion of the finings for the interviews

So far in this section, the findings of the statistical analysis were discussed. During the analysis, a significant difference in quality of communication, as a factor that determine transaction cost, was found between planning and execution phases. The existing literature on transaction cost does not cover this significant difference. Thus, in order to obtain a deeper understanding of the subject, qualitative interviews with 4 project managers were conducted. The purpose of the interviews was to find the reasons for the significant difference found in the statistical analysis. The interviews were analyzed to find sections where the interviewees talked about factors that differentiate the quality of communication in project phases. In this part of the discussion section, the findings of the interviews are discussed in light of the literature in this respect. This part is related to RQ2.

Quality of communication can change over time in a project. During the interviews, it was found that 3 factors (communication channel, informal communication, and availability of information) can cause the significant difference found in the statistical analysis. In this part, these factors are discussed in relation to the theory. In addition, uncertainty is also discussed as a factor that affect the quality of communication in general because of its paradoxical features regarding transaction cost.

Communication channel

All respondents note that the choice of communication channel can impact the quality of communication. This is in line with the theory as Hellriegel & Slocum (1996), Housel (1977), and Lloyd & Varey (2003) mention that members of a project team can communicate through different channels which may impact the quality of communication (Hellriegel & Slocum Jr, 1996b; Housel, 1977; Lloyd & Varey, 2003).

%75 of the respondents considered face-to-face communication as the best and most preferred channel. %25 of the respondents preferred phone calls "because it is more convenient and faster" but also mentioned that some misunderstandings can happen in phone calls. Other respondents also stated that they use video calls and phone calls more often because it is cheaper and more convenient. The findings were in line with the literature where face-to-face communication found to be better than written channels like email (Dewhirst, 1971) and phone calls (Zaidel & Mehrabian, 1969). Face-to-face communication is the best channel also because it conveys the highest amount of nonverbal communication (Housel, 1977; Wilson, 1974). Generally, two-way channels like face-to-face meetings, video conference, and phone calls have higher quality of communication than one-way channels like email and digital databases because they provide the possibility of dialogue in which misunderstandings can easily be clarified. One of the respondents preferred phone calls which is not in line with the literature. The reason was the convenience of this channel.

Both from theory and from respondents' answers, it is fair to conclude that quality of communication is the highest in face-to-face meetings. After that, video calls, phone calls, and written channels (including email as well as online portals and databases) have highest to lowest quality of communication respectively. Using better communication channel would improve the quality of communication and as a result, reduce transaction cost in project.

So far, face-to-face meeting was considered to be the best communication channel because of their effect on communication and transaction cost. However, it may have its own downsides too. When it comes to communication with stakeholders outside the company, face-to-face meetings requires traveling. Traveling, proportionate to the distance, can cause emissions and therefore sustainability issues. This can be a disadvantage of face-to-face communication.

Face-to-face communication can have a paradoxical effect on transaction cost. On one hand, face-to-face meetings increase the quality of communication which leads to a reduction in transaction cost. On the other hand, face-to-face meetings require traveling in many cases which lead to higher transaction cost as it imposes traveling cost to companies (traveling cost is a form of transaction cost). Thus, companies may face a trade-off when it comes to face-to-face meetings that requires traveling. In addition, in special circumstances like in Corona pandemic, face-to-face meetings may not be the safest communication channel.

Quality of communication can change in different phases. %50 of the respondents noted that the quality of communication can change over time in projects due to the nature of different phases. Respondent 4 mentioned that:

> Communication is mostly done through email in the planning phase. Face-to-face communication is mostly used during the execution phase. Communication in the termination phase is not at the same level as planning and execution phase. there are some rest points at this phase to be done, but it does not need as much communication. Quality of communication drops especially after you pay the contractor.

Respondent 2 stated that:

> Communication becomes better in a project over time as a project progress. As projects proceed, things become clearer and the need for communication may drop after a while in the execution phase. At this point, communication channel may change to email. Communication can be done through an intranet interface as well.

This finding supports the statistical findings regarding the change in quality of communication in different phases shown in Figure 30.

All respondents agree that a certain amount of communication has to be done through email to provide documents which can be used later in the project or even after project completion for documentation and knowledge transfer purposes. It is especially important in the initiation and planning phase where the need for documentation of agreements, legal documents, drawings, and plans is high. Emails are needed in execution phase as well for reporting for example, but phone calls, video calls, and meetings constitute a bigger portion of communication channel in the execution phase compared to the planning phase according to the respondents.

Considering the positive effect of two-way communication channels (face-to-face, video call, and phone call) on the quality of communication, it can be concluded that, choice of communication channel is a factor that has caused a better quality of communication in the execution than in planning phase. It can lead to lower transaction cost. However, face-to-face communications that require travelling may increase transaction cost and cause environmental issues.

Informal communication

Informal communication is a factor that can improve the quality of communication. It is considered to be the best way of communication if possible (Lloyd & Varey, 2003). It is an effective way of discussing and finding solutions (Christensen, 2008). This is in line with the findings as %75 of the respondents considered informal communication as a factor that positively affects the quality of communication. On the contrary, an employee survey by Foehrenbach and Goldfarb show that the respondents preferred formal communication channels for receiving information (Foehrenbach & Goldfarb, 1990). This was the case in one of the interviews as well:

> Informal communication can negatively impact traceability and comprehensiveness of information. Some important data may be missed during informal communication.

All in all, respondents believed that informal communication can positively impact the quality of communication, but it may not be used where documentation is needed. This is in line with the theory as Turner & Müller echo that a balance between formal and informal communication would lead to best results (Turner & Müller, 2004).

%75 of the respondents reported that informal communication is more common in the execution than in planning phase while %25 considered it to be equal in both phases. Respondent 3 noted:

> Informal communication is more common in the execution phase because of the nature of the work in this phase. In the planning phase, documentation is more necessary which requires written communication channels like email and digital databases. Communication with the execution teams that do the physical work in the field is mostly in form of informal phone calls.

In conclusion, considering the fact that informal communication improves the quality of communication, higher portion of informal communication can mean that this factor affect the quality of communication to be better in the execution phase. This also supports the statistical findings regarding the difference in quality of communication between planning and execution phase shown in Figure 30.

Access to/availability of information

Access to/availability of information was identified in 2 interviews as a factor that positively affect the quality of communication. It is in line with the literature as Lloyd and Varey (2003) mentioned ease of access to information as a factor that can improve the quality of communication. Access to/availability of information was reported to be generally better in the execution phase in the in the interviews. It is in line with the literature as Olsson (2006) and Samset (2014) state that the amount of available information increases over time in projects. This is illustrated in Figure 31.

As illustrated in figure 31, quality of communication and available information increase till the middle of the execution phase. Although availability of information affects the quality of communication, they have different trends. Quality of communication reaches its pick in the middle of execution phase where available information is at almost %50 of its maximum level. In addition, after this point in the middle of execution, quality of communication drops although available information keeps increasing. This is paradoxical as availability of/access to information was found to be a factor that improve quality of communication.

