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Performance of Construction Projects:
Essays on Supplier Structure, Construction Costs and Quality Improvement

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ABSTRACT

The performance of the construction industry and its contribution to the welfare of society in comparison to other industries such as the manufacturing industry has lately been the focus of many commissioned reports and academic research publications. The so-called "iron triangle" of time, cost and quality have been the most important metrics of construction project performance, especially for the selection of appropriate procurement methods. The perceived inefficiencies emanate from, among other things, increasing construction costs, conflicts and client dissatisfaction, the fragmented nature of the industry, low competition, cost overruns and delays, and lack of quality improvement. There is observed disparity in increases in housing construction costs and an apparent lack of quality improvement of infrastructure transport projects. In Sweden, metropolitan regions experienced higher construction cost increases, while small regions showed less costs increases during economic booms. In order to address these perceived inefficiencies, numerous strategic and project level decisions that influenced the way that publicly owned properties and projects are procured, constructed, operated, and maintained have been made. The decision to transfer quality-related activities and quality assurance responsibilities from client to contractor approximately 20 years ago is one of the decisions that could have an impact on current quality of infrastructure transport projects. The disparity in increases in construction costs and quality improvement concerns could not only influence the performance of construction projects, but also can affect the way different actors in the sector interact with each other and achieve their divergent objectives.

The aim of this study is twofold. First, it tries to explain the observed disparity increases in construction costs between big (metropolitan) and medium/small regions. Second, it attempts to ascertain the extent of quality problems in infrastructure transport projects after the transfer of quality assurance responsibilities, and suggests measures that could improve the quality of infrastructure transport projects. Surveys and interviews were used as a means to collect data concerning both supplier structure in relation to housing construction costs and quality of construction projects. Other empirical data from a secondary source were also used.

The first part of the research offers an understanding of the behavior of contractors in specific economic situations, specifically by taking into consideration the long-run relationship between contractors and owners/developers. It ascertains that if contractors/subcontractors display opportunistic behavior during the economic boom, the result will be increased higher construction costs. We utilized transaction cost theory in exploring construction sector structures in an attempt to understand changes in the sector from an efficiency perspective. The analysis can also enrich the current understanding of the governance structure of Swedish construction firms and how they could influence construction costs.

As the response from the survey suggests, quality of infrastructure projects has not decreased after the transfer of quality assurance from client to contractor. However, the high number of respondents that indicated quality is the same as before the transfer raises a concern of lack of quality improvement. Respondents have overwhelmingly indicated that the lack of public client competence was one of the contributing factors of quality problems. It is argued that with client competence it is important to build-up through proper knowledge management, incentive systems, and training. Further, the retention of new skilled and experienced workers is an essential element for continuous quality improvement goals and objectives. A second opinion practice from independent experts and committees that focuses on the quality aspect of the projects can be introduced in the provision of infrastructure transport projects. Finally, it is argued that without client competence and a company culture that creates the right incentives, no procurement method can guarantee high quality.

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INTRODUCTION

The construction industry is the backbone of the economic activities in many developed countries, where around 5-11 percent of their GDP is spent yearly on various types of construction projects and related activities (Bennett, 2003: 3). It was the biggest industrial employer in Europe with 30 percent of the workforce in 2007 (FIEC, 2008). Construction projects can be broadly categorized as building construction, engineering construction or industrial construction (Halpin, 2006; Bennett, 2003). Engineering construction is further divided into highway and heavy construction depending on whether the owner and designer are public or private. Public sector entities often own engineering construction projects and facilitate their provision.

The housing sector is one of the major sectors in the construction industry and will therefore determine the success and failure of this industry. It plays a large role in the economy of many developed countries. Twenty-six percent of the European Union's construction activities was from housing construction (European Construction Industry Federation, 2005). Housing construction was normally used as an economic stabilizer in many countries. The construction sector, especially residential, was used by Sweden's central government as a cyclical stabilizer when keeping with Keynesian economic theories (Swedish Industry, 2004).

As Abowtiz and Toole (2010) pointed out, construction projects are a by-product of a social process involving many actors. Different actors are involved in the realization of a common object (infrastructure or building project) in exchange for monetary or social value depending on their objectives and goals. Clients, consultants and contractors are often the three main actors in construction projects. The degree of involvement for each actor in the provision of a specific building or infrastructure project and their expected role in delivering the desired performance of the project is governed by the contractual agreements. The client as an initiator and owner of projects uses consultants for project planning and design activities (if an in-house team is not used), and then contracts construction activities with contractors. The contractual relationship between the three main actors and how they interact with each other varies from one form of contract to another. Thus, it not expected that performance metrics such as time, cost and quality remain unchanged between different forms of contracts and procurement methods.

It is noteworthy to mention that the terms *contract* and *procurement* are often used synonymously, but they could in fact have different meanings. Procurement refers to strategy or method covering the whole process of delivering a project from the planning and development phase to the construction and completion stage, even extending to the warranty period. It could also include other stages such as operation and maintenance. Contract seems to refer to the unidirectional relationship between actors such as consultancy contract (between client and consultant), building contract (between client and contractor) or form of payment such as fixed price and cost-reimbursement contracts. When our unit of analysis is the organizational level and supplier structure, rather than individual projects, we use the two aforementioned terms interchangeably.

The performance of the industry and its contribution to the welfare of society in comparison to other industries such as the manufacturing industry has lately been the focus of many commissioned reports and academic research publications. Bernold and AbouRizk (2010) mention two clusters of performance measures: *efficiency* and *effectiveness*. While efficiency focuses on operational ratio and productivity matters in the short term, effectiveness comprises measures focusing on long-term improvement goals such as the amount of rework and owner satisfaction of completed projects. The so-called "iron triangle" of time, cost and quality have been the most important metrics of construction project performance, especially for the selection of appropriate procurement methods (see El Wardani et al., 2006); however, other factors such as safety and environment impact were also considered.

The perceived inefficiencies in the construction sector emanate from, among other things, increasing construction costs, conflicts and client dissatisfaction, the fragmented nature of the industry, low competition, and cost overruns and delays (Latham, 1994; Egan, 1998; Flyvbjerg, 2003; Toakley and Marosszeky, 2003; Lind, 2003). Swedish housing construction costs have risen more than the rate of inflation during the last decade (1994-2004). In Flyvbjerg's (2003) report to the British Department for Transport, he noted that transport projects are inherently risky due to the long planning horizon and complex project interface, which often induces changes related to uncertainty at the early project stages, technical standards, and geotechnical conditions. Furthermore, the fragmented and short-term nature of construction projects coupled with numerous stakeholders with different objectives makes it difficult to achieve high-level and consistent quality (Toakley and Marosszeky, 2003).

Increasing construction costs affect households' welfare in terms of housing affordability, and it weakens the relationship between developers and contractors, possibly destabilizing the housing market as well as the whole economy. Sweden's metropolitan regions experienced increasingly higher construction cost, while small regions showed less cost increases during economic booms. The effect of construction costs escalation was not evenly felt in all regions, and there was also an imbalance of housing stocks in various regions (Atterhög and Lind, 2004). The supply of new residential apartments stagnated, while at the same time construction costs were high, particularly in the metropolitan regions where the housing demands were stronger. Higher construction costs reduce residential construction, and thus affect the movement in house prices and rent levels (Somerville, 1999).

Quality improvement concerns of infrastructure transport projects have also been an issue that demanded closer examination. In order to curtail these shortcomings or the failure of transport projects in meeting their objectives, interested parties (government and private sector) put into practice different procurement and contracting strategies, as well as various construction management approaches. Numerous strategic and project-level decisions that could influence the way publicly owned properties and projects are procured, constructed, operated, and maintained must be made by senior management and project managers. An example is the decision to transfer quality-related activities and quality assurance responsibilities from client to contractor approximately 25 years ago.

Trade-off decisions between allocated budget, schedule and specifications are also involved in the process of procuring projects. These decisions can have both short- and long-term effects on how public client organizations interact with other actors in the construction industry such as contractors, subcontractors and consultants. Furthermore, the internal resource and competence of public client organizations and municipal housing companies, which play a major role when choosing the most appropriate methods for carrying out housing and infrastructure transport projects, could also affect the cost and quality of projects.

The dominance of different supplier structures in certain regions or economic conditions could shape the selection of delivery method made by the client, which in turn could impact how the skills and experience of the client organization's workforce develops in the long run and ultimately the performance of the construction projects that these public organizations

provide to the public. Similarly, heavy reliance on a single procurement method such as traditional Design-Bid-Build in the provision of infrastructure transport projects combined with the shortage of skilled and experienced workers can have a negative impact on the quality of construction projects. Furthermore, the delivery process of construction projects and hence their performance could be influenced by:

- The contractual and supplier structure of different entities involved in the project such as the use of consultants, general contractor or all-in-one contract.
- The political and legal system of the client organization such as lowest price policy, competition regulations, and internal resource capacity of the client organization.
- Other market forces such as competition, technology and overall economic environment.

These were some of the issues that we intended to investigate in our research. Based on observation of abnormal construction cost increases among Swedish regions and concerns for quality improvement after quality assurance transfer, a number of research questions were formulated. They will be presented in the next section along with detailed and more elaborated objectives of the thesis.

AIMS AND OBJECTIVES OF THE THESIS

This observed increasing disparity in housing construction costs and apparent lack of quality improvement of infrastructure transport projects are two issues that could not only influence the performance of construction projects, but also can have an impact on the way different actors in the sector interact with one another and achieve their divergent objectives. There is a large volume of literature dealing with the problems of high construction costs, but only a few studies tackle this issue within the context of the changing economic conditions and the governance structure of construction firms. The type of relationship between developers and contractors, the firm structure (such as developer-contractor or independent developer/contractor), and the level of foreign supplier competition found in these various regions might, among other aspects, explain the disparity in increasing construction costs. The difference in cost increases offered the opportunity to compare the regions and investigate numerous factors—contractual relationship, firm structure, foreign supplier and government

policy such as subsidies—that can exist in some regions but not in other regions or have different magnitude of influence. The identified factors could alleviate or exacerbate construction costs.

Similarly, there is an enormous body of literature that deals with quality concerns of construction projects; however, the impact of quality assurance transfer on a public client organization and quality improvement methods of infrastructure projects has not been thoroughly examined. Thus, the aim of this study is to answer the following questions:

1. How can we explain the observed disparity in construction cost increases between big (metropolitan) and medium/small regions?

2. What can a client do to improve the quality of infrastructure transport projects?

In addition to the above questions, sub-questions that further highlight the cost and quality attributes are discussed in the thesis. One of the questions this study will attempt to address is: Are there common understandings of what constitute costs or how we define quality? The effect of subsidized interest rates on housing construction costs in different regions is another example of sub-questions that is considered in this thesis. The impact of the quality assurance transfer must be first investigated and assessed before any attempt to study different, possible quality improvement methods.

This research comprises two separate topics (supplier structure in construction in relation to construction costs and quality improvement) but one common goal of addressing construction project performance. The more specific research objectives are:

Construction costs aspect:

- To gather and synthesize construction cost-related concepts in a way that makes it easier to identify factors behind increasing construction cost and disparities among the regions.

- To discuss the role that the previous working relationship and the strength of the relationship between developers and contractors play in the construction costs of building projects.

- To explore how developers perceive the behaviour of vertically integrated firms and the organization patterns in the construction industry in relation to construction costs.

- To analyze the level of foreign suppliers, imported materials and labour during the study period, and the impact that increased competition could have on construction costs.

- To explain the various specific organizational forms that could emerge in response to changes in economic and market conditions.

- To investigate the role of government subsidies for housing construction.

Quality improvement aspect:

- To gather and synthesize quality-related concepts in order to single out factors that could have contributed or hampered quality improvement the public client organization desired.

- To explore the extent of quality improvement after the transfer of quality assurance-led responsibilities from client to contractors.

- To investigate unintended consequences that could result from this quality assurance transfer and are detrimental to the quality of infrastructure transport projects. In other words, can we explain these consequences if we combine some of the mainstream decision-making and organizational theories related to quality attributes?

- To analyze and explain the role of procurement methods and public client characteristics (such as client competence and its internal processes) on the delivery of the desired quality level.

In order to find answers for the aforementioned research questions and achieve the above objectives, a methodical research approach that is clearly established in the construction research community is needed. Our intention in this section is not to get deeply involved in the philosophical debate of which paradigm or research approach is more suitable to any

specific construction related topic such as construction or project management. However, we need to explain why our research approach is suitable to answer our research questions, and thus could produce justifiable results that not only contribute to the existing body of knowledge in this field but also provide some answers to practical questions with regard to the quality improvement of construction projects. However, first an overview of research methodology, the different research paradigms, and the assumptions behind them, as well as a review of the methodological debates that have taken place in this field for the last two decades, will be presented.

RESEARCH DESIGN

There is no undisputed agreement on what constitutes good research that satisfies and prevails over the theoretical and philosophical differences among researchers in the construction and built environment discipline (Amaratunga et al., 2002). Some of the major issues that are behind these differences have their roots in what should be the object of analysis, what approach or method is more appropriate for certain research question, and how to collect and analyze data, as well as how to interpret the findings. In other words, the underlying basic question boils down to whether construction-related research is more in line with natural or social science, and whether theories and approaches discerned from one specific paradigm is more appropriate to answer certain research questions and exclude the use of other paradigms. In order to develop a convincing argument for our choice of research methodology and methods, we need to review these competing research paradigms, research types, and refer to how various scholars argued their preferred paradigm and research methodology. Jonker and Pennink (2010) presented a research pyramid that explains how different actions in the research are systematically interconnected. The pyramid has four levels:

- Research paradigm level: the researcher expresses their basic approach and how they view the reality.

- Research methodology level: the researcher decides on a way to conduct their research that is tailored to the research paradigm.

- Research method level: the researcher identifies specific steps of actions that is needed to be executed sequentially.

- Research technique level: the researcher specifies practical tools for generating, collecting and analyzing data.

Our brief research review process follows a similar approach to Jonker and Pennink's. We also describe the classification of some of the major research types and how they are related to specific types of research problems.

Research paradigms

First, the word *paradigm* needs to be defined. Fellow and Liu (2008) define paradigm as "a theoretical framework which includes a system by which people view events". They added that paradigms serve to determine what views are adopted, and the approach to questioning and discovery. Bryman and Bell (2007) gave a similar but slightly different definition of paradigm, explaining it as "a cluster of beliefs and dictates which for scientist in a particular discipline influence what should be studied, how research should be done and how results should be interpreted". Guba and Lincoln (1984) proposed a definition of paradigm that is based on answers given by the proponent of any given paradigm to three interconnected fundamental questions. They define paradigm as the basic belief systems or worldview that guides the investigator not only in choices of methods but answering:

- Ontological question: what is the form and nature of reality?

- Epistemological question: what is the nature of the relationship between the knower or would-be knower and what can be known?

- Methodological question: how the inquirer goes about finding out whatever they believe can be known?

From the above definitions of paradigm, several significant points can be interpreted. First, paradigms shape the views or beliefs that, as researchers, we hold with regard for our research questions. Second, these beliefs will influence our research process and how we collect and

analyze data, and how we present our research findings. Thus, it is important as a researcher to recognize the research paradigm that would eventually determine your research process, ultimately distinguishing it from other paradigms.

Two major paradigms dominate the debate surrounding which research approach is suited for the construction sector: *positivism* and *interpretivism*. Positivist researchers are defined as researchers that only recognize non-metaphysical facts and observable phenomena that are rooted on quantitative approaches, and are closely related to rationalism, empiricism, and objectivity (Fellow and Liu, 2008: 17). Interpretivist researchers are defined as researchers that emphasize that truth and reality are socially constructed and thus influenced by persons involved (ibid). Interpretive research is likely to feature in qualitative studies, wherein people with a positivist tradition often question its objectivity (Fellow and Liu, 2008: 27).

Seymour et al. (1997) advocate the use of a more qualitative and interpretivist approach in construction research. They suggested that researchers in construction management need to concentrate on interpretive methods, since it recognizes the view points of practitioners rather than positivist approaches, which heavily depend on causality relationship results. The article did not only generate a great deal of criticism and strong reactions from other authors, but it also started (as intended) a constructive debate on the subject itself. Abowitz and Toole (2010) agree with the argument of Seymour et al., and state that construction is essentially a "social" process where "construction can be considered to be the application by people of technology developed by people to achieve goals established by people involving the erection or retrofitting of infrastructure and buildings".

Runeson (1997) argued against the claim of Seymour et al. (1997), explaining that the object of study are people. He also rejected the suggestion that construction management is not amenable to an objective and verifiable casual relationship. Runeson (1997) insists that "*positivist research methods are our best insurance against bad research*". Wing et al. (1998) stated that an interpretivist approach could be suitable for certain types of problems, but a positivist approach is more likely to produce general practical solutions. Smyth and Morris (2007) reviewed 68 papers from the *International Journal of Project Management* that were published in 2005 and found that positivism was the most dominant research epistemology (66%) in the sample. Based on analyses of 107 papers and notes published in Construction

Management and Economics, Dainty (2008) also found that 76 of the papers used quantitative methods. Both Dainty (2008) and Smyth and Morris's (2007) papers acknowledged that their selection of papers and analysis could be biased. Nevertheless, this historical dominance toward a positivism approach might suggest that positivism is the most appropriate methodology for the practitioner-oriented discipline like project management (Wing et al., 2007).

The debate over paradigms was not confined to researchers' preference between only positivism and interpretivism. Other alternative approaches have also been promoted. Interpertivist researchers have been criticized for their tendency to seek specific explanations with limited powers of generalization, while positivists are criticized for their reliance on identifying *general* patterns based on cause and effect that marginalizes the *particular* (Smyth and Morris, 2007). Positivist methodology fails to address many project issues except in a few cases, while interpretivists understand perceptions well but poorly address the general (Smyth and Morris, 2007). Two possible means to address these shortcomings or criticism of the two dominant paradigms are:

- To exploit another approach such as *critical realism* that simultaneously recognizes the reality of the natural order and the events and discourse of social order (Smyth and Morris, 2007; Bryman and Bell, 2007). Critical realism, also known *postpositivism* (Guba and Lincoln, 1994) or simply *realism*, offers a methodology that neither seeks the particular nor the general, instead it tries to measure casual powers that explain the structure, mechanism and processes. (Smyth and Morris, 2007).

- To adopt a methodological pluralism approach, and combine both positivist and interpertivist approaches when solving the research problem in order to compensate for the weakness of each approach (Bryman and Bell, 2007; Dainty, 2008; Amaratunga et al., 2002). Without endorsing the criticism that Seymour et al. (1997) laid on the appropriateness of positivist methods in construction management, Dainty (2008) echoed the dominance of positivism in this field and the need to embrace other methodological perspectives in order to gain richer insight and a more complete understanding of the human aspect of the sector. The use of a mixed method approach, such as a combination of quantitative and qualitative approaches, can be a better one

in certain situations than a single method since it can improve the weakness of any single method (Amaratunga et al., 2002).

Gill and Johnson (1997), cited in Fisher (2007), described how the connection between positivist and interpretivist approaches works in a methodological pluralism framework. They argue that if you take a positivist stance then aspects of an interpretivist approach could be brought in as a useful adjunct to the research but not the other way around. After positivist research identifies an association between two variables then an interpretivist approach can help the understanding of the casual connection and the mechanism, which shows in all complexities how different aspects interact (Fisher, 2007). Dainty (2008) asserts that quantitative findings may have not come to light without earlier qualitatively derived results.

Based on our research questions described in the previous section and our main objectives, we focus on selecting an appropriate research approach that could provide a solution to both research problems: explaining (the disparity of) construction costs and exploring quality improvement methods. In both parts of the thesis, a multi-paradigm research approach was deemed to be more appropriate than a single approach because of the nature of our research inquiry and object of analysis that involved both process and product. We utilized both the quantitative and qualitative methods since the findings from the quantitative paper allow us to build the theoretical foundation for the ensuing paper in that part of the thesis. Fellow and Liu (2008) claim that construction management research tends to be either process oriented, for example organizational culture or both processes, and product oriented such as studies of the impact of different procurement approaches on project and project management performance. In our investigation concerning the quality of construction projects, we used a realistic research approach. This approach enables us to acquire knowledge that would indicate what should be done in order to improve the quality without intricately defining quality from the perspective of all parties involved in projects or how to measure it. The realist approach allows the researcher to retain many of the ambitions of positivism, while recognizing the subjective nature of research and its inevitable values (Fisher, 2007). Propositions/conjectures are presented that so far can only be partly tested, but are based on information from qualitative studies.

Research methodology and methods

Methodology must be given careful consideration at the beginning of the research so that the most suitable approaches and research methods are adopted (Fellow and Liu, 2010). This statement from Fellow and Liu does not only emphasize the significance of good research methodology in the quest for knowledge contribution and finding a solution for practical problems, but it also underscores the different meanings of the two words *methodology* and *methods*. The two words are often used arbitrarily (Jonker and Pennink, 2010). It is clear from Fellow and Liu's abovementioned statement that methodology covers more than just research methods. Jonker and Pennink (2010) define methodology as the process of defining and defending the logical order the researcher needs to follow in order to achieve a certain predetermined result such as knowledge, insight, intervention or change. They also state that methodology helps make the main outline of the approach transparent to the researcher and to academia and business. In fact, research methodology influences the actual research methods that are used to investigate a problem, and collect, analyze and interpret data (Dainty, 2008).

Methodology encompasses the rationale and the philosophical assumptions that underline a particular study (Dainty, 2008), while methods indicate specific steps or actions that should be taken in a certain order during research (Jonker and Pennink, 2010). Methods concern the techniques that are available for data collection, analysis and those which are employed in a research project (Fellow and Liu, 2008). It is expected that if the research methodology is good and the actual research is properly conducted, the resulting research would not only be useful in organizational practice but also meet academic standards (Jonker and Pennink, 2010). This notion of practical and academic needs brings up the existence of different types of research and research questions.

Fellow and Liu (2008) described several classifications of research types. One of their classifications is based on the outcome of the research. *Pure* research focuses on the discovery of theories and laws of nature, while *applied* research is directed to end-uses and practical applications. Jonker and Pennink (2010) also classified research into *scientific* (fundamental) and *applied*. A fundamental researcher improves the existing body of knowledge by generating new knowledge and insights into the basis of research, while applied research is more concerned with problem solving and strives to obtain knowledge

about a particular issue that contributes to the improvement of the issue (Jonker and Pennink, 2010). Fellow and Liu (2008) stress that although academics are often oriented to pure research and practitioners tend to pursue development work and application, the two research types are complementary to each other, particularly in the context of construction. Furthermore, Fellow and Liu (2008) categorize problems associated with applied research as closed and open-ended problems. The nature and variables involved in close-ended problems can be identified easily and a single correct solution can be reached, while open-ended problems tend to be complex and could produce many alternative solutions (Fellow and Liu, 2008: 9).

Another classification is based on the research methods adopted: quantitative and qualitative research. Quantitative approaches adopt a scientific method that relies on theory and hypothesis testing procedures, while a qualitative research objective is to gain an understanding and collect information and data that would allow theories to emerge (Fellow and Liu, 2008). As we mentioned earlier, the two methods are not mutually exclusive; however, quantitative findings could be used as a supplementary source for a qualitative enquiry in other parts of the research, and the other way around. Fellow and Liu (2008) stress that qualitative data, which are commonly subjective such as opinion surveys, can and should be analyzed objectively, often using quantitative techniques.

Fellow and Liu (2008) described another classification that is based on the purpose of the research question. This classification was an essential tool in our research process, and it is further explained below. According to this classification, the five types of research are:

- *Instrumental*: when the intention is to construct or calibrate research instruments. This type does not have that much application in our research topic and we are not discussing it any further.

- *Descriptive*: to systematically identify and record a phenomenon, process or system. Since identification is done from a particular perspective and for a specified purpose, objectivity, accuracy and comprehensiveness are important (Fellow and Liu, 2008). Commonly, a descriptive research type is carried out to enable the subject matter to be

categorized, and the research may be undertaken as a survey or as a case study (ibid). Paper 1of the second part of the thesis exemplifies this type of research.

- *Exploratory*: when the intention is to test or explore aspects of theory. An hypothesis is an integral part of this type of research, where either hypothesis is set up then tested or variables are identified and hypotheses are produced in order to be tested in further research. Paper 2 of the first part of the thesis is an exploratory research type, where three hypotheses are put forward and partly tested.

- *Explanatory*: when the researcher is seeking to answer a particular question or explain a specific issue. Hypotheses are also used in this type of research and a theory can be used to develop the hypotheses. Paper 4 in the second part of the thesis is a good example of this type of research, where we try to explain the impact of subsidy on housing stocks.

- *Interpretive*: when the purpose of the research is to fit findings to a theoretical framework or model, and empirical testing cannot be done due to some unique aspect. In this circumstance, variables are grouped according to an assumed relationship with the intention of replicating reality as close as possible. Paper 2 of the second part of the thesis is an attempt to fit our survey finding with decision-making theories in relation to quality of construction projects.

Our research and research questions in the first part of this thesis seem to fit well with the description of the fundamental type of research, since the main objective of that part was finding theories that could explain the disparity of construction cost growth between big and small regions. The intention was to contribute to the existing body of knowledge concerning construction costs rather than finding a solution to a specific real problem. On the contrary, the second part of the thesis tries to address quality improvement concerns related to the transfer of quality assurance. It is intended to contribute to a practical solution to a real issue. Thus, this type of research could be characterized as applied research.

Before we undertook our research, we considered the difficulties and challenges that we may encounter when obtaining information related to construction costs and quality of specific construction projects. We also contemplated the usefulness of these unique projects attributes, related to cost and quality, to the main questions of understanding construction cost factors and improving the performance of construction projects. Surveys and interviews were used as a means to collect data concerning both supplier structure in relation to housing construction costs and quality of construction projects. Other empirical data from a secondary source were used in some of the papers. SPSS and STATA were utilized in our data analysis.

Though the response rate of both the semi-structured survey in the first part of the thesis and the survey in the second part are considered to be high compared with the typical questionnaire surveys of the construction industry, the inference power of the responses were limited due to uncompleted answers, disproportional participants of public developers, and respondents' disparate opinion about what constitutes quality.

The following research methodology (Figure 1), which is quite similar to a methodology adapted by Arditi and Gunyadin (1998) in their investigation of factors that affect quality, is envisioned to produce the desired contribution of knowledge and practical proposals to address quality improvement questions.

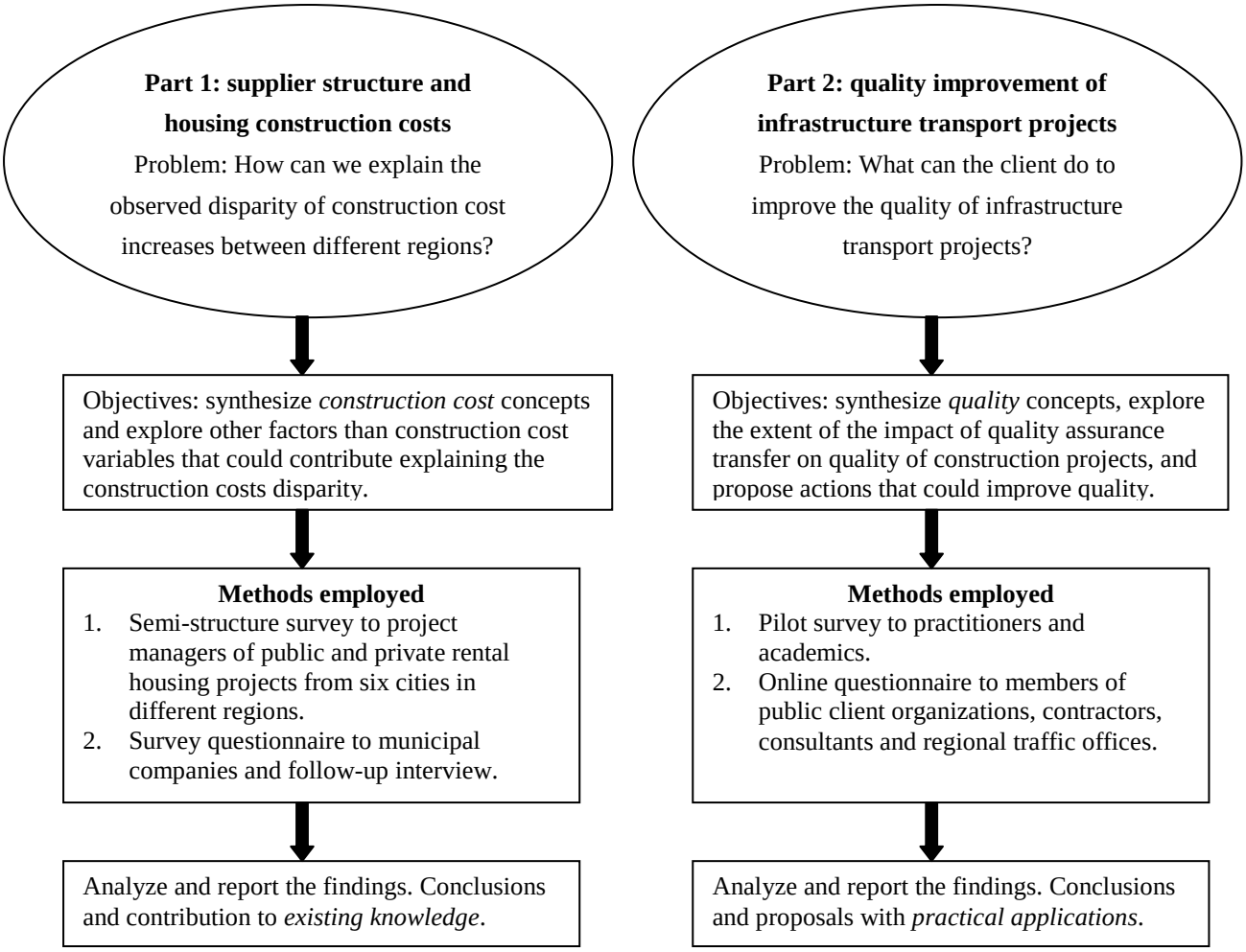

Figure 1: Research methodology of part 1 and 2 of the thesis.

SUMMARY OF THE PAPERS

As the above figure illustrates, this thesis contains two parts of research that have been carried out at two different times. With regard to context, the two parts cover a common subject—the performance of construction projects—but each part deals with a specific issue. Part 1 deals with supplier structure in relation to housing construction costs, and part 2 focuses on quality improvement methods for infrastructure projects. The first part of the thesis concerns a research project funded by FORMAS (The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning). It is inspired by a research question that was based on observation of the disparity in construction cost increases among metropolitan and

other small and medium regions of Sweden. It comprises four theoretical and empirical papers, and it was mainly completed in 2006 as a part of licentiate fulfillment, except for Paper 4 and the empirical part of Paper 3.

The second part concerns quality improvement methods for infrastructure transport projects and is funded by the industry actors (Trafikverket, SBUF, and NCC) through the Centre for Operations and Maintenance (CDU). After the transfer of quality of assurance of the public project from client to contractor almost 25 years ago, the industry has recognized the need to investigate quality control and quality assurance responsibilities. This part of the thesis consists of five interrelated papers. It starts with a more conceptual paper and ends with recommendation of what needs to be done in order to improve quality of infrastructure projects.

Part 1: Supplier structure and housing construction costs

The cost concepts and categories, as well as clarification of cost and price terminology contained in the first paper, served as a catalyst for the other papers of this part, where a number of more specific factors that could influence construction cost and organizational structure ramifications were examined. Paper 2 is a typical quantitative research study where theory, hypothesis testing and deductive approach are followed. The empirical study presented in Paper 2 indicated the importance of the organization structure that is analyzed in the third paper.

The original version of the third paper[1] that was included in the licentiate presentation is not included in this thesis because the theoretical part of that paper is supplemented with empirical results from a survey and follow-up interviews generated the version of the paper included here (Paper 3)[2]. Paper 4 was carried out at a later stage when more data concerning construction costs and other explanatory variables became available[3].

Paper 1: *Construction costs – central concepts, categories and determining factors*

The first paper of this part is intended to review various construction cost concepts. Unclear descriptions of what constitutes cost and what the building price is made up of is a common source of confusion and may hinder any attempt to single out the source of increasing

construction costs. A direct and indirect cost structure seems to include most of the cost components incurred by the various actors in the construction process and indeed enhances the distinction between cost and price in relation to supplier structure.

The factors influencing construction costs were formed into four groups/layers: project-specific factors, client-contractor-related factors, competition and market conditions, and macroeconomic and political factors. The grouping is based on the extent to which the construction actors, especially contractors and clients, could influence the factors. By aggregating many factors influencing construction costs into four groupings, it is easier to analyze a specific situation as one can first determine what type of factor or layer to focus on.

The usefulness of each group of factors in explaining the disparity of regional cost growth breaks down to whether the impact of these factors is confined to a specific project region or the whole country. Project characteristics and client requirements such as size and quality could influence both the amount and the unit prices of the input resources needed to undertake a project and could increase the direct cost portion of the estimated construction costs. However, the issues related to the direct costs are mainly dealt with locally. Import of materials and labor mobility may resolve shortages of resources.

The impact of project-specific factors on regional construction cost differences could mainly be linked to the indirect cost portion of the construction costs, where client-contractor-related factors such as contractor/client type and the extent of the relationship between contracting parties seem to influence these costs. Besides, not all client-contractor-related factors are helpful to explain regional cost increase differences. Contractor and client type as well as procurement method do not differ greatly between metropolitan and small regions. The client-contractor relationship is the only factor in this layer that presumably influences construction costs through indirect cost components, where a long-run and strong past relationship between the parties could reduce transaction costs and the incentive to price according to current demand.

Client-contractor-related factors are very susceptible to the level of competition and the intensity of construction activity. The level of competition and construction activity influences the cost of inputs and could also have an enormous impact on indirect costs.

Competition and market conditions affect both the direct and indirect costs, but their impact on the latter is more exacerbated when client-contractor-related factors are taken into consideration. Macroeconomic and political factors such as inflation and interest rate fluctuations, as well as labor laws, general labor conflict and building regulations can impose heavy costs and delays in a building project. Most of the factors in this layer are uncontrolled but clients and contractors can predict them.

Two groups of factors are considered in our analysis of construction cost differences. Client-contractor-related factors as well as competition and market conditions seem to contribute to explaining the observed increased cost disparities and will be the focus of the next paper. The other two layers—project-specific factors and macroeconomic and political factors—are, respectively, mainly confined to a specific project or in most cases not confined to any specific region. Thus, their contribution to the analysis of regional construction cost differences is deemed to be negligible.