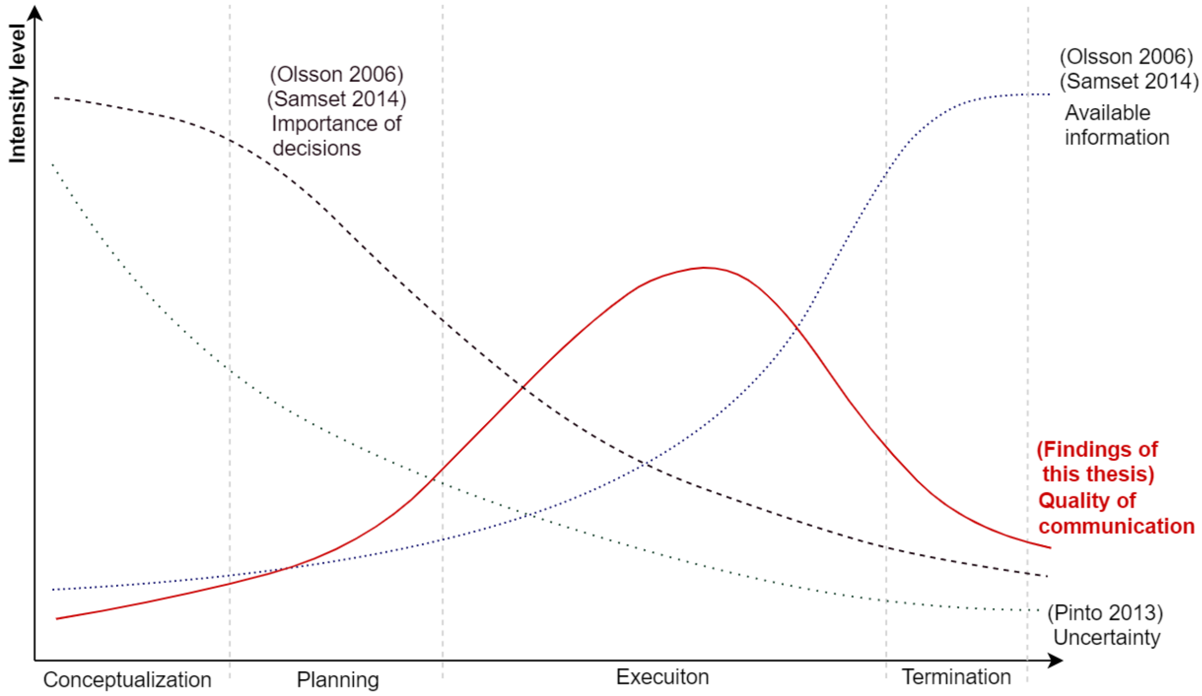

Figure 31 Quality of communication, available information, uncertainty, and importance of decisions in a project life cycle

The availability of information is very low in early phases of projects although it is most needed in these phases where uncertainty is high (Pinto, 2013) and project managers need to make important decisions (Samset, 2014). One of the respondents said:

> Availability of information is especially significant in the planning phase of offshore projects in oil-and-gas industry. Sometimes, some important information is not provided to the project-team in the beginning and in the planning phase. After the execution phase, when it comes to analysis and delivery of the deliverables, they realize that something is missing because the project-team was not informed about some significant information in the beginning. It results in reworks, longer duration, and cost overrun in some cases. This specially happens when they do not communicate directly to the end-user. Some important information may miss when they do not have direct communication with end-user.

Considering the positive effect of availability of information on quality of communication and knowing that availability of information is better in execution than in planning phase, it can be concluded that availability of information can impact the quality of communication to be better in execution than in planning phase.

Increasing the level of/access to information in the early phases can be a very good way to reduce transaction cost through improving the quality of communication. It can reduce transaction cost as it decreases the consequences of lack of information for decision making in planning phase mentioned by a respondent. It also helps to deal with high uncertainty in early phases which is a source of transaction cost itself according to Williamson (1985).

Uncertainty

Uncertainty was identified in %50 of the interviews as a factor that can positively affect the quality of communication. One of the respondents said:

> Uncertainty can affect the quality of communication as more and better communication is needed to clarify things and to reduce the uncertainty.

This is in line with the literature as Hellriegel & Slocum (1996a) mention that to overcome uncertainty, organizations need to have extra information and better communication. To deal with uncertainty, project team members may choose to use better communication channels like face-to-face or video call meetings instead of a one-way communication like email. This in turn increases the quality of communication as a result.

The effect of uncertainty on transaction cost can be paradoxical. On one hand, uncertainty can reduce transaction cost through its positive effect on quality of communication which is a determinant of transaction cost (Li et al., 2015). On the other hand, uncertainty itself is one of transaction cost dimensions (Oliver E Williamson, 1981) that increases transaction cost in general.

Besides, despite the positive effect of uncertainty on quality of communication, we see in Figure 31that their trends are very different especially in early phases where uncertainty is very high and quality of communication is very low.

Uncertainty is the lack of enough available information that is needed for a task (Hellriegel & Slocum Jr, 1996b). Considering the contradictory nature of uncertainty and availability of information, it is surprising to see that they both cause an increase in quality of communication.

5.3 Theoretical contribution of the research

Dudkin & Välilä (2006) mention a lack of empirical studies on quantification of transaction cost because the available empirical data on transaction cost is limited and the data is usually confidential (Dudkin & Välilä, 2006). Thus, there is a need for more empirical research on transaction cost in construction projects (De Schepper et al., 2015; Dudkin & Välilä, 2006; Farajian, 2010; Guo et al., 2016; Haaskjold et al., 2019; Li et al., 2015; Rajeh et al., 2015).

This study contributes to the body of knowledge with more empirical data and research on transaction cost in construction projects. It is also worth mentioning that there was no research before that compare determinants of transaction cost between different project phases. In addition, no research was found that qualitatively investigate quality of communication between project phases and particularly between planning and execution phases. This paper for the first time, investigates quality of communication in different project phases from a transaction cost perspective. During the interviews, availability of the stakeholder was mentioned as a factor that affect the quality of communication especially in relationship with big-size contractor companies. This factor was not found in the literature on communication in project context. Furthermore, this study is also a response to Li *et al.*'s (2015) call for more empirical research on their framework of determinants of transaction cost in construction projects.

5.4 Practical implications of the research

The total cost of organizations consists of production cost and transaction cost. Construction industry is known for high transaction cost. Project managers would definitely like to decrease transaction cost in their projects. Findings of this study show that some of the factors that affect transaction cost are stronger in some phases than in other phases. More specifically, findings show that quality of communication, as a factor that affect transaction cost, is significantly better in execution than in planning phase. The findings of this research can tell project managers which incentives to focus on in order to improve this situation/imbalance. More specifically, based on the findings, project managers can focus on using better communication channels, having more informal communication, and especially improving access to information in the planning phase in order to improve the imbalance in quality of communication between planning and execution phases of their projects.

The findings may also be interesting to project managers that are interested in reducing transaction cost through improved collaboration because quality of communication is a determinant of transaction cost that has the biggest impact on collaboration in projects (Haaskjold et al., 2019).

6 Conclusion and further research

This study was conducted based on a need for more empirical research on transaction cost in construction projects mentioned by Dudkin & Välilä (2006), Farajian (2010), Li *et al.* (2015), Rajeh *et al.* (2015), De Schepper *et al.* (2015), Guo *et al.* (2016), and Haaskjold *et al.* (2019).

The **purpose** of this paper was to contribute with more empirical data to the understanding of transaction cost in different phases of construction projects, regardless of the type of contracts. To fulfil this purpose, the statistical (main part) of this research was conducted based on high-quality empirical data from 142 construction projects in Norway. The qualitative part of the research was conducted based on data from 4 qualitative interviews with project managers in Norway. The data include different project phases and is not restricted to specific contractual arrangements. The data also covers all 3 types of construction projects, namely, building, industrial, and infrastructure.

Besides, this paper is a response to the call from Li *et al.* (2015) for more research on their framework for determinants of transaction cost in construction projects. The determinants of transaction cost in this research were selected from their framework.

The **objective** of this paper was to make a statistical comparison of 'the strength of the factors that affect transaction cost' between different phases of construction projects. To fulfil this objective, a statistical analysis was conducted on data from 142 projects which aimed to check if there is any statistically significant difference in factors that affect transaction cost between different project phases. In other words, this study shows which factor (that affect transaction cost in construction projects) is significantly better in one phase than other phases. The study also highlights the reasons for that significant difference.

Through a statistical analysis on high-quality data from 142 projects, the first research question was answered:

RQ 1A. Is there a statistically significant difference in factors that affect transaction cost between conceptualization and planning phase?

Conclusion: No, there was no statistically significant difference in the factors that affect transaction cost between conceptualization and planning phase of construction projects.

RQ 1B. Is there a statistically significant difference in factors that affect transaction cost between conceptualization and execution phase?

Conclusion: No, there was no statistically significant difference in the factors that affect transaction cost between conceptualization and execution phase of construction projects.

RQ 1C. Is there a statistically significant difference in factors that affect transaction cost between planning and execution phase?

Conclusion: Yes, there was a statistically significant difference in quality of communication (as a factor that affect transaction cost) between planning and execution phase of construction projects. In fact, quality of communication was better in execution phase than in planning phase.