Paper 2: *Long-run relationships, Vertical Integration and International competition: Can they contribute to explaining regional construction cost differences*?

The second paper covers the empirical part of the research. It contains the responses from the developers (interviews and posted questionnaires), and the analysis of the following three hypotheses that were postulated in order to examine the observed construction cost increases.

a) *A long-run relationship between contractor and client tends to a lower cost increase during the boom.*

b) *If the contractor in the rental housing market is also active as a developer in the same market, the construction costs tend to be higher.*

c) *If it is easier for foreign suppliers to enter the market, then cost increase will be lower.*

The cyclical pattern of housing construction activities could induce one of the contractual parties—developer or contractor—to enhance their economic position at the expense of the other when there is no long-term relationship between them. Thus a short-term relationship may inhibit collaboration between the contractual partners and induce higher transaction costs

that would ultimately inflate housing construction costs. The first hypothesis postulates that the existence of a long-run relationship between the actors in the housing building sector is a key factor in the fluctuation of construction costs. A long-term relationship curtails the opportunistic behavior associated with changing economic conditions of the housing construction sector. The presumption here is that contractors do not unreasonably increase the construction cost for short-term gain and sacrifice the fostered relationship with the client that could lead to repeated work in the future. The client will eventually have the upper hand in a recession or in economic downturns, and the contractor will then be in a position to have to accept lower construction costs or compete with other contractors and face uncertainty.

Apart from the benefits of competition, it is reasonable to contemplate that the concentration of a few vertically integrated firms (contractor-developer type) in metropolitan regions is one of the sources of the increased construction costs observed in these regions. Vertically integrated firms must take into account the price effects that the new projects could have on the existing properties developed by this firm or projects undertaken by the same vertically integrated firm. In Sweden, a few large companies dominate the construction of rental apartments and condominiums. Some of these companies are not only contractors but also active to a large degree with project development for their own accounts (Swedish Industry, 2004).

The two above characteristics of Swedish residential construction—few companies (oligopoly) and governance structure (vertical integration)—might have some effects on the construction cost of rental apartments and condominiums. In other words, those few companies might have a market power to control the construction costs of residential building projects contracted by property companies and/or municipalities. The focal point of the second hypothesis is to examine if there is a connection between the higher construction cost observed in these regions and the share of the vertically integrated construction (contractor/developer) firms operating in these regions.

The final hypothesis is intended to check the impact that foreign firms could have on construction costs. The higher the presence of foreign suppliers in a region the higher the competition and the lower the construction costs increases will be. The shares of foreign firms active in Swedish housing construction such as contractors, major subcontractors or suppliers,

and the regions that they are active in are the focus of this hypothesis. Though foreign competition and globalization of the construction industry can lead to borderless activity, geographical location of a region or cities, and convenience of main transportation lines, are still important. For instance, the impact of foreign competition could be different in terms of labor and construction materials to a city bordering another country, for example Malmö as compared to a city that is located further inland.

In order to test these hypotheses, data were collected from a number of rental housing projects from six cities in different regions. In non-metropolitan region, the long-term relationship between a developer and contractor is a crucial strategy and incentive mechanism when securing repeated work for contractors and lower construction cost increases for the developers. The short-term relationship, and normal and adversarial relationship, was more prevalent in the metropolitan region. The working relationship is also affected by the level of construction activity and project characteristics (size, complexity, etc.). Many rental housing developers of rental housing did not recognize the effects of vertically integrated contractors on construction costs, and hence the relevance of concentration levels of vertically integrated firms in any region became inconsequential. The involvement of foreign contractors was not reported in any project considered in the study, and the usage of imported materials was almost non-existent.

Paper 3: *Organizational modes in the residential building sector in Sweden*

Paper 3 describes various organization structure models and their implications on construction costs, as well as the interdependence that exists among construction actors. A holistic approach for analyzing the housing industry in relation to different possible organizational patterns may enable us to understand bearers of risk and incentives, responsibility and control mechanisms, consequently shedding light on construction cost determinants. Several criteria are utilized in a theoretical evaluation of the efficiency of the organization patterns in the building sector. The analysis examines how risk is allocated among the actors, and how various supplier structures influence competition in the market, the degree of flexibility to respond to macroeconomic changes, and the needed competence level of actors.

The use of existing theories such as transaction cost theory and resource-based view allowed us to conceptualize various organizations in the construction sector. In response to market and

economic changes, as well as competitive pressure and necessary competence to compete efficiently, major actors in the construction sector may undergo processes of integration and separation. Owner, developer and contractor integration might increase the competence and competitiveness of the integrated organization, but it may also limit the flexibility of the amalgamated organization to adapt to economic changes. On the other hand, a separate developer, contractor and specialist contractor may allow these actors to adapt competitively to the economic environment, leading to a better risk allocation. However, the required competence of each actor may increase in order to engage contracting processes efficiently and autonomously. Thus, the need for flexibility in adjusting unstable economic and market conditions may lead to less integration of construction actors.

Two organizational structure patterns that represent the two extremes of possible models and three transitional models are proposed. The first organization form, which is called the base model, contains an integrated owner, developer and contractor with no outside contracting. This organization model is exposed to both market risk (development and construction businesses) and the risk emanating from not subcontracting and the subsequent higher fixed costs that could be transformed into variable costs by changing the organizational pattern. The base model is mirrored by another organization model that contains similar actors but is totally separated and where subcontracting is central. The other three models emerge when the major actors in the building sector integrate or separate, and subcontracting and the services of specialty contractors and consultants are considered.

Based on the analysis of the results from the survey and the follow-up interviews, we can conclude that frequent developers tend to contract directly with specialty contractors and get the opportunity to work repeatedly and build long-term relationships. In the absence of a strong relationship with contractors or subcontractors, infrequent developers that are not integrated may rely on the services of consultants and utilize the expertise and resources of the consultants that could otherwise be costly for this type of developer to acquire. In either case, the prevailing organization structure depends on, among other factors, the economic environment, the competence demanded by the preferred organizational mode, and the degree of flexibility in terms of business and construction activity associated with different organizational modes.

Paper 4: *The effect of subsidy on housing construction in various regions of Sweden*

Though this empirical paper does not say as much about the issue of organizational structures as the other three papers, it highlights how other factors such as a subsidized interest rate contributed to overbuilding of multi-family apartments in metropolitan regions. That could partially explain construction cost differences among different regions in Sweden. We hypothesize that housing stock is a function of many variables, including construction and production costs, as well as the subsidy interest rate that indirectly affects both costs. If we are able to empirically validate that subsidy interest rates have an impact on the housing stocks of different regions and preferences of various tenures of properties, then we can deduce that the observed disparity of construction cost growth among various regions of Sweden can be partially explained by the construction cost differences due to the subsidy interest rates.

A balanced quarterly panel data that covers six regions of Sweden was analyzed. The data shows that more multi-family units were produced in the three metropolitan regions (Stockholm, Gothenburg and Malmo) than in small regions; however, significant differences in the production of single-family houses existed. Furthermore, significant production costs differences were observed only between multifamily houses among different regions.

Part 2: Quality improvement methods for infrastructure transport projects

As our research methodology in Figure 1 describes, the approach we take in carrying out this part of the thesis "Quality improvement methods for infrastructure transport projects" is partly identical to the first part of the thesis except for the use of a realistic research approach in defining and delineating quality attribute. Two important considerations that this part of the thesis benefited from is a pilot survey and the use of a steering or reference group with well-informed persons from the sector. Fellow and Liu (2008) recommend that all questionnaires should be piloted initially and discussed with a supervisor and other researchers in order to ensure that they are free from mistakes, easy to answer and unambiguous. Fellow and Liu (2008) also pointed out the increasing popularity to form a steering group of researchers, industrialists and practitioners in applied research. The objective is to ensure the combination of rigorous research with practical relevance (ibid).

Paper 5: *Quality in infrastructure projects: concepts and framework for explanatory and exploratory studies*

The precise definition of the word *quality*, as many similar words such as *reality* and *truth*, are elusive. The first paper of this part of the thesis was intended to review various definitions and concepts of quality. After a thorough literature review of quality, we were able to establish a conceptual definition that is easily related to construction projects in a more general sense. Quality was classified as relative and absolute, where relative quality is based on the expectation of the client and the contract terms, while absolute quality refers to standards and specifications that all interested parties could agree to be the best and highest quality.

Furthermore, we considered other dimensions of quality that could influence how we classify quality. This other dimension, the extent that an attribute of quality is measurable (easy or difficult), allows us to put forward two hypotheses that are designed to provide possible explanations of different scenarios. We have envisioned that quality is either low in absolute terms but not necessarily in relative terms, or it is low in relative terms but not necessarily low in absolute terms if the ambitions of the project were very high (see Table 1). The hypothesis also outlines that low relative quality more often occurs when measurability is low.

Table 1: Quality levels and their classifications.

	Quality measures based on expectation and standards	
Quality level	**Absolute**	**Relative**
Scenario 1: Low	Yes	No
Scenario 2: Low	Yes/No	Yes

In the first scenario, the client has been provided what they have contacted for, but the absolute quality is rather low, as this is what they could afford to pay. This scenario was not given further discussion since both quality attributes (easily or difficult measurable attributes) do not influence this perceived lack of quality. However, the client's goals caused the low quality. If there is dissatisfaction it is only because the client was unaware of what was contracted.

In the second scenario, quality is judged to be low in relative terms but not necessarily in absolute terms (and perhaps especially quality attributes that are more difficult to measure). In

order to explore factors that could explain why construction project experience low relative quality (our second scenario), we have utilized a Fishbone or Ishikawa diagram. This diagram allows us to systematically put together various factors that could influence how construction projects are managed, and explain how these factors could affect the outcome of each phase of construction projects.

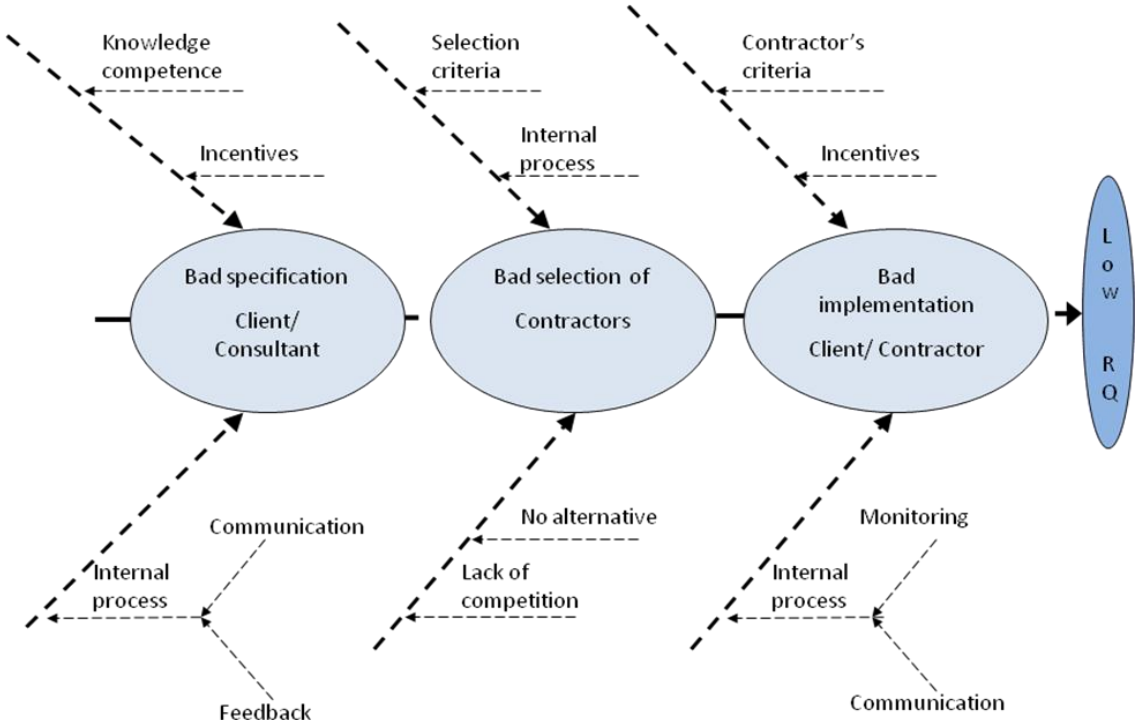

Figure 2: *Fishbone or Ishikawa diagram on factors leading to Low Relative Quality.*

An online survey questionnaire was administered based on factors developed from the Fishbone diagram analysis. The survey was also intended to find the extent of quality of current infrastructure transport projects compared to before the transfer of the quality assurance system. The results of the survey suggest that quality has not declined after the transfer but a good number of respondents indicated that it is the same level as before. The absence of a quality level increase can either be positively associated with consistency of keeping up with technical and environmental changes or lack of quality improvement. The second aspect, lack of continuous quality improvement, is the focus of this paper since this concern was the basis for carrying out this research. Other variables or factors that could

contribute to explaining this quality improvement stagnation were mentioned in the survey, and further investigation was carried out in subsequent papers.

Paper 6: *Decision-making theories in relation to quality of infrastructure transport projects*

The success of a decision does not only depend on whether that decision was the efficient one, but whether it was effectively implemented by the subordinates who were entrusted to carry it out. A decision to transfer quality assurance of construction of infrastructure transport projects from the client to contractors, in this case the Swedish Transportation Administration Trafikverket (formerly known as Vägverket and Banverket), was taken approximately 25 years ago.

As the result of the survey in the first paper suggests, the outcome of that decision is somewhat mixed and there are signs of lack of quality improvement. There could be many reasons behind this quality assurance transfer, but it is beyond the focus of this research. One can assume, however, that this decision was not intended to compromise the quality of construction projects. However, unintended consequences can arise if there is a trade-off between cost and quality during the planning and design phase. There could be another kind of trade-off between the schedule to complete a project and the desire to achieve a certain quality level during the construction phase. Anderson (1992) claims that the quality of the project manager is one of the many factors that affect the quality of a project. Project managers decide whether certain product quality attributes meet the highest required threshold or if a lower quality level is accepted.

In this short paper, decision-making theories were reviewed in order to find out whether, at the project level, quality-related decisions during construction and inspection stages have produced unintended consequence. The answer to either question is not straightforward. However, a general discussion of decision theories in relation to quality of construction projects and the response from certain questions of the survey are adequate to explore the impact of these decisions on quality improvement aspirations.

Respondents from the survey indicated that the quality problem of the completed structure depends largely on how well the project actors have done their job, the competence of the

client, and the quality of the tender/bid documents. They also suggest that project managers can accept project quality levels that are lower than those specified by the contract but still fall within the acceptable limits. From a theoretical perspective, conflict avoidance was seen as one of the reasons that this kind of decision is taken. Conflicts could make future relations worse and thereby create more problems. Lack of communication between major actors and less involvement of personnel and management on-site were also reported.

We can denote from these responses that decisions made by management at each level of the organization in relation to the provision of project might have inadvertently affected the quality level of projects. It is also possible that quality improvement goals were compromised when the client's representative accepted sub-optimal quality level in order to avoid conflicts.

Paper 7: *Framework for quality improvement of infrastructure projects*[1]

Numerous authors have tried to determine the causes of decreasing quality of construction projects. The Fishbone diagram in Paper 5 describes some of these factors that could lead to low quality. Inappropriate mechanisms of project delivery such as poor consultant and contractor selection, bad design and inadequate project supervision are some of these factors that could negatively affect the quality of construction projects. One common denominator that has some bearing on the majority of these factors is the level of client competence and their involvement in the process. It is the client who is in charge of identifying their own needs, selecting qualified consultants and contractors, choosing appropriate procurement methods, and delegating quality-related activities such as quality assurance. We are not saying that other actors in the sector have no role in quality level determination, but public clients such as initiators and owners of the public projects have the main responsibility of delivering high performance projects.

While the same number of respondents from the survey suggested that the quality level of construction projects are either the same level as before the transfer or better than before, respondents have overwhelmingly indicated (81%) that lack of public client competence was

[1] Published in Conference Proceedings: 6th Nordic Conference on Construction Economics and Organization – Shaping the Construction/Society Nexus Volume 3: Construction in Society, pp. 223-235.

one of the contributing factors of quality problems. This lack of client competence raises several questions:

- What are the main causes or contributors of this reported lack of client competence?
- Did the quality assurance transfer contribute to the client competency deficiencies?
- Does this lack of client competency influence the choice of appropriate procurement method?

Against this backdrop, the paper was intended to look at the extent to which different procurement methods can contribute to the desired quality of infrastructure projects. An important question is how these procurement methods respond to the perceived lack of client competence, since each one of them not only demands a certain level of client involvement but also specific skills and knowledge. In Sweden, the majority of public construction projects are procured with traditional Design-Bid-Build (DBB), although other procurement methods such as public-private partnerships and those that are performance-based have been recently promoted. These other procurement methods have thus far not gained any prominence in public sector procurements in Sweden.

Shortage of skilled and experienced workers in the sector could partially explain this reported lack of client competence and might have contributed also to the perceived quality stagnation. Heavy reliance on DBB coupled with the shortage of skilled workers might have further exposed the client's lack of competence since DBB requires a high level of client involvement. We have not empirically substantiated the reasons behind the heavy reliance on DBB in public construction projects, but several theoretical explanations were found in the literature. Familiarity of DBB and its ability to satisfy public accountability, as well as higher client control of the project's outcome in terms of cost and design, are some of the explanations mentioned in the literature.

The use of warranties might have lessened some of the concerns of quality problems since it can give the public client more assurances that completed projects will meet the desired quality level even if the public client is facing a shortage of skilled workers. In the United

States, state agencies have used warranties when they faced staff and budget shortages. Warranties can, however, be problematic when attributes are difficult to measure.

In this paper, we have extensively explained how important client competency is in determining quality attributes and hence the most appropriate procurement methods. Furthermore, we have clearly stated that whatever procurement method must be employed requires strong client competence, skills and expertise in order to effectively deal with private sector counterparts.

Paper 8: *Procurement type and quality in infrastructure projects*

This short conceptual paper discusses the same issue that has been treated in the preceding paper but from a particular aspect. The discussion in Paper 6 was centered on people from the organization and how their decisions affect the quality of the project. In Paper 7, we started discussing the process (procurement methods) and product (quality of the project), as well as certain aspects of people (competency and client workforce). In this paper, the focus is mainly on the quality of the product.

The central arguments in this paper relate to the following questions:

1. Is it possible to increase the quality level of a project by using a specific procurement method?

2. Is there a specific procurement method that consistently results in lower quality?

If either of these two questions has positive answers then we would have solved certain problems related to the quality of construction projects by choosing or avoiding the use of that specific procurement method. The hypothesis argued for in the paper is, however, that the answer to both questions is no.

General contract theory and transaction cost theory were used as a framework for our discussion. After a schematic description of major procurement methods, two central questions were identified: how quality could be affected by who is responsible for the design and how quality is affected by bundling of construction and operation/maintenance activities. In the first issue, coordination gains by letting the contractor do the detailed design stands

against the incentive problems when there are attributes that are difficult to observe. In the second issue, the stronger incentive for life-cycle cost when construction and maintenance are bundled stand against a problem specifying functional characteristics in long-term contracts. The possibility and incentives for the contractor to build up knowledge of the relation between construction characteristics and life-cycle cost is also a problematic feature for the bundled alternative.

Regardless of who is responsible for the design of construction projects, a competent client can mitigate potential quality problems that can arise during design or construction phases. Furthermore, client competency gives more flexibility and knowledge capacity to choose whatever procurement method is deemed appropriate for any particular project.

In conclusion, there is no quick fix when it comes to improving quality in infrastructure projects, and there is no procurement method that can guarantee a better quality than others. However, client competence and a proper incentive system cannot only increase the prospect to build projects with a high quality level, but also reduces a client's heavy dependence on other actors in the sector for the provision of these projects.

In order to build the required competence and skills, as well as expertise and experience, public client organizations such as Swedish Transportation Authority must have a sustainable knowledge management system. This issue will be the focus of the next paper.

Paper 9: *What can the client do to improve the quality of infrastructure transport projects?*

Public sector clients play different roles in the provision of transport infrastructure projects. They are responsible for identifying the needs of end-users, determining performance objectives of projects and ensuring that the most appropriate procurement method that minimizes risks and optimizes outcomes is chosen. Public sector clients could also have a major influence on the actions and behaviors of other actors in the sector, ultimately improving the overall performance and productivity of the construction sector. It is expected that only a public sector client with a skilled and experience workforce supplemented by appropriate knowledge management can fulfill these responsibilities.

In this paper, we argue that a perceived lack of client competency in the public construction sector in Sweden could have its roots in inadequate knowledge management within the client organization, especially when the public sector is experiencing a shortage of skilled and experienced workers. The importance of the incentive structure and the "company culture" within an organization is also underlined. This then must shape the internal processes of the client organization such as design type, procurement method and construction procedures.

Thus, a more structured and proper knowledge management will not only minimize the loss of tacit knowledge and enhance the public sector's internal process capacity, but it will reduce reliance on specific procurement methods without economic and technical justifications. Furthermore, certain strategies such as incentive schemes, post-review reporting for accountability and transparency purposes could improve the public sector's knowledge assets. A second opinion from independent experts and committees that focuses on quality and ensures that a proper procurement method is chosen can be introduced in the provision of infrastructure transport projects.

RESEARCH CONTRIBUTION

The harmonization of cost concepts, categories and the clarification of important terms can be seen as a step forward that will smooth the progress of identifying the factors affecting the construction costs that could ultimately explain the cost escalation and differences among the Swedish regions.

The contribution of this part of the research is also to offer an understanding of the behavior of contractors in specific economic situations by taking into consideration the long-run relationship. It ascertains that if contractors/subcontractors display opportunistic behavior during the economic boom, the result will be an increased higher construction cost. The analysis can also enrich the current understanding of the governance structure of Swedish construction firms and how they could influence construction costs. We attempt to utilize transaction cost theory when exploring construction sector structures, which should be seen as a first step in trying to understand changes in the sector from an efficiency perspective. The contributions are unique in the sense that neither the behavioral relationship between client and contractor nor structural analysis of firms has been fully investigated. The third

hypothesis of the second paper invigorates what many academics and professionals already pointed out, which is the need for increased competition and more foreign supplier participation in the sector in order to ease the increase in construction costs.

As the response from the survey suggests, quality of infrastructure projects has not decreased after the transfer of quality assurance from client to contractor. However, the high number of respondents that indicated quality is the same as before the transfer raises a concern of lack of quality improvement. Smyth (2010) contends that in order to achieve continuous improvement that implies consistency, knowledge must be transferred across projects and embedded as a capability or competence. The shortage of skilled and experienced workers in the public client organization might have undermined knowledge transfer opportunities and thus contributed to the perceived lack of quality improvement in public construction projects.

A project manager's decisions with regard to quality specifications and standards during the construction phase of projects can also influence continuous improvement goals if project managers frequently resort to an acceptable quality level that is not optimal in order to avoid or minimize conflicts with contractors or the displeasure of senior managers.

The desire to increase the use of other procurement methods such as PPP seems to be wishful thinking at the moment, when it is interpreted as reducing the need to have a public client with a highly skilled and competent workforce that can not only deal with the technical aspects of construction projects but are also trained to manage the nuts and bolts of long-term contracts from legal and financial aspects.

Longer warranty periods and the use of performance-based contracts could improve the current procurement system and produce the desired quality level if client competence is built-up through proper knowledge management and incentive systems. This includes training and retention of new skilled and experienced workers that are essential elements for continuous quality improvement goals and objectives.

In summary, competence, whether it is a developer's competence in housing production or client competence in the provision of public infrastructure transport, seems to play a significant role in determining what kind of housing supplier structure developers adopt in

different economic situations and the level of involvement that clients can bestow on the production of infrastructure projects. Public clients that are less competent, skilled and experienced will most likely rely on what procurement methods the market offers, the same way a less competent developer or infrequent developer with a shortage of skilled and experienced workforce will be best served by consultants or other forms of housing supplier structures. Competence cannot, however, be discussed separately from the incentive structure and organizational culture, as these determine whether competence will be developed and used.

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Part 1:

Supplier structure and housing construction costs

Paper 1

Construction Costs: Central Concepts, Categories and Determining Factors

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Abstract

Causes of construction cost escalations can be numerous and any effort to ascertain them in order to explain regional disparities requires that all the major construction cost components affected by the increase must first be recognized. Imprecise concepts and categories as well as mix-up of what constitute cost or price makes it difficult to systematically identify these cost constituents. The aim of this paper is to synthesize these concepts and systematize the factors that determine construction cost factors in a way that makes it easier to tackle the issue of Swedish regional construction cost escalation differences. The factors influencing construction costs were divided into four groups/layers based on the extent to which the construction actors, especially contractors and clients, could influence the factors; project-specific factors, client-contractor related factors, competition and market conditions, and macroeconomic and political factors. Factors in the first and final groups may not contribute valuable analysis that explains the regional construction costs differences. The other two groups of factors; client and contractor-related factors and competition and market conditions could have huge influences on construction costs and hence could explain different construction costs increase observed between metropolitan and smaller regions in Sweden.

Keywords: Construction costs, direct and indirect costs, cost overrun, cost escalation.

1. Introduction

While there is no notable disagreement about the consequences of high construction costs, much of the difference of opinions arises from the question of the real causes of higher construction costs (Saukkoriipi and Josephson, 2003). European Commission report (2003) emphasizes the consequences of this high construction cost on certain cities of Sweden by referring to the latest housing market survey of the Swedish Department of Housing that states that Sweden's commercial centers (e.g. Stockholm, Gothenburg, Malmö) suffer from an acute shortage of housing, and lack of student accommodation at university sites. One reason given for the low level of construction in Sweden was that the present production cost makes it almost impossible to build rental housing and make a profit. Interviews with municipalities (Boverket, 2003) indicate that many of them (over 80%) believe that higher production cost is one of the major obstacles in housing construction.

Large cities are often associated with higher living expenses for workers and thus commensurate with higher wages. Shortage of easily constructible land, constrained construction-site accessibility that could increase material delivery costs as well as demand for on-site specific construction equipments and techniques due to close proximity of other buildings may also raise the level of building cost in many major cities. Thus, it is reasonable to assume that, in normal circumstances, large cities will experience higher construction costs as compared to small or medium sized cities. Thus, the central question in this research project is not to analyse differences in construction costs between various regions, but instead to focus on differences in the *increases in production costs* that have been observed in the various regions in Sweden in recent years.

In order to address the reasons behind this disparity among the regions, it is imperative to identify the factors that could influence costs and their effect on the various construction cost components. Constituents of construction costs are numerous and the impact of individual components on the total construction costs is much related to the prevailing economic conditions, supplier structure and the size of the market.

Furthermore, the uniqueness of building projects as a product with distinct location, ownership, and amenities together with a construction team that changes regularly, demands that both project-specific factors as well as the environment in which the project is carried out must be considered in the analysis. The levels of competition and construction activity do not only influence the availability of the input sources and their prices but it could also influence the behaviour of construction parties in terms of relationship and transaction costs.

It is also important to elucidate the distinction between costs and price, which is ostensibly one of the sources of disagreements of what makes up construction costs. What is considered cost by one of the actors in the building process might be regarded as price for another actor.

The objective of this paper is threefold.

- To describe some of the conceptual mix-ups in the construction cost debate such as cost and price as well as various types of costs in relation to the components of construction cost structure.
- To discuss factors that could have impact on the level of the cost components and examine how these factors could cause contrasting regional cost escalations.
- To put forward a model of possible causes of the observed construction cost escalation among the regions.

The paper is organized as follows: The distinction between cost and price in relation to different stages of the building process will be reviewed in the second section. There the meanings of price and cost are described followed by a brief discussion of how price-cost is treated in different supplier structures. Review of factors that are considered as construction costs and factors that influence construction costs are examined in sections three and four respectively. A framework that will be used in later parts of the research project is presented in section four. Section five focuses on the implications of the ascribed factors on the regional cost differences. The final section contains concluding comments.

2. The Cost – price distinction

Before we embark on examining construction cost constituents and factors that affect them, it is noteworthy to point out that a lot of literature on construction there is an unclear distinction between the words price and cost. The two words became synonymous and a source of confusion in construction contexts such as i.e. cost estimating, pricing, building cost or building price. Unambiguous definition of construction costs not only helps to identify relevant elements of construction costs and who incurred those costs but also facilitates the identification of factors that affect construction costs. For instance, whether the land cost is a part of the construction costs or a separate item is very essential in determining not only who incurred these costs (developer or contractor) but also its influences on the total production costs especially when the contractor also acts as a developer.

Fleming (1965) draws a distinction between building prices and building costs by referring to the building prices as the market price for building work payable by a client and the building costs as the costs incurred by a contractor in carrying out work. Building price reflects variation in profits whilst building cost does not. Another way to describe the relation between the concepts is to say that building costs can be estimated and described in two ways. One is the price charged for the finished building - building price according to Fleming - and the other is the cost of the resources to create it (Ferry et al., 1999) - building cost according to Fleming. The seller's price is a buyer's cost, such that the contractor's price is the client's cost while the subcontractor's price is the contractor's cost.

Duncan (1996) contends that care should be taken to distinguish cost estimating from pricing when a project is performed under a contract. He argues that pricing is the business decision that uses cost estimate as one of many considerations. But when the contractor also acts as a developer, or when a developer sells the finished project to the final user, land prices and other developer's overhead costs are included in the transaction and often are called price rather than cost. Bowen and Edwards (1985) describe a situation where the price and cost differentiation is crucial. They contend that price always reflects some consideration of profits while the term cost does not always do this.

In the empirical part of this research, rental apartment projects are the centre of attention and in these projects developers use independent contractors who charge construction cost plus some profit margin. In such a case construction price is the logical concept to use. The developer's overhead is also not easy to identity, as a number of overheads within an organization have to be divided between projects. Since our intention is to investigate the construction cost increases in the various regions of Sweden where many contractors also act as developers, the use of the words *cost* and *price* will depend upon the market structure and the specific question asked. The next section will start by trying to identify components of the construction cost/price that are charged by the contractor to the developer.

3. Construction costs categories and components

3.1 Cost categories

Having discussed the difference between price and cost in the previous section, further clarification of the word "cost" itself is indeed necessary in order to be able to identify whether a specific cost element is quantity, location, or time dependent. In accounting circles, the word "cost" is seldom used without qualifying adjectives and hence different kinds of cost must be clearly expelled out (Lock, 2003).

There are some costs that are simply recognizable and self-explanatory that relate to a specific item or product such as labour or material costs. Thus, they have been termed as *direct costs*. Other costs that are neither specific nor easily identifiable, i.e. overhead costs are often labelled as *indirect costs*. Carr (1989) define direct cost as the costs that are not counted if the activity has not been performed and indirect costs as the ones that would have occurred even if an activity had not been performed. Materials, labour, and equipment qualify as direct costs because of their physical traceability to the construction activity taken place while project and general overhead, and (perhaps) profits are indirect costs. Indirect costs are also those small costs that would be direct except that assigning them to activities is not economical (Carr,

1989). Ferry et al. (1999) did not consider profit[1] as part of the contractor's costs. They see it as the difference between the builders' cost and the client's price. Akintoye and Skitmore (1991) regard the mark-up as a prior estimate of profitability.

Variable and *fixed* costs are two often-used terms in the construction literature that relate to direct and indirect costs respectively in an unclear way. While the distinction of direct and indirect costs depends much on traceability of specific cost to a particular activity, variable and fixed costs emphasise the rate at which different costs vary when the level of the work activity changes. Costs that remain virtually unchanged and continue to be incurred even though the workload might fluctuate between extreme limits are termed as fixed costs (Lock, 2003). Indirect costs usually represent the largest component of fixed costs. To the contrary, variable costs are typically confined to the direct costs and their rate of incurrence depends on the level of work activity. Stewart (1982) claims that fixed costs are only truly fixed over a given range of output because of the inflation that swells the operating and general overhead costs over time.

More broadly defined and less used construction cost terms are *hard* and *soft* costs. Geltner and Miller (2001) describe the former as direct costs of the physical components of the construction project such as land cost, labour, material and equipment, developer fees, construction management, and overhead costs. The soft costs included cost of design, legal, and financing.

Most of the components of construction costs are integrated in the above cost related sets of terms and some authors have tried to quantify them and put a figure on the different weights of these components in the total construction costs. Labour and materials costs have not only been prominently cited as components in the construction cost structure but they have also been tagged as the largest proportions in the total construction costs. Bertelsen and Nielsen (1997) mention that in Denmark the typical building costs for social housing schemes can be divided as follows; materials 50 percent, labour 30 percent, heavy equipment 5 percent, construction management and supervision absorbs the other 15 percent. The Construction commission (SBI:s Byggkommisionen 2002) reports that construction materials were approximately 40 percent of contractors' costs in multi-family housing projects though this figure could be lower due to discounts on bulk material. Construction materials account for over half of the final cost of housebuilding while the cost of labour account for less than third, and overheads and profit stand for the rest (Stone and Reiners, 1954).

Adams' (1975) study that examines residential construction industry in the early nineteenth century not only supports the importance of labour and material costs in the total construction costs scheme but it also highlights the ambiguity surrounding the inclusion of other elements in the construction costs structure. He mentions that a simple labour-material breakdown in

[1] Mark-up rather than profit is used when site overheads are excluded in the indirect costs (Tah et al, 1994)

1859 of all construction projects surveyed indicated that 56 percent of total costs were attributable to direct, on site, labour costs and 44 percent to materials. Beyond the labour-material structure of the construction costs, Adams (1975) counted overhead and profit in labour costs in the 1959-1962 figures (it is not clear whether he included it in the 1859 figures). However, Xiao and Proverbs (2002) in their comparative analysis of the performance of contractors in three countries used unit price that is composed of labour, materials, plant, overheads and profits as separate percentage components. Adams was surprised to find out that the 1959-1962 cost structures was similar to those of the early century in terms of the total breakdown of costs between labour and materials (52 and 47 percent respectively). His data show that there has been very little basic change in cost structure of residential building over a period of almost two centuries. He concluded that the cost structure of the industry has been stable for on site building over a long period of time.

Labour and materials costs alone would not provide an accurate picture of the movement of total construction costs (Adams, 1975). Wigren (1995) tries to separate construction costs changes into three main components; change *in factor prices, in quality, and in efficiency.* He uses a factor price index that measures price changes of all factors of production i.e. wages, prices of different kinds of building materials, transport costs, interest, value added tax, etc. However, the index was not constructed to measure regional cost changes.