Based on the findings of the first research question and through qualitative interviews with 4 project managers, the second research question was answered:

RQ 2. What is the reason for the found differences in research question 1 if there is any?

Conclusion: The reason is 3 factors that may cause a better quality of communication in execution than in planning phase:

- Communication channel
- Informal communication
- Access to/availability of information

As a conclusion, it was found that quality of communication, as a factor that affect transaction cost, is better in the execution than in the planning phase of construction projects. The reason for that found to be 3 factors that make a difference in quality of communication between the 2 phases, namely, communication channel, informal communication, and access to/availability of information.

6.1 Limitations and further research

There were 2 main limits on the scope of this research. First, the data for the research was limited to the projects that were conducted in Norway. Second, termination phase was excluded from the scope because the available data for this phase was not sufficient. Therefore, for further research in the field, it is suggested to expand the area of empirical investigation to other countries. It is also suggested to expand the empirical analysis to termination phase of construction projects.

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8 Appendices

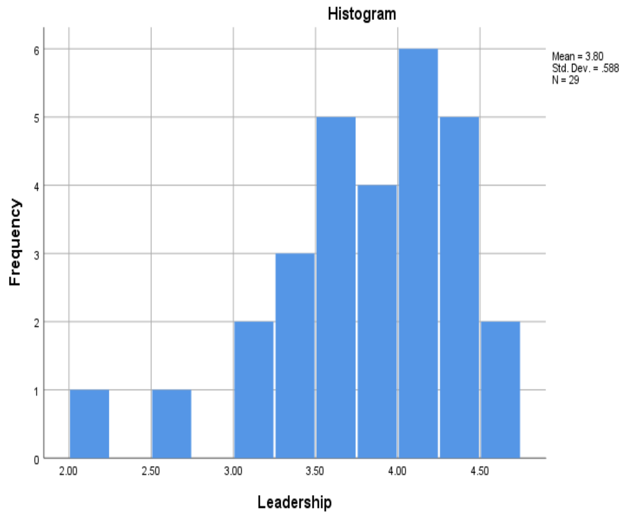
Appendix A

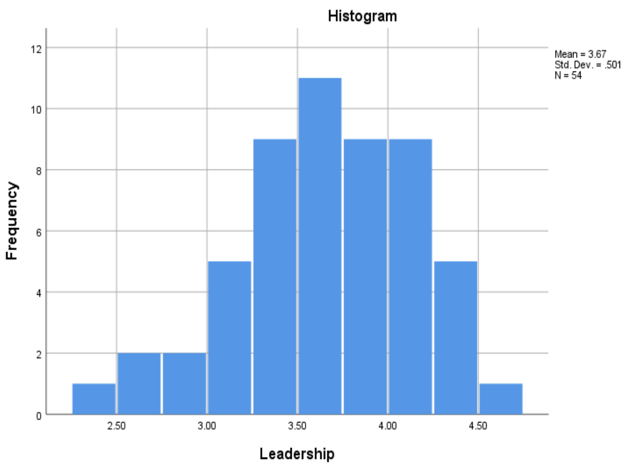
<u>Normality of the constructs in different phases; an assumption for t-test</u>

1- Leadership

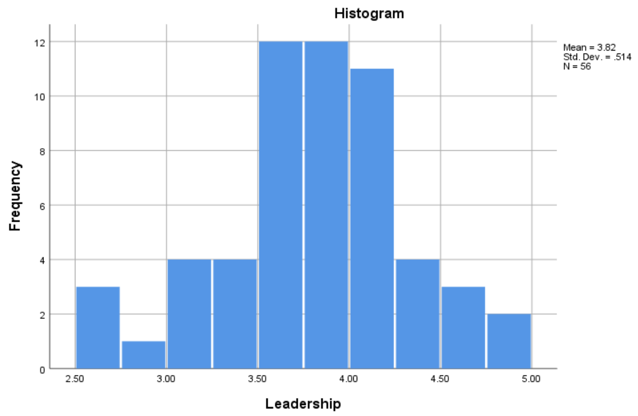
Descriptives

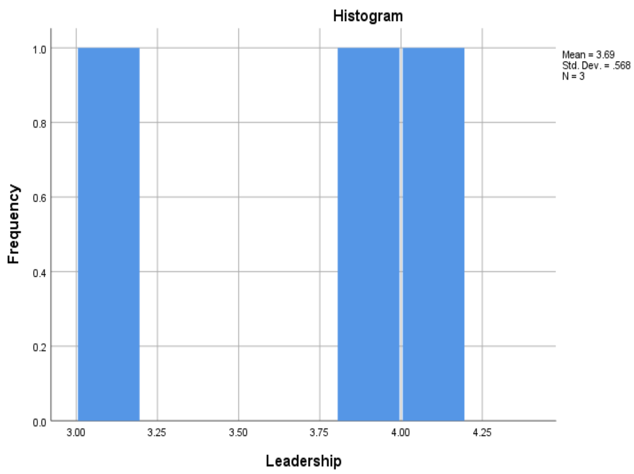
Prosjektfase			Statistic	Std. Error
Tidligfase	Mean		3.8007	.10927
	95% Confidence Interval for Mean	Lower Bound	3.5769	
		Upper Bound	4.0245	
	5% Trimmed Mean		3.8436	
	Median		3.9727	
	Variance		.346	
	Std. Deviation		.58843	
	Minimum		2.11	
	Maximum		4.62	
	Range		2.51	
	Interquartile Range		.79	
	Skewness		-1.13	.434
	Kurtosis		1.28	.845
Prosjektering	Mean		3.6743	.06821
	95% Confidence Interval for Mean	Lower Bound	3.5375	
		Upper Bound	3.8111	
	5% Trimmed Mean		3.6862	
	Median		3.6496	
	Variance		.251	
	Std. Deviation		.50124	





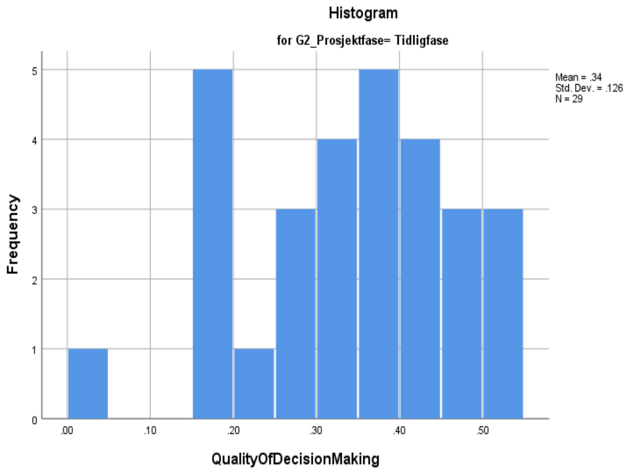
	Minimum		2.45	
	Maximum		4.70	
	Range		2.25	
	Interquartile Range		.78	
	Skewness		-.307	.325
	Kurtosis		-.260	.639
Bygging	Mean		3.8235	.06865
	95% Confidence Interval for Mean	Lower Bound	3.6859	
		Upper Bound	3.9611	
	5% Trimmed Mean		3.83	
	Median		3.88	
	Variance		.264	
	Std. Deviation		.51376	
	Minimum		2.64	
	Maximum		4.91	
	Range		2.28	
	Interquartile Range		.66	
	Skewness		-.251	.319
	Kurtosis		.132	.628
Ferdigstillelse	Mean		3.69	.32796
	95% Confidence Interval for Mean	Lower Bound	2.2782	
		Upper Bound	5.1004	
	5% Trimmed Mean		.	
	Median		3.98	
	Variance		.323	
	Std. Deviation		.56804	
	Minimum		3.04	
	Maximum		4.06	
	Range		1.02	
	Interquartile Range		.	
	Skewness		-1.69	1.225
	Kurtosis		.	.

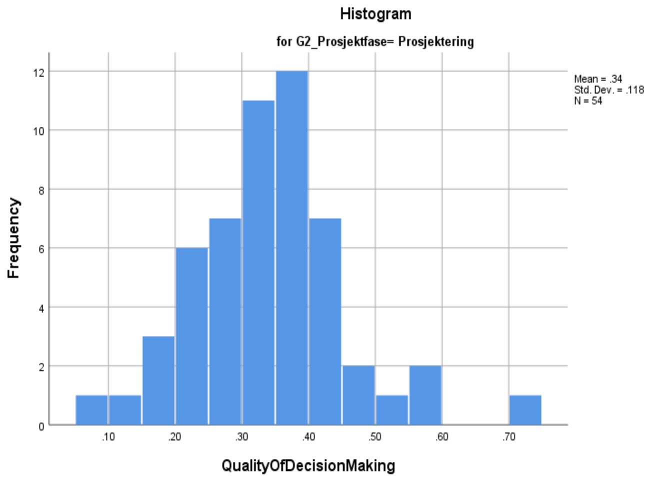


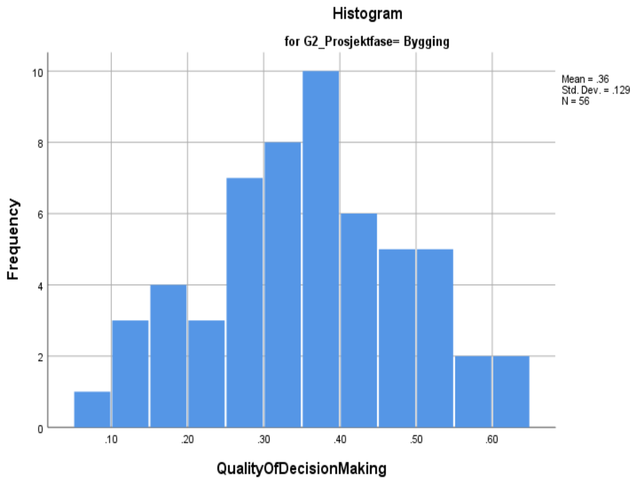


2- Quality of decision-making

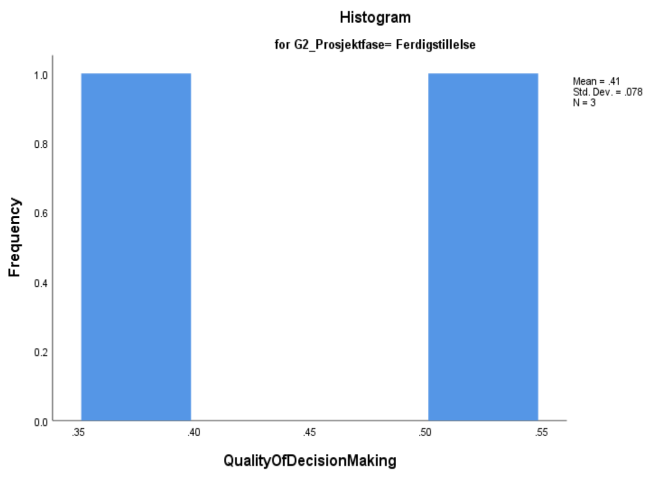
Descriptives				
Prosjektfase			Statistic	Std. Error
Tidligfase	Mean		.3389	.0234
	95% Confidence Interval for Mean	Lower Bound	.2910	
		Upper Bound	.3868	
	5% Trimmed Mean		.3451	
	Median		.3580	
	Variance		.016	
	Std. Deviation		.12594	
	Minimum		.00	
	Maximum		.52	
	Range		.52	
	Interquartile Range		.18	
	Skewness		-.705	.434
	Kurtosis		.317	.845
Prosjektering	Mean		.3362	.0161
	95% Confidence Interval for Mean	Lower Bound	.3038	
		Upper Bound	.3685	
	5% Trimmed Mean		.3318	
	Median		.3400	
	Variance		.014	
	Std. Deviation		.1185	
	Minimum		.07	
	Maximum		.71	
	Range		.64	
	Interquartile Range		.14	
	Skewness		.541	.325
	Kurtosis		1.434	.639
Bygging	Mean		.3561	.0173
	95% Confidence Interval for Mean	Lower Bound	.3215	
		Upper Bound	.3907	
	5% Trimmed Mean		.3556	
	Median		.3687	
	Variance		.017	
	Std. Deviation		.12925	
	Minimum		.08	
	Maximum		.63	
	Range		.54	
	Interquartile Range		.19	
	Skewness		-.094	.319
	Kurtosis		-.545	.628
	Mean		.4133	.0448







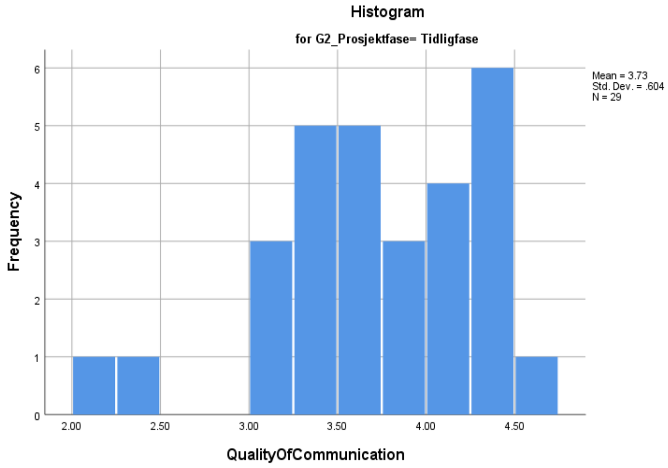
Ferdigstillelse	95% Confidence Interval for Mean	Lower Bound	.2204	
		Upper Bound	.6063	
	5% Trimmed Mean		.	
	Median		.3900	
	Variance		.006	
	Std. Deviation		.0777	
	Minimum		.35	
	Maximum		.50	
	Range		.15	
	Interquartile Range		.	
	Skewness		1.230	1.225
	Kurtosis		.	.