Table 1: *Cost terms and comments*

Pairs of cost terms	**Emphasis is on:**	**Cost Items**
Direct and Indirect costs *Comment:* more comprehensive when other elements such as subcontractor's costs is included	Traceability and the ease of identifying items	Input sources, equipments, overheads and profits
Variable and fixed costs *Comment:* fixed or not fixed is matter of time due to inflation.	How the cost of input changes when the rate of activity changes.	Similar to direct and indirect costs but they are connected to them in unclear way.
Hard and soft costs *Comment:* very broad definition	Phase of the construction process and developer's costs.	Land cost and developers' fee is added as well as legal and administration fees.

As the above table demonstrates, various cost concepts encompass the many items in the construction cost structure. The problem is that some important factors such as subcontractors' costs are left out of the picture while the inclusion of others such as land cost re-introduces the debate of who is incurring what cost. In the next section, we will try to expand the direct and indirect cost elements in a way that would allow us to delineate the cost that is charged to developers by the contractors.

3.2 More detailed divisions into cost components

Many authors have expanded the cost structure beyond labour-material breakdown and have identified construction cost components with respect to which actor incurred the cost and how the costs have been accounted for. They also underline the uneasiness of describing construction cost elements with certainty. Meikle (2001) states that a contractor's construction costs are not generally known and describes them as an aggregate of the costs of materials, labour, and equipment to undertake the work and the contractor's finance, management and various site and office overheads. The contractor then charges these costs plus a margin profit to the developer. When the developer's cost is added then its called the total costs of the production factors (Jagren, 2003). The level of the project costs is dependent on whether the analysis is based on contractor or developer's estimation and the two estimations differ because of the extra costs incurred by the developer such as land cost, finance, etc. Berger (2004) argues that often when we say construction cost we mean total production costs while the term production cost refers to the sum of land cost and construction costs. Construction cost means cost for erecting buildings and construction components but excludes the land cost.

It is also difficult and subjective when one tries to differentiate direct and indirect cost elements from the tender price (Tah et al, 1994) but one can simply define these costs in terms of their tractability to the specific work. Tah et al (1994) note similar components of direct and indirect cost as Carr (1989) but they also include subcontractors' costs as part of the direct cost and allowances for risk as part of the indirect costs. Akintoye (2000) also considers subcontractor costs as a factor of production just like labour, material and equipment. He argues that it is often the case that subcontractors carry out more than 50% of the work of any particular project and hence the main contractors include subcontractors' prices in their estimation.

When the developer and the contractor are part of the same organization there is no overt price determination for the project (Hillebrandt, 2000) hence cost and price separation becomes hard since the required level of profits and various overheads are not easily determined. Indeed, this has been one of the sources of confusion in the distinction of the two words – cost and price - as we have discussed earlier. The profit of the contractor is counted at the developer's level for a vertically integrated firm. If the developer and the contractor were separate, then the contractor's direct and indirect cost plus his profit would be the cost charged by the contractor to the developer. Subsequently, the developer's cost plus the profit that the developer seeks will equal the price charged to the final owner if the final product is sold to a new owner. In the residential rental market the developer and owner are, however, often same entity.

The following figure depicts the cost and/or price structure of a building project when the developer and the contractor are the same.

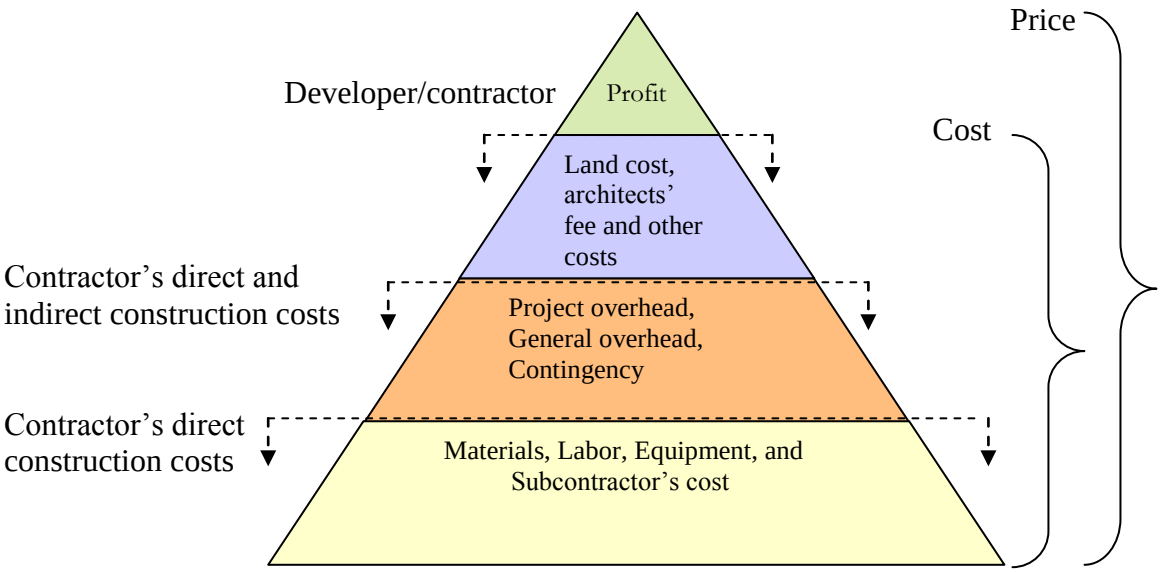


Figure 1: *Price/Cost structure of a generic building project*

This categorization of the final total construction costs is not much different from the total construction cost that is typically measured in the following two ways: The Input approach where the costs of all the components required to build a dwelling are summed up to give the total cost or the output models that are based around the final prices/costs of dwellings produced by construction companies (DTZ Research, 2004). The main difference between the input approach and the above pyramid of cost structure is that the input model, and similarly the input price index do not take into consideration the productivity and profit margins of the contractor.

Fleming (1966) asserts that one way to ascertain the constituents of price is through labour and materials cost indices that may or may not incorporate some allowance for changes in productivity, overheads, and profits. Interestingly, in relation to the discussion about costs and prices, Fleming emphasises that failure to allow for changes in profits means that the index will be insensitive to changes in market conditions and will be a measure of costs rather than prices.

Table 2: *A short Summary of the construction cost component*

Author	Components	Comments
Adams, R. (1965)	Labour and material as well as overhead and profits.	Includes profits and overhead cost in the labour cost
Carr (1989)	Direct costs: labour, material, and equipment. Indirect costs; project overhead, general overhead, and profit	Did not include subcontractor's costs in the direct/indirect costs of the contractor. Considers project overhead as indirect costs.
Tah et al (1994) and Akintoye (2000)	Similar as Carr (1989) plus subcontractor's costs and risk allowance as indirect cost component.	Define mark-up as indirect costs without site overhead.
Jagren (2003)	Material, labour, equipment, transportation utility, electrical power, and overhead costs.	Emphasize the difference between total production costs and construction costs.

Cost components that are identified by the above listed authors are not necessarily an exhaustive cost structure. However, it is evident that the constituents of construction cost have changed over time; from Adams' simple labour-material break down to Jagrens' multi-itemized components. The significance of the inclusion of the different cost elements in the cost structure pertains to the scope of our analysis which is identifying factors that could be associated with cost increase differences among the regions. The direct and indirect costs components stated by Tah et al (1994) and Akintoye (2000) seems to be suitable in our analysis since it is neither too broad to include elements that have some trivial regional cost differences, such as electrical power, nor too concise to limit labour-material cost structure. Most of the major components i.e. labour, materials, subcontractor's costs, overheads, and profits can be found in their cost structure.

4. Factors influencing construction costs: A framework

Factors that could influence or determine the magnitude of construction costs are numerous. Chan and Park (2005) state that cost is affected by a large numbers of factors because of the fact that construction is a multidisciplinary industry and its work involve many parties such as the owner and various professionals, contractors and suppliers. Thus, a project cost not only

depends on a single factor but a cluster of variables that are related to the characteristics of the project and to the construction team as well as the market conditions.

Generally, construction cost increases for the developer can arise in two situations (Donner, 2000). The first is when unexpected events or actions occur that forces costs to increase for the project as a whole and where the risk is already allocated in advance. Ferry et al. (1999) describes this form of risk allocation as contingencies and it is an amount the contractor is instructed to add to his tender as a cushion to absorb unforeseen extras. Though an adequate amount of risk allowance is estimated to be around 5% of the above-the-line cost for projects that does not entail excessive degree of risk (Lock, 2003). Performance on previous projects and the level of market competition dictate how much allowance to allocate for covering unforeseen conditions. This situation is often caused by factors that are beyond contractors or developers' control such as inflation. The second situation comes up when an unexpected event occurs but where the risk allocation is not specified in advance and the extra costs will depend on the bargaining power and anticipation of other party's behaviour.

4.1 Cost overruns and cost escalations

One may need to take up the question of whether a cost increase during a project can be categorized as cost overrun or a cost escalation. Basically, a distinction between the two terms is crucial in order to understand whether the cost increase experienced by a specific project is attributable to cost overruns that are particular to that project or that it could be characterized as cost escalation, which is a situation when costs change over time for similar projects in a region.

Cost escalation and cost overruns are often used interchangeably in the construction literature and pose some difficultness if one needs to know precisely the cause and the factors that are escalated. On one hand, cost escalation is usually attributed many factors pertaining to both the original cost estimate (Stewart, 1982) and to unforeseen overruns during construction, which indicates that cost overrun is one of the factors that are behind construction costs escalations. On the other hand, cost overruns among other factors are often caused by the escalation of the unit price of resources such as labour and materials.

Cost overrun, when the final cost of the project exceeds the original estimates (Avots, 1983), can be considered as an idiosyncratic or a unique cost increase. It is difficult to take a broad view of its occurrences in any specific city or region because of the uniqueness of the project in terms of architecture, geological, client quality requirements, and the efficiency of the actors in the building process, etc. Contractor-specific factors such as type of contract and context of contract contribute the magnitude of contractor's cost overburden when a cost overrun occurs (Akinci and Fischer, 1998). Some of the most referred anomalies in the construction costs are delay of project start or delay of completion that cause unexpected cost

increase, quality deficiency that could trigger disputes and repair costs, and cost increases due to factor prices or an unforeseen situation that could introduce extra costs. Koushki et al (2005) identified several factors that cause delays and cost increases in the construction of private residential projects in Kuwait. Changed orders, financial constraints and owner's lack of experience in construction were the main causes of time-delays while contractor-related problems, material-related problems and financial constraints were the main causes of cost-overruns.

A cost escalation is defined "as the increase in any element of project costs when the cost of that element is compared between two different periods" (Lock, 2003). Davey (2000) and Stewart (1982) present factors that could be attributed to cost escalation though they are difficult to be categorized as cost overruns or cost escalation. Davey (2000) states that cost escalation causes fall into five categories:

1. Changes to requirements often initiated by the costumer
2. Technology costs arising from eagerness to use latest technology,
3. Changing quotations
4. Impact of risk by adding allowances to prevent excessive costs and expected outcomes
5. Organizational stability as a result of project team or work breakdown.

The last three factors could be the result of changing market conditions where unit prices are rising; uncertain outcomes that increase the amount or risk allowance added to the estimated cost; and that mergers or takeovers between struggling and flourishing firms took place.

Meanwhile, Stewart (1982) attributes cost escalations to several factors that are either not controllable or that to a varying degree are manageable. They include the accuracy of original cost estimate, degree of government regulation and control, construction completion delays, number of design changes, and labour related matters such as their availability, skills, and increases in fringe benefits. He claims that generally cost escalation above the inflation rate is a combination of underestimating the amount of work that *would* be needed to undertake the project and overrunning the amount of work that it *should* have taken to do the job. Notice that the factors that Stewart mentions cover both cost overruns and cost escalations according to the definition above.

4.2 A Framework of influencing factors

Most of the significant factors affecting project costs are qualitative such as client priority on construction time, contractor's planning capability, procurement methods and market conditions including the level of construction activity (Elhag et al, 2005). Technological and project design, contractor's expertise and management ability, and the client's desired level of construction sophistication play an important role in determining the cost of the project. Gyourko and Saiz (2006) in their investigation on construction costs and the supply of

housing mention some potential factors that can explain differences in construction costs across U.S. housing markets. The extent of unionization within the construction sector, local wages, topography of the area, and local regulatory environment cause higher costs according to their study.

Construction cost increases seem to materialize after the commencement of the construction but the problem is deep-rooted during contract estimation and tendering stage. Wallström (1985) claims that according to Sjögren (1980), ninety-five percent of the final cost of the construction is fixed before even the construction phase started. Akinci and Fischer (1998) separate factors affecting cost estimates of project from those affecting final cost projects. Factors that affect cost estimates are estimator-specific factors, and design and project specific factors (vagueness in scope, design complexity, and project size). Factors that affect the total cost incurred at the end of project and that increase the gap between the actual cost and the estimated cost of a project are also gathered into two major groups: *Construction specific factors as well as economic* and *political environment-specific factors*. The former includes unknown geological conditions, weather conditions, and client- and subcontractor generated risk factors. Contractor-specific factors affect the allocation of risk between the owner and the contractor and specifically contract clauses may result in ambiguity and disputes that could decrease the cost effectiveness in a project (Akinci and Fischer, 1998).

Similarly, Akintoye (2000) presents twenty-four variables that affect the project cost estimation and he grouped them in seven areas. Some of them may also have an impact on the final construction costs. The seven factors are *Project complexity, technological requirements, project information, project team requirement, contract requirement, project duration, and market requirement.* Shash and Abdul-Hadi (1992) also presented thirty-seven factors affecting contractor's mark-up decision in Saudi Arabia. They found that the size of a project was the most heavily contemplated factor among these factors when contractors are deciding the mark-up for a project.

Other factors that have been mentioned as affecting the price of the project during construction are the quality and the constructability of the design, managements techniques employed by the contractor, location of the project, and macroeconomic conditions (Williams, 2003). Iyer and Jha (2005) in their analysis of factors affecting cost performance of Indian construction projects state that conflict among project participants, presence of poor project specific attributes, hostile socio economic relations and climatic conditions, aggressive competition at tender stage, and short bid preparation time adversely affect construction costs. They indicated that coordination among project participants was the most significant of all factors having maximum positive influence on cost performance.

In a follow-up study, Shash and Abdul-Hadi (1993) discussed how pre-qualification requirements might give contractors valuable information in evaluating the level of

competitiveness. They assert that if pre-qualification requirements limit the contractors who can bid for the project to certain class or grade, contractors may have the ability to reasonably estimate the number of bidders and their identity, which in turn can affect the level of their bids. Mochtar and Arditi (2001) state that this type of mark up decision assessment, that includes learning about competitors' identity and how many of them there are, may help the bidder to determine the severity of the competition and accordingly in setting the optimum mark-up that maximizes expected profit and the chance of winning the project. How the client designs the bid process may therefore be one factor that affects the price/cost.

In order to carefully analyze these numerous and non-easily quantifiable factors influencing construction costs, four groups of factors were formed based on the extent to which factors could be influenced by the construction actors especially contractors and clients (see Table 3).

Table 3: *four groups of factors influencing construction costs*

	Factors influencing construction costs: Examples
1. Project-specific factors	- Project size - Project complexity - Quality
2. Client and contractor-related factors	- Contractor type * - Client type ** - Procurement method - Contractor-client relationship
3. Competition and Market conditions	- Level of competition - Level of construction activity
4. Macroeconomic and political factors	- Inflation and interest rate - General labour market rules and other government regulations

* Large, medium or small
** For example public or private

By aggregating many factors influencing construction costs into four groupings, one can determine which type of factor or layer to focus on. In the next step a detailed analysis of a specific interesting area could be made. This more structured approach will later be used in the analysis of construction cost escalation disparities among the regions.

The *project-specific* layer contains factors that are considered to be related to a particular project such as the size, the complexity and the required quality of the project. Here, client quality requirements and project characteristics are in the hands of the clients and they are

often subjected to pre-requisites that contractors must comply with. Furthermore, the size and complexity of the project affect the organizational structure of the contractor and the project work breakdown unit costs as well as duration of the project (Akintoye, 2000). Size of the contract is clearly a major determinant of the number of firms who can undertake the work (Hillebrandt, 2000). A large project requires more of all inputs than a small project and only some of the total contractors in the country have the capital, management, and other scarce inputs to carry out such a project. Besides, there is evidence that for main contractors labour expenditure required per unit of work decreases when the size of the contract increases (Stone and Reiner, 1985). According to the same source, the size of the contract does not appear to have any marked effect on the labour expenditure of subcontractors.

The size of the contract also affects the overhead percentage that contractors charge the developer. Contractors adjust the general or company overhead base to the nature of the contract, the size and complexity of the project, the contractor's need for work, and contractor's experience with the client or the number of contractors competing to win the project (Assaf et al, 2001). The adjustment may take the form of penetration strategy where contractor lowers the profit margin in order to outbid other competitors that are entrenched in the specific market (Mochtar and Arditi, 2001). Project-specific factors may favour certain contractors who have the capability to undertake the tendered project and thus limit the competition (this issue will be discussed later in other parts of the research).

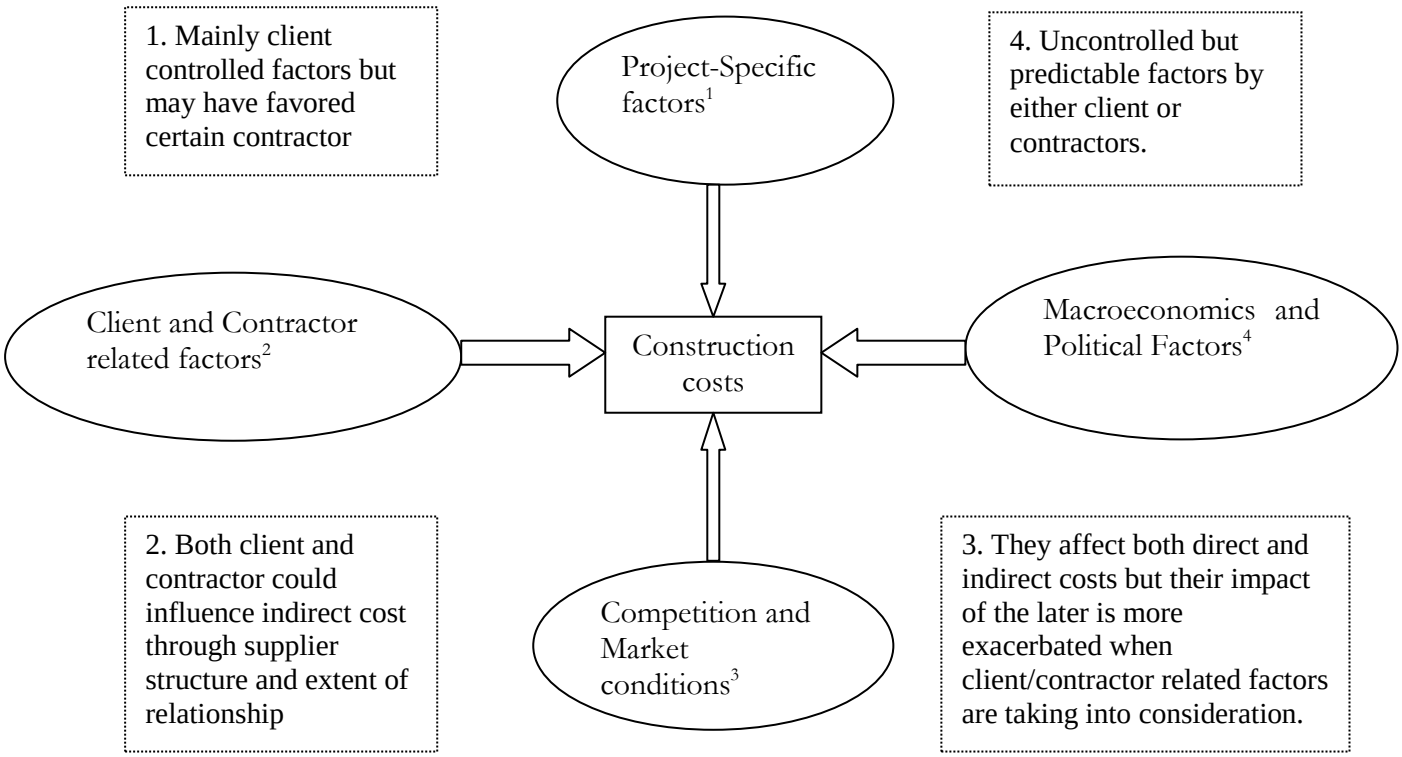
Factors in the *client and contractor related factors* layer are of a qualitative nature with the exception of the contractor type. Large contractors can maintain sizeable manpower and machinery and obtain discounted construction materials. Stone and Reiners (1954) draw a connection between contract size and the size of contractors. They state that only the largest firm normally undertakes the largest contracts, while both small and large firms undertake the small contracts. When a contractor believes that it possess a competitive advantage over the other bidders in terms of delivering the owner's most important requirements, the company tends to practice what Mochtar and Arditi (2001) termed as "skimming" where the bid offer is relatively higher than the figure a market normally would allow.

Risk allowances and mark-ups charged by contractors may depend on whether the client is a private or a public entity. Hendrickson and Au (2003) claim that contractors may tend to submit high bids for public projects in order to compensate for the bureaucratic and restrictive contract terms. Different procurement methods intend to fulfil different objectives; cost level certainty, completion time, quality work, etc. Municipal companies are subject to competition regulations and other constrains that favour certain contract form and procurements methods i.e. all-in-one or general contract and fix price. Contractor-client relationship, for example whether there exist long-run relationships or partnering relations between the parties can be important for what happens in changing economic conditions.

The competition and market condition layer comprises factors that are difficult to control by the contractor and client but that can have a huge impact on contractor's costs and mark-ups. An unstable construction market would make it difficult for contractors to decide on the optimal level of overhead costs that enables contractors to win and efficiently administer projects. Similarly, the intensity of competition that contractors confront affects their bidding strategies. More competition encourages many contractors to tender any contract and also makes it difficult for contractors to develop a clear and decisive strategy (Drew et al., 2001). This especially concerns the mark-up level that would allow a contractor to win the tender at a profit margin that is in line with the strategic position of the firm in that market (Akintoye, 2000).

Macroeconomic and political factors such as inflation and interest rate fluctuations as well as labour laws, general labour conflict and building regulations can impose heavy costs and delays in a building project. Direct costs are affected by the unit price increases while the influence of these factors on indirect costs often is through overhead costs. Generally, overhead costs are calculated as a percentage of direct costs and thus are affected directly by the inflation of unit prices of labour, materials, etc. in addition to other cost increases caused by government regulations. Labour strikes often cause delays that not only result in loss of productivity but also could induce quality deficiencies stemming from hasty job completion of the contractor or subcontractor that could result into repair cost, and disputes. Below is a summary of the four layers showing the influencing factors and their impact on direct and indirect costs.

Figure 2: Layers of determining factors and comments



5. Regional construction costs disparities and possible sources

5.1 Literature review

After we have been able to identify relevant construction cost constituent and factors that affect them, the next step is to discuss possible explanations for cost increases in general and especially for the differences in cost increases between regions. The causes of cost escalation are many and complex, ranging from labour and material inflation to demand and market conditions not to mention government actions and other major events (Capano and Karshenas, 2003). Thus, the regional cost escalation differences could be explained by the inflationary occurrences, as well as escalations associated with, among other things, hot construction market activity, limited competition, and increased quality.

Escalations, which mainly include the increase in the amount of resources in actual or estimated, direct costs of labour and material (Stewart, 1982), are usually treated with provisions and some form of compensation that considers price level changes over time. Labour cost is one of the most contentious factors among all the factors that affect construction costs and the debate evolves around the role of labour changes, their level of skill and productivity, unionized or non-unionized, and labour and employment laws. Vermande and Mulligan (1999) argue that buildings are produced and consumed locally, and that the proportion of input products i.e. labour costs and the costs of raw materials (around 60% of the output) are only to a small degree involved in external trade. Meikle (2001) makes same argument that the construction price differences that existed in UK regions were attributed partially to the local resource costs (labour and material) and partially to differences in demand. Gibb (1999) states that in the labour market, craftsmen and labour-only subcontractors tend to operate within the limited geographic market areas, with only site management being more likely to work across regions. He concludes that labour and management issues that arise from specific building techniques are not relevant as a source of regional differentiation and that the same is true for many human relation issues that also are country wide (taxation, employment law, etc.).

In Sweden, a recent survey conducted by Bodsten (2006) indicates that the majority of the contractors and developers that were interviewed believe that labour wage differences (5-15 percent) exist among the regions in Sweden. The responses regarding the construction material prices were mixed but the majority of the developers believe that there is less than five percent regional price differences as compared to a majority of the contractors who believe that there is more than fifteen percent difference. Factors such as inflation and interest rate have huge impact on construction costs, especially the unit prices of all inputs, but their effects is national and are not confounded in a specific region.

Two other factors that often are mentioned in the construction costs debate are the quality of the buildings and labour productivity. Meikle (2001) asserts that neither qualitative nor productivity improvements contribute significantly to the long-term differences in price trends. Other authors consider quality changes as a major contributor to construction costs increase. Higher standard and improved quality of housing could be the cause of the higher construction cost in recent years in Sweden (Lind, 2003) though the construction cost of specific housing standard increased dramatically during the same period in some regions probably because of demand factors. Barlow and King (1992) also state that quality changes probably account for two-thirds of the cost increase in apartment construction in the early eighties. However, they also claim that a general rise in construction costs in metropolitan regions in late eighties was largely a result of overheating in the commercial sector. Gibb quotes from Ball (1996) that there is quite strong evidence that industrial and commercial building crowds out house building by competing away building inputs in the expanding regions.

An important factor that Bodsten (2006) speculates about is that vertically integrated contractors have some control on input materials such as concrete, asphalt, and gravel that could be used as price mechanism against small contractors when the latter wins the tender. This control method can be seen as a result of backward vertical integration where the firms that owns the input resources or have some sort of agreement with the suppliers of these inputs that compel suppliers to exclude selling the inputs to competitors or sell with higher prices which would make it unfeasible for competitors to use it. As the level of vertical integration, and the access to external or foreign suppliers can differ between regions, this can also affect regional construction cost. We will return to this issue later.

5.2 Data for analysing regional differences in cost increases

Projects differ in terms of location, size, complexity, and ownership. These unique characteristics coupled with local economic conditions and the levels of construction activities have bearing on construction costs. The actors in the building projects have diverse objectives i.e. contractors tend to maximise profits while the developers strive to minimise costs with time and quality constraints. These divergent goals and the immobility of buildings as well as the local market conditions and contractor/client type could definitely determine how the initial costs get estimated as well as the final level of construction costs. Contractors and clients have different latitude influencing these four groups of factors mentioned above.

Project-specific factors are dictated by project location differences and client requirements. These factors are mostly known before the tender is finalized and they are subjected to pre-requisite and thorough cost estimation process. In Sweden, municipal housing companies dominate the rental market in most cities and the project design and estimations are carried out by outside professionals. There could be a time lag between when documents are prepared

and when the final contactor is chosen. However, there is no evidence that different regions practice different estimation methods that could cause cost escalation of input sources such as labour and materials. With regard to quality and complexity of projects, Bodsten (2006) notes that the contractors and the developers interviewed do not believe that quality and construction techniques were important factors explaining construction cost differences among the Swedish regions.

Project-specific factors have more influence on direct cost than client-contractor related factors, which have bigger impact on indirect costs. It is reasonable to assume that the issues related to the direct costs are mainly dealt with locally. Import of materials and labour mobility may resolve shortages of resources. Thus, the indirect cost analysis will be addressed when client-contractor related factors are discussed.

Factors such as inflation and labour strikes that are included in the macroeconomic and political layer could affect unit prices of labour and material. There are few or no available input sources data in Sweden at the regional level except salary tabulations (see table 4).

Table 4: *Changes of labour earnings in both incentive and time wageworkers of several cities 1997-2004.*

	Earnings	**Incentive wage**	**Time wage**
Stockholm	25,9%	18,5%	22,1%
Malmö	13,2%	18,8%	13,8%
Göteborg	27,2%	23,6%	25,3%
Örebro	22,4%	19,0%	18,9%
Jönköping	26,2%	23,0%	22,4%
Linköping	39,4%	24,0%	27,4%
Umeå	21,8%	20,5%	19,2%

Source: Svenska Byggnadsarbetarförbundet

The table shows that there are no systematic differences of the labour salaries between Stockholm and four of the cities (Örebro, Jönköping, Linköping and Umeå) that will be part of the empirical study. The above table is used to indicate the relative lack of systematic differences in the labour salaries. However, the reliability and usefulness of the numbers on the table can also be questioned since salaries of plumbers and electricians are not included in the table, and because union or non-union classifications were not considered. The factor price index compiled by the Swedish Statistics Bureau (SCB) does not decompose cost components by regional level and also does not include profits and productivity measures which make it difficult, if not impossible, to undertake a meaningful comparison of unit price changes.

5.3 Focus in the empirical research

Three of the four factors among the client-contractor related factors described above apparently could be found in each region. Contractor and client type as well as procurement method do not differ greatly between metropolitan and small regions. The four large Swedish contractors operate in most of the regions and their clients on the residential projects are municipal companies that usually procure these projects with fixed price contracts. The common contract method is also either general or all-in-one contract form (see paper 3 for some recent trends).

Client-contractor relationship is the only factor in this layer that presumably influences construction costs through indirect cost components where a long run and strong past relationship between the parties could reduce transaction costs and the incentive to price according to current demand.

Client-contractor related factors are very susceptible to the level of competition and the intensity of construction activity. The level of competition and construction activity influences the cost of inputs and could also have an enormous impact on indirect costs. Competition level is a function of the number of contractors in the market as well as the size of the firms operating in that region. As we have mentioned earlier, a few large firms dominate Swedish housebuilding market and most of them are active as developers and contractors. A region with low competition and high demand of contractors' services may encourage opportunistic behaviour that could increase construction cost. The opposite situation of high competition and low demand could bolster clients' negotiation position to solicit lower construction costs. One of the hypotheses that this research is investigated is that a region with high concentration of vertically integrated firms would have higher construction costs and the empirical part of the research will try to test it by soliciting developers' views on this proposition.

Incongruence of objectives of the contractor and client as well as local market conditions and contractor/client related factors might determine how the initial costs get estimated and the level of final construction costs. The type and structure of client and contractor concurrently with the intensity of construction activities in various regions could influence the kind of relationship between the contracting parties and could result in a change in transaction costs. In order to procure specified project with clients' cost and quality desires and at the same time providing contractors with a reasonable profit margin, market and non-market contracting become the two possible strategies to rely upon.

The first strategy is when the parties in the building process hinge on market contracting in which arm's length contracts with the provision of every predictable outcome are practised. With human bounded rationality and complexity of building projects, unforeseen events and

variations are inevitable to encounter. This leads to confrontation and adversarial relationship that ultimately introduce higher construction and transaction costs as a result of repair cost due to any mis-specified or deficient quality, and monitoring cost in order to ensure that what is promised is delivered, as well as cost of litigations.

The second strategy is that of when construction parties transact with a non-market contracting strategy where trust and past working relationships as well as long-run relationships are the established rules of contracting. Contractors expect that clients will treat them fairly and not only provide satisfactory profits but will consider or even secure them prospect workload in exchange of lower or unreasonable non-escalating construction costs. Thus, a thorough investigation of the strength of the relationship between actors in the building process and the nature of supplier structure could provide an explanation of construction costs disparities observed among the regions.

The empirical part of this research will focus on how long-run relationship between contractors and developers (clients) in the presence of lower competition and higher construction activity could influence the construction costs. In other words, can the type of relationship between the parties explain at least part of the observed regional construction cost disparities?

Furthermore, it will be examined whether vertically integrated contractors can be another part of the explanation of the cost escalation differences among the regions. Respondents' perception of whether the vertically integrated contractors tender higher price is sought after. That could help us to conjecture the form of relationship and the direction of correlation among vertical integration, construction cost levels, and local externalities such as the level of competition and construction activity

6. Conclusions

This paper was intended to lay the foundation for an analysis of construction cost differences among the regions by synthesizing various cost concepts and shedding light on some of the confusions inherited from ambiguous cost related terminology. The harmonization of these concepts and cost categories as well as the clarification of important terms can be seen as step forward contribution that will smooth the progress of identifying the factors affecting the construction costs that could ultimately explain the cost escalation differences among the Swedish regions. A direct and indirect cost structure seems to include most of the cost components incurred by the various actors in the construction process and indeed enhances the distinction between cost and price in relation to supplier structure. The two words have similar meanings when a contractor also acts as a developer since various overheads and

profits then are inseparable from the cost structure. When they are separate entities, contractors price that includes construction costs plus his profit becomes the developer's costs.

Factors that affect construction cost levels were grouped into four layers

1. Project-specific factors
2. Client-contractor related factors
3. Competition and market conditions
4. Macroeconomic and political factors

The first is Project-specific factors such as size, quality, and complexity of the project that can be unique for the particular project and are dictated by the individual client requirements. The second is client-contractor related factors that could influence indirect costs through supplier structure and extent of relationship. This layer comprises qualitative factors such are contractor and client type, procurement methods, and the client-contractor relationship. The third layer is competition and market conditions that mainly affect construction costs through the factors in the second layer. The final layer contains macroeconomic and political factors that are often uncontrollable but predictable occurrences and are not confined to specific projects in any region.

In the following empirical research the focus in on regional differences in changes in production costs. Factors in layer four could then be disregarded. As the comparison will focus on rather similar rental housing there is also reason to believe that factors in layer one are of small importance. Factors in layer two and three will then remain as the most interesting areas. It has been argued that these layers can be related in the sense the structure of the contractor-client relationship have an impact on how the level of activity on the market will affect costs. The motive for focusing on regional differences in the supply structure is of course also that this is an area that has so far not been analyzed in the Swedish research about differences in cost levels and in cost changes over time.

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Paper 2

Long run relationships, Vertical Integration, and International competition:

Can they contribute to explaining regional construction cost differences?[♣]

Author: Abukar Warsame

Abstract

The existence of opportunistic behavior by contractors or sub-contractors in the bidding process encouraged by the governance structure of construction companies as well as the kind of relationship that exist between contractors and clients is thought to have some bearing on the rising construction cost observed in some regions of Sweden. Three hypotheses were formulated concerning the impact that long run relationship between contractors and developers, vertically integrated firms, and the increase of international competition could have on the construction cost increase. The hypotheses were tested by collecting data from a number of projects from six cities in different regions. The semi-structured survey produced inconclusive results. Long run and collaborative relationship was prevalent in small region though respondents in this region did not see a strong connection between construction costs increase levels and the kind of observed relationship. In the Stockholm region short-term relationships were mostly prevalent. Vertical integration and foreign competition impacts on construction costs were not significant in either region.

Keywords: Construction costs, vertical integration, long run relationship, competition

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1. Introduction

Swedish housing construction costs have risen more than the rate of inflation during the last decade. The effect of the construction costs escalation was not evenly felt in all regions and there was also an imbalance of housing stocks in various regions (Atterhög and Lind, 2004). Some regions of the country i.e. metropolitan regions (Stockholm, Gothenburg, and Malmo) experienced soaring construction costs whilst smaller regions had lower construction cost increases (Lind, 2003). The supply of new residential apartments stagnated at the same time as the constructions costs were high, particularly in the metropolitan regions where housing demand was stronger.

There is a large volume of literature dealing with the problems of the high construction cost but only few studies tackle this issue within the context of changing economic conditions and governance structure of construction firms. In order to unearth the roots of construction cost escalating disparities between large and small regions, one can focus solely on the components of construction costs – direct and indirect costs - and anticipate that unit price (labour, materials, and equipments) and overhead costs differences that exist between the regions will explain the observed divergences. The unit price variations between the large and small regions can persist as long as trading of the materials and labour movement are uneconomical. In the absence of any institutional restrictions such as labour regulations and tariffs, construction workers and materials will be constantly and freely transferred from low to higher economic rent places of these resources. Inflation is one general factor that influences the unit prices of construction input resources and only a national measurement of inflation occurrence exist in Sweden but not regional. Thus, a systematic comparative study of regional construction unit prices may be difficult if not impossible.

Another alternative is to examine other factors such as supplier structure and client-contractor relationship as well as competition and expect that some overhead and transaction costs associated with them would explain the differences of cost escalation between the regions. The organization structure of the construction industry as well as competition and level of construction activities encourage opportunistic behavior and market driven attitudes that are detrimental to the development of long-run relationships between the parties and consequently increases construction costs due to the excessive transaction costs.

Many authors agree about the need for new working philosophies and techniques such as those already adopted and refined in other industries. Exploitation of different economic theories coupled with greater understanding of the social behavior has introduced many concepts such as partnering, strategic alliance, relationship marketing, lean production, joint ventures, and globalization of the industry (Latham, 1994; Bresnen and Marshall, 2000). The center of these new ideas is to improve and nurture the relationship between actors in the industry by reducing conflicts, enhancing the quality of the product or service, and ultimately reducing the cost. London and Kenley (2001) stress that improved relationship and integration of key stakeholders are critical to deal with what is perceived as industry's underperformance,

inefficient, fragmented, and wasteful. These two key concepts - relationship and integration – will be the base of our analysis of factors causing regional construction cost escalation disparities.

Against this backdrop, three hypotheses about the implications of supplier structure, the degree of working relationship between contracting parties, and the level of foreign competition on construction costs were put forward.

- *Hypothesis 1*: A long run relationship between contractor and client tends to a lower cost increase during the boom.

- *Hypothesis 2*: If the contractor on the rental housing market is also active as developer on the same market, the construction costs tend to be higher.

- *Hypothesis 3*: If it is easier for foreign suppliers to enter the market, then cost increase will be lower

The aims of this paper are twofold. First, it is intended to ascertain factors that developers perceive to be crucial to the construction cost increases. Second, it tries to evaluate respondent views on factors influencing construction costs based on these hypotheses; long run relationship (henceforth LRR), vertical integration and foreign competition by testing their statistical validity.

The rest of the paper is organized as the following: Section two covers literature review and some brief discussion of the research issues. Methodology and project descriptions are described in section three. Section four contains the presentation and analysis of results of the questionnaire. What the respondents perceive as the causes of construction costs disparities among the regions, especially the responses related to long run relationship between client and contractor, vertical integration, and foreign competitions are treated in this section. Other important factors that were raised in the survey and the summary can be found respectively in the last two sections of this paper.

2. Background: Theory and literature review

2.1 Long Run Relationship

The cyclicality of the construction industry, especially the house building sector plays a big role in determining the longevity of the relationship that exist between contractors and clients, or between contractors and their sub-contractors. A sector study carried out by the NIB Capital Bank (2002) exemplifies how small and medium sized construction companies might

suffer most from the cyclicality and how long-term relationship might provide a solution to fluctuations in demand.

One can argue that relationship and integration are two opposite strategies not complementary ones, if we assume that London and Kenley (2001) imply physical integration of key stakeholders not integration in the sense of cooperation. First, the need for long-term relationship diminishes if the actors in the construction process are integrated and have unified management. Second, in the absence of integrated actors, long or short-term relationship becomes the alternative strategy to successfully undertake building projects because of the nature of the construction industry that is characterized to be a project-based activity where the relationship lasts during the undertaken project. In other words, project collaborating dominated the working relationship between the parties rather than strategic collaborating that could have lasted longer. Thus, the direct or indirect benefits experienced by the players in the industry cannot be long lasting due to the nature of construction industry and varying economic conditions.

A feature of the construction industry that brings to the fore the concept of relationship is the extensive use of subcontracting. Eccles (1981) states two prominent characteristics of the construction industry that resonate the relationship prevalence between construction actors; the organization of the production work force into a variety of trades and the practice of subcontracting parts of the project to other contractors and subcontractors. Subcontracting can develop a set of stable relationships between the general contractor and special trade subcontractors, called a quasi-firm that is in some way intermediate to market and hierarchy (Costantino et al., 2001). Good past relationship with a contractor was among other factors found to have the greatest effect on lowering of the subcontractor's bid to general contractors (Uher and Runeson, 1985). On a project basis this relationship takes the form of classical contracting, but as parties cooperate over the years the same relationship takes the form of relational contracting.

The first hypothesis being investigated focuses on the idea that when the parties are interested in keeping a long-run relationship they will not use the short-run opportunities to increase/decrease the price when the business cycle changes.

2.2 Vertical integration

There is a large amount of literature and research about vertical integration and its application in different industries such as Cable Television industry (Chipty, 2001), Gas supply(Gilbert and Hastings, 2001; Hastings, 2004), Pulp and Paper industry (Ohanian, 1994). Some of the theories developed from these literature i.e. Market Foreclosure, Double Marginalization, and Raising rival's cost are among others applicable to the construction industry especially the developer/contractor type of organization pattern that is common in Sweden and elsewhere. Traditional approaches to vertical integration have tended to focus on vertical integration as a response to preexisting market power problems or as a strategic move to create or enhance

market power in upstream or downstream markets (Joskow, 2003). Most of the studies of vertical integration were modeled under the typical upstream- downstream relationship or structure necessitated by the cost of intermediate goods needed to produce a final products. However, that is not always the case in the construction industry because it has some particular characteristics, which make it substantially different from other industries, specially manufacturing. The main distinctive feature of construction is the nature of the final product, characterized by its uniqueness, immobility, and variety (Gonzalez-Diaz et al., 2001).

In spite of limited theoretical support of vertical integration and its applicability on construction firms, it could be speculated that the structure of residential construction firms influence the construction costs. These firms are often vertically integrated in the sense that they act both as contractors and as developers on their own in the same market. The basis for this speculation is that many construction projects are so big that only a few large firms can undertake them - firms that usually are vertically integrated in the sense described above. Swedish vertically integrated firms, which have strong financial capability to undertake numerous large developments (Swedish Industry, 2004), may tender a higher price for a new rental or condominium projects. On one hand, winning that contract safeguards the prices of other similar properties owned by the integrated firm. On the other hand, not winning the tendered contract will not exempt them developing rental units or condominiums of their own and still be competitive in the market. They can then divert those resources e.g. machinery and equipment to other projects undertaken by the firm without incurring too much loss of productivity. Their strong financial position also allows them to survive even if they lose a few customers by raising opportunistically the construction costs. The second hypothesis for this paper is based on the idea that this type of vertical integration might have gone further in larger regions and that this contributes to the cost increases there.

2.3 International competition

The presence of foreign contractors and subcontractors may not only increase the competition and lessen the dependency of fewer actors in the deliverance of building projects but it also enhances the availability of construction workers as well as cost-efficient construction materials. According to Bergström (2001), the cost of construction materials, which constitute approximately one-third of total construction costs have shown price increases over and above other industrial products, with price rises even during periods of low demand. One of the reasons is that construction trade is concentrated to a small number of large companies i.e. one company accounts for more than 50% of total sales of cement, reinforcement steel, and plasterboard. Srejber (2001), in her speech, echoes the concerns of low competition in the construction material sector. She claims that the sector is characterized by a high company concentration with considerable entry barriers and weak import competition. Swedish Competition Authority report (2003) also states that the share of construction material imports remains low while concentration in this sector is high. The report stresses the need for closer examination in the price and cost differences of construction materials that exist between Sweden and EU. It concludes that the competitive pressure that a higher level of imports

would engender is being checked by special national rules and the voluntary type approval of construction products.

The benefits of foreign supplier competition can be found in many studies. Xiao and Proverbs (2002) note that the presence of many prominent foreign contractors such as Skanska (Sweden), AMEC (UK) and many others in the US domestic construction is one of the reasons that USA experienced the lowest construction cost compared to UK and Japan. They contend that increased competition drives down the construction cost. The effects of foreign suppliers and contractors are multidimensional. Lind (2003) accentuates four ways that foreign competition (globalization) could affect the housing construction are.

- Increases the supply of construction material or ready-in-use components.
- Enables foreign contractors to expand their activity to other countries
- Allows foreign developers to come in to the market
- Enables construction workers to come in to the market

Porter (1980) proposes a five-force model - entry, threat of substitution, bargaining power of buyers, bargaining power of suppliers, and rivalry among current competitors - that are the base for any industry's competitiveness and its profitability. In the Swedish housing sector, it is has been noted that competition between the firms is very low and no threat of new entrants or foreign suppliers is noticed. Thus foreign competition could at least bring more firms, labor, materials etc, and change that trend by re-shaping some of these forces and ultimately reducing the construction costs.

The third hypothesis presented above starts from the beliefs that there might be regional differences in how easy it is for foreign firms to enter the market and that this can be one determinant of regional differences in cost increases.

3. Methodology and project descriptions

Vermande and Van Mulligen (1999) describe three approaches for comparing costs of building of a hypothetical international project and they are: Standardized identical buildings, Standard building with local modifications and, functionally similar building. The first two approaches seem to be theoretically possible but practically difficult to carry out due to the differences that exist in architecture, standards, availability of projects, etc. The third approach of typical, functionally similar buildings is suitable in our *regional comparative study.*

In Sweden, the three main owners of residential apartments are municipal housing companies, private real estate companies, and tenant-owner associations. All rented housing is built with some form of financial public support (Lujanen, 2004). Thus certain information related to production costs and project specifics are reported to a government authority. Information of condominium projects, especially cost related ones, are not easily available since the majority of the contractors who carried out the construction work are also developers and thus in the final transaction is included not only the construction costs but land cost as well as profits. There are also considerable price differences in condominiums because of amenities and luxuries associated with it. These two facts were enough to exclude condominiums in our survey and concentrate only on the rental projects.

Data collection from both contractors and developers would have been desirable but we chose our survey to be directed to only developers for the following reasons:

- First, construction companies consider construction costs as a sensitive and confidential subject since disclosing it could reveal the profit margins of the firm. Developers are not necessarily constrained to conceal the price charged by the contractors in order to keep secret their profit margins. Aside being buyer than seller, price of the undeveloped land is also included in their final value of the development.

- Secondly, a high degree of concentration of large construction firms in Sweden, especially in the big regions creates a situation where one contractor is working with many projects and thus limits the number of respondents relative to the number of developers that are available. It is true that developers may have also several projects undertaken by the same contractor but that is considered helpful in our investigation since it enables us to acquire more information regarding their relationship with the contractor.

A survey was carried out in Stockholm and five medium-sized cities that are deemed to represent regions for both escalating and non-escalating costs (Table 1).

***Table 1**: Surveyed projects*

City / Type of Developer	**Municipal**	**Private**	**Tenant-owner association**	**Number of respondent (both mail and interview)**
Stockholm	9	7	3	12
Västerås	4	1	-	4
Örebro	6	1	-	6
Linköping	2	4	2	2
Jönköping	2	-	-	2
Umeå	8	3	-	7
Grand total	**31**	**16**	**5**	**33**

Projects that were built between 1998 and 2003 are considered in the survey since that period encompasses both high and low construction activities. Only projects that contain more than 20 units and that were equipped with elevator were chosen in order to have functionally similar buildings. The fact that the sample contains only one metropolitan city and several medium-small cities and the selected projects are not weighted according to the size of regions or cities reduces the appropriateness of evaluating one city against another especially Stockholm versus every and each city. Thus, a collective comparison between these cities and Stockholm will be conducted. Furthermore, having many municipal respondents and few private ones from both regions makes it difficult to compare the two regions along developer-type and hence reduces the comparability of the two regions in that perspective, but still some differences will be mentioned.

Questionnaires were addressed to the project mangers. Each questionnaire contained thirty-seven questions based on factors that were identified from the literature and informal discussions with professionals. Closed questions and Likert scaled-response format questions that elicit structured response from the project managers were employed in this six-part questionnaire.

The first two parts of the survey were intended to get hold of the company and project details as well as respondent retrospectives on this specific project, especially the cost aspect. Project mangers were asked about the level of construction costs of the specific project (high, average, and low) as compared to the final project cost. They were also asked to compare the construction costs of the project with other similar projects in the region. The rational behind these two different cost related questions is to differentiate between cost overruns that are unique to an individual project due to project location and client requirements and cost escalations that are mostly general to similar projects in a region. Forms of contract relates to whether single contractor carries out the whole project and have one-to-one relationship with the developer or if more than one main contractor is involved in the process. The latter does not only increase the number of participants of the project but also requires developer competency to act as a main contractor or the hiring of professional consultant instead. Four forms of contract were identified from the literature; divided, general, coordinated and all-in one contract.

The third part of the survey contains questions that could reveal the type of relationship between the developer and contractor. The duration and the magnititude of the relationship between contracting parties were crucial in our study of construction costs. Thus, respondents were asked several questions that solicit how often these two parties have worked together in the past, as that may be indicative of the type of relationship. Other questions were how long the contractor and client have had this working relationship and the share of workload from the client that has been given to a specific contractor based on their working relationship. Managers were asked to describe the degree of strength of relationship and the existence of factors that might have harmed their relationship with the contractor such as disputes arising from technical deficiencies, delays, and unexpected cost increase.

Participation of foreign firms (main contractors or subcontractors) that could have impact both on labour and product market in the Swedish housing construction sector was the focus of the fourth part of the survey. Though developers do not deal directly with subcontractors and material suppliers, respondents were still asked to indicate their knowledge of any foreign contractor/subcontractor and the level of imported construction materials used in their projects. Participation of foreign firms in the bidding stage and even willingness to participate were also equally important in the investigation and thus questions in that regard were included in this part of the survey.

There are other possible approaches of determining whether the relationship was short or long in lieu of asking respondents directly whether they have had long or short-term relationship with contractors. The fifth part was related to the developer's selection criterion when choosing a contractor. The tendering phase is one of the most crucial stages in the construction process. There are factors, i.e. level of competitions, level of construction activity, size of the project, strength of working relationship between the parties, etc. that play a big role in deciding which contractor get invited or considered and which ultimately get selected. In this part, respondents have been presented with two types of questions.

One type of questions in which respondents have to choose one of the Likert scale responses from developer's selection criteria i.e. the number of projects and years worked together, share of developers' workload undertaken by the contractor (size of the projects), prior repeated work commitment, was intended to reveal the significance of past relationship in the selection process. These factors are not exhaustive as a selection criterion, but they seem to measure same underlying construct – dependability – where long-term relationship is developed and reciprocity between the contractual parties ensues. Strength of relationship can have an impact on the transaction costs and risk allocations between the parties, which causes higher/lower construction costs.

The second type of questions in this part was of a ranking type and was intended to enable respondents to rank seven pre-determined factors. The factors are; previous working relationship, past project performance, technical superiority, financial strength, foreign or national contractor, lowest bidding price, and the location of the contractor. Here, the emphasis is client requirements and procurement regulations rather than prior relationship.

The final part of the questionnaire concerned the general opinion of the respondent on issues such as long-term relationship, competition, and supplier structure. Their familiarity of these subjects and their perception of how these factors affect construction costs were sought in this part. Effects of increased foreign main contractors/subcontractors and imported material were solicited as well as the impact on long-term relationship on construction costs. One more important question was respondent's view of vertically integrated contractors´ bid in regard to construction costs. In addition to the survey and accompanied interview with developers, separate interviews with several professionals in the industry were carried out in order to find out their views on topics such as construction costs, competition, and supplier structure.

***Table 2**: Questionnaire summary*

	Short description of various parts
Part one and two	To get hold of company and project details as well as respondent's retrospectives on this specific project especially the cost aspect of contract form. Respondents were asked to compare the construction of the project with similar projects in the region and with the original budget of the project. Cost overruns and cost escalations are differentiated.
Part three	Attempts to reveal the type of relationship between the developer and contractor. The strength of the relationship and concurrencies of factors that might have harmed their relationship with the contractor i.e. quality deficiency, cost increase, and delays were sought after.
Part four	The degree of foreign contractors and subcontractors participation and the level of imported material usage in the projects were the focus of this part.
Part five	Intended to ascertain developer's selection criteria of contractors and how various factors get weighted in the tendering process. It was also aimed to check, among other things, developer's behavior toward rewarding or penalizing contractors based on prior project performance.
Part six	The final part was concerned the general opinion of the respondent on issues such as long-term relationship, international competition, and supplier structure (vertically integration). Their familiarity of these subjects and their perception of how these factors affect construction costs were sought in this part.

From a quantitative point of view, 63% response rate of the preliminary survey (33 out of 52) seems very high compared with the typical 20-30% postal questionnaire surveys of the construction industry. Only ten questionnaires were answered fully and properly while the rest of respondents preferred to complete the questionnaire during the interview.

4. Presentation and analysis of results

4.1 Regional construction cost levels

A meaningful analysis of the survey answers is constrained by the size of the sample and the quality of the responses and thus mainly descriptive and limited analytical discussions will be conducted. Apart from the information gathered through the interviews and questionnaires, the three hypotheses that we have formulated above were tested and will be discussed in relation to what is deemed to be the facts prevailing in these regions and what are the believes of the respondents.

The two regions do not only differ in the level of construction costs of the surveyed projects (compared to similar projects in respective region) but they also differ in the number of projects that have experienced cost overruns and exceeded their original budget. Construction cost of all the projects from small cities except one project were reported to be within the average construction costs of their regions (Table 3). Several projects from small regions however, have reported to exceed the original budget when respondents were asked about the level of the construction cost of the same project with respect to its original budget. Only one project in small regions has encountered higher construction costs than similar projects in the region but the number of projects that exceeded their estimated budget was one third of the surveyed projects in the small regions.

***Table 3**: Construction cost and Relative construction cost levels (in brackets) by Region Type*

		Region Type	
		Big region	**Small region**
CCs level	**Low**	2 (1)	1 (1)
	Average (within budget)	6 (2)	19 (13)
	High	4 (9)	1 (7)

For several projects in Stockholm it was reported that construction cost of their project were higher than the average construction costs of the region. A good number of projects have experienced somewhat higher or much higher construction costs compared to the original estimated cost due to different causes. Construction costs of some projects in both regions were reported to be high because of its location dependency (i.e. Hammerby sjöstad - delicate soils), strong demand for construction works at that time, high quality requirements, and design changes initiated by the owners.

Respondents along the region affiliation gave different accounts of what has caused the overruns. All the respondents from the small region claim that the construction costs were

higher because of the design changes initiated by the owner and not because of excessive costs inflicted by the contractor. Respondents in the Stockholm region have indicated that contractors were mainly responsible for the extra costs of the projects incurred by the owners except when labour disputes prolonged the completion time of the projects. They claim that contractors were opportunistically increasing the construction costs and capitalizing the higher demand of their services during the upbeat construction market.

As we have contended at the beginning of the paper, these typical factors of direct and indirect costs may not be enough to elucidate the cost escalation differences that exist between large and small regions. In the next couple of sections, we will explore other factors that could explain the cost disparities by evaluating the three hypotheses that we have put forward earlier in relation to the construction costs.

4.2 Long run relationship and construction costs

In this hypothesis, we postulate that if the actors in the construction process, especially contractors and developers, establish a good lasting working relationship, it may inhibit contractors or subcontractors' enticement to increase construction costs in hot markets.

Respondents were asked to give their opinion about the effect of LRR in construction costs by ticking one of the four options in that question (see question #33 in the Appendix). Most of the developers in the big region agree that LRR would decrease construction costs while the opinion of the developers from small region is evenly divided in the three response options (Table 4). Only one third of them agree that LRR decreases construction costs while two thirds either believe that LRR has no implications on construction costs or simply do not have opinion.

Table 4: *Long-Run relation (LRR) and Construction costs by Region Type*

		Long Run Relation (LRR) and CCs			
		Decrease costs	**Cost Un-affected**	**No opinion**	**Total**
Region Type	**Big region**	9	1	2	12
	Small region	7	8	6	21
	Total	16	9	8	33

In Stockholm, municipal companies did experience LRR with contractors but it was hardly characterized as a mutual good relation because project bulkiness and large contractor shortage always constrained developers' choices. Some private developers have specified that when they were not satisfied with the cost and quality of one project, it has affected their decisions working with that contractor in another project. Meanwhile, a developer (municipal), despite their dissatisfaction with the contractor on both the quality and cost, decided to do the opposite and work with the same contractor in another projects. The

response from the respondent when asked the rationale behind that decision appears to mirror what Bidder (1980) described as the client/contractor relationship mutual metaphor (Table 5).

Table 5*: Client/Contractor relationship: Mutual Metaphors.*

Topic	**Client's thoughts**	**Contractor's thoughts**
Clients	A dog's life	Our life blood or a necessary evil
Contractors	A necessary evil	A dog's life

First, few competitors offered their service of undertaking the second project and none of them tendered a lower price (competition regulatory policy) than the first contractor did. Basically, there was a shortage of contractors who were capable of undertaking that kind of workload financially and technically (~300MSEK project). One municipal company respondent has mentioned that some times political pressures to speed up project implementation constrains their search of viable contractor and forced them to accept higher estimated bids that could have been avoided had they had time to extend the tender period or delay the project until construction activity cools down. Second, they argued that knowing what kind of contractor that they are dealing with gave them an opportunity to envisage the desired outcome and hence device an appropriate tool to achieve it rather than starting a new adventure with another contract. Third, the relationship with the contractor is multi-dimensional and one has to look at the overall performance of the contractor, which has been satisfactory in all other areas except these increased construction cost that emanated from the poor quality.

Good working relationship did not only produce non-increasing construction costs (average or lower) for the developers but it also secures more projects for the contractor as some respondents expressed. A municipal company in a small region reported that a collaborative working relationship with the contractor resulted in lower construction costs for them and consequently more works for the contractor. A practice that is much related to the LRR is the prior commitment of repeated work with the contractor and all the respondents from small regions and two thirds of big regions rated this as an important factor. Respondent indicated that this practice is not a formal promise but rather an informal one where a contractor undertakes a project that is part of similar successive projects. The developer desires to maintain uniformity of the projects and the contractor needs a steady workload. It is win-win situation for both actors where accumulated information and skills acquired from one project gets utilized in subsequent project. One respondent stated that three more projects were rewarded to the same contractor after very successful delivery of an earlier project as result of LRR.

Private developers are not obliged to practice strict competitive tendering as Municipal companies do. For instance, open tender and lowest bid price must be practiced in the public procurement when choosing a contractor, which does not encourage municipal companies to

exploit the benefits of LRR. How do the municipal companies balance between competition required by the law and cooperation necessitated by the market? One municipal company practiced what some literature termed as "cooption" where the client tries to balance both the benefits of competition and cooperation. The respondent described a case where a losing contractor complained that a project was not rewarded on the basis of lowest bidding price policy and thus forced the tender to be re-opened. The lowest bid price was replaced with best offer strategy that has enabled the municipal developer to consider not only the price but also pervious working relationship and past project performance with the contractor.

Developers from the Stockholm region consider lowest price and financial strength more important than other factors in the tendering process. The firms in the big region have also seen technical superiority as crucial since lumpy projects and limited space to carry out construction that were very common in Stockholm region may require better coordination and control as well as specific techniques and equipments.

The test reported below shows that we could reject the null hypothesis (10 percent significance level) that there are no differences in developers' opinions about whether long run relationship between clients and contractors affects construction costs (Table 6). Both the asymptotic and Exact Sig. are less than the 10 percent significance level and we reject the null hypothesis. In other words, we can conjure that the existence of long run relationship in the small regions may have helped to prevent opportunistic behavior between the parties though only one-third of developers in the small region acknowledged the benefits of LRR (Table 4). Developers in big regions also vehemently agree that LRR decreases construction costs but they also have reported higher construction costs.

***Table 6**: Mann-Whitney U Test Statistics for regional views on hypothesis 1*

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)	Exact Sig. (2-tailed)
LR relation and CCs	42,50	162,50	-2,167	,030	,040

Grouping Variable: Region Type

4.3 Vertical integration and construction costs

The research question is to substantiate any connection between vertical integration and higher construction costs increase. Is there a difference of opinions between the developers in large and small regions on whether a vertically integrated firm tenders higher price than non-integrated firm. The hypothesis was put in the form of question (question #37 in the appendix) that solicit respondents view of whether vertically integrated firms would tender higher construction costs during the bidding process than contractor that is not active as developer

An equal number of developers from both regions have indicated not having an opinion whether a vertically integrated contractor would tender higher construction costs than non-integrated firm (see Table 7). Moreover, some small region respondents have concerns when large contractors, who were also active as developers (vertically integrated), get involved in the rental market by constructing their own projects. Respondents were reluctant to speculate whether the effects of this full vertically integrated firm[1] but one respondent offered one possible motive that triggered already vertically integrated contractors to enter the rental market. Currently, two forms of subsidies - interest rate and investment - are available to all residential building projects but that will be changed in the near future. The subsidies are going to be limited to only rental apartment projects and large firms are anticipating these changes.

Table 7: *View of Vertically Integration and construction cost by Region Type*

		Vertically Integrated			
		Agree	**Disagree**	**No opinion**	**Total**
Region Type	**Big region**	1	5	6	12
	Small region	14	0	7	21
	Total	15	5	13	33

A Mann-Whitney U test shows that we can reject the null hypotheses (at 10 percent significance level) that state that there are the same views in both regions about whether vertically integrated contractors tender higher prices than non-integrated contractors (Table 8). In other words there is a difference of opinions between developers of large and small regions and indeed one can infer with cautious that vertically integrated contractors could influence construction costs.

Table 8*: Mann-Whitney U Test Statistics for regional differences in views of Hypothesis 2*

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)	Exact Sig. (2-tailed)
VI and CCs	7,00	112,00	-3,844	,000	,000

Grouping Variable: Region Type

In some small regions municipal companies where highly dependent on the services of a few large contractors, and the dissatisfaction of employing divided or coordinated general

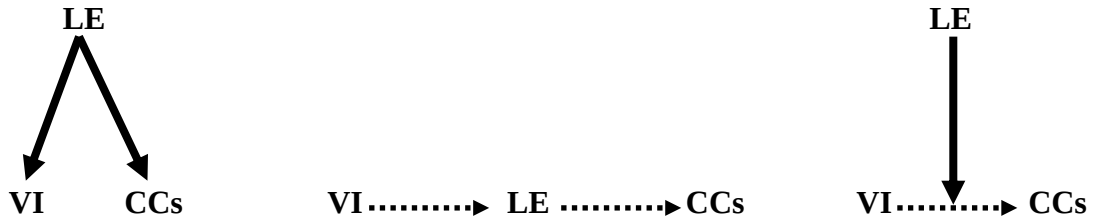
[1] We used the word "fully" with vertically integrated in order to emphasize the contractor is not only involved in the construction of multifamily housing (construction of condominiums and rental apartments) but that the contractor may also own rental buildings.

contracts is making their situation to be described as between a stone and hard rock. Large contractors have often chosen not to participate in a coordinated contract. One possible explanation given by the respondents was that the contractor's margin of profits might diminish with this procurement method because large contractors, including vertically integrated contractors make their profits from different sources such as labor, material, and land cost. Non-participation could also be the result of contractor's strategic decision of prioritizing other projects including their own projects.

Several explanations could be given why vertical integration was not a big issue in the Stockholm region. Higher overhead costs as a result of being vertically integrated coupled with high construction activities and fewer competitors may have exacerbated the construction costs in the big regions. The size of projects and limited easily constructible land that requires special techniques and equipments may have limited the number of qualified contractors. Thus, few capable contractors benefit from the low competition by choosing only the most profitable projects.

Small regions may have benefited from the presence of more medium and small construction firms that have not only increased competition but also contributed to the fostering of long run relationships with the developers. However, vertically integrated firms were also active in these cities and involved in the construction of both rental and condominium projects. According to Boverket (The National Board of Housing, Building and planning) and information gathered from regional contacts in HSB, at least two of the four biggest vertically integrated firms (SKANSKA, NCC, JM, and PEAB) were active in the condominium market of the cities considered in the survey.

Since vertically integrated firms operate in both regions with high and low cost increases, one may question the plausibility of the relationship between high construction costs increase and vertically integrated firms. It could be argued that the existences of some antecedent intervening variables such as degree of competition and construction activity level (termed here as Local externalities) influence the decisions taken by the vertically integrated firms. However, one cannot be sure whether construction cost increase resulted from the actions taken by the integrated firm with the intention of raising rival's cost or as result of local externalities. If we let VI stand for our vertically integrated firm, LE for the local externalities, and CCs for the construction costs (see Fig. 1), then the relationship between the three variables can take one of the following forms (Pickvance, 2001).



a) Spurious relationship between VI and CCs

b) Local externalities interprets relationship between VI and CCs

c) LE specifies the relationship between VI and CCs

Figure 1: *Possible relations between VI, CCs, and LE (local externalities).*

The first picture depicts a situation when local externalities have a very strong casual influence on both construction costs and the degree of vertical integration. The correlation between integrated firm and construction costs is entirely due to the effect of the degree of competition and construction activity level. The second picture illustrates a situation in which the vertically integrated firm influences the local externalities, which influences construction costs. Integrated firm indirectly has an impact on construction costs. The last picture shows that the local externalities determine the relationship between the integrated firm and construction costs.

4.3 International competition and construction costs

The respondents from both regions have shown some sort of agreement and lack of opinion concerning the effect of foreign contractor/subcontractor participation on construction costs. Most of the developers in Stockholm and more than half of developers from small region have agreed that foreign actors could reduce construction costs. Meanwhile a good number of developers from small region reported having no opinion about any effect of foreign agents (Table 9). Foreign subcontractor involvements responses were similar with foreign main contractor responses. Imported materials have drawn analogous response as foreign contractor involvement except that one more municipal and one more private developer in Stockholm expressed their disagreements on lower construction cost with increased import material and labour. Respondents emphasize that benefits of cheaper foreign construction material is offset by higher transportation costs while strong labor union also opposes overseas work forces.

Those developers who agree that more firms either from other regions of the country or abroad would reduce construction costs have tried to contact firms located outside the region, especially firms in small regions, but the financial and technological requirements discouraged these firms. Interviewers pointed out that the challenges and obstacles were very strong and forced even some local contractors to abandon their ambition of hiring foreign subcontractors. Two examples discussed were a Danish subcontractor that was considered by JM in an earlier Hammerby sjöstad project and the recent case of Lithuanian firm.

Furthermore, respondents of both regions have indicated that neither contractor's location nor the country origin of contractor is relevant during the tendering process.

Table 9: *View of effect of Foreign Main Contractor on construction cost by Region Type*

		Foreign Main Contractor				Total
		Strongly agree	**Agree**	**Disagree**	**No opinion**	
Region Type	**Big region**	0	8	4	0	12
	Small region	2	12	0	7	21
	Total	2	20	4	7	33

The hypothesis concerning that foreign contractor and subcontractor participation would decrease construction cost was statistically validated. The null hypothesis that there are no differences in developers' opinion about the impact of foreign supplier presence on construction costs was rejected at 10 percent significance level (Table 10). While all the respondents from Stockholm region have an opinion about the influences of foreign supplier on construction costs (8 agree and 4 disagree), developers from small region either have agreed with the statement (10 out of 17) or have no opinion at all.

Table 10*: Mann-Whitney U Test Statistics for regional differences in views about Hypothesis 3*

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)	Exact Sig. (2-tailed)
Foreign main contractor and CCs	40,00	145,00	-2,782	,005	,009
Imported material and CCs	15,00	120,00	-3,474	,001	,000

Grouping Variable: Region Type

5. (Other) important factors according to the survey

In spite of emphasizing that construction costs is different from total production costs during the interview, most of the participants in the survey and the separate interviews insist that among other things land and various taxes cause construction costs to be high. As one professional respondent pointed out, higher land cost might be offset by higher density buildings and let developers earn enough profits, but it still increases total construction costs. Another professional argues that things are even more complicated in the contractor-developer situation because land price also is included in the final price and during these years of study the developer-contractor companies built many residential multi-family projects and most of these projects were condominiums. In his opinion the SCB (Statistics Sweden) may have used a lot of these projects when they were estimating the construction cost figures. His argument is that these companies had not only reported what it cost them to build as a contractor but also their costs as developer and that may be even the source of the cost-price confusion.

Other factors that were raised as the cause of construction cost disparities are competition and local market conditions and labour costs. It has been indicated that medium size construction companies with 50 or less employees are dominant in the residential construction market in non-metropolitan cities that makes competition among them highly noticeable. Respondents have noted that this reflects why developers in small-medium cities do not only consider the lowest price as the sole criteria for choosing contractor but also consider the relationship between parties, quality of product delivered, and reputation of the contractor.

In Stockholm, respondents believe that construction costs were higher in those years because of market conditions (high demand) that were favorable to the contractors. In other words, contractors have had the upper hand and selected only those projects that they could make extra profit from and developers were competing for the few contractors that were offering their services. Lucrative constructions of condominiums have also had a big impact on construction costs of residential apartments. Early 1990s condominiums were very profitable and that might have driven up the construction costs. The cost increases may have persisted and had spillover effect on other types of housing.

The influence of labor cost and the price of construction material on the construction costs were investigated and produced a mixture of views. Labour in big cities may cost more in order to compensate them for commuting expenses, high rents, etc. Several respondents believe that labour cost may be one factor that has the biggest impact on construction costs due to labour laws and salary structure in the sector. Several respondents believe that price differences of construction material in various regions of the country may be negligible. They also indicated that material products easily get transported within the country although they have different opinions on foreign materials. For instance, that cheaper prefabricated concrete

elements in Umeå got transported to Stockholm every Monday was one example given by an industry insider.