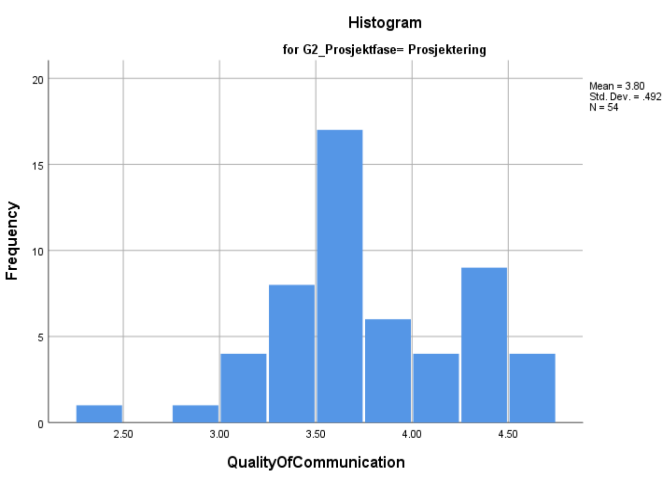


3- Quality of communication

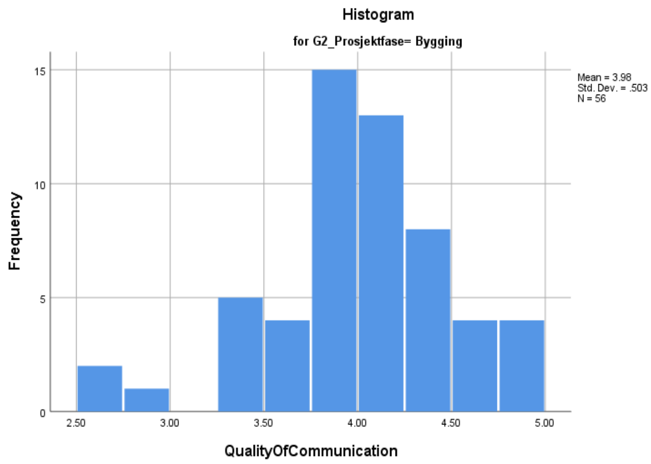
Descriptives

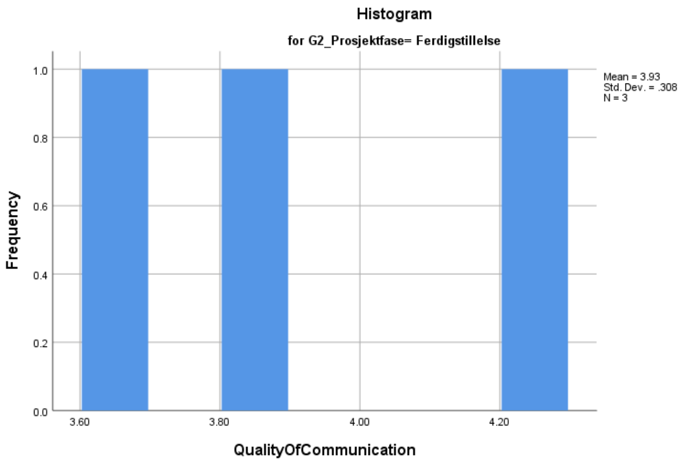
Prosjektfase			Statistic	Std. Error
Tidligfase	Mean		3.727	.1122
	95% Confidence Interval for Mean	Lower Bound	3.497	
		Upper Bound	3.957	
	5% Trimmed Mean		3.764	
	Median		3.666	
	Variance		.365	
	Std. Deviation		.60428	
	Minimum		2.20	
	Maximum		4.59	
	Range		2.39	
	Interquartile Range		.91	
	Skewness		-.743	.434
	Kurtosis		.438	.845
Prosjektering	Mean		3.799	.0669
	95% Confidence Interval for Mean	Lower Bound	3.6648	
		Upper Bound	3.9333	
	5% Trimmed Mean		3.806	
	Median		3.705	
	Variance		.242	
	Std. Deviation		.4919	





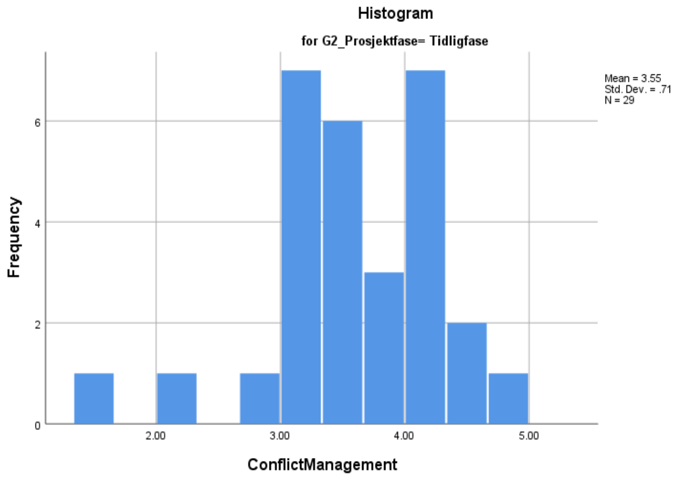
	Minimum		2.45	
	Maximum		4.70	
	Range		2.25	
	Interquartile Range		.77	
	Skewness		-.030	.325
	Kurtosis		-.216	.639
Bygging	Mean		3.976	.0672
	95% Confidence Interval for Mean	Lower Bound	3.8416	
		Upper Bound	4.1110	
	5% Trimmed Mean		3.9985	
	Median		4.004	
	Variance		.253	
	Std. Deviation		.5030	
	Minimum		2.50	
	Maximum		4.95	
	Range		2.45	
	Interquartile Range		.53	
	Skewness		-.594	.319
	Kurtosis		1.055	.628
Ferdigstillelse	Mean		3.929	.1776
	95% Confidence Interval for Mean	Lower Bound	3.1649	
		Upper Bound	4.6929	
	5% Trimmed Mean		.	
	Median		3.883	
	Variance		.095	
	Std. Deviation		.3075	
	Minimum		3.65	
	Maximum		4.26	
	Range		.61	
	Interquartile Range		.	
	Skewness		.652	1.225
	Kurtosis		.	.

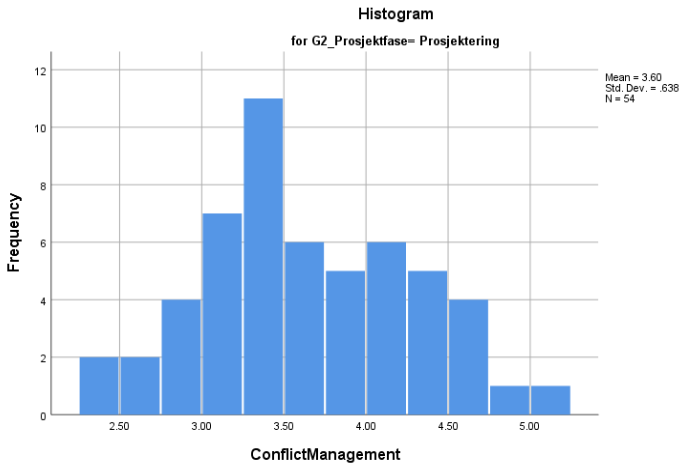


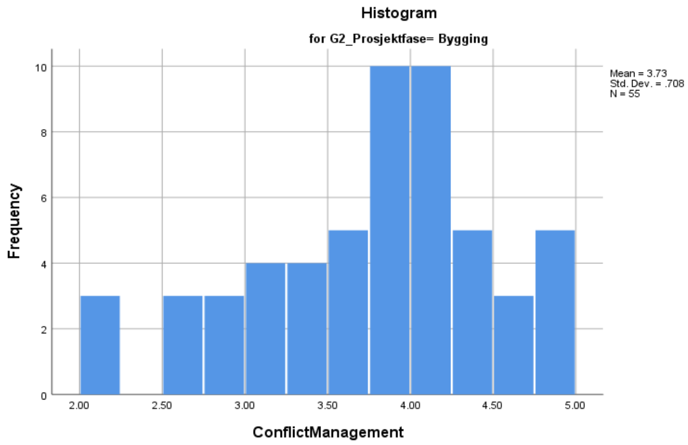


4- Conflict management

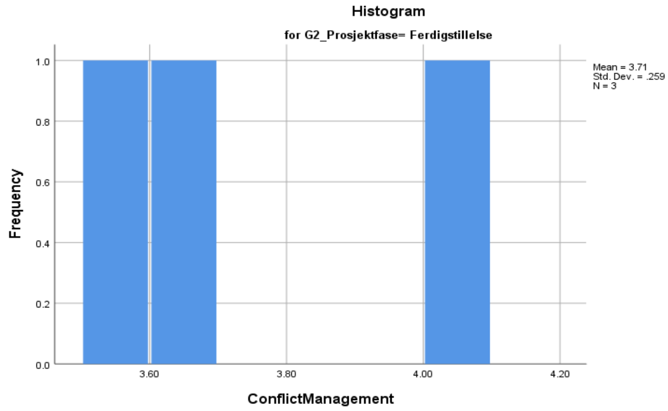
Descriptives				
Prosjektfase			Statistic	Std. Error
Tidligfase	Mean		3.55	.1318
	95% Confidence Interval for Mean	Lower Bound	3.28	
		Upper Bound	3.82	
	5% Trimmed Mean		3.60	
	Median		3.53	
	Variance		.504	
	Std. Deviation		.710	
	Minimum		1.50	
	Maximum		4.67	
	Range		3.17	
	Interquartile Range		1.02	
	Skewness		-.979	.434
	Kurtosis		1.54	.845
Prosjektering	Mean		3.60	.0869
	95% Confidence Interval for Mean	Lower Bound	3.43	
		Upper Bound	3.778	
	5% Trimmed Mean		3.601	
	Median		3.600	
	Variance		.407	
	Std. Deviation		.6383	
	Minimum		2.25	
	Maximum		5.00	
	Range		2.75	
	Interquartile Range		.84	
	Skewness		.096	.325
	Kurtosis		-.528	.639
Bygging	Mean		3.729	.0955
	95% Confidence Interval for Mean	Lower Bound	3.5376	
		Upper Bound	3.9206	
	5% Trimmed Mean		3.7535	
	Median		3.860	
	Variance		.502	
	Std. Deviation		.7083	
	Minimum		2.14	
	Maximum		4.88	