Two issues that are associated with cost increase were quality and completion time of the project. Factors contributing to delays or quality inferiority were not the focus of the survey but the occurrences of either anomaly were investigated. Four municipal projects in Stockholm have experienced delays and dissatisfaction with the quality of the projects. Though developers accepted that certain delays cannot be blamed on contractors and indicated their willingness to share the costs of the delays, they also pointed out that delays induce the contractor to hasten finishing the job that could result in deficient quality work. Nevertheless, most of the claims and disputes were solved through mutual agreements.

The survey also shows the extent to which metropolitan and small regions use different contract form and tendering process, which may have some implications on construction costs (Table 11). Most of the projects in small region were under the control of a single contractor with an all-in-one contract form and a reported average construction costs. Only one project under general contract was reported to have higher construction costs. Meanwhile, two thirds of projects in Stockholm used general contract form and four of them incurred higher construction costs.

Table 11: *Construction costs level and contract type in both regions*

Region Type		Contract Form			Total
		Divided contract	General contract	All-in-one contract	
Big region	**Low**	1	1	0	2
	Average	2	3	1	6
	High	0	4	0	4
	Total	3	8	1	12
Small region	**Low**	0	0	1	1
	Average	3	1	15	19
	High	0	1	0	1
	Total	3	2	16	21

Since the Divided/Coordinated contract entails the participation of several contractors and subcontractors, respondents pointed out that this type of procurement can increase the construction costs in two aspects. First, sometimes substandard and deficient work becomes no ones fault and subsequent repair necessitates extra cost succumbed by the developer. Second, developers incur extra costs stemming from coordination and monitoring of the various actors and activities, not to mention the demand of greater competence from developers. Small region companies have indicated that employing the All-in-one contract procurement method with one or two large contractors over a period of time have provided an

opportunity to foster a long-term relationship and consequently less unjustifiable construction costs increases.

The interviews with small region municipal companies indicate shifting views of which procurement performs better than the other. For instance, those companies who already procured with general contract (GC) preferred either the use in All-in-one contract or coordinated general contract (CGC) method. A municipal company who already implemented each of these methods is now contemplating the use of partnering. The type of partnering the municipal company is intend to implement is project partnering that could be extended to long-term partnering strategy. Though partnering is not considered a form of contract but rather an attempt to establish non-adversarial working relationships among project participants through mutual commitment and open communication (Johansson and Åkerblom, 2004), the respondent claims that it provides an opportunity to avert the need of CGC while at the same time reduces opportunistic behaviors such as market driving cost increases. Nyström (2005) notes the two highest ranked motivation of client's use of partnering were getting more out of the project for the same amount of money and a better collaboration environment.

6. Conclusions

Semi-structured interviews and posted questionnaires yielded mixed results. In non-metropolitan region, long-term relationship between developer and contractor is a crucial strategy and incentive mechanism in securing repeated work for contractors and lower construction costs increase for the developers. Short-term relationship as well as normal and adversarial relationship was more prevalent in metropolitan region. The working relationship is also affected by the level of construction activity, project characteristics (size, complexity, etc.). Many developers did not recognize the effects of vertically integrated contractors on construction costs and hence the relevance of concentration levels of vertically integrated firms in any region became inconsequential.

The involvement of foreign contractors was not reported in any project considered in the study and the usage of imported materials was almost non-existent. However, some respondents believe that foreign suppliers' participation might increase competition especially construction materials and labour and thus alleviate the rising construction costs in big regions. Other respondents agree partially with that assessment but argue that cheaper construction materials are offset by higher transportation and maintenance costs.

Developers' responses about the effect of vertical integration and long run relationship on construction costs raised an interesting observation. Developers in the Stockholm region, where higher construction cost increases of the projects are observed and most of the projects are constructed by vertically integrated firms, have different perceptions than small region developers, who believe that vertically integrated firms tend to set higher prices. Meanwhile,

small region developers who reported to have lower construction cost increases and long run relationship with contractors indicated that they do not perceive that lower construction cost increases were a result of that relationship. Developers from Stockholm region (who mostly experienced non collaborative relationship with the contractors) believed more in the benefits of long run relationship compared to their counterparts in the small regions.

It is possible that developers from both regions responded to these questions (long run relationship benefits and vertically integrated firm's tendering behavior) from an expectation point of view rather than from the existing situation that they were operating in. In other words, the responses of small region developers were driven by concerns that the market power of a vertically integrated firm may lead to unfair pricing whilst the responses of Stockholm region developers were motivated by the desire of having long run relationship in the face of high competition and high construction activity that encourages market driven attitudes.

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Appendix: *Supplier structure and housing construction costs questionnaire*

Dear Sir/Madam,

The aim of this survey is to ascertain information that could enable us to understand the causes of residential construction cost increases in the different regions of the country. All information you provided in this questionnaire will be kept confidential and the research results will be shared with interested participants of this survey.

Part A: Company details

1. Company name
   ……
2. Name of the respondent and current position in this company?

   Name (Optional):…….

   Title:…….....
3. Which year was your company founded?
   ……
4. How many properties (apartment buildings) did your company own before 1998?

   ……
5. How did the number of properties (apartment buildings) change from 1998 until 2003?

   ……

Part B: Project details

6. Name of the project
   ……..
7. Location of the Project: Municipality_____City: _____
8. Number of Apartments: _____

9. Were you with this company during the construction of this project?

   Yes [ ] No [ ]

10. If the answer of the above question is yes, what was your position at that time?

    Title: _____

11. Project's starting Year ……. Completing year: ……

12. Name of the main contractor of this project.
    ……

13. What type of strategy could best describe the contract form of this project?

    [ ] Divided contract (Delad entreprenad)
    [ ] General contract (Generalentreprenad)
    [ ] Coordinated General contract (Samordnad generalentreprenad)
    [ ] All-in-one contract (Totalentreprenad)
    [ ] Other

14. How many times have your company worked with this contractor before this project?……..

15. How many times have your company worked with this contractor after this project?…….

16. What is your estimate of the construction costs of this project (excluding land, fees etc.) compared to similar project in the region?

    [ ] High [ ] Average [ ] Low

17. What is your estimate of the construction costs of this project compared with the original budget? (Please check the appropriate answer)

Less than original budget		**Within budget**	**Bigger than the original budget**	
Much lower	Somewhat lower		Somewhat higher	Much higher

18. Was the land built on this project owned by your company

    [ ] Yes [ ] No

19. Concerning the project schedule would you consider that the project was: (Please check the appropriate answer)

Ahead of schedule		**Within schedule**	**Exceeded schedule**	
Much ahead	Somewhat ahead		Somewhat exceeded	Much exceeded

Part C: Relation to contractor

20. The working relationship that your company have had with the main contractor could be generally described as:

    [ ] Long-term [ ] Short term

21. How would you describe the working relationship between your company and the main contractor during this project?

    [ ] Collaborative [ ] Normal [ ] Adversarial

22. Was there any major dispute during this project due to:

    - Unforeseen changes that cause unexpected cost increase.

      [ ] Yes [ ] No

    - Quality or technical deficiencies.

      [ ] Yes [ ] No

    - Project start or completion delays.

      [ ] Yes [ ] No

    - [ ] Other

Part D: Foreign firms participation

23. Did any foreign firm participate in bidding for this project?

    [ ] Yes [ ] No

24. Did any foreign firm contact your company before the formal bidding and show some interest of undertaking this project?

    [ ] Yes [ ] No

25. Did any foreign subcontractor participate in the implementation of this project?

[ ] Yes [ ] No

26. Compared to similar projects in the region, the proportion of imported construction materials used in this project were:

[ ] Higher than normal [ ] Normal [ ] Less than Normal [ ] No opinion

---

Part E: Selection criteria

27. When choosing a contractor, the number of projects carried out by the contractor on behalf of your company is:

[ ] Very important [ ] Important [ ] Un-important [ ] No opinion

28. The number of years the two parties have worked together is:

[ ] Very important [ ] Important [ ] Un-important [ ] No opinion

29. The share of workload (size of project) that has been rewarded the contractor is:

[ ] Very important [ ] Important [ ] Un-important [ ] No opinion

30. Prior commitment for repeated work with the contractor is:

[ ] Very important [ ] Important [ ] Un-important [ ] No opinion

31. Communication efficiency and conflict resolution capability of the contractor is:

[ ] Very important [ ] Important [ ] less important [ ] No opinion

32. Which of the following factors does your company give priority when tendering new project? Please rank them according to importance. (1 = most important and 7 = least important)

	Rank
Previous working relationship	
Previous project performance	
Technical superiority of the contractor	
Financial strength of the contractor	
Whether the contractor is foreign or national	
Lowest bidding price	
Location of the contractor	

Part F: General opinion

33. What in your opinion is the effect of long run relationship in construction costs?

    [ ] Increases costs [ ] Decreases costs [ ] Costs Un-affected [ ] No opinion

34. Do you think that more international (main) contractors in the Swedish housing construction market would lead to lower construction costs

    [ ] I strongly agree [ ] I agree [ ] I disagree [ ] I strongly disagree [ ] No opinion

35. Do you think that more international sub-contractors in the Swedish housing construction market would lead to lower construction costs

    [ ] I strongly agree [ ] I agree] I disagree [ ] I strongly disagree [ ] No opinion

36. Do you think that more use of imported construction material in the Swedish housing construction market would lead to lower construction costs

    [ ] I strongly agree [ ] I agree [ ] I disagree [ ] I strongly disagree [ ] No opinion

37. Some contractors are active in development of residential housing (Developer – Contractor) while others are solely contractors. Do you think that a contractor who is active as developer, not only build projects similar to this one but also own projects similar to yours, would tender higher construction costs during the bidding process than contractor that is not active as developer?

    [ ] I strongly agree [ ] I agree [ ] I disagree [ ] I strongly disagree [ ] No opinion

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Other comments:

Thank you very much for your co-operation

Paper 3

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Organizational modes in the residential building sector in Sweden

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Traditional organizational studies emphasize department groupings and the management style of different organizations that are often based on common tasks, products, geography and processes. They also mainly emphasize the connection between construction supply chain and procurement methods but have not analysed of how external factors shape the organization structure and consequently the supply chain. Three things are analysed: the impact of competitive pressure, required competence and degree of flexibility on various modes of construction organization used for producing multi-family residential housing in Sweden from a transaction cost theory perspective. Organization structures depend on the level of project engagement, competence demanded by the preferred organization mode as well as the economic environment, and the level of construction activities.

Keywords: Organization structure, flexibility, risk allocation, competition, competence.

Introduction

In recent decades studies in the area of industrial organization have increased dramatically. The fundamental question underlying this trend is why production is organized in a specific way, i.e. what is produced in-house and what is outsourced and bought on the market from external suppliers. This is, however, a very simplified way of describing the alternatives. Lansley (1994) argues that a construction firm can be seen as a broker of opportunities for projects and as an intermediary acquiring resources to undertake building projects. From a functional point of view, Tenah (1986) defines a construction company as a group of people sharing specialized knowledge to design, estimate, bid, procure and obtain resources to complete a construction project. These functions definitely extend beyond the boundary of a single firm and involve relationships with subcontractors, manufacturers and material suppliers (Tenah, 1986). Thus, the interaction of these entities and how they transact their services and products shapes the organizational structure of a project and ultimately determines the governance structure of the specific firm (Shirazi *et al.*, 1996). The boundaries of an organization determine the extent of organizational influence on external forces and resources as well as its degree of industry control (Santos and Eisenhardt, 2005). Winch (1989) argues that the prime object of construction management research should be the firm, and the project should be seen as a temporary coalition of these firms together with the client. In line with Winch's argument, we will focus more on the possible organization patterns of the firm—or group of firms—delivering the building project rather than the project.

The choice of a procurement method is often dependent on the availability of appropriate contractors who can successfully carry out the desired project; a better understanding of various organizational structures in terms of their weaknesses and strengths is thus crucial. Traditional organizational structure studies emphasize department groupings and the management style of different organizations that are often based on common tasks, products, geography and processes. They also mainly focus on the connection between construction supply chain and procurement methods with less consideration on how external factors could shape the organization structure and the supply chain.

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Hughes *et al.* (2006) exemplify this approach by mapping the supply chain in terms of tiers from the main contractor. Briscoe *et al.* (2004) illustrate the multidimensional aspect of the relationship between the business environment, procurement route undertaken and the level of supply chain integration. Furthermore, they emphasize the importance of client organization in the supply chain and how environmental variables could influence the client organization decisions. However, it seems that most of the above research did not extend the analysis to include the effect of these external forces on the organizational structure and hence supply chain integration.

The objective of this research is to begin a process of analysing various models of construction organization used for producing multi-family residential housing in Sweden from a transaction cost theory perspective, focusing on the vertical integration aspect of this perspective. The study explores in a limited way the role of different factors that are focused on in the theories, using general information about the historical development of residential projects in Sweden and results from a questionnaire and follow-up interviews to Swedish housing companies.

Three factors that are crucial to a discussion of why certain organizational structures are more efficient will be analysed:

(1) How flexible the organization is when there are changes in the economic environment and in the level of demand. This is related to how risks are allocated between different actors.
(2) To what degree all parts of an organizational structure are put under competitive pressure. The more parts that are exposed to these pressures, the more efficient the organization should be.
(3) The level of competence that an organizational structure requires and the possibilities for the unit and sub-units to continuously retain this competence.

Literature review

Differentiation and integration of construction organizations in relation to other construction actors have some bearing on how risk is allocated and how organizations respond to economic changes in the environment. Walker (1996) refers to Lawrence and Lorsch's study (1967), which states that there is no best way to organize but rather that organization is a function of the nature of the task to be carried out and its environment.

The effectiveness of the design of a particular organization is contingent on various factors including technology, size and the environment (Child, 1984; Carnall, 2007). Child (1984) regards contextual factors as the most important determinants of organizational structures. The environment could be seen as a collection of conditions with specific impacts on the organization (Shirazi *et al.*, 1996). The characteristics of the business environment in which an organization operates—such as the nature of competition—have a measurable effect on the organizational structure (Brensen, 1990; Brooks, 2006).

The level of separation and integration of the players in the construction process can present opportunities as well as challenges for members of the construction project coalition. Grant (2005) claims that lack of vertical integration partially reflects the need for flexibility in adjusting to cyclical patterns of demand and the different requirements for each project. Integration of various actors in the building process increases the avenues for an organization to earn profits. The Swedish building industry is very fragmented with large numbers of small companies and few large ones as a result of acquisitions and mergers (Bröchner *et al.*, 2002). It is also composed of several sub-markets with high levels of concentration and significant vertical and horizontal integration (Roseveare *et al.*, 2004). Barlow and King (1992) claim that the increased use of vertical integration in the building process is an alternative solution that has enabled firms in Sweden to affect production costs.

Integration of developer and contractor with specialist contractors might increase the competence of the integrated organization, but it may also limit the flexibility of the amalgamated organization to adapt to economic changes. In contrast, a separate developer, contractor and specialist contractor may allow these actors to adapt competitively to the prevailing economic environment, lead to better risk allocation, but increase the required competence of each actor. Reliance on consultants or other forms of contracting could rise in the absence of the essential competence.

Construction firms—big or small—have different capacities to undertake one or more contracts simultaneously, which creates a source of uncertainty. There are times when a general contractor may not be able to retain a large number of labour specialists because of the uncertainty surrounding labour needs as dictated by time, location and speciality (Eccles, 1981). The bulkiness of construction material affects transportation costs and can easily result in a regionalized market structure (Lowe, 1987), which reduces the flexibility to transfer materials to where they are most needed. One of the major purposes of subcontracting is to reduce these uncertainties and pass much of the risk on to the

subcontractor, given that the subcontractor has greater capability to handle these risks in comparison to the general contractor. Smaller organizations are characterized by centralized power for formulating strategy and adaptability in responding to economic changes (Shirazi *et al.*, 1996). However, owing to limited resources in the face of non-integration, smaller organizations may become unable to undertake large projects because of input shortage during high construction activities that favour large firms.

Research methods

It appears difficult to provide a unified theory or approach that fully explains the basis of organization structures (Bridge and Tisdell, 2004). Santos and Eisenhardt (2005) claim that transaction cost theory provides one unique view of the boundaries of organization (cost efficiency) but other concepts such as power, competence and identity could reveal varied views of organization structures. Robins (1987) states that the purpose of a transaction cost analysis can be either to explain a prevailing institutional structure or to explain the adoption of a specific organizational form in response to conditions faced by any individual firm. It is the second type of analysis that is adopted in this paper. Masten *et al.* (1991) state that it is not helpful to prove or disprove transaction cost theory because of the difficulties of gathering meaningful data and hence to measure directly the cost of different organization structures (Chang and Ive, 2001). This study will use examples from the development of the Swedish house building industry in addition to an online survey of municipal housing companies to illustrate the theoretical arguments. This study is exploratory, the result of which is to identify issues that will be further investigated in a more elaborate study. The purpose is not to make inferences but rather initiate a process of understanding the nature of organization structure and suggest some of the factors that are crucial to this development.

In Sweden, the three main owners of residential apartments are municipal housing companies, private real estate companies, and tenant-owner associations. This study focuses only on municipal housing companies. There are more than 300 municipal housing companies in Sweden, but not all of them are big and continuously building housing units, especially during the study period (1995–2006) that covers both high and low construction activities. Only 24 municipalities have a population of more than 75 000 inhabitants and thus only a fraction lends itself to a study of this nature. Twenty-one such municipal companies satisfied the criteria of size, continuous operation during different phases of the business cycle, as well as type of product (i.e. residential rental but not students and senior housing units). Questionnaires (see Appendix 1) were e-mailed to top management in each organization and follow-up interviews were conducted.

Models for the organization structure in the residential construction sector and a theoretical analysis

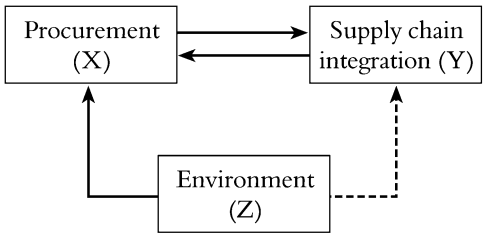
The theoretical framework

In response to the dynamic business and economic conditions, construction firms may adopt different types of organizational structures that influence procurement methods and best economize on the transaction costs of carrying out building projects (Hughes *et al.*, 2006). Williamson's (1975) transaction cost theory, a development of the ideas in Coase (1937), is one of the most important tools that can be used to explain the practice of differential contractual forms and procurement methods (Lansley, 1994). A transaction cost approach explicitly regards efficiency as a fundamental element in determining the nature of organizations (Ouchi, 1980).

Briscoe *et al.* (2004) conclude that many environment variables originating from the supplier organization affect the decisions made by the client organization and thus the client's integration to the supply chain is vital. Among the environment variables stated are experience of managers (competence), volume of construction work and the organization's attitude and awareness of risk (flexibility and risk allocation) as well as the construction and client's own business market (competition). Technology can be related to variations in organizational structure (Child, 1984; Shirazi *et al.*, 1996; Carnall, 2007); however, it is not considered in this study.

Adopting Briscoe *et al.*'s (2004) construction supply chain research model with some modification (Figure 1), three rather broad criteria that are in line with a transaction cost approach were chosen as a method of evaluating different organizational structures (see Table 1): how flexible the organizational model is in situations where the external market changes; what kind of competence any organization model demands from the client (Bassett and Carr, 1996; Briscoe *et al.*, 2004; Santos and Eisenhardt, 2005); and how the strength of competitive pressure impacts on the organization's activities (Briscoe *et al.*, 2004; Grant, 2005).

These criteria can be formulated as propositions about when there will be changes in the organizational



Note: Z causes X and Y, and X moderated by Y

Figure 1 Modified construction supply chain research model

structure. The fundamental proposition is that organizational change can be seen as a reaction to problems in one or more of these three dimensions, and that the new model can handle these problems better and leads to a more efficient use of resources. New circumstances will, however, sooner or later lead to problems for this model too. There will be organization change when:

(1) *Other organizational forms can manage risk better.* Construction firms are often confronted with uncertainties that arise from workload fluctuations owing to the general business cycle of construction activity and the amount and size of contracts awarded. Workload dynamics may necessitate certain forms of organization structure in order to handle risks stemming not only from the business cycle but also from successfully bidding and managing projects with optimal resource allocation. This proposition focuses on the degree of flexibility and risk allocation that an organization is capable of responding to in a changing economic environment, and the ease with which it efficiently utilizes its resources.

(2) *Other organizational forms are more efficient because more units are put under competitive pressure.* Construction firms cannot gain a sustained competitive advantage over others because competitive pressures force firms to be more or less similar in efficiency (Ball *et al.*, 2000). Otherwise the result might be inefficiencies that lead to new organization patterns. The competition proposition implies that prices in various construction markets follow a similar pattern (Ball *et al.*, 2000) and this puts competitive pressure on the parties in the construction firm to adopt a suitable organizational structure for different situations. In the long run, if an organizational structure leads to a situation where more units of a process have to compete with others for work, then it should lead to higher efficiency. From an incentive perspective, Grant (2005) notes that vertical integration gives rise to what is termed low-powered incentives due to the internal supplier–client relationship, which is governed by the vertically integrated organization rather than the market with its high-powered incentives.

(3) *Other organizational forms are better at maintaining the competence needed.* Different organizational patterns entail various degrees of competence in order to maintain an edge over an equally ranked competitor. The third proposition stipulates that in an efficient organizational structure all actors must have the right competence and be in a situation where it is possible for them to keep their competence updated.

The basic models: potential strengths and weaknesses

Organizations can assume many different forms but we focus on the following five modes or models that seem to have been the most frequently observed during the last 50 years. A common feature of organization models is that the client is the initial owner of the project. For simplicity, the term 'owner' will be used in the models.

The first model represents an organization that acts as developer/owner and has the capability to construct its own building with little or no resources from outside. This is called an owner-developer-contractor (Figure 2: ODC, henceforth M1). The firm has the human asset capabilities as well as physical assets that are essential to undertaking building projects from start to finish. A large

Table 1 Criteria used for evaluating organization structure and their definitions

Criteria	Definitions
Flexibility and risk allocation	Degree and ease with which major construction project parties handle uncertainties posed by changes in the economic environment and the level of demand. It measures organization's capability to adapt to economic and environmental changes.
Competition	Degree to which each organizational unit or sub-unit is put under competitive pressure.
Competence	The level of competence that an organizational structure requires and the possibilities for the unit and sub-units to continuously maintain this competence.

Figure 2 Model 1 ODC: integrated owner-developer-contractor

enterprise with centralized hierarchical organization allocates all its resources, products and services internally by administrative means rather than market means. A case that could fit the above characterization is a municipal housing company with resources and a capability to construct its own building projects—something that could be found in Sweden in the 1960s.

A typical structure (Figure 3) found in many markets is that of a separate company that carries out the direct building activities (OD-C model, henceforth M2). There is competition between different contractors, and the chosen contractor builds from an order decided by the client/owner/developer. In this model it is assumed that the contractor carries out all the work with his or her own staff. One interpretation is that the building part of an integrated firm now might have been divested and competes with other firms for the job. The relation between the owner-developer and the contractor can differ considerably depending on the specific contractual form.

In the next model called OD-C-SC (henceforth M3), the contractors in the above model have outsourced considerable parts of the work to subcontractors, who are also hired after some kind of competitive process (Figure 4). These subcontractors can work for any one of the main contractors.

The model described in Figure 4 has been the dominant model in the Swedish residential construction sector for a number of years. In reality there might be further levels of subcontracting. In recent years two more models have been observed. In Figure 5 the owner/developer hires the speciality contractors directly instead of going through a (main) contractor (OD-SpCs, henceforth M4), and in Figure 6 the owner/developer hires a special consultant (OD-Cons-SpCs, henceforth M5) to work with finding and coordinating the speciality contractors.

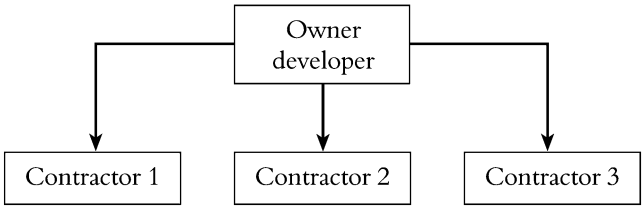


Figure 3 Model 2 OD-C: owner-developer and a separate contractor

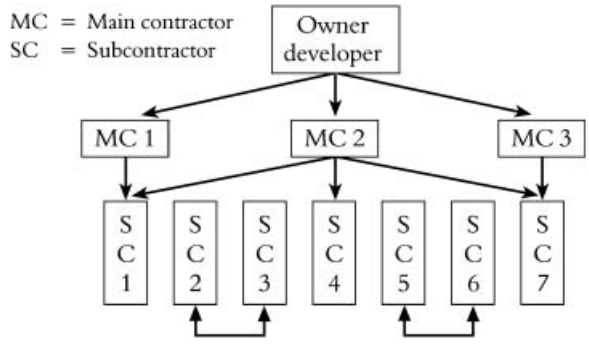


Figure 4 Model 3 OD-C-SC: owner-developer and a separate contractor contracting with subcontractors

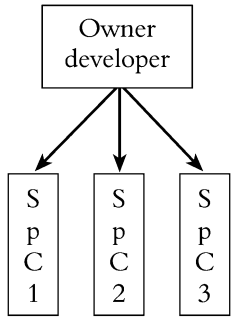


Figure 5 Model 4 OD-SpCs

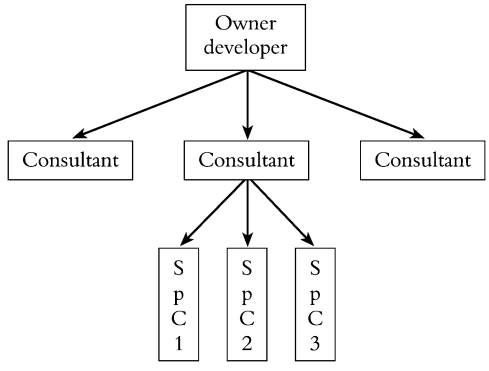


Figure 6 Model 5 OD-Cons-SpCs

From M1 to M2 organization structure

The owner-developer-contractor model faces challenges as well as opportunities ranging from increased risk exposure, bureaucratic costs to improved level of competitiveness in terms of capacity and less reliance on other firms to provide the desired inputs. Uncertainties of the development and construction markets are present simultaneously in the M1 model as

well as the risk that arises when the organization is not subcontracting.

The M1 organization type could improve the competitive position of the firm and the competence of its entities. Organizations strive to become bigger by acquiring or merging with other firms in order to benefit from economies of scale or scope. Thus, a vertically integrated organization with capital and manpower muscle can improve its competitive advantage. However, small firms and speciality subcontractors have an advantage over large firms in small jobs and repair work (Foster, 1964). Most of the competitive advantage of large firms may become ineffective for small projects and a variety of other situations (Foster, 1964). Thus, an organization must be large enough to compete and at the same time small enough to specialize in certain construction works.

The main problem with M1 from the competition point of view is that of control, meaning that various parts of the organization could be inefficient because they are sheltered from competition. The differentiation between owner/developer and contractor presents the developer with an opportunity to deal with other contracts and to practice a market base procurement. Nevertheless, the separation compels the developer to acquire the necessary competence to efficiently carry out the transaction process—from design and specification to tendering and procurement of the final product. M2 organization structure might replace M1 type for two reasons:

(1) The independent contractor can handle market fluctuation better than the integrated firm.
(2) The contractor is put under more competitive pressure as the developer can choose between different contractors. There could be a reduction of bureaucracy costs as a result of splitting, as well as efficiency due to transacting at arm's length with high-powered market incentives.

From M2 to M3 organization structure

The opportunity to transform fixed costs to variable costs through subcontracting practices is absent in the M2 organization structure. Thus, this form of organization could still be characterized by lack of flexibility and inability to allocate risk. The M3 organizational structure tries to rectify this. The benefits that contractors gain from subcontracting are reduction of overhead and construction costs stemming from lack of local market knowledge and the need for supervision.

An important issue is how subcontractors handle market risk. Subcontractors can work for different developers, and they might also be able to work in large regions. They can also informally cooperate with other subcontractors if they have excess supply or excess demand for specialists. They might also work with maintenance projects and directly for owner-occupiers in the housing market. Finally bankruptcy costs might be lower for small subcontractors.

There still might be a problem of lack of competition in the contractor market as in M2. If that is the case, developers face competitive pressures to:

- integrate with a non-vertically integrated firm or establish a contracting section within their organization;
- protect against opportunistic market-driven behaviours with painstaking contract;
- gravitate towards direct contracting with speciality contractors.

The required competence of the developer in the first scenario is not of great importance unless the developer is permitted to procure projects externally. However, the other two scenarios demand higher developer competence in order to tender, manage, monitor and evaluate the performance of contractors.

From M3 to M4 or M5 organization structure

Developers have no direct contract with subcontractors in the previous forms. Though they are not the real beneficiaries of subcontracting they are still not exempted from any risk from the subcontractor's underperformance. When a frequent developer acts as owner/developer, speciality contractors and developers have the opportunity to work repeatedly and build long-term relationships. Speciality contractors are not only participants in the new projects offered by the developer but also have the opportunity to carry out repair and renovation work in the old projects owned by the same developer. This would imply a reduction of transaction costs for both parties. Learning by doing is a philosophy that the owner/developer can benefit from. Developers may accumulate the skills and experience needed to carry out future projects without the employment of an outside agent.

The situation is somewhat different when the developer is not frequently developing building projects. On the one hand, speciality contractors and the developer may not have fostered a good working relationship. The developer might not have the skills to find the right speciality contractors and coordinate their work. On the other hand, the developer might not want to use the M3 organization structure because of the absence of competition between the main contractors. In this situation, the hiring of a project leader or consultant firm could provide the necessary skills of contracting (this procurement method is also called project management). In this organization model, the

owner/developer's competence and the increased use of subcontracting for risk allocation might not suffice to compete against larger vertically integrated organizations carrying out major projects. Ball *et al.* (2000) state that banks and insurance companies may not be able to monitor contractor performance and thus rely on size as a proxy for competency and solvency. Therefore, larger firms may have an advantage over smaller firms when it comes to financing. The organization models discussed above are not necessarily in sequence but they are given in that order only for the purpose of illustration of changes taking place in organizational modes.

Results

Sixteen municipal companies responded and follow-up interviews with seven of the respondents for further elaboration of their original responses were conducted. The number of units belonging to these municipal companies in 1995 was between 4000 and 23 000 units. Only three municipal companies have built more than 100 units per year during 1995–2000 while the rest of the companies have had either zero production or around 50 units per year. However, things changed during 2001–2006. Most of the municipal companies were active in the construction market where only four of them have built fewer than 50 units per year. There were also noticeable changes in both numbers of employees and project managers but in different directions.

Actual changes in the organizations

Though the sample size is limited, the results suggest that the economic environment affects the organizational structure of municipal housing companies. When companies do not build continuously or build few projects, as was the case during economic downturns, they tend to use consultants and hence lose in-house competence. Seven companies have tried a different type of organization structure for their construction projects while nine companies have used the same organization structure during this 10-year period (see Table 2). Several respondents point out that they employed the M5 type of organization structure to carry out their construction projects when construction activities were low. A few more companies utilized the M2 organization structure instead of M5, when the construction activities recovered and big projects (more than 50 units is considered a big project) were in demand (around 2001). One of the reasons that M2 was chosen is that it has offered them an opportunity to rebuild in-house competence that was lost during economic downturns.

Table 2 Organization structure of municipal housing companies 1995–2006

Municipal companies	Around 1995	Around 2000	Around 2006
1	M2	M5	M5
2	M3	M3	M3
3	M2	M2	M2
4	M3	M3	M5
5	M5	M5	M5
6	M3	M5	M2
7	M2	M2	M2
8	M3	M5	M2
9	M3	M3	M3
10	Other*	Other*	M3
11	M3	M3	M3
12	M3	M5	M2
13	M3	M3	M3
14	M4	M4	M4
15	M4	M4	Other
16	M3	M3	M3

Note: *Other means another possible organization structure such as partnering or there was no construction activity in that specific period.

In spite of some evidence that M2 or M3 was utilized very often with big projects, respondents strongly rejected the statement that M4 and M5 are more appropriate for small and mid-size projects than big projects. While the majority of the companies (nine) reported reduction of their employees, half of the organizations experienced an increase in the number of project managers. The increase in project managers can be connected to the increase of construction activity. The M4 model demands a higher engagement and competence level from project managers. Interestingly, this model is currently the least used organizational structure in the sector and does not seem to be in tandem with the increase in project managers as reported in the survey.

Discussion

In order to ascertain the pattern of organization structures between 1995 and 2006, the three propositions stipulated earlier were formulated as statements in relation to the five organizational models. Integrated organizational structure (M1) seems to reduce the uncertainty of resources since huge resources are handled within the organization but it lacks flexibility to utilize those resources during economic downturns. This model does not demand greater involvement of developers that would necessitate higher competence and puts no

Table 3 Organization structures with related responses of the survey

Organization models	Flexibility	Competition	Competence	Common in the future Agree/Disagree/No opinion
M1	Low	Low	Low	2/10/4
M2	High	Low	High/Low	7/6/3
M3	High	Low	High/Low	7/6/3
M4	High	High	High	9/5/2
M5	High	Low	Low	10/2/4

competitive pressure on any sub-unit since procurement of the project occurs within the organization. Low levels of flexibility, competitive pressure, and required competence of developers can be characterized by the M1 model. As Table 3 also shows, the majority of respondents believe that the ODC model will not be popular in the future.

On the contrary, non-vertically integrated developer models (M2 or M3) seem to offer better production flexibility for the developers and reduction of uncertainty emanating from economic fluctuations. However, these models tend to be associated with low competition since there are few firms of that type in the market who can undertake all the construction activities with in-house resources. The effect of non-vertically integrated models on competence as well as their attractiveness in the future was not conclusive.

Municipal housing companies have been extensively using both M2 and M3 models without differentiating whether a contractor uses his own resources or subcontracts. This also reflects their response about this issue where half of them stated that there is an advantage in terms of increased competition when the main contractor uses more speciality contractors rather than his own personnel. Nevertheless, there are only a few contractors of the M2 and M3 calibre in the market who can undertake big housing projects while still building their own multi-family project (condominiums). Thus, from a competition point of view, both models may face little competitive pressure from the market, which could also explain why respondents view these two models as costlier than other models. Concerning the level of competence that developers maintain or acquire, both models (M2 and M3) tend to promote less engagement of the developers and thus contribute loss of developers' competence levels.

The two other models (M4 and M5) seem to offer great flexibility and risk allocation since both of them are versatile to economic cycles, but their similarity ends there. There are many speciality contractors in the market that could make the M4 model more competitive than the M5. The M4 model may require more engagement from the developer and thus score high on both competition and required competence level. In contrast, the M5 structure may not demand higher involvement or greater responsibility from the developers. However, there are not many suitable consultants in the market to coordinate these speciality contractors when they are undertaking projects on behalf of the owner/developer. This may explain why M5 has scored low in both competition and required competence levels.

Conclusion

A better understanding of the various organizational structure models, and how they relate to the economic and market forces that determine their efficiency could assist in predicting the type of organizational structure that could emerge in the future. Will the dominating position of the big contractors be broken by the use of consultants and speciality contractors? Will the big contractors then respond by being even more active as developers themselves?

The use of transaction cost theory as a tool for exploring different organization structures in the construction sector makes it easier to predict how major actors in the building projects respond to economic and business challenges that are vital for their survival. It may explain why certain organization structures have dominated at some point in time. It helps to reveal forces (competitive pressure, higher level of required competence, greater flexibility, etc.) that make it necessary to bring in another form of organization.

Five main organization models were envisioned to prevail when major actors in the building process are allowed to integrate or separate in response to uncertainty and ever-changing construction business. A more unstable economy causes under-utilization of the resources amassed by the M1 model where the transferability of labour and material from a low to a high demand region is not economical. In this situation, a separate owner/developer and contractor structure with permitted subcontracting practices (model 3) might provide risk reduction and greater flexibility. As

the first proposition states, risk is allocated to those who can handle it better and a new organization mode emerges.

When major actors deal directly with speciality contractors or are subcontracting, it enables them to reduce overhead and construction costs stemming from uncertainties of workload and lack of local knowledge. However, the new model may demand higher engagement and hence higher competence of developers. As the second and third propositions state, the M3 model may answer this lack of competence but it could introduce a limited competition. The use of consultants could rise when developers infrequently undertake projects and thus lack the resources and skills necessary to successfully carry out building projects.

In order to demonstrate the relevance of organization structure in explaining housing construction cost disparities among the regions, it would be of research interest to examine organization structures in the housing sector of other countries that have similar housing policies and markets like Sweden, e.g. Denmark, The Netherlands and Austria. Further issues of interest include partnering and industrialized production of housing and how they fit in with various organization structures.

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Appendix 1

Survey of the organizational change in the residential building sector

Part A: Company details

1. How many apartment units did your company own around 1995? If your organization was not established in that year, please indicate the year and number of apartments.
2. How many apartment units did your company build on average per year between 1995–2000?
3. How many apartment units did your company build on average per year between 2001–2006?
4. Between 1995 and 2006, the number of employees in your organization has: Increased, Decreased, Neither, No Opinion.
5. Between 1995 and 2006, the number of project managers in your organization has: Increased, Decreased, Neither, No Opinion.

Part B: Organization structure and contract type

6. Please check the form of organization structure that best describes the model that most of your projects was procured at that (around) specific time.
7. If there was an organization structure change between 1995 and 2000, what was the main reason for this change?
8. If there was an organization structure change between 2000 and 2006, what was the main reason for this change?
9. In your opinion, which organization model is dominating the market?
10. Concerning the organizational structure that is the most common today, what do you think are: the strong points of this structure and the weak points of this structure.
11. What was the most common method of payment that your organization procured most of the projects between 1995 and 2006? i.e. fixed price, cost reimbursement, etc.
12. Concerning the form of payment that is the most common today, what do you think are: the strong points of this method of payment and the weak points of this method of payment.

Part C

Please check the answer that best reflects the strength of your agreement or disagreement with the following propositions about different organization structures in housing construction sector.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

C1: Concerning the ODC-model (integrated owner developer contractor)

13. The ODC-model reduces uncertainty as everything is handled within the same firm.
14. The ODC-model leads to underutilization of resources in periods with low demand.
15. The ODC-model leads to inefficiencies, as the internal units are not put under competitive pressure.
16. The ODC-model will be common in the future.
17. Is there any other aspect of this model that you think is important to take into account?

C2: Concerning the OD-C and OD-C-SCs models (owner/developer with main contractor with or without subcontracting)

18. The OD-C and OD-C-SCs models make it easier to increase or decrease of the volume of new construction.
19. The OD-C and OD-C-SCs models leads to low competition as there usually only are a small number of main contractors that can take the job.
20. The OD-C and OD-C-SCs models can lead to low quality, as it is difficulty to monitor the contractor.
21. It is difficult to keep enough competence (from developer perspective) in your own organization when you use the OD-C and OD-C-SCs models.
22. The OD-C-model will be common in the future.

Year	ODC	OD-C-Cs	OD-SpCs	OD-Cons-SpCs	Other
Model					
Around 1995					
Around 2000					
Around 2006					

23. The OD-C-SCs model will be common in the future.
24. Is there any other aspect of this model that you think is important to take into account?

C3: Concerning the OD-SpCs model (owner/developer that uses several specialized contractors)

25. An advantage with the OD-SpCs model is that it increases competition because there is a large number of specialized contractors.
26. It is very difficult to use the OD-SpC-model if you do not build frequently as you then do not have the competence and experience to contract and coordinate a large number of specialized contractors.
27. The OD-SpCs model can lead to lower quality as it is less clear who is responsible for what.
28. The OD-SpCs model is more suitable to use for small and mid-size projects rather than large projects that require more resources and financial strength to cope with.
29. The OD-SpCs model will be common in the future.
30. Is there any other aspect of this model that you think is important to take into account?

C4: Concerning the OD-Cons-SpCs model (owner/developer utilizingc to help finding and contracting with specialized contractors)

31. It is most likely to use the OD-Cons-SpC-model than ODC-Spcs model if you do not build frequently as you then do not have the competence and experience to contract and coordinate a large number of specialized contractors.
32. A problem with the OD-Cons-SpCs model is that there are only a small number of qualified consultants in the market.
33. The OD-Cons-SpCs model is a good model when you want to create competition but you do not build frequently.
34. The OD-Cons-SpCs model is more suitable to use for small and mid-size projects rather than large projects that require more resources and financial strength to undertake such projects.
35. The OD-Cons-SpCs model will be common in the future.
36. Is there any other aspect of this model that you think is important to take into account?
37. Is there any other aspect of organization models that you would like to comment or share with us?

Paper 4

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The effect of subsidy on housing construction in various regions of Sweden

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Abstract

Purpose – The purpose of this paper is to explore the extent that interest subsidies have impacted on the total production of Swedish single- and multifamily houses. It also intends to examine whether tenure neutrality provision of interest subsidy that subsidy policy advocates was maintained.

Design/methodology/approach – Using a multiple regression of two models, a balanced panel data from 1975 to 2006 that consist of various related construction cost variables of all regions of Sweden will be analyzed. Instrumental variable (IV) and seemingly unrelated regressions (SUR) will be utilized to examine the role of subsidy on housing production and tenure neutrality, respectively.

Findings – The results seem to indicate that a general subsidy is expected to be ineffective since it may increase the existing stocks of a low demand region but not the housing stocks of big regions where the demand is high. Moreover, a targeted subsidy may change the balance between different types of housings since lower construction costs due to the subsidy could favor the development of certain profitable housing types.

Originality/value – The paper tries to substantiate (empirically) the assertion that subsidy policies contributed both to the production of housing units in low demand regions and distortion of the preference of different tenures.

Keywords Sweden, Housing, Construction industry, Government policy

Paper type Research paper

1. Introduction

Housing production, whether is for consumption as a normal good such, i.e. renting or as investment for future income and wealth accumulation, plays a major role in the economic welfare of households and the overall development of the housing policies in many countries. It has been estimated that households in most of European Union (EU) countries spend approximately one quarter of their budget in housing expenses (Housing Statistics, 2005/2006) and Sweden has the highest figure of housing expenditure (28 percent) in Europe. This high expenditure on housing, coupled with the Swedish Government objectives for high-quality housing standards and all-inclusive affordable housing units might have stimulated the implementation of most (if not all) of the common housing policies designed to achieve various social policy objectives in the housing sector in developed countries (van Der Heijden and Haffner, 2000; Kemeny, 2001). Housing policies that range from rent regulation and family income support allowances to indirect control of housing markets through publically owned entities and various fiscal incentives has been common in the EU (Housing Statistics, 2005/2006). Turner and Whitehead (2002) and Berg and Berger (2006) noted that Sweden, especially during 1990s, used housing policies that emphasized interest rate subsidies to

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investment and income related benefits as well as low risk to financiers, investors and household without distorting neutrality between tenures. They pointed out that interest subsidies for new rental buildings and for new owner-occupied buildings as well as property tax for owner-occupied buildings were among the policies implemented by the government.

In the housing literature, numerous discussions and debates have been raised about the effect of subsidies between owner-occupied and rental housing, between urban and inner-city dwellers, between low-income households and middle-income households, and between communities and regions (Rosen, 1985). One of the policies that the Swedish Government implemented in the past is the subsidization of housing production. Two issues that are often raised in the housing subsidy discussions are the efficiency and the impartiality of resource allocation of the subsidy system (Haffner and Oxley, 1999). The former concerns whether housing subsidies in general or the type of subsidy produced the desired outcome. The latter concerns whether the chosen subsidy policy provided equal opportunity for different property types without causing distortions in the housing market. Apgar (1990) contends that under subsidized construction programs, housing units may be built in depressed regions or construction may take place during the business cycle when construction costs are high relative to market rents.

In Sweden, there are assertions that there was overbuilding in small regions with low demand of housing and shortage of housing in big regions where demand was higher. Thus, it is a matter of interest to investigate if the subsidy policies, especially the interest subsidies, contributed this imbalance between regions. Furthermore, in order to maintain the balance between different property types when subsidy programs are implemented, a tenure neutrality provision is emphasized provided that other demand and supply shifters of housing production remain the same level as before that policy is introduced. Haffner (2003) refers to Kemney's book that states "tenure neutrality is based on the principle that governments should balance subsidies between tenures and maximizes comparability between the social-legal status of households in different tenures". However, subsidy policies are not in line with the tenure neutrality ethos that politicians advocated (Tuner and Whitehead, 2002). Lindh and Malmberg (2008) noted that a gradual withdrawal of interest subsidies for housing and an introduction of property taxes on own homes increased user costs and caused a fall of residential construction stocks. The change of housing subsidies and tax system at the beginning of the 1990s, among other things, were expected to affect the market mechanism in the previous period (Berg and Berger, 2006). Land costs, financing alternatives and different regulatory systems between tenures as well as house prices may diminish the efficacy of subsidy in terms of upholding the tenure neutrality provision. The aim of this paper is to explore finding an answer to the following two questions:

(1) From efficiency perspective: did the housing interest subsidy increase the production of housing stocks?

(2) From tenure neutrality perspective: did the housing interest subsidy cause distortion among different tenures of properties in terms of preference?

The rest of the paper is organized as follows: in Section 2 contains a brief literature review of issues related to the subsidy and what variables are relevant explaining housing productions in general. Section 3 explains the theoretical model underpinning our study

while Section 4 describes the empirical strategy of our models and how we selected them. Section 5 contains the data description, assumptions and analyses of the empirical results. Finally, Section 6 contains conclusions and further research suggestions.

2. Literature review

Most of the literature in housing supply consider price and other cost shifters as the main determinants of new housing supply and often the focus is to estimate the price elasticity of supply. Wigren and Wilhelmsson (2007) noted two approaches to estimate the relationship between housing supply and its determinants; estimation of housing stocks in levels and estimation of reduced forms. DiPasquale (1999) summarized various reduced forms from previous studies in the housing supply. He stressed that empirical studies on housing supply suffer poor performance of various measures of construction costs. In their study, Gyourko and Saiz (2006) used key drivers of construction cost variables such as local wages, unionization, topography and regulation in order to explain the heterogeneity in the cost of building across America. Though interest subsidy is not one of the direct input factors in the construction or production costs its affect on costs and housing stocks has not been rigorously examined.

Governments around the world utilize various types of subsidies in order to counter problems of housing shortages and affordability concerns. Reduced interest rate or alternative investments of construction loans are examples of subsidy policies on the supply side that are intended to offset high construction costs and thus boost the housing stocks. Vouchers and direct financial aid for low-income households belong to the demand side of the subsidy policies. Each of the aforementioned subsidy policies is associated with positive and negatives outcomes depending on the point of view from the different stake holders affected by that specific policy. As Haffner and Oxley (1999) pointed out, some common underlying objectives of subsidy programs are:

- influencing the behavior of suppliers or demanders;
- keeping prices and costs low or stable; and
- facilitating a transfer from taxpayers to the producers or consumers of certain good.

Murry (1999) and Gyourko (2008) argue that subsidies for newly constructed housing do not produce net additions to a nation's housing stocks because the effect of subsidized starts is often offset by the displacement of unsubsidized starts. In other words, subsidized housing for one property type may reduce the demand for another type of housing or simply lead to increases in removal of least desirable dwelling from the housing stock (crowding-out). This phenomenon could create a distortion in the housing market and could hamper the typical filtering process where dwelling with different levels of quality are expected to be transferred in the hands of various income groups.

Cost effectiveness of alternative subsidy programs are debated in many housing literature. The appropriateness of demand-side or supply-side subsidy program depends on the nature and extent of program induced price and rental levels of different tenures (Apgar, 1990). Apgar (1990) emphasis the best policy must balance competing goals of expanding the ability of participating low-income households while limiting negative externality effects that such policy could impose other housing types. Donner (2005) states that a general welfare policy intended to provide every household with modern and good standard dwelling played an important role in Swedish housing policy. The construction of the large housing stocks through the "Million Homes

Programme" and the demolishing of older residential buildings as well as the creation of municipal housing companies that are in charge of the huge stocks of rental residential buildings were part of that policy. These dwellings are open to all households regardless of their income rather than only disadvantaged groups.

Figure 1 shows the imbalance of multifamily housing production between regions was evident in early 1990s where the production of multifamily housing per capita was the highest in southern and middle regions. The production of multifamily houses increased rapidly during 1985-1993 (ESO-Report, Dr 2002:9). The amount of buildings in Stockholm region was constant whilst the production more than doubled in the rest of Sweden. The report states that municipalities with fewer than 30,000 inhabitants had the highest amount of production of multifamily houses. The increase of the production was influenced by the deregulation of the finance market in 1985. That gave developers an opportunity to get easy credits and incentive to build even at places that did not have any demand (Dr 2002:9). Migration from smaller towns to the three metropolitan regions (Stockholm, Göterborg and Malmö) also created an imbalance of housing demands and vacancy levels among the regions (Donner, 2005).

From the perspective of the situation described above, a general subsidy policy would not be the optimal policy but a targeted policy is preferred instead. Turner and Whitehead (2002) summarize the changes in Swedish housing policy in 1990 where various types of subsidies were implemented; subsidy for all new building, significant tax benefits, and social-sector rents. They mention that reduction and restriction of housing subsidies started in 1992 when the Dannel Commission proposed a system to phase out interest subsidies on new construction by 1998. However, all financial subsidies have been wiped out 2000 (Berg and Berger, 2006) though non-financial subsidies such as rental control (now it is called rent-setting) and housing support for low-income households are still in place. Interest deduction from mortgage payments of owner-occupied housing is considered as one of the subsidy policies that intend to

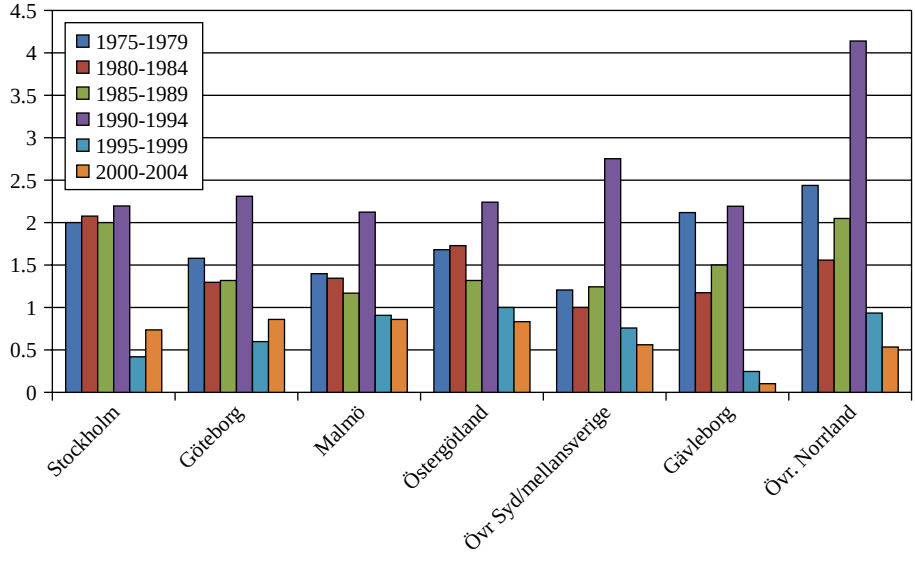

Figure 1.
Average production of multifamily houses per capita (10,000 inhabitants) during 1975-2004

reduce cost of housing (Rosen, 1985) and it is still in place. However, the total effect of owner-occupied interest subsidies were linked with the condition of tax deductions in order to ensure that its total effect should be neutral in relation to other types of tenure (Donner, 2005).

3. The theoretical model

Housing subsidy programs could have several goals and increasing total housing production is one of them (Swan, 1973). The following models try to explore whether the various types of subsidy policies implemented in Sweden for the last four decades (1975-2004) had a positive impact on the total housing production in different regions. Later we will look into models that investigate changes in the tenure neutrality provisions but first we present the theoretical models underpinning our empirical models. These theoretical models are adapted from Wigren and Wilhelmsson (2007) model of housing stock changes. A housing market in long run equilibrium can be described as:

$$Q_t^D = Q_t^S \tag{1}$$

where Q^S is equal to supplied quantity and Q^D is equal to demanded quantity. Subscript t is equal to time period t:

$$Q_t^D = \alpha_0 - \alpha_1 P_t + \alpha_2 X_{1t} - \alpha_3 X_{2t} \tag{2a}$$

$$Q_t^S = \beta_0 + \beta_1 P_t - \beta_2 Z_{1t} + \beta_3 Z_{2t} \tag{2b}$$

where P is equal to price, X_1 is equal to other positive demand determinants (such as disposable income and population) and X_2 is equal to negative determinants such as property taxes, Z_1 is equal to negative supply determinants (such as construction cost and land cost) and Z_2 represents positive determinants such as interest subsidies. Instead of analyzing the relationship in equations (2) and (3), a reduced form can be analyzed based on the equilibrium condition in equation (1). In equilibrium, the quantity demanded is equal to quantity supplied and solving Q^* as equilibrium quantity we will obtain equation (3):

$$Q^* = \delta_0 + \delta_1 X_{1t} - \delta_2 X_{2t} - \delta_3 Z_{1t} + \delta_4 Z_{2t} \tag{3}$$

where:

$$\delta_0 = \frac{1}{\alpha_1 + \beta_1}\left(\frac{\alpha_0}{\alpha_1} + \frac{\beta_0}{\beta_1}\right); \quad \delta_1 = \frac{\alpha_2}{\alpha_1(\alpha_1 + \beta_1)}; \quad \delta_2 = \frac{\alpha_3}{\alpha_1(\alpha_1 + \beta_1)};$$

$$\delta_3 = \frac{\beta_2}{\beta_1(\alpha_1 + \beta_1)} \; and \; \delta_4 = \frac{\beta_3}{\beta_1(\alpha_1 + \beta_1)}$$

Inclusion of housing stocks in the estimation serves to pick up any systematic depreciation patterns (Swan, 1973). Construction (C) is defined as the change in housing stock and can be hypothesized to be equal to:

$$C_t = \lambda(Q_t^* - Q_{t-1}) \tag{4}$$

where λ is equal to an adjustment process (DiPasquale and Wheaton, 1994), which allows for disequilibrium in the short run. Combining equations (3) and (4) gives:

$$C_t = \lambda\delta_0 + \lambda\delta_1 X_{1t} - \lambda\delta_2 X_{2t} - \lambda\delta_3 Z_{1t} + \lambda\delta_4 Z_{2t} - \lambda Q_{t-1} \quad (5)$$

All our estimations of construction stocks for big, growing and contracting regions will be based on equation (5).

4. Empirical models

4.1 Empirical strategy

In this study, a panel data set is utilized. It is fully balanced and consists of six cross-sections and 120 periods. As we have more periods than cross-sections we are more concerned of serial correlation and non-stationarity than of heteroscedasticity and cross-sectional correlation. However, cluster-robust standard errors are estimated in order to relax the assumption about independent and identically distributed errors across cross-sections (Cameron and Trivedi, 2010).

Before the specification of any economic model involving time-series data it is prudent to determine whether the variables in question are stationary or non-stationary. Our empirical analysis starts by testing the variables for unit root, that is, non-stationarity. We have used Levin *et al.* (2002) test when the variable has both a between and a within variation and Dickey-Fuller test when only within variation can be observed. A drawback of the Levin-Lin-Chu test is the assumption that all panels have the same autoregressive parameter. Im *et al.* (2003) relax that assumption. Hence, we have also utilized this test. If a unit root cannot be rejected, the variables are tested whether they are co-integrated or not with the Levin-Lin-Chu and Im-Pesaran-Shin test. A unit root test of all the variables was conducted and it was found that all of them are non-stationary. All the tests show that the residuals from the estimate models with non-stationary variables are stationary (see the Appendix, Table AI-AIII), that is the variables are cointegrated (Granger, 1981).

The first benchmark model estimated is a static model. The model is tested for serial correlation (Drukker, 2003; Wooldridge, 2002). If serial correlation is detected, an autoregressive, AR (4), is included in the empirical model. The next step is to analyze if a dynamic model fits the data better. It is reasonable to argue that some lags between the dependent variable and the independent variables exist. However, the theory fails to give a suggestion about optimal lag structure. We have used a grid search methodology where we have chosen the model that minimizes the root square mean errors.

Based on the above theoretical strategy, three sets of models were estimated using equation (6) (Table II). The first model is a simple pooled ordinary least square (OLS) model. The next models tests instead whether fixed or random effect models are more efficient than the pooled OLS. Both these models estimate individual regional effects. The fixed effect model allows that the individual effect to be correlated with the independent variables, but the random effect model assumes that the individual regional effect is purely random and, therefore, uncorrelated with the other independent variables, that is, a stronger exogeneity assumption. Hence, the choice about fixed effects or random effects is fundamentally whether the individual idiosyncratic regional effects are correlated with the dependent variables or not. If the effects are purely random, the estimates should be identical, because both are consistent (Cameron and Trivedi, 2010). We have used Hausman (1978) test in order to

test whether the individual effects are random. A rejection of the null hypothesis indicates that the fixed effect is the preferred model.

However, we suspect that we have a more severe problem with endogeneity as production and production cost is a simultaneous decision. Therefore, we have estimated a model using the instrumental variable (IV) approach. The underlying assumption is that the instrument variables are all correlated with production cost, but not the stochastic error.

In the static and all the dynamic models, we implicitly assume that all correlations are constant across regions and over time. This may of course, not be true. We relax this assumption by classifying the regions into three different types (metropolitan regions, growing and contracting region) and estimate the correlations in each type. Growing and contracting regions are defined by the overall change in population over the period. We also estimate two different models before and after 1995 (the year when the subsidized interest were the highest) in order to investigate parameter heterogeneity over time.

4.2 Model for regional housing stocks

To be more concrete, we used reduced form estimation models derived from structural housing demand and supply equations where this kind of model suffice to answer question such as whether subsidy programs produce desirable objectives (Murray, 1999). The construction and production cost[1] variables seem to be endogenous since they might be determined simultaneously with the dependent variable (total production). In order to address this situation, two-stage least square (2SLS) or IV regression was deemed to be appropriate in our model rather than OLS. Murray (2006) ascertains that IV estimator use the elements of IVs and their correlation with the endogenous variable to estimate the coefficients of an equation consistently. The endogenous variable or troublesome explanatory (as described by Murray) requires elements of IVs of that are:

- uncorrelated with the error term;
- correlated with the endogenous variable; and
- not explanatory in the original equation.

In our case, unemployment rate is found to meet the three above conditions and thus is used as instruments for the construction cost variable. A rule of thumb that many researchers rely on for selection of instruments is the size of the F-statistics of the first-stage regression (Baum, 2006) and the F-value of our first-stage estimation is significant.

Equation (6) is the full model equation where the excluded instrument and instrumented variable as well as the remaining exogenous variable (included instruments) are combined. All the variables are logged in order to interpret their changes as elasticity. We assume also that housing construction takes time and thus warrants at least a lag of one year for all the explanatory variables in the model. Since big regions are expected to have more population, income was divided with population in order to adjust the household and regional size differences:

$$\begin{aligned}\ln(TP_{it}) = {} & \beta_0 + \beta_1 \ln(PC_{it}) + \beta_2 \ln(Inccap_{it}) + \beta_3 \ln(Stockcap_{it}) + \beta_4 \ln(Sub_t) \\ & + \beta_5 \ln(VAT_{it}) + \beta_6 \ln(Interest_{it}) + \beta_7 \ln(Pop_{it}) + \beta_8 \ln[AR(4)] + \mu_{it}\end{aligned} \tag{6}$$

The above reduced form model (6) contains variables that belong to both the demand and supply side. From the demand side we have considered income per capita, cost of capital and population and from the supply side of the housing market we included production cost level, taxes for construction material, interest rate and total stock per capita. In order to reduce the problem of serial correlation one-year lag of the total production is included in the model. Since the subsidy system was mainly directed towards production (Boverket, 2005), interest subsidies are considered to influence the cost of housing and thus are included in the supply side.

4.3 Model for tenure neutrality provision

In order to learn more about the impact of interest subsidy on tenure neutrality provision we utilized a three-stage least square (or seemingly unrelated regression – SUR) models that would allow us to find any systematic differences between the total production of multifamily and single houses. The SUR model developed by Zellner (1962) is useful for analyzing a system of multiple equations with suspected correlated error terms. Thus, two or more equations are estimated jointly in order to allow cross-equation restrictions to be tested and to gain efficiency (Baum, 2006). We have used same variables as our model for regional housing production except that we know concentrate the differences between the productions of multifamily houses and single-family house in both metropolitan and other regions. The variation of total production of multifamily units of each region and the related explanatory variables will be compared with the total production of single-family houses in that region.

Knowing that some of our explanatory variables such as production cost are decided simultaneously with the dependent variable, first we estimated the regression between the endogenous variable and its instrument. That is the average production cost regressed against the unemployment rate, interest rate, and taxes for construction materials. Then we predicted the fitted value of that regression and included in our SUR model. In other words, the predicted value of average production costs is included in the equation of the second stage where the total production of multifamily and single houses are the dependent variable and income, stock per capita, subsidies, population and so one are independent variables.

5. Empirical results

5.1 The data

Our balanced quarterly panel data from 1975 to 2004 covers six regions of Sweden, capturing the whole of Sweden. Sweden has 290 municipalities divided into 72 FA-regions (functional regions). The regions in this report are built on those functional regions, divided into three main groups based on the population changes from 1975 to 2004 (see population changes in Table I). Table I describes the variables that are considered in our analysis of housing production and their respected units as well as the average value of these variables. The original data contained nominal construction cost figures and income per capita. Factor price indices and consumer price index (CPI) were used to calculate the production cost figures and income per capita in real terms, respectively.

Total production is the sum of all the production of property types. Production cost comprises the sum of construction costs and cost of land as well as a markup for developer and the profit for the developers. On average, 130,000 more units of multifamily houses were produced in the three metropolitan regions than small regions

Table I.
Data description

Variable	Definition	Unit	Big regions (average)	Growing regions (average)	Contracting region (average)	Non-stationary test[a]
TP-mf	Total production multifamily houses	Units	716.969	733.854	583.333	I(1)
TP-sf	Total production single-family houses	Units	619.131	928.742	619.083	I(1)
PC-mf	Real production cost[b] multifamily houses	SEK/m^2	2,641.299	2,346.185	2,316.941	I(1)
PC-sf	Real production cost single-family houses	SEK/m^2	2,252.352	2,132.920	2,050.160	I(1)
Inccap	Real income per capita	SEK/person	386.083	363.675	352.976	I(1)
Stockcap	Stock per capita	Units/person	0.454	0.480	0.455	I(1)
Sub	Interest subsidy	Percentage	5.062	5.062	5.062	I(1)
VAT	Construction taxes for single- and multifamily houses	Percentage	0.105	0.105	0.105	I(1)
Interest	Interest rate	Percentage	0.065	0.065	0.065	I(1)
Pop	Population	Number	1,291,422	1,742,087	904,995	I(2)
Δ Pop	Population change between 1975 and 2004	Percentage	0.207	0.030	−0.025	

Notes: [a]Non-stationarity tests were conducted through Levin-Lin-Chu, Im-Pesaran-Shin and Augmented Dickey-Fuller test; [b]CPI and factor price indices were used as a deflator for income per capita and production cost figures, respectively

each year during the study period while there was no significant difference in the production of single houses between the two types of regions. Similarly, significant real production costs differences exist only between multifamily houses (about 300 SEK/m^2). Growing regions have slightly higher stock per capita than metropolitan regions. Interest subsidies and unemployment rates were the same level for both regions. Metropolitan regions are more populated than small and medium regions and also experienced higher income per capita. The first year's subsidy is the difference between the market and interest rate subsidy. The subsidy interest rate is determined by the National Board for Housing, Building and Planning. For each project, the rate is fixed for five years, after which time the interest subsidy is changed according to the prevailing rate at that time (OECD Report: Economic Survey of Sweden, 2007). Construction material taxes (VAT) for multifamily and single-family houses are almost same level for all the regions and are paid by either the seller (contractor) or the buyer (developer). Two year bond is considered to represent the market interest rate.

5.2 The empirical results

In Table II, the benchmark models are presented. We start with the simple pooled OLS and continue with different dynamic models with and without individual regional effects (fixed and random). Later, the fixed effect models are estimated as a 2SLS (instrument variables) model and, finally, as an autoregressive (AR4) model in order to control for serial correlation. In all models, we reject the null hypothesis that the error contains a unit root, that is, the variables are co-integrated and we can estimate the models in levels.

Around 76 percent of the variation in housing production across regions and over time can be explained by the static model. However, the results indicate that a dynamic model explains the model better than the static version. The results indicate that the lag structure is around eight quarters for production cost, income per capita and housing stock per capita. However, VAT have a lag structure of 16 quarters. On the other hand, subsidies and interest rate have a more instantaneous effect. A pooled OLS is an appropriate and consistent model if the random effect model is the appropriate model. On the other hand, if the fixed effect model is the suitable model, pooled OLS is inappropriate (Cameron and Trivedi, 2010). Our Hausman test strongly rejects the null hypothesis that random effect provides consistent estimates. Even if the fixed effect model supports a weak form of endogeneity, we have used an IV approach in order to remedy the problem. Moreover, as the Wooldridge (2002) test strongly rejects the null hypothesis of no serial correlation; we estimate an autoregressive (AR) model with a lag of four quarters.

Most of the estimated coefficients in the dynamic fixed instrument variable models (FEIV and FEIVAR) suggest that the signs are in accordance with economic theory. Furthermore, all the variables are statistically significant at the 5 percent level in the dynamic IV models. Production cost is expected to have an inverse effect on total production of housing and our model predicts that a 1 percent increase of production costs will cause about 0.5 percent reduction of total housing production. Moreover, the high housing stock per capita is supposed to have a negative effect on housing production according to our model. The total stock per capita variable has the largest coefficient in our model and predicts that a 1 percent increase of this variable causes 3 percent decrease of the total production. Observe that a 1 percent increase in the

Table II.
Static and dynamic models of OLS, fixed and random effect models with IV and autoregressive

Variable	Static OLS	Dynamic FE	Dynamic RE	Dynamic FEIV	Dynamic FEIVAR
PC	0.198 (1.61)	0.576 (2.26)	0.309 (1.49)	−0.511 (−3.44)	−0.649 (−5.68)
Inccap	1.540 (3.43)	1.969 (3.70)	1.583 (3.43)	2.537 (5.06)	2.093 (4.51)
Stockcap	−4.325 (−4.20)	−12.443 (−7.40)	−4.811 (−4.36)	−5.742 (−6.96)	−3.236 (−3.67)
Sub	0.245 (1.72)	0.297 (2.36)	0.175 (1.18)	0.354 (3.47)	0.162 (1.85)
VAT	0.076 (1.01)	−0.621 (−16.39)	−0.789 (−13.90)	−0.682 (−18.96)	−0.403 (−9.12)
Interest	0.773 (4.30)	−0.117 (−0.76)	0.134 (0.86)	−0.383 (−2.44)	−0.273 (−1.75)
Pop	0.891 (12.92)	−1.910 (−1.28)	0.898 (12.51)	3.748 (5.50)	2.527 (2.36)
AR (4)	–	–	–	–	0.369 (4.23)
Cons	−17.62 (−6.83)	4.642 (0.23)	−23.40 (−9.63)	−63.586 (−6.39)	−42.019 (−2.73)
Observations	720	624	624	624	624
R^2	0.76	0.81	0.98	0.99	0.99
Wooldridge	0.0367	–	–	–	–
Hausman-test	–	–	0.0005	–	0.0081

Notes: Dependent variable is TP (total production of both single- and multifamily houses); white heteroscedactictiy-robust *t*-statistics within brackets. Co-integration test with Levin-Lin-Chu and Im-Pesaran-Shin unit-root tests of all the above six models conclusively rejects the null hypothesis that panels contain unit roots

average housing stock per capita is equal to around 1,000 apartments in a city of the size 250,000 inhabitants, that is, a substantial change. The variables VAT and interest rate have a negative impact on the total production of houses.

On the positive side, increase of population, income per capita and interest subsidies may encourage the production of more housing units. The first two variables stimulate the demand side of housing production while the subsidy lessens the costs of supplying additional houses into the market. A 1 percent increase of income per capita could cause total production to increase around 2 percent. An increase of population seems to cause a large proportional increase of total production of housing units. A study in metropolitan USA data between 1970 and 2000, Glaeser *et al.* (2006) found a perfect relationship (estimated coefficient close to one) between the population and housing stocks. Our variable of main concern shows a weak positive relationship with production in the autoregressive model and a stronger connection in the FEIV-model. A 1 percent increase of interest subsidy may increase the housing production by 0.16 and 0.35 percent, respectively.