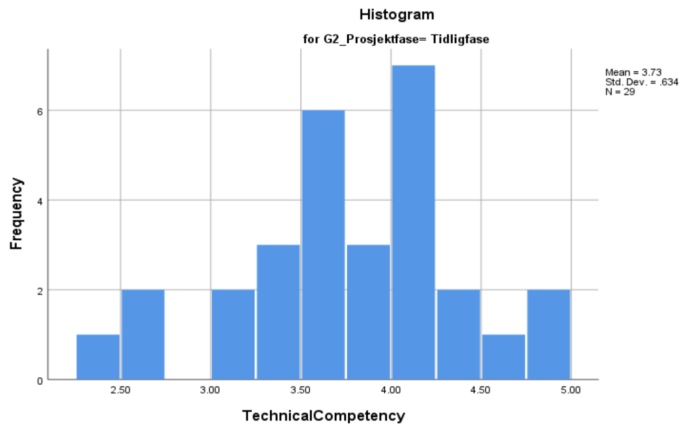
	Range		2.74	
	Interquartile Range		.97	
	Skewness		-.477	.322
	Kurtosis		-.355	.634
Ferdigstillelse	Mean		3.710	.1498
	95% Confidence Interval for Mean	Lower Bound	3.066	
		Upper Bound	4.354	
	5% Trimmed Mean		.	
	Median		3.630	
	Variance		.067	
	Std. Deviation		.25942	
	Minimum		3.50	
	Maximum		4.00	
	Range		.50	
	Interquartile Range		.	
	Skewness		1.256	1.225
	Kurtosis		.	.

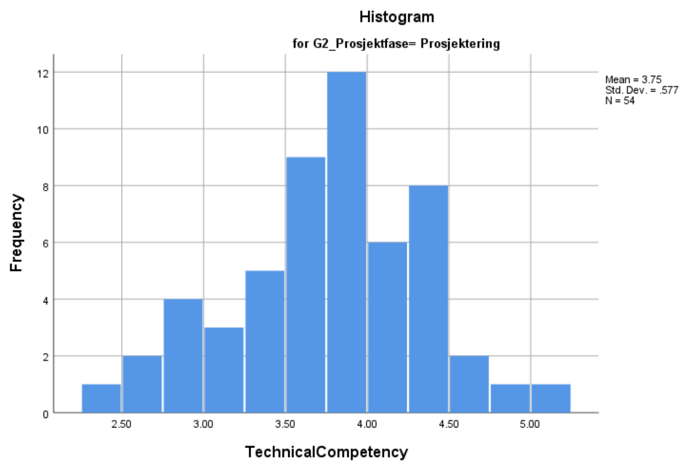


5- Technical competency

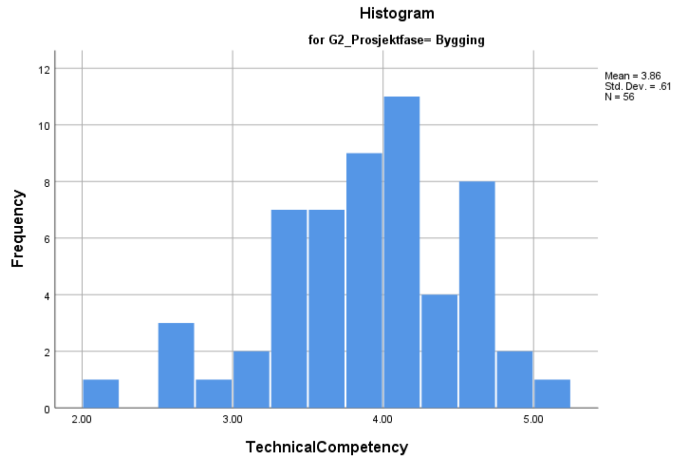
Descriptives

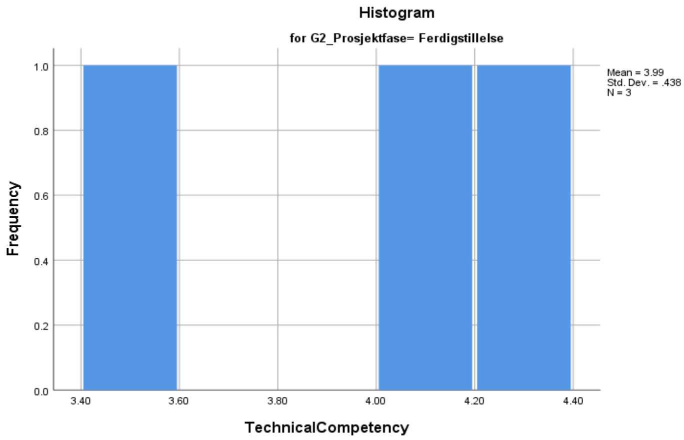
Prosjektfase			Statistic	Std. Error
Tidligfase	Mean		3.74	.117
	95% Confidence Interval for Mean	Lower Bound	3.4923	
		Upper Bound	3.9750	
	5% Trimmed Mean		3.75	
	Median		3.83	
	Variance		.403	
	Std. Deviation		.634	
	Minimum		2.25	
	Maximum		4.92	
	Range		2.67	
	Interquartile Range		.66	
	Skewness		-.334	.434
	Kurtosis		.372	.845
Prosjektering	Mean		3.75	.078
	95% Confidence Interval for Mean	Lower Bound	3.5943	
		Upper Bound	3.9093	
	5% Trimmed Mean		3.7592	
	Median		3.80	
	Variance		.333	
	Std. Deviation		.577	





	Minimum		2.32	
	Maximum		5.00	
	Range		2.69	
	Interquartile Range		.74	
	Skewness		-.311	.325
	Kurtosis		-.049	.639
Bygging	Mean		3.86	.081
	95% Confidence Interval for Mean	Lower Bound	3.7016	
		Upper Bound	4.0281	
	5% Trimmed Mean		3.8815	
	Median		3.89	
	Variance		.372	
	Std. Deviation		.609	
	Minimum		2.20	
	Maximum		5.00	
	Range		2.80	
	Interquartile Range		.86	
	Skewness		-.428	.319
	Kurtosis		.064	.628
Ferdigstillelse	Mean		3.99	.253
	95% Confidence Interval for Mean	Lower Bound	2.9010	
		Upper Bound	5.0790	
	5% Trimmed Mean		.	
	Median		4.12	
	Variance		.192	
	Std. Deviation		.438	
	Minimum		3.50	
	Maximum		4.35	
	Range		.85	
	Interquartile Range		.	
	Skewness		-1.25	1.22
	Kurtosis		.	.