5.2.1 Testing for parameter heterogeneity. By imposing regional dummies and time constrains, we have tested the variation and significance of these variables on the three metropolitan regions and other regions. Table III summarizes the outcome of five models.

The first model (All) is the unconstrained model with all the regions and the whole study period of 1975-2004. The next three models (Big, Grow and Con) are intended to test whether the regions (big, growing, and contracting) have experienced different level of interest subsidy contribution of housing stocks. Turner (1996) claims that withdrawal of housing subsidies and economic recessions dropped the volume of new housing construction during 1992-1993 and it continued to reach an all-time low of approximately 12,000 units in 1995. In order to check the impact of interest subsidy on total housing production after the Dannel Commission made their proposal to phasing out subsidy systems, we have selected to use year 1995 since the interest subsidy for single-family houses was at its peak that year. Therefore, the remaining two models (1975-1995 and 1996-2004) are intended to explain the effect of interest subsidy before and after the phased out process started.

Overall, we can reject the assumption about parameter homogeneity. Hence, most of the estimated parameters change in space and slightly less over time. Interest subsidy and real income per capita seem to have influence on the total housing production in all the regions. The interest subsidy is statistically significant in almost all the models, but it has a larger coefficient in contracting regions. Hence, a 1 percent increase in the subsidized interest rate has a much higher impact on production in contracting regions where demand is weak. A 1 percent increase of interest subsidy is associated with 0.19-1.16 percent increase of the total housing production on growing and contracting regions, respectively. The interest rate sensitivity is higher in contracting regions and in the three major metropolitan areas than in the growing regions (where we unexpectedly estimated a positive parameter though statistically insignificant). However, VAT seems to be of less importance in the big regions. The estimated coefficient of real income per capita is larger in the growing and contracting regions compare to big regions. A 1 percent increase of real income per capita in big regions correspond to 1.5 percent increase of total production, while the same percentage increase of real income could cause just over 4 percent of total housing production in contracting regions. Total stock per capita has the biggest estimated coefficient and is statistically significant only in big

Table III.
Parameter heterogeneity

Variable	All	Big	Space Grow	Con	Time 1975-1995	1996-2004
PC	−0.649 (−5.68)	−0.445 (−3.07)	−0.725 (−9.60)	−0.406 (−0.99)	−0.404 (−3.33)	−0.123 (−2.82)
Inccap	2.093 (4.51)	1.496 (3.15)	3.296 (13.11)	4.193 (5.28)	1.626 (3.34)	1.736 (2.06)
Stockcap	−3.236 (−3.67)	−5.245 (−3.15)	−1.954 (−1.13)	−10.405 (−2.33)	−1.417 (−1.34)	−1.488 (−0.31)
Sub	0.162 (1.85)	0.121 (1.95)	0.191 (1.94)	1.164 (3.91)	0.759 (10.01)	0.216 (1.18)
VAT	−0.403 (−9.12)	−0.253 (−6.60)	−0.414 (−6.36)	−0.395 (−1.64)	−0.282 (−4.66)	−62.568 (−0.64)
Interest	−0.273 (−1.75)	−0.534 (−3.36)	0.053 (1.58)	−1.269 (−2.93)	−0.333 (−1.82)	−0.356 (−1.10)
Pop	2.527 (2.36)	−1.757 (−2.37)	0.137 (0.11)	−9.201 (−1.00)	0.817 (0.55)	9.219 (1.53)
AR (4)	0.369 (4.23)	0.526 (6.52)	0.247 (1.92)	0.074 (0.68)	0.456 (5.44)	0.182 (2.62)
Cons	−42.019 (−2.73)	16.445 (1.69)	−12.371 (−0.84)	96.688 (0.81)	−17.780 (−0.92)	−247.203 (−1.06)
Observations	624	312	208	104	408	216
R^2 (within)	0.755	0.683	0.781	0.856	0.649	0.289

Notes: TP, total production for both multifamily and single houses; *t*-values are in the brackets; All = all regions; Big = big regions; Grow = growing regions; Con = contracting region; dynamic fixed autoregressive IV regressions

and contacting regions. A 1 percent increase of existing stock could induce the reduction of total housing production by 10 percent in contracting regions. The results concerning parameter heterogeneity over time seems to follow an expected pattern. The subsidies were one of the most important determinants in the first period but its importance is zero in the second period. Most of the other parameter estimates are within the same magnitude in the two periods.

5.3 Interest subsidy from tenure neutrality perspective

With regard to our second research question, we utilized, as mentioned above, three-stage regression. We estimated three different models in order to see any noticeable change with respect to subsidy impact on tenure neutrality provision. Table IV indicates that both equations explain the variation of the total production for multifamily and single houses.

Looking closely at the magnitude and the significance of estimated coefficients, we can observe a considerable difference between these coefficients with respect to property tenures. The weighted average cost is statistically insignificant and does not contribute in explaining the total production of multifamily house in the big regions and in the contracting regions. However, that same variable is statistically significant in the equation of single-family housing production where a 1 percent increase of the weighted average construction cost reduces the total production of single-family houses by 2.5 percent in the aggregate model and 2.6 and 4.6 percent for big and growing regions, respectively.

The variable of concern is the interest subsidy and how it differs between the two tenure choices (multi and single family). The coefficients of all the three multifamily

Variable	All	Big	Grow	Con
Dependent variable TP-mf				
PC-mf	−0.731 (−4.72)	−0.415 (−1.80)	−0.768 (−2.83)	−0.916 (−1.72)
Inccap	1.916 (7.69)	0.884 (2.29)	−3.013 (5.51)	3.793 (3.04)
Stockcap	−1.570 (−2.40)	−6.465 (−1.51)	−0.562 (−0.17)	2.469 (0.46)
Sub (multifamily)	0.778 (8.77)	0.735 (4.50)	1.044 (5.59)	1.112 (3.00)
VAT	−0.265 (−2.98)	−0.469 (−3.59)	−0.161 (−1.06)	−0.209 (−0.75)
Interest	−1.008 (−6.25)	−1.226 (−4.29)	−0.925 (−2.50)	−0.526 (−0.97)
Pop	0.639 (12.41)	1.135 (6.22)	0.897 (7.29)	−2.481 (−0.16)
AR (4)	0.330 (8.04)	0.283 (5.13)	0.122 (1.64)	0.255 (1.66)
Cons	−15.619 (−9.30)	−24.022 (−3.75)	−23.119 (−5.74)	22.773 (0.11)
Dependent variable TP-sf				
PC-sf	−2.492 (−7.71)	−2.668 (−5.78)	−4.645 (−7.74)	0.021 (0.03)
Inccap	1.168 (6.75)	1.217 (4.47)	2.140 (5.46)	3.884 (5.26)
Stockcap	−0.287 (−0.56)	−3.846 (−1.38)	0.380 (0.16)	−5.162 (−1.84)
Sub (single family)	−0.049 (−1.83)	0.007 (0.14)	−0.005 (−0.09)	0.268 (3.18)
VAT	−0.040 (−0.53)	−0.301 (−2.86)	−0.236 (−1.55)	0.184 (1.14)
Interest	0.211 (2.28)	−0.142 (−0.80)	0.196 (0.79)	0.533 (2.08)
Pop	0.212 (5.24)	0.391 (3.31)	0.335 (3.60)	−45.355 (−4.54)
AR (4)	0.790 (21.70)	0.583 (10.72)	0.703 (9.98)	0.732 (8.32)
Cons	11.037 (5.24)	6.315 (1.31)	20.737 (4.91)	598.607 (4.70)
Observations	503	252	167	84
R^2 (multifamily)	0.77	0.70	0.86	0.74
R^2 (single family)	0.92	0.83	0.95	0.96

Table IV. Three-stage regression for multifamily and single-family houses

models are statistically significant where the coefficients of multifamily production in growing and contracting regions are higher than the coefficients in big regions. In the single-family house production equations, on the other hand, the variable subsidized interest rate is only significant in contracting regions. In the single-family equations for the big and growing regions, production cost is more important together with income per capita. Hence, in regions where demand is higher, production cost seems to be of more importance than in regions where demand is weak. In those regions, subsidy seems to promote production and not macroeconomic fundament.

6. Conclusions

Though it is not easy to single out the impact subsidy has on the total housing production, our econometric results indicate that interest subsidy has a positive impact on the total production of housing units and especially multifamily units. Furthermore, it is quite apparent that subsidized interest rate is more important in regions where demand is weak, such as in population contracting regions, than in growing regions. The production cost sensitivity is higher in growing regions than in contracting.

With regard to the production of single- and multifamily houses and whether tenure neutrality provision has been maintained, the estimated coefficients of interest subsidies indicate that this kind of subsidy policy might have encouraged the production of multifamily houses in big regions. Although the existence of a surplus of multifamily housing in small regions coupled with increase of population and shortage of multifamily houses in big regions could cause distortion of tenure production, our result suggest that the interest subsidy stimulated more for the production of multifamily houses since the subsidy could drive down the total production cost of multifamily houses.

Note

1. Construction cost is different than production cost since the latter is included land cost as well as markup for developer and other overhead costs incurred by the developer.

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Appendix

Table AI.
Unit-root test for error correction term – OLS model

Test method	Number of panels and periods	Statistics	*p*-value
Levin-Lin-Chu	6, 120	Unadjusted t −11.1579 Adjusted t^* −3.5923	0.0002
Im-Pesaran-Shin	6, 120	−8.5658	0.0000

Note: LR variance: Bartlett kernel, 15.00 lags average (chosen by LLC)

Table AII.
Unit-root test for error correction term – model with dynamic pooled OLS

Test method	Number of panels and periods	Statistics	*p*-value
Levin-Lin-Chu	6, 104	Unadjusted t −13.6955 Adjusted t^* −10.8351	0.0000
Im-Pesaran-Shin	6, 104	−11.5290	0.0000

Note: LR variance: Bartlett kernel, 15.00 lags average (chosen by LLC)

Table AIII.
Unit-root test for error correction term – model with dynamic, fixed effect, IV and AR (4)

Test method	Number of panels and periods	Statistics	*p*-value
Levin-Lin-Chu	6, 104	Unadjusted t −14.5470 Adjusted t^* −11.3336	0.0000
Im-Pesaran-Shin	6, 104	−12.3883	0.0000

Note: LR variance: Bartlett kernel, 15.00 lags average (chosen by LLC)

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Part 2:

Quality improvement methods for infrastructure transport projects

Paper 5

Quality in infrastructure projects: concept and framework for explanatory and exploratory studies

Author: Abukar Warsame

Abstract

There is a shift from conformance approaches of construction projects to excellence in terms of real performance. One of the major goals of today's project is to achieve the highest level of quality rather than just meet the specified level of quality. In Sweden, approximately 25 years ago, major construction contractors replaced the traditional client/owner control system of public finance construction projects with quality assurance systems managed by the contractors themselves. Anecdotal evidence exist that shows that the quality of infrastructure projects may not be as high as before due to many different reasons, including low productivity and incentive problems. However, thorough formal investigations that evaluate the effectiveness of the quality assurance transfer have not been carried out.

The main purpose of this paper is to understand the extent and type of quality problems in infrastructure projects as a foundation for studies about what can be done to improve quality. It aims to explore the extent of any perceived quality problems that could be associated with quality assurance transfer. The type of research question issues that this paper intends to address is very complex in terms of describing what constitutes quality and what people remember about projects that they might or might not have been involved in many years ago. This entails the use of different types of research processes and approaches such as realistic research, descriptive and exploratory questionnaire as well as explanatory studies that would not only allow us to ascertain the overall quality level of infrastructure transport projects. However, it also gives us some indication of those specific concerns needed for further investigation.

The results of our survey suggest that there has not been a deterioration of the (relative) quality level of infrastructure projects after the transfer of quality assurance from client to contractor. However, the expectation that the transfer would improve the quality level does not seem to be fully materialized since almost half of the respondents suggest that the quality level remained the same as before the transfer. The lesson drawn from this is that the question of what really happened to quality and why is less important than finding ways to improve quality in the future.

Keywords: Infrastructure projects, quality improvement, quality assurance, quality concepts

1. Introduction

Construction projects result in durable products that last for many years and often require huge investment and a lengthy construction process. Thus, the nature of construction projects entails the involvement of many stakeholders, designers, owners/clients, contractors, subcontractors, and consultants. The term *construction client* could also mean both the owner and the end-user of the facility. The participants of construction projects have different objectives and varying degrees of responsibilities throughout the realization of the project, that is planning and design, construction and operation, and maintenance of the project or infrastructure. Consequently, these stakeholders can be expected to assert different levels of success on the construction project based on their expectations in the stage they are involved (Soetanto et al., 2001).

A project can be considered successful when it is delivered within the specified budget and time, and has met the specified level of functionality. Xiao and Proverbs (2002) stress that the achievement of a low cost and speedy construction period should not compromise the quality of the project since poor quality could lead to extra costs in terms of rework and repair. There are crucial elements that would cause the owner, designers/architects, contractors, and the end-users of the project to be dissatisfied and thus negatively assess project performance. In a study of critical success factors for construction projects, Sanvido et al. (1992) point out that the financial reality of doing business appears to be a common factor for all three participants (owner, designer and contractor) of a project. A common loss for all the stakeholders of a construction project could therefore be the associated cost of quality, which is estimated to be relatively high (more than 15%) in terms of total project cost (Davis et al., 1989; Abdul-Rahman, 1995).

Though quality assessment based on satisfaction or expectations is appealing to construction clients but problematic to ensure (Ward et al., 1991), quality-related issues such as long-term defects and persistent maintenance problems are extremely important success factors for the project owners (Sanvido et al., 1992). Some of the attributes or criteria that clients of a construction project can easily use to assess the project's performance, which are attributable to the level of quality achievement and thus client satisfaction, include the number of defects during construction or operation during the warrant period or shortly after its expiration. The level of response to the client's requests or needs during the construction or operation phase can also be a useful measurement of a client's satisfaction. An unplanned or unexpected increase in administrative overhead costs, as well as an increase in the level of operation and maintenance costs, could indicate poor quality infrastructure.

These attributes are mainly unique to individual projects and are not easily used as a yardstick to define quality of each infrastructure project. Later, in our framework of quality definition, we will further explore the role of a particular client requirement on the expected quality level of the final product.

1.1. Background

Maylor (2005) asserts that there is a shift from conformance approaches of construction projects to excellence in terms of real performance. One of the major goals of today's project is to achieve the highest level of quality rather than just meet the specified level of quality (Maylor, 2005). Winch (2010) describes several quality management systems, referring to total quality management (TQM) as the highest level approach or "the motivation of continuous process improvement to achieve higher and higher levels of conformance to intention". Quality assurance that relies on external accredited procedures is the next level of this TQM. Inspection and quality control routines that rely on physical checks and management control techniques are at the bottom layer of Winch's quality management categorization. These different approaches are not alternatives but complements to each other and each approach can operate independently and satisfactorily from others (Winch, 2010).

In Sweden, approximately 25 years ago, major construction contractors replaced the traditional client/owner control system of public finance construction projects with quality assurance systems managed by the contractors themselves.

It is beyond the scope of this research to ascertain the reasons behind the transfer of quality assurance; however, a question remains: has this change really improved the quality of infrastructure projects? Possible outcomes of this transfer of responsibility of quality control and inspection could be:

1. The quality level before the transfer was better in the past. The deterioration of the quality level could be attributed to the exchange of the control system of quality assurance.

2. After the transfer, the expectation was to improve the quality level at that time but that did not happen.

3. The quality level of current infrastructure projects is higher than those built before the transfer of quality assurance.

Anecdotal evidence exists that shows that the quality of infrastructure projects may not be as high as before due to many different reasons, including low productivity and incentive problems. However, thorough formal investigations that evaluate the effectiveness of the quality assurance transfer have not been carried out.

1.2. Purpose

Quality is the most difficult attribute to measure out of the three often-quoted criteria (iron triangle): cost, time and quality. Although all three are interconnected and the change of one affects the other two, cost and time have gained greater attention than quality because of their perceived ease of assessment. Quality is always difficult to define, lacking of quantifiable measurement. It is often perceived that quality belongs to the agent who is defining it, and the

purpose for using it and the definitions of quality "fit to purpose" may explain that recourse. For instance, elements of a project's quality process in the design and delivery system are most likely visible to owners and/or contractors than to the end-users (Yasamis et al., 2002). Conversely, the end-users' opinions could indicate a certain dissatisfaction of a facility or infrastructure such as roads and highways. Though this dissatisfaction is attributable to the quality level of that specific project, it is not necessarily an indication of non-conformance by the contractor (Liljegren, 2003). It seems that quality and client satisfaction or expectations are treated synonymous in literature that deal with the quality performance assessment and thus contribute to the problem of defining quality with precise terms.

The main purpose of this paper is to understand the extent and type of quality problems in infrastructure projects as a foundation for studies about what can be done to improve quality. It aims to explore the extent of any perceived quality problems that could be associated with quality assurance transfer. It is imperative to have a good grip on the meaning of the word *quality* and its context in construction projects if we want to explore the possible outcomes of the quality assurance transfer. Thus, we intend to synthesize quality concepts and definitions in order to establish a conceptual framework for quality in infrastructure projects. We also put forward several propositions and possible explanations that are intended to discern the reasons behind any perceived low quality of infrastructure projects. These propositions are further analyzed in forthcoming papers.

2. Method

The type of research question issues that this paper intends to address is very complex in terms of describing what constitutes quality and what people remember about projects that they might or might not have been involved in many years ago. This entails the use of different types of research processes and approaches such as realistic research, descriptive, exploratory, and explanatory studies that would not only allow us to ascertain the overall quality level of infrastructure transport projects. However, it also gives us some indication of those specific concerns needed for further investigation.

The first issue that must be dealt with is finding a common understanding of the quality characteristics of construction projects that is not confined to a single part of a project or specific project, but is broad enough to capture main factors that could be attributed to low quality. (We will explain the subjective nature of quality level later.)

Fisher (2007) pointed out that realistic research is one of the preferred research methodologies, explaining that the acquired knowledge tends to give good indications of what should be done. The realistic research approach acknowledges the argument over the definition of what constitutes a thing or attribute such as quality, but this does not prevent him from believing in the existence of quality, which can be defined and measured (Fisher, 2007). Quality problems will be structured by breaking them into relevant constituent parts—from the inception phase to the realization of the project and to the operation phase. Realist researchers try to establish a relationship between these parts to form a testable hypothesis in

order to find patterns and associations that would not only explain the current situation but would lead to a feasible solution for quality deficiency. Following the above approach, quality concerns of infrastructure projects will be broken down into:

a) attributes that are definable and easily measurable; and

b) attributes that seem to be difficult to quantify or measure but are generally categorized to be part of quality domain.

Second, after a thorough review of concepts and various definitions of quality, we put forward several propositions and an explanatory framework that are intended to elucidate various possible outcomes of quality levels. These propositions could be useful in explaining what could have led to an undesirable quality level and at what stage of the construction process quality problems are mostly associated with. Hence, propositions and related explanations based on the literature review were very instrumental in constructing relevant questions for the survey.

Third, with the use of a survey we try to establish the extent of quality problems in the current infrastructure projects. From the results of the survey, we can also contemplate plausible causes and explanations for shortcomings of quality of infrastructure projects. The following figure (Figure 1) illustrates the three main parts of our conceptual framework, and we will discuss each part in more detail in subsequent sections.

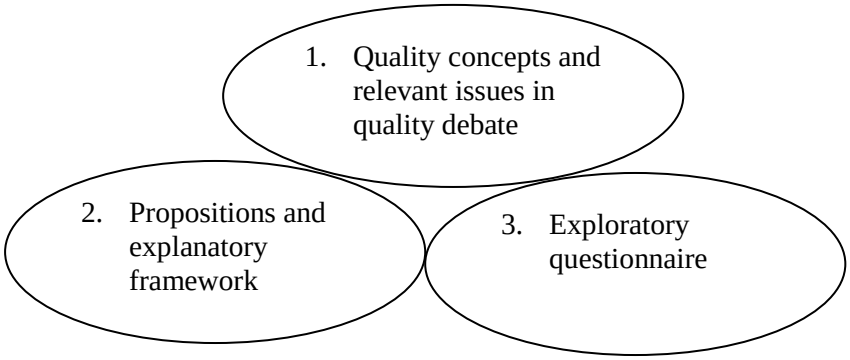

Figure 1: Conceptual research framework.

After a pilot survey with a number of practitioners and academics in the field of construction, an online questionnaire (see Appendix) was sent to 128 selected respondents (45, 35, 37, and 11 from contractors, clients, consultants, and regional traffic offices respectively). A 52% response rate (67 respondents) was achieved. The composition of respondents was intended to ensure a fair representation of different stakeholders of construction projects that would allow us to ascertain the extent of quality concerns in the sector. Through our reference group and major construction organization websites, as well as professional associations' websites, we have determined the appropriate persons in each organization that could answer our questionnaire.

Questions from the survey, except those related to the respondent's personal information such as titles, affiliated organization, experience, were designed to capture the relevance of certain

attributes or situations for the quality of infrastructure transport projects. Considering the fact that our survey solicits past information about quality and respondents' memories, which are imperfect, we choose a mix of open and closed questions, as well as statements, that would enable the respondent to give voluntary accounts of facts and opinions concerning the quality of infrastructure transport projects.

3. The concept of quality

The construction industry has embraced many quality-related concepts that have their origin in the manufacturing industry. The concepts have been tailored to meet the uniqueness of the construction projects and in the process some inevitable ambiguity were introduced. The question of quality definition always suffers some ambiguity, whether it is classical and concise definitions such as "fitness for purpose" and "conformance to requirements", or the broader definitions such as the one British Standards Institution (BSI) produced: "The totality of features and characteristics of a product or services that bear upon its ability to satisfy stated or implied needs". The vagueness of the term *purpose* and what level of tolerance of conformity one may expect, as well as what are the implied needs of the client, signifies the challenges in finding an all-in-one quality definition. Reeves and Bedner (1994) summarize the strengths and weaknesses of various quality concepts. They emphasize how these multiple perspectives that are historically associated with concept of quality have made theoretical and research advances difficult.

3.1 Quality concepts based on the level of measurement

Seymour and Low (1990) argue that no absolute definition of quality exists and each definition tends to be adapted to a certain circumstance. They state that there are two tendencies that push the debate about what constitutes quality. One tendency stresses the technical aspect of quality, where very precise criteria determine the measurement of value and quality. Toakley and Marosszeky (2003) refer to this type of quality as *objective quality* or *conventional project quality* (McConachy, 1996), where it is possible to conform to standards, and sampling and process control are also amenable.

The other tendency emphasizes the need to consider elements such as the divergence of interest of actors in the construction project, and advocates the inclusion of their perspectives rather than relying on an exclusively technical aspect. It stresses the limitation of quantification and the measurement of the quality, explaining that there will always be other important elements of quality that are not easily measurable or quantifiable by nature, but some of their attributes may be possible to measure it. Customer perceptions, evaluation and contractual relations are some of the components of this kind of quality and are often termed as *subjective quality* (Toakley and Marosszeky, 2003) or *contemporary project quality* (McConachy, 1996). Seymour and Low (1990) proposed a framework of quality definition that comprises four orders: technical; occupational; economic; and legal/contractual, which

are intended to balance the exclusive dependency on the technical measure aspect of the objective quality and the less quantifiable subjective quality.

3.2 Quality concepts based on construction project phases

A construction project has some unique characteristics that influence the way quality is defined and how it is assessed. Different phases of the construction process and the involvement of various actors in each phase create several ways in handling quality assessment. Project quality is a team effort that requires the cooperation of all the participants in the project (see Figure 2). From a functional point of view, a high-quality project is one that confirms its requirement in terms of budget and time while encountering a low level of conflicts, ease in understanding drawings, ease of maintenance and operation, life cycle cost (Arditi and Gunaydin, 1997).

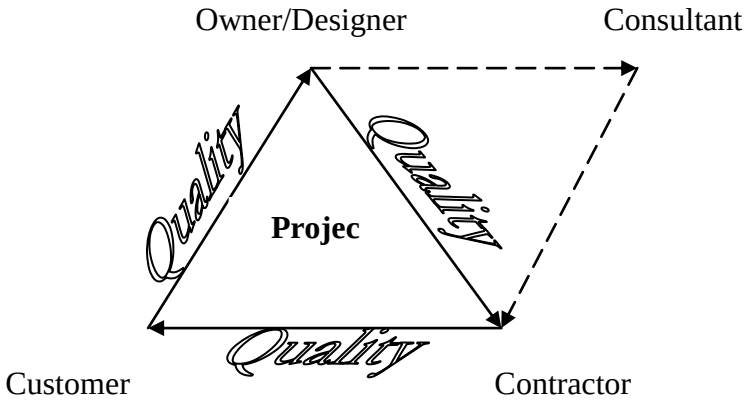

Figure 2: Quality triangle or trapezoid.

Project realization starts with the client/owner defining their objectives and needs to the designer/architect. Lawrence (1990) argues that the first step in producing a quality project is defining the client's needs and expectations. If the owner and the end-user of a project are not the same, as often is the case for the infrastructure project, the expectation of the owner must be matched with the end-user's needs during the design phase (Lawrence, 1990) and translated to project characteristics that will in turn become the requirements of the project. A well-defined characteristic of a product may not meet the expectations of the client if the expectations were not clearly conveyed to those responsible in producing it during the various stages of the project (Foster, 1989). This shows how important it is to consider both the expected quality of the project and the process that produces that final product. Yasamis et al. (2002) separate construction quality into the project and corporate level. Their analysis of quality at the project level focuses on what is termed as *quality product* (the constructed facility as received by the end-user) and *quality service* (contract planning as received by the owner).

Winch et al. (1998) suggest four quality definitions and denote the first of the four as *quality conception*, where the client explains their expectations of the project to the designers. The designers interpret these expectations as requirements of the project and prepare the detailed documents with standards and specifications for tendering purpose. Once the project moves to

the construction phase, other forms of quality definitions such as *quality of specification* and *quality of realization* are introduced. The former emphasizes the technical standards while the latter refers to techniques associated with total quality management (Winch et al., 1998). Finally, *quality of conformance* emphasizes whether the objectives set in the three prior quality measures were met and the manner in which they were implemented.

3.3 Quality concepts based on performance and expectations

One of the challenges in the debate surrounding quality is what level of quality performance is acceptable for a project. Does a minimum requirement set for each dimension of quality help to eliminate the ambiguity over what level is expected of the constructed facility or from the contracting service (Yasamis et al., 2002)? Furthermore, the gain of one participant in the construction process may become the pain of another since each activity related to quality could result in extra costs. For instance, if construction clients are imprecise in their quality expectations and could not define them properly, contractors may view the outcome as a moving goalpost, where any level of quality achievement becomes unattainable. Conversely, a narrow and restricted definition of the level of quality and expectation may encourage contractors to set their goal to meet the minimum requirement of the project rather than to strive to construct a project with superior quality than the client has specified. In a competitive market, contracting firms would not spend more than what is normally required to meet the client's requirements (Abdul-Rahman, 1995).

Customer/client satisfaction is often used as a measurement of quality performance assessment of construction projects, and the level of satisfaction is determined by the gap between client expectations of the specific project and how the client perceives the final product. Bresnen and Haslam (1991) suggest that clients often augment their assessment of performance depending on their baseline expectations. Most of the time project performance is assessed when the construction of the project is completed. This type of end-result assessment could be influenced by the changing business environment, customer preferences, and technological innovations. Public infrastructure projects could take several years to complete, which may cause variations in roles and also adjust objectives and expectations (ASCE, 1988). Thus, these changes are inevitable occurrences that require a broader understanding of how the end-result or final product assessment might differ from one that is based on conforming to the requirement, where a detailed description of what must be done is assessed during the construction project.

Bresnen and Haslam (1991) claim that there could be a relationship between the levels of satisfaction that the client expresses and their previous experience with similar work because familiarity could improve the critical awareness of the client. Clients with experience in related work will likely express a stronger satisfaction with good time and cost performance and a stronger dissatisfaction with poor performance (Bresnen and Haslam, 1991). The client's expectations are much more difficult to quantify than their objectives, specifically because they are usually not formalized and documented to the same degree as the objectives (ASCE, 1998). One of the reasons that expectations might not be explicitly formalized is the client's concern for extra costs due to the expectations of the contract, and thus may opt to

wait until the early phases of the project (ASCE, 1998). Regardless of how the quality is defined or how the expectations are revealed, the needs of the end-user of a project must be transformed to an acceptable level of product quality. A study carried out by Al-Nakeeb et al. (1998) found that the majority of interviewed companies use customer surveys as a measure to assess their quality. This type of quality assessment may be adequate for certain projects with homogeneous customers/end-users and if customers have the necessary expertise to evaluate the specific project. However, infrastructure projects, which often take a long period of time between when an infrastructure project is conceptualized and designed and when it is ready to be used, have many end-users and the feedback often takes time. Thus, a reasonable assessment of quality of a project is very challenging.

Battikha (2003) suggests a slightly different definition than Winch et al. based on quality level scale. Client needs and expectations are at the base of deciding the quality of the project. The higher the standard levels to which the needs/expectations are to conform, the higher the degree of the quality will be (Battikha, 2003). It is expected that clients will be dissatisfied if the gap between what is achieved and what is expected in terms of project performance surpasses some kind of threshold. This type of behavioral-based assessment introduces another set of quality definitions. *Quality in fact* is when the project meets the specifications, and *quality in perception* is when the project meets the client's expectations. A product can be of high quality and yet may not meet the customer's expectation and vice versa.

These various definitions and concepts indicate the challenges that the construction sector is facing and the need to devise comprehensive quality assessment methods that encompass both quantifiable and non-quantifiable aspects of quality that could assist our attempt to improve the performance of construction projects. Figure 3 illustrates one possible way of classifying various types of quality within construction projects. It is a modified construction quality framework similar to the one that Yasamis et al. (2002) propose except that it focuses on a project level quality dimension.

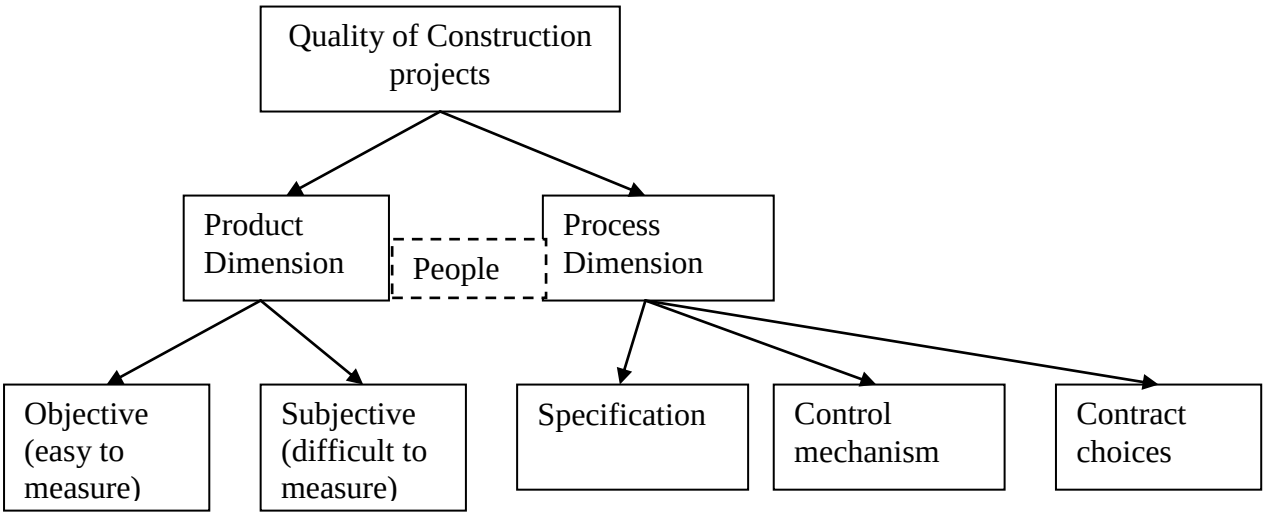

Figure 3: Modified framework to construction quality.

Construction is a project-based industry, and a project is viewed as the outcome of product and the process, as well as the human resource involvement that made the production of the project possible. These two dimensions (product and process) are connected to each other, and there are many interactions and activities that bind them through human involvement. Assessment of any construction project that takes into consideration the performance of the project in terms of these three dimensions is very challenging, and the outcome may not be commonly agreed to by all of the parties involved because of varying interests and expectations. In particular, quality attribute poses the most notable challenge because of its subjective nature and it is difficult to measure.

4. Propositions and explanatory framework

4.1 Our quality framework

We will first try to discuss when a quality can be considered absolute or relative and then explain some quality attributes of infrastructure projects. A quality attribute will be considered as a factor of an **absolute** infrastructure quality if we can establish a fixed set of criteria that conforms to high industry standards and at the same time is not dependent on client specifics. A road that has high absolute quality is a road that "everyone" can agree is a very good road given generally agreed quality criteria. Looking at another market, we could say that an expensive BMW or Lexus are cars with very high absolute quality. High absolute quality would then mean that needs on all levels are satisfied. Vassallo (2007) suggests that infrastructure quality can be measured through a set of criteria, and he proposes a quality index that reflects gross social benefits.

Relative quality introduces the dimension of budget restrictions and specific preferences of the client. (In this paper the client is the starting point.) A construction client may prefer to procure an infrastructure with certain rather low absolute quality levels because this quality is judged to be reasonable given requirements of how the road is used and the cost for different alternatives.

We might also introduce the concept of **comparative** quality. In this case the quality of one project is compared to the quality of another project. Given that the client has the same demands (procured the same quality levels in various dimensions), the information about comparative quality will give information about relative quality. However, studies about comparative quality can also be used to evaluate relative quality.

However, expectations and needs of clients/customers may change overtime and relative quality would be influenced by these changes. Thus, it is difficult to establish a threshold for infrastructure quality in the long run. A distinction can also be made between **explicit relative quality**, where the evaluation is made in terms of the explicit requirements formulated by the client, and **implicit relative quality**, where the evaluation is made in relation to what the client expected for quality given the amount of money they were willing to spend.

It is not enough to classify the quality attribute based on these absolute and relative connotations; however, we need to look at other dimensions such as measurability of the attributes that would allow us to extend our investigation of the causes of the client's discontent of quality. Clients in the construction industry expect to acquire projects that maximize the value of their investment and meet certain requirements and specifications that satisfy the needs of construction project customers. Schexnayder and Ohren (1997) organize quality characteristic into groups such as strength and durability of the infrastructure, as well as conformance to the desired functional dimensions and environment. A similar grouping as Schexnayder and Ohren's (1997) quality attributes could be useful and is explained below.