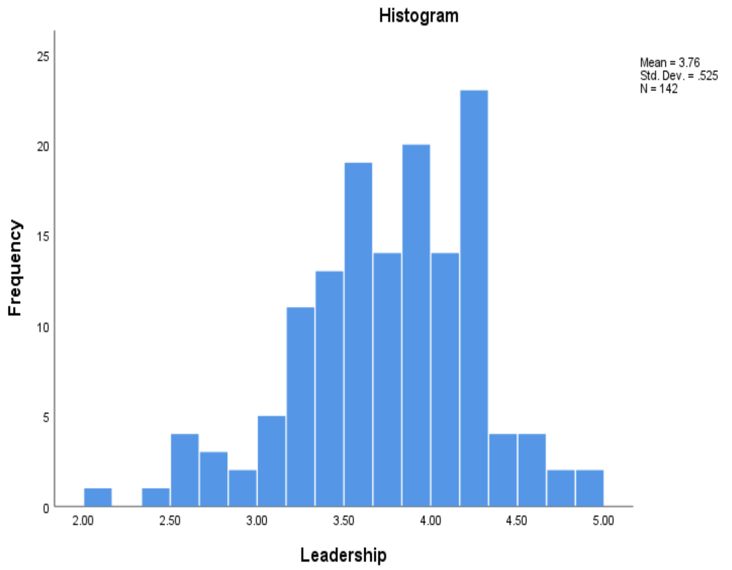


Appendix B

Normality of the constructs as an assumption for Cronbach alpha

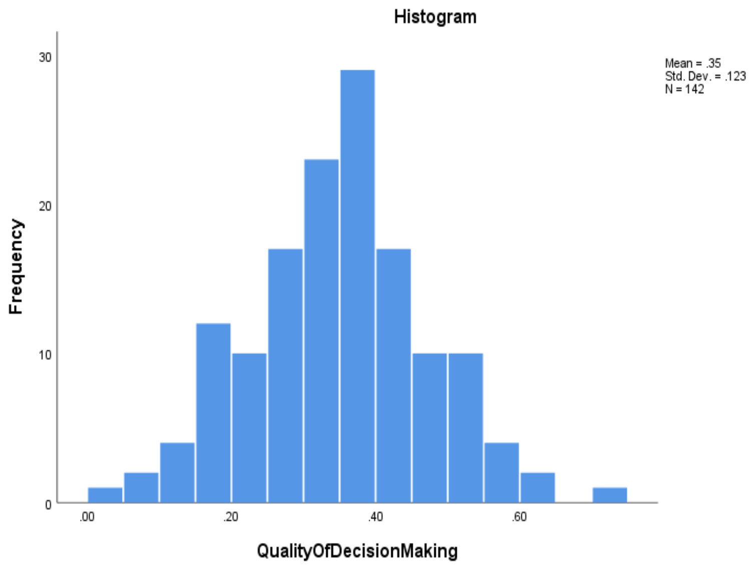
1- Leadership

Descriptives			
		Statistic	Std. Error
Mean		3.7593	.04405
95% Confidence Interval for Mean	Lower Bound	3.6722	
	Upper Bound	3.8464	
5% Trimmed Mean		3.7742	
Median		3.7973	
Variance		.276	
Std. Deviation		.52497	
Minimum		2.11	
Maximum		4.91	
Range		2.81	
Interquartile Range		.73	
Skewness		-.475	.203
Kurtosis		.164	.404



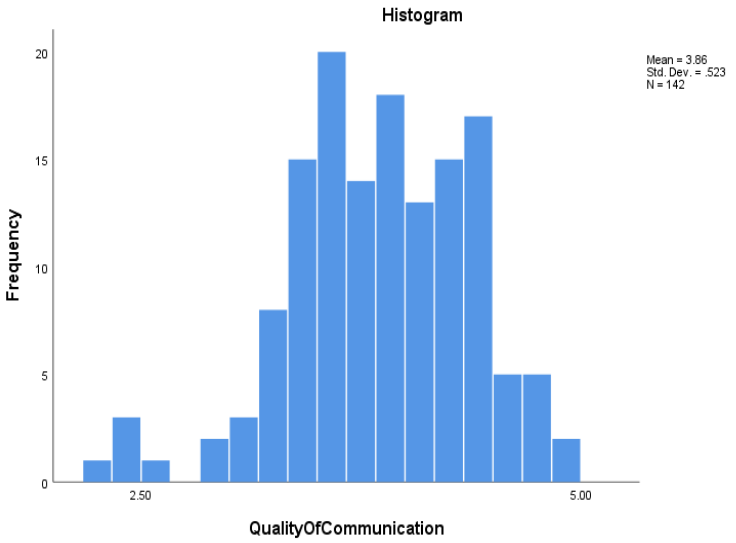
2- Quality of decision-making

Descriptives			
		Statistic	Std. Error
Mean		.3462	.01035
95% Confidence Interval for Mean	Lower Bound	.3257	
	Upper Bound	.3667	
5% Trimmed Mean		.3454	
Median		.3575	
Variance		.015	
Std. Deviation		.12334	
Minimum		.00	
Maximum		.71	
Range		.71	
Interquartile Range		.16	
Skewness		-.010	.203
Kurtosis		.149	.404



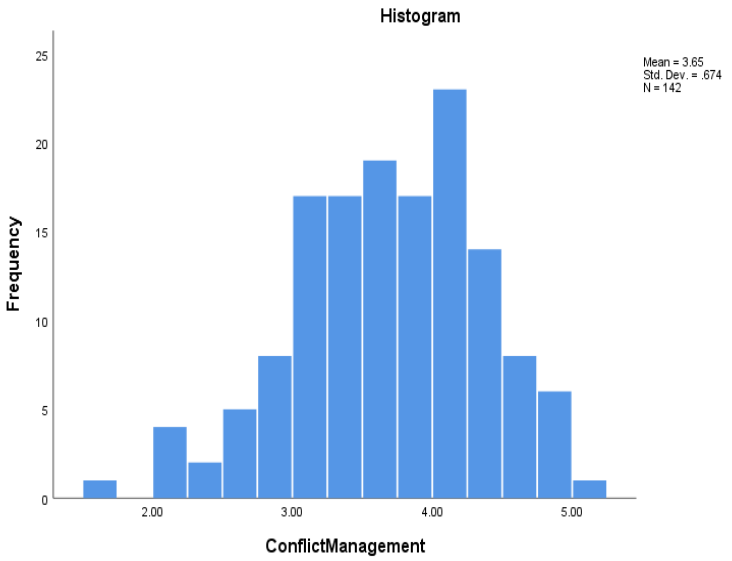
3- Quality of communication

Descriptives			
		Statistic	Std. Error
Mean		3.8570	.044
95% Confidence Interval for Mean	Lower Bound	3.7702	
	Upper Bound	3.9439	
5% Trimmed Mean		3.8768	
Median		3.8817	
Variance		.274	
Std. Deviation		.52348	
Minimum		2.20	
Maximum		4.95	
Range		2.75	
Interquartile Range		.72	
Skewness		-.483	.203
Kurtosis		.467	.404



4- Conflict management

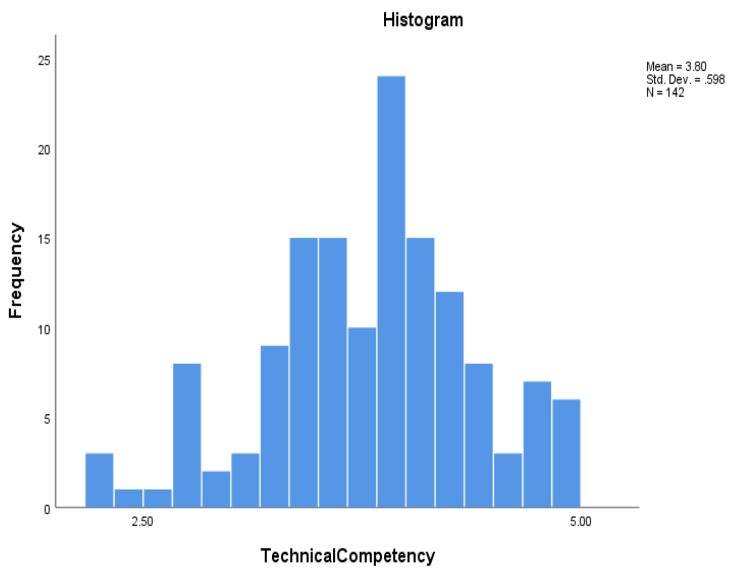
Descriptives			
		Statistic	Std. Error
Mean		3.648	.056
95% Confidence Interval for Mean	Lower Bound	3.536	
	Upper Bound	3.760	
5% Trimmed Mean		3.668	
Median		3.670	
Variance		.454	
Std. Deviation		.67370	
Minimum		1.50	
Maximum		5.00	
Range		3.50	
Interquartile Range		.95	
Skewness		-.396	.203
Kurtosis		.017	.404



5- Technical competency

Descriptives

		Statistic	Std. Error
Mean		3.7977	.05014
95% Confidence Interval for Mean	Lower Bound	3.6986	
	Upper Bound	3.8968	
5% Trimmed Mean		3.8104	
Median		3.8525	
Variance		.357	
Std. Deviation		.59750	
Minimum		2.20	
Maximum		5.00	
Range		2.80	
Interquartile Range		.75	
Skewness		-.361	.203
Kurtosis		.012	.404



Appendix C

Cronbach alpha results from SPSS:

Leadership

Case Processing Summary

		N	%
Cases	Valid	53	37.3
	Excluded[a]	89	62.7
	Total	142	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.933	.936	12

Quality of decision-making

Case Processing Summary

		N	%
Cases	Valid	142	100.0
	Excluded[a]	0	.0
	Total	142	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.691	.688	5

Quality of communication

Case Processing Summary

		N	%
Cases	Valid	83	58.5
	Excluded[a]	59	41.5
	Total	142	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.836	.840	5