- *Strength*: the ability of pavement to resist or handle the external loads. This quality attribute will be designated as objective since the structure such as pavement must have the desired strength to satisfy the general needs of a certain type of end-user for safe and satisfactory performance. In other words, the design of the structure and the bearing load of the pavement can be easily determined once the type of road is decided and the typical end-user is defined. The assumption here is that horizontal structure such as roads, highways and railways entails a certain strength that is considered to be at least the minimum requirement for that kind of infrastructure. Not meeting the minimum required strength of the completed project and associated quality problems may not only pose danger to end-users of the structure, but it also involves rework and extra costs. Barber et al. (2000) mention the extra re-work and cost required when drivers of plant and equipment have prematurely used an area of thin capping surface of ongoing construction road that is not ready to bear heavy weight. The quality attribute in terms of strength can be considered easily quantifiable and amenable compared to many other characteristics.

- *Environment*: the structure's ability to withstand both the environment in which it is constructed and the environmental forces during the construction process and operational phase. General design concepts and specification requirements that are derived from statistics and experience can address the primary needs of a generic infrastructure project, but specific requirements and mitigation of uncertain climate for individual projects requires further understanding of future events and contextual forces. Walker (1996) asserts that environmental forces and their consequent effects on the client and the construction process determine the level of intensity of activity on a system and project. It is possible to agree on the quality attribute in relation to environment requirements and measure it, but it may be difficult to quantify beyond the short term since infrastructure projects are expected to endure harsh climates and intensive usage over a number of years.

- *Functional dimensions* or *geometry*: conformance with the plan dimensions and tolerance such as the smoothness of the road surface. Though this quality attribute is unique for each project, most requirements and specifications must conform to regulatory frameworks and industry standards. From the viewpoint of functionality, a high-quality project is described by ease in understanding drawings and specifications, as well as ease of operation and maintenance (Arditi and Gunaydin, 1997). One important factor that the

client in the construction industry highly cherishes is the ease with which they can update the design and the possibility to alter construction work already in progress if they deem it necessary (Ward et al., 1991). Thus, the quality attribute of functional dimensions contain many attributes that are easily quantifiable but are less uniform and highly subject to a wide range of client preferences and expectations. Conformance to requirement type of quality definition is appropriate in this situation.

- *Durability*: the ability of the pavement or structure to last for a desired length of time. Yasamis et al. (2002) define the durability attribute of quality dimension as the duration that a facility or structure is used by an end-user before it becomes obsolete or replaced. Considering that infrastructure projects last many years and the role of other above quality dimensions in the life span of such projects, it is more likely the durability characteristic is not going to be an easily measurable attribute of quality. For the same reason, it can also be difficult to agree to a common definition of quality in terms of durability, since that will depend on the level of repair and maintenance spent on the project and the desired conformity and safety levels. Warrants play a big role in determining the longitivity and durability of a structure. The ideal guarantee protects the client from unexpected failures and assurances to achieve a desired performance without paying an unnecessary premium of the warrant. However, one negative aspect of a warrant is its tendency to place the clients in a comfort zone, where they are satisfied with what the warrant provides. Since warrants cover any problems that could arise during the guarantee period, the client may stop taking the necessary actions such as quality control and inspections that would safeguard them from long-term quality deficiency. Again, this illustrates the relative aspect of durability attribute and how it is difficult to measure. The most appropriate definition of this type of quality dimension is one that considers both the subjective and objective nature of quality such as "the totality of features and characteristics of a product or services that bear upon its ability to satisfy stated or implied needs"[1].

After breaking into relevant parts and systematically tackling the problem of quality definition, it is now time to put forward couple of propositions that are at the heart of the realistic research approach. We opted to use a proposition rather than hypothesis because a proposition concerns *constructs* and relationships between them, whilst a hypothesis concerns *variables* and relationships between them (Fellow and Liu, 2008).

[1] BS EN ISO 9000: 2000

4.2 Explanatory propositions

PROPOSITION 1**:** *The client may have received a low absolute quality but not necessarily a low relative quality.*

Stage 1: Possible explanation

The project conforms to the specifications and requirements in which the contractual agreement had stipulated, but the client is not satisfied with the quality level of the final product. The client received the level of quality that they could afford but not a high absolute quality level. During the construction phase, contractors of construction projects have the skills to judge what procedures and process could produce the desired project. It is not unusual for contractors of construction projects to provide some valuable or extra services to their clients if the costs of supplying that service or extra quality attribute do not exceed the satisfaction of their client and the subsequent opportunity to work with the client. Lewis (1995) categorized this service quality as an *enhancing factor* since adding this attribute may lead to customer satisfaction and not delivering it does not cause dissatisfaction, which indicates that the client has achieved or surpassed their expected relative quality level.

PROPOSITION 2**:** *The client may have received a low relative quality (low RQ).*

A low relative quality project is one that does not meet the requirements of the project in terms of strength, durability, functional dimensions, and environmental challenges from the individual client perspective. The client in this type of project is expecting to acquire a project that meets the needs and expectations of a typical customer—*fitness for purpose*. They are not interested in procuring a project with high specific requirements such as high durability, unique design and functionality or negligible maintenance costs that will cost more.

A project could be classified as a low quality project in relative terms if the project has not been able to satisfy the needs of the most easily measurable components of quality attribute such as strength of surface and functional dimensions. However, it cannot be straightforwardly judged as low quality if it satisfies the easily measurable attributes of quality but not the attributes that are difficult to quantify. Construction projects are durable products that require enough time to assess their quality performance. It also involves many different stakeholders that could evaluate the quality of the project differently at any specific time. Some of the attributes related to quality such as durability and environment effects are not easily visible to all actors involved in the project or easily measurable by all parties.

The following Fishbone or Ishikawa diagram (named after its inventor Kaoru Ishikawa) can offer a better mind-mapping approach of the second scenario of low relative quality (low RQ) and what factors could cause construction projects to experience low relative quality (Figure 4).

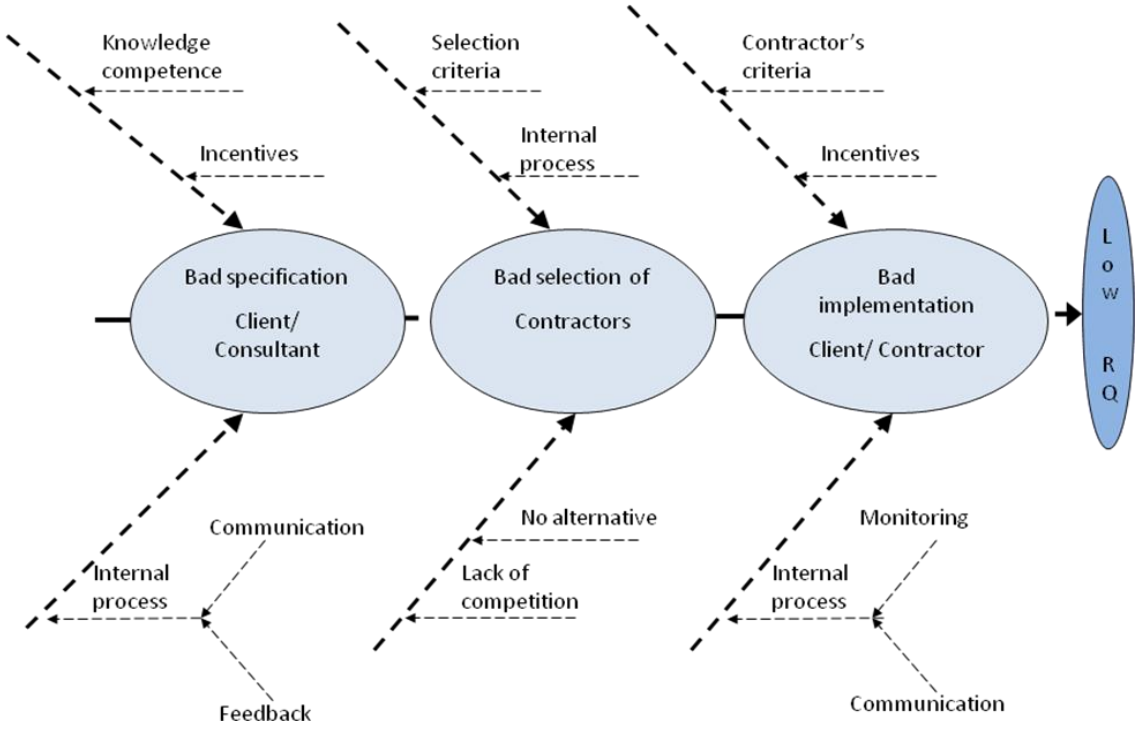

Figure 4: *Fishbone or Ishikawa diagram on factors leading to Low Relative Quality*.

Stage 1: Possible explanation for *Bad specification of customer/client requirement*

In the traditional procurement, the client either uses their own design team or appoints a consultant to design the project based on the needs of the client/customer. Typically, design teams assist the client in the areas that they have strong experience such as the functional, technical, schedule, and quality-compliance areas (ASCE, 1988). Since this kind of quality often depends on the performance of the architect/designer and the degree of conforming to the client's needs, it is often defined as "quality of design" (Yasamis et al., 2002). It is this quality design that guarantees the needs of the end-users are met provided that the design itself is adequate and the contractor followed the contract document (Davis et al., 1989).

Although the design process for building and infrastructure projects might differ in terms of detail specifics, the overall goal of achieving the highest desirable quality is always crucial. Josephson and Hammarlund (1999) found that in three of the seven building projects they investigated design defects were the largest portion of defects that has been reported. They claim that 32% of the defect costs originated in the design phase, where the client and design team were mainly responsible for the task. Kuprenas (2008) argues that time and money spent on the design phase improves the quality of the project because less quality-related problems are encountered during construction, while the overall project costs may increase. The whole-of-life quality is implemented during this planning and design phase (Toakley and Marosszeky, 2003). How much time is needed to prepare the documents of the project and

how much costs the clients are willing to pay for these services play a major role in desired level of quality. Quality failure of this type, when a project does not satisfy the needs of the most easily measurable components of quality attributes, could be attributed to a bad specification of the design and misspecification of what is expected from the contractor. Several possible sources that contribute to this bad specification are:

- Lack of knowledge/competence of the client and/or the design team. Whether the client of a project is a public or private organization, their level of satisfaction of project quality can be linked to the level of involvement in the process (Bubshait, 1994). The level of involvement may depend on the client's knowledge and competence of what is supposed to be procured in relation to detailed information about not only the needs and expectations of end-users of the project, but also how the quality objectives can be achieved in a well-planned and controlled manner. A better informed and knowledgeable client can select the most suitable delivery or procurement method that meets their construction project needs (Bresnen and Haslam, 1991). Bubshait (1994) found several factors that exhibited a high degree of correlation with project quality and more closely related to the knowledge and competence of the client: client/owner participation in the preliminary studies of the project; the identification of end-users' requirements; project review; and the establishment of design criteria. It is also obvious that incompetent consultants can be connected to a client's lack of competence in selecting qualified consultant.

- Lack or inefficient communication between the client and the design team and failure to incorporate feedback from customers to the development of current or future project design. It is at this stage where clear communication between the client and the end-user and between the client and the designer is needed. Oakland and Marosszeky (2006) emphasize that the conformance aspect of quality must be present, and the operational process during the execution must be capable of producing the design. Similarly, Davis et al. (1989) suggest that the "conformance to requirements" definition of quality can be more objective and encourage the achievement of the specified requirements, and hence the desired level of quality through comprehensive dialogue among the stakeholders of the project. In other words, a quality design should take care of the aspects of identifying the need, developing what satisfies the need, checking the conformance of the need, and ensuring the need is satisfied (Oakland and Marosszeky, 2006).

- One more element that could encourage this bad specification outcome is lack of incentive from the client or consultant to procure the highest desirable quality level of infrastructure projects. The types of incentive that we are referring to here is not the financial incentives or bonuses offered to contractors and consultants in order to motivate them, but lack of incentive to produce an error-free design that is not influenced by other ulterior motives. In most cases, the selection of a consultant does not undergo the same competitive tendering as the contractor selection process. If the selected consultant is facing time and political pressure to submit a project design

without proper consideration of all the needs and objectives of the client and end-users, most likely that design could encounter quality problems during implementation.

Stage 2: Possible explanation for *Bad selection of contractor or contract type*

Arditi and Gunyadin (1998) found that the selection of an appropriate contractor was very important in achieving high-quality performance. Management's commitment to continuous quality improvement was also found to be very important. Selecting a contractor that could not execute the specification and agreed requirements or bad documentation and lack of quality management policy could also be blamed for the low RQ. Contractors have an incentive to deliver the desired quality if clients judge their performance when selecting contractors for subsequent projects. Some common practices of a client in the public sector that very often lead to unsatisfactory quality construction projects is lowest price procurement with no consideration of the contractor's prior performance. Owners may, for example, choose to cut several quality management-related costs such as the cost of an inspector, who is required to be present on the site at all times. Another reason for clients shifting these responsibilities to contractors could be that projects are becoming larger with increases in risk, which has necessitated a risk-sharing strategy in order to drive down construction costs (Ferreira and Rogerson, 1999). Different contract types offer various ways of achieving this goal of risk shifting and responsibilities, which influences how clients deal with the quality management, thus quality assurance is affected. The contract type will affect the type of observation that the owner considers significant and the response they would expect for non-conformance in the initial plan. The use of sealed competitive has forced contractors to seek every advantage during construction to control cost and maintain a profitable stance (Arditi and Gunaydin, 1997). Yasamis et al. (2002) argue that cost should be an order-qualifier and be used as a characteristic that qualifies a contractor to be considered or not, but not as a final factor in the selection process. If owners include their evaluation of the quality performance of the contractor, it may encourage contractors to improve and document their quality management in order to be competitive and maintain a continuous flow of business (Yasamis et al., 2002). This approach may also reduce the possibility of awarding the contract to unqualified or incompetent contractors that compete with a low price.

Stage 3: Possible explanation *Bad implementation during construction process*

The combination of bad specification and bad contractor selection could definitely lead to an unsatisfactory outcome, but the project can also encounter similar failure due to bad implementation of the construction process by the contractor. If good specification and easy measurability of the quality characteristics are not established during the construction phase, then a product that satisfies the client's quality demand and are equitable to the contractor may be difficult to achieve (Schexnayder and Ohre, 1997). As we mentioned earlier,

realization of a construction project is a group effort, operating under contractual agreements and a mutual understanding of each party's goals and objectives. A client's expectation of a high quality product with minimum costs and shortest delivery time may not be in line with a contractor's desire to maximize compensation for their effort when delivering the minimum requirement, since higher standards and specification may involve extra costs. The nature of construction projects and their inevitable divergent objectives of the participants would require both explicit agreements based on standards and specifications that deal with the measurable and quantifiable aspect of the quality, as well as a harmonious relationship and trust among the participants that is essential to mitigate the implicit and hard-to-define aspect of the quality. Even if the specifications were followed, sometimes these specifications may not always produce the desired end result since these specifications are based on past conditions that may not be similar to the current situation.

One factor that can adversely affect the quality performance of projects during the construction process is aggressive competition during the tendering and selection phase (Jha and Iyer, 2006). The tough competition coupled with the lowest price policy could force the winning firm (characterized by "the winner's curse") to accept an unrealistic project price that becomes a source for quality problems. Contractors may use many layers of sub-contracting in order to shift some of the risk, and in the process this could affect the quality of the project. If the contractors have weak incentives to deliver a quality project and/or if non-conformance with contracted standards has little consequence on their business, it could be a breeding ground for low quality performance. These behaviors of quality indifferences can be curtailed if, for example, the clients consider the previous quality performance of the contractor during the selection process, and hence the contractors may change their behavior toward quality performance knowing the consequence and rewards of their behavior.

5. An exploratory questionnaire

5.1 Overview of quality level

After only a few questions related to information about the respondents, respondents were asked for their general assessment of past and current quality problems. In the questionnaire, the concept of relative quality had been described in the introduction. According to the respondents, quality of construction projects constructed in the last five years is either at the same level or even better than the quality level of projects built 20 years ago. More than 43% of respondents believe that the quality level is higher today, while a similar number of respondents suggested that the quality level has not changed during this period. Table 1 contains a more detailed breakdown of how different groups view the quality level of construction projects.

According to the responses in the table (Table 1), one of the possible outcomes of quality assurance transfer that we have contemplated earlier in the background section can be eliminated. Only a few respondents think that the quality level of construction projects has

decreased over time (6%), indicating that *quality of current construction projects are not lower than quality of construction projects 20 years ago*. Contrary to expectations, clients are overrepresented in the group that believes that quality is higher.

Table 1: Respondents' views on past and present quality levels.

		Quality level				
		No opinion	Quality is lower today	Quality is almost the same level	Quality is higher today	Total
Type	Client	0	2	10	15	27
	Consultant	1	0	7	11	19
	Contractor	3	1	10	3	17
	regional office	1	1	2	0	4
Total		5	4	29	29	67

However, the equal number of responses between same and high quality levels seems to point out two different trends. The first direction is that the quality level of infrastructure projects is higher than before. This outcome does not lend to too much further discussion since the quality of construction projects has improved and things seem to work well. How much of this quality level increase that is attributable to quality assurance policy is, however, an open question. The second direction that the answers point in is that the quality level is the same as before, which raises two interesting observations. On one hand, actors in construction projects might have ostensibly succeeded to keep up the quality level of construction projects with the advancement of technology and ever-changing expectations of clients and end-users. The construction sector is characterized by heavily fragmented and competitive, project-based activity, and low technology appreciation and skills (Dainty et al., 2007). Furthermore, the sector has also been portrayed as less appreciative to changes and improvements (Dainty et al., 2007). Thus, we can cast some doubt on the suggestion that the construction sector has followed economical and technological changes. However, we can also suggest that warranties of workmanship and material, as well as long-term relationships between actors in the construction projects, might have helped the sector sustain the quality level of projects.

On the other hand, same quality levels of construction projects seem to suggest that quality improvement of projects have stagnated over this period. This apparent lack of quality improvement is more worrying than retaining the quality level, especially when the next level of quality aspiration after quality assurance is *continuous improvement* (see Winch, 2010), and this should concern both relative and absolute quality.

5.2 Quality problems discovered in different phases of a project

In order to increase our knowledge of the prevalence of quality problems in relation to different phases (construction phase, final inspection phase and during the warrant period), respondents were asked their opinion about how often quality deficiency occurs and who

discovers it, as well as what actions are taken when quality problems are discovered. The first question in this part was who discovers quality problems during the construction phase. A number of clients (12) indicate that they discover quality problems, while 20 respondents from the contractor side believe that they discover these problems. Responses from the client side were almost inconclusive when asked who finds quality problems during construction (client or contractor). Respondents indicate that client complaints are limited to a few isolated projects (47%), though 21% of them point out that client complaints about quality problems are present in the majority of the projects.

We were interested to know the correction actions taken by different stakeholders of a construction project (client and contractor) when quality problems are discovered. The question now is what actions are taken in order to mitigate any quality deficiency. Three possible scenarios are envisioned:

1) Complete removal of the defective product or structure.

2) Repair without complete removal.

3) Deductions from payments if the quality is not exactly the required level but acceptable within certain limits.

The last two scenarios were more prevalent when quality deficiencies were needed to rectify, though a complete removal were sometimes considered. A combined 43 respondents indicated that quality problems discovered during the final inspection *often* get fixed by means of reparations without complete removal or contractors accepted payment deductions. Another 25 respondents also suggested that *sometimes* quality deficiencies are mitigated through payments deductions if quality is deemed to be within the acceptable limits.

The situation is somewhat different when it comes to quality problems during the warranty period or shortly after it expires. The majority of respondents (42) indicate that clients very seldom discover or complain about quality during this period. If quality deficiencies are discovered during the warranty period, a complete removal or payment deductions are not the preferred options. Twenty-five respondents or 42% of them say that contractors very seldom remove the defected part or structure. Another 20% (20 respondents) say that payment deductions seldom happen. The prevailing measurement to rectify a quality problem during the warranty period is reparation without complete removal. Barring any major deficiency that is detrimental to the operation and safety of end-users, this action seems to be a logical solution since the project has been in use up until the warranty period. Asking for a deduction or complete removal would be inequitable on the contractor side.

5.3 Quality problems related to the product

The second part of the questionnaire tries to determine which part/s of infrastructure frequently or most commonly experiences quality problems and which part does not. Based on their own experience, we asked respondents to identify components that they deem to cause more/less quality problems. Responses from these open questions were numerous and

difficult to summarize. One way to overcome this problem is to group the responses in relation to the product and process dimensions—subgrade, substructure, superstructure, and fixtures, as well as process-related factors such as specifications and design. The grouping and interpretation of each respondent's comments on quality problems are very subjective and require a thorough approach when analyzing them.

As you can see from Table 2, a good number of respondents (20) identified pavement and surface as the parts of infrastructure that most commonly experience quality problems. Only three respondents indicated that these parts seldom experience quality problems. Process related factors, specifications and design are also identified as contributors of most common quality problems. Responses related to quality problems associated with fixtures such as railings and drainages are mixed, where almost an equal number of respondents suggested that these components either experienced more or fewer quality problems. Similar opposing responses can also be seen in quality problems related to substructure elements such as bearing and reinforcement.

Table 2: *Grouping of most and least common quality problems and examples*.

Component	Subgrade (*Undergrund*) (e.g. foundation)	Substructure (*Underbyggnad*) (e.g. bearing and reinforcement)	Superstructure (*Överbyggnad*) (e.g. pavement/surface)	Fixtures (e.g. railings and drainages)	Miscellaneous (process related factors, specifications and design)
Very Common Quality problems	+ + + + + +	+ + + + + + + + + +	+ + + + + + + + + + + + + + + + + + + +	+ + + + + + + + + + + + +	+ + + + + + + +
Less Common Quality problems	_ _	_ _ _ _ _ _ _ _ _	_ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _	_
Real example of quality problem	x x	x x	x x x x x x x	x x x x x	x x x x x x x

Note: A plus sign indicates how often a component is flagged as a source of quality problem, while a minus sign indicates that the component experienced fewer quality problems. An x sign indicates which part respondents have real example of quality problems.

As we already mentioned in the introduction section and also explained in our quality framework, some of the components that respondents flagged as prone to quality problems are

not surprising because quality attributes associated with them can be easily quantified. Unsatisfactory smoothness or roughness index of pavement, as well as unexpected maintenance of surfaces, could signal bad quality. At the same token, for non-easily quantifiable quality attributes connected to substructure, it is not surprising that they produce inconclusive responses. These quality anomalies reported in these three different open questions (Table 2) were expected to be mainly unique to individual projects, and thus it is hard to generalize.

One open question that is related to questions in Table 2 was about soliciting from respondents one or more projects in their part of the country that they consider would be particularly interesting to look at. Only a few projects were mentioned and none of them were mentioned enough to raise our interest to further investigate that project.

5.3 Quality problems related to business environment and process

The third part of the questionnaire contained a number of statements that respondents indicate their level of agreement/disagreement to. We were interested to find out if time and location of a project have any impact on the quality level of construction projects. There were no quality differences between projects constructed during periods with high or low demand. The majority of respondents stated that they do not have an opinion whether major differences of quality exist among the regions. This lack of opinion about quality level among the regions is not surprising since construction projects are local, and thus respondents may not be aware what happens beyond their region. On the other hand, one may expect that respondents would have some idea about the nature of quality in construction projects among the regions since they belong to only few big contractors and clients that operate each region of the country. It is a matter of interest to know whether this high level of "no opinion" can be interpreted as a lack of total quality management within the contractor and client organizations.

Several statements about quality problems in relation to the size and number of sub/contractors were also purposed. Respondents agree that quality problems are higher when many subcontractors are involved in a project compared to one major contactor. Thirty-seven respondents suggest that construction projects with many subcontractors experience quality problems. Considering the increased use of subcontracting in the sector, this is an interesting development and one that needs further investigation. We reformulated the question and asked respondents if projects constructed by major single contractors experienced more quality problems than when a project is contracted out to several small contractors. Again, 74% of respondents disagree that quality problems in construction projects are bigger when a major contractor is responsible for the whole work. Respondents are almost split with the notion that quality problems are bigger when one small contractor is responsible for the project.

Different contract forms seem to play a less significance role on quality problems in the final structure. As can be seen in Table 3, the opinions on the question whether all-in-one contract leads to less quality problems are split among all groups of respondents. Twenty-four respondents disagree with the statement that problems all-in-one contractors (which is often

used in design and build projects) experience less quality problems than when you use a general contractor (which is commonly used in Design-Bid-Build contracts), while 18 agree and 25 have no opinion (see Table 3).

Table 3: Quality problems in the finished project are significantly less for all in-one contractors (*totalentreprenad*) than for general contractors.

		Quality problems in relation to contract form			Total
		Disagree	No opinion	Agree	
Type	Client	10	5	11	26
	Consultant	9	3	2	14
	Contractor	4	7	4	15
	regional office	1	2	1	4
Total		24	17	18	59

From the literature point of view, many proponents of the design-build procurement method suggest that combining design and construction under the responsibility of a single contractor could reduce quality problems associated with the design phase. Similarly, proponents of traditional Design-Bid-Build claim that quality is better when the client has more control over the design phase and appoints consultants or uses an in-house team of designers. What we are seeing here is that the responses suggest that no procurement method per se has a major impact on the quality level of infrastructure projects. Furthermore, we also found it interesting that a high number of respondents declared no opinion.

Quality of construction projects rests on the shoulders of human resources such as designers, site managers and project managers. As respondents indicated, quality problems in the finished structure depends largely on how well the project actors have done their job, the competence of client, and the quality of tender/bid documents. A combined respondent percentage of more than 80% fully or partially agreed that the lack of client competence contributed to quality problems of finished infrastructure projects (see Table 4).

Table 4: Quality problems in relation to client competence.

		Quality problems and client competence			Total
		Disagree	No opinion	Agree	
Type	Client	4	0	20	24
	Consultant	1	1	11	13
	Contractor	1	3	10	14
	regional office	0	0	4	4
Total		6	4	45	55

When respondents were asked if there is another factor that could explain how large the quality problems would be, they frequently mentioned the skill and experience of people who are involved in the projects. Respondents also pointed out that the lowest price policy contributes to quality problems in the finished structure. They suggested that low tendering prices encourages short cuts and bad quality.

6. Conclusions and lessons learned

In order to improve the quality of infrastructure transport projects, better comprehension of quality definitions and the factors that affect quality—especially relative quality—is important. Considering the uniqueness of each infrastructure project and specific client characteristics, we have discussed various concepts of quality such as absolute, relative and comparative quality. Infrastructure may be judged to be successful if it has fulfilled the quality level that its owner expected based on specific requirements such as cost, schedule and, for example, how the road is used. The quality level of such projects could be classified as relative quality since it conforms to budget restrictions and certain requirements of a particular client. A client might have expected to achieve a project with absolute quality when in fact it has procured a project with a relative quality level compared to other similar projects. An absolute quality is when a product or infrastructure project conforms to high industry standards that are not dependent on client specifics. Furthermore, there are quality attributes that are easily quantifiable and amenable in general such as the strength and functional dimension of road surface, and quality attributes such as durability of the pavement that is not easily measurable due to the longevity of the infrastructure and unpredictable usage and varying environment conditions.

Based on these various quality concepts and broad literature review of quality, a Fishbone or Ishikawa diagram was utilized to single out factors that could lead to low relative quality, divided into the specifications stage, the procurement stage and the implementation stage.

In order to increase our knowledge of the role of these factors and the development of the overall quality level of infrastructure projects, an online questionnaire was administered. The results of our survey suggest that there has not been a deterioration of the (relative) quality level of infrastructure projects after the transfer of quality assurance from client to contractor. More respondents believed that the quality of infrastructure had increased compared to those who believed it decreased. However, the expectation that the transfer would improve the quality level does not seem to be fully materialized since almost half of the respondents suggest that the quality level remained the same as before the transfer. The lesson drawn from this is that the question of what really happened to quality and why is less important than finding ways to improve quality in the future.

The main exploratory points from the questionnaire and the possible subsequent research theme that could be focused on in subsequent papers will be briefly discussed below.

One may question the efficiency of the apparent frequent acceptance of quality levels that are within the limits of specified levels during implementation and the effectiveness of quality transfer decisions. In other words, do different decisions at the organizational level and project level contribute to quality improvement stagnation? This will be the focus of the next paper (paper 2) of this part of the thesis.

The inconclusiveness in responses surrounding how quality could be affected by different contract forms and the increasing number of procurement methods available in the market makes it necessary to further investigate this issue. If one assumes that all different procurement methods require the same skills and competence from the public client workforce then this would not be a major concern, since the public client could utilize any method that would provide the best value for money. This is hardly the case. Different procurement methods seem to demand different levels of involvement from the client that commensurate client skill and competence, as well as risk and responsibilities levels of the client. Paper 3 and 4 of this part of the thesis will attempt to address the role of client competence and procurement methods in improving quality of infrastructure projects.

One result from the questionnaire is that highly qualified personnel from the public client organization and a high level of client or client representative involvement are crucial in reducing the gap between the expected and the achieved quality level. Communication improvements among major actors, as well as early briefing and meetings that address design and geotechnical problems could also reduce or eliminate some of the quality problems that have been mentioned in this survey. This could be achieved if the public client organization has a skilled and experienced workforce with incentives to use and develop its knowledge. Proper knowledge management and an improved internal process of the client organization are essential elements of lessening skill and competence shortages of the public client organization, together with an organizational culture that stimulates this. These issues will be the theme of the final paper of this thesis.

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Appendix: Quality improvement methods for infrastructure transport projects[1]

1. If you compare projects that were built 20 years ago with a projects that are built over the past 5 years, in your opinion how quality in general has changed?
   [ ] Quality is higher today [ ] Quality is the same [ ] Quality is lower today [ ] No Opinion

2. How often quality problems of construction projects are discovered by client/contractor during the construction?
   [ ] almost all projects [ ] majority of projects [ ] few isolated projects [ ] very rarely [ ] No Opinion

3. How often quality problems of construction projects are discovered by client/contractor during the final inspection?
   [ ] almost all projects [ ] majority of projects [ ] few isolated projects [ ] very rarely [ ] No Opinion

4. What actions are taken when quality problems are discovered during the final inspection?

	Never	Rarely	Sometimes	Often	Always	No Opinion
Complete **removal** of deficient product or structure						
Repair without complete removal						
If the quality is within acceptable certain limits, **deduction** of predetermine payment						

5. How often quality problems of construction projects are discovered by client/contractor during the warranty period?
   [ ] almost all projects [ ] majority of projects [ ] few isolated projects [ ] very rarely [ ] No Opinion

6. What actions are taken when quality problems are discovered during the warrant period?

	Never	Rarely	Sometimes	Often	Always	No Opinion
Complete **removal** of deficient product or structure						
Repair without complete removal						
If the quality is within acceptable certain limits, **deduction** of predetermine payment						

7. How often quality problems of construction projects are discovered by client/contractor after the warranty period (1-3 years)?
   [ ] almost all projects [ ] majority of projects [ ] few isolated projects [ ] very rarely [ ] No Opinion

8. From your experience, which component or part of structure that experience *most of* quality problems

9. From your experience, which component or part of structure experience *least of* quality problems

10. Do you have any examples of serious quality problems that you have direct experience from the projects that you were involved?

11. Contractor's project managers are often aware that there are quality problems but look the other way in order to maintain schedule and budget.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

12. Client's project managers are often aware that there are quality defects but look the other way in order to maintain schedule and budget.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

13. Projects constructed during high construction activity have more quality problems than projects constructed during low construction activities.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

14. There are large regional differences in quality problems in the construction sector.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

15. Which region experiences the biggest quality problems?
    [ ] Big regions [ ] Medium regions [ ] Small regions [ ] No difference [ ] No Opinion

16. Quality problems are greater when there are many subcontractors involved in construction.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

17. Quality problems are greater when big contractor is responsible for the project.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

18. Quality problems are greater when small contractor is responsible for the project.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

19. In your opinion, is there any other factor from the contractor side that is important for how big quality problems could be?

20. Quality problems in the finished project depend largely on how well the designer did his job.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

21. Quality problems in the finished project depend largely on the tender documents.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

22. Quality problems in the finished project depend largely on client's competence.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

23. Quality problems in the finished project are significantly less with all-in-one contractor (totalentreprenad) than general contractor.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

24. Quality problems in the finished project will depend largely on client's lowest price policy in the contractor selection process.
    [ ] Agree [ ] Partially Agree [ ] Disagree [ ] No Opinion

25. At a later stage of the project we intend to implement some case studies to better understand the mechanisms that lead to poor quality. Are there one or more projects in your part of the country that you consider that would be particularly interesting to look at?

26. Is there anything that you would like to emphasize about quality problems in infrastructure transport projects?

[1]This questionnaire was originally in Swedish but has been translated to English for this publication.

Paper 6

Decision-making theories in relation to quality of infrastructure transport projects

Author: Abukar Warsame

Abstract

Infrastructure transport projects are characterized by long-term assets that often require an enormous initial investment, and high operating and maintenance resources. They also involve many stakeholders with divergent goals and objectives. Generally, the realization of these projects takes several years from the inception of the project to planning, construction, and the operational phase. Numerous decisions will be made during the realization of a project. Some decisions occur within a single organization such as an owner's decision to adopt a procurement or contracting strategy, while other decisions involve more than one organization or actor such as quality assurance procedures during the construction phase.

The aim of this paper is to explore the extent to which decisions intended to ensure meeting project members' planned budget, time and technical specifications could have produced a less desirable quality level of transport projects. An online survey of 68 respondents and a critical analysis of quality-related decisions during the construction and final inspection of infrastructure transport projects indicate that current quality assurance practices could be the source of an inadequate quality level or lack of quality improvement.

The competence level of a client is indicated as one of the sources of quality problems. The decision to transfer quality assurance responsibility from client to contractor may have contributed to this lack of a client's competence skills, creating a higher dependence on a supplier's judgment of the quality level of projects. A recurring acceptance of an adequate quality level could become the norm rather than seeking the highest level of quality specified during the contracting phase. Thus, a downward spiral of quality level acceptance could hamper the drive toward quality improvement goals for infrastructure transport projects.

Keywords: Decision-making, competence, infrastructure projects, quality assurance, quality improvement.

1. Introduction

Transport projects are part of the infrastructure domain, providing basic services to industry and households. Winch (2010) claims that infrastructure projects have been widely associated with cost overruns and time delays, as well as failing to achieve objectives that would benefit the economy and society. In many countries, government is the predominant client of civil engineering works such as infrastructure projects (Winch