Technical competency

Case Processing Summary

		N	%
Cases	Valid	142	100.0
	Excluded[a]	0	.0
	Total	142	100.0

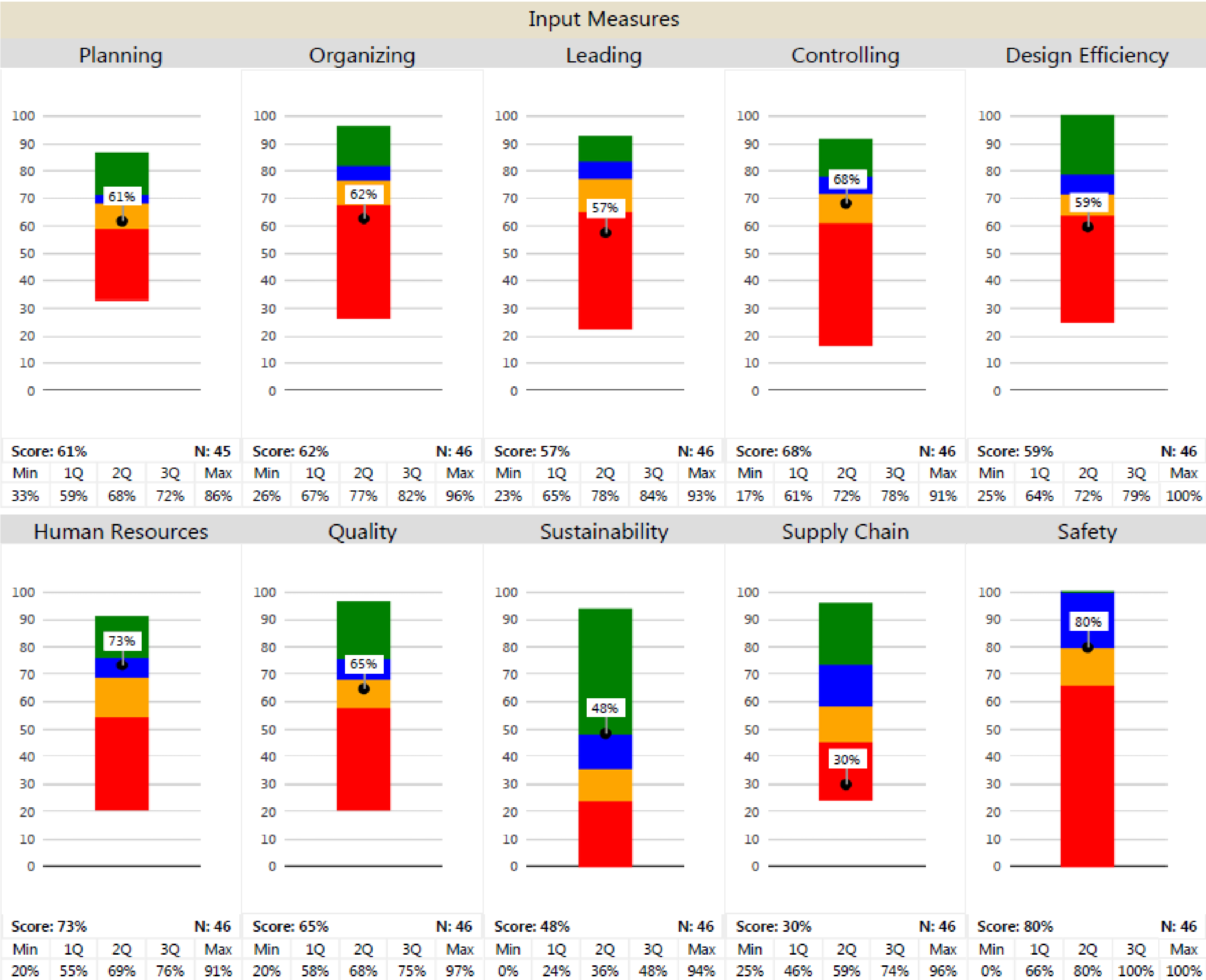
a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.649	.650	2

Appendix D

The figure shows a sample of bar charts regarding leading/input measures in CII1010 benchmarking database. It is provided by CII1010 user-manual.



	Fourth quartile: 25% of the projects with the top scores (best performance).
	Third quartile: projects with score between the median and the third quartile
	Second quartile: projects with scores between the first quartile and the median.
	First quartile: 25% of the projects with the lowest scores for the measure.

Appendix E

Following is the interview guide for the qualitative part of the research.

1- Thanks for this opportunity to give information that contributes to the body of knowledge and my master thesis.

2- The information of this meeting will be used anonymously in my research and privacy considerations are applied base on NSD.no the Norwegian center for research data.

3- This meeting is not recorded. I would take notes of keywords and right after the interview, I will write a summary of what I remember.

4- After this meeting, I will send you a copy of the summary of our conversation by tomorrow noon. So, you can take a look at it and correct or verify it.

6-Face sheet questions

- How many years of professional experience you have, in total as either engineer or a manger or a member of project-team?
- Do you have international experience?
- What is your position in the company?
- How long have you been working with your company?
- Does your company operate in international market as well?

In my research, I realized that based on the data from 146 construction projects in Norway, there might be a difference in quality of communication between planning and execution phase. The purpose of our conversation would be to find the possible reasons for that.

Communication in this context can mean both internal communication with people in your organization and also external communication with customers, owners, contractors or other stakeholders.

*Can you describe briefly how projects are done in your company in different phases?

7- How is the communication in your projects in different phases (including initiation, planning, execution, and termination phase)? in-person meetings, phone calls, video calls, and email?

8- Can you please mention similarities and differences in communication between planning and execution phases? What do you think can be the reason for the differences? How those reasons/factors are different in the phases?

9- Can you give me examples of communication issues that can happen in different phases?

(After he/she mentioned things) Is it the same in all phases? What do you think can be the reason for the issues? Are the reasons/factors same or different in planning and execution phases? or is their effect same or different in planning and execution phase?

10- Do you think the way communication happens, face-to-face or phone call or email, can affect the quality of communication? Can you compare the portion of different communication channels (including in-person meetings, phone calls, video calls, and email) in planning and execution phase?

11- Do you think that trust between stakeholders may or may not affect the quality of communication in planning and execution phase? If yes, how? Trust can be for example because the other party is competent enough to do their job or because you have worked before with that person or organization. How is trust in planning and execution phases?

12- Do you think ease of access to information may or may not affect the quality of communication in planning and execution phases? If yes, how?

13- Do you think that informal ways of communication may or may not impact the quality of communication? If yes, how? Is the informal communication more common in the planning or execution phase? or is it the same in both phases?

14- Do you think the availability of the other party, the contractor's project manager for example, may or may not affect the quality of communication? Sometimes for example, project manager of the contractor is busy and is not very available to communicate with. Can you say that the availability of the other parties is usually better in one of planning or execution phase for communication or there may not be so much difference?

15- do you think the frequency of your relations with a stakeholder, either a colleague or a contractor, may or may not affect your communication with them? In other words, would it help your communication with someone if you worked with them before or knew them? Could this factor more influential in the planning or execution phase? Or it there may not be so much difference?

16- Do you think that project uncertainty can or cannot affect the quality of communication? Does your communication get better when there is high uncertainty? Is there any difference in this respect between planning and execution phases or there is not much difference?

Appendix F

The result of notification test at NSD which shows that the paper does not need to be notified to the agency.

Result of Notification Test: Not Subject to Notification

You have indicated that neither directly or indirectly identifiable personal data will be registered in the project.

If no personal data is to be registered, the project will not be subject to notification, and you will not have to submit a notification form.

Please note that this is a guidance based on information that you have given in the notification test and not a formal confirmation.

For your information: *In order for a project not to be subject to notification, we presuppose that all information processed using electronic equipment in the project remains anonymous.*

Anonymous information is defined as information that cannot identify individuals in the data set in any of the following ways:

- directly, through uniquely identifiable characteristic (such as name, social security number, email address, etc.)
- indirectly, through a combination of background variables (such as residence/institution, gender, age, etc.)
- through a list of names referring to an encryption formula or code, or
- through recognizable faces on photographs or video recordings.

Furthermore, we presuppose that names/consent forms are not linked to sensitive personal data.

Kind regards,
NSD Data Protection

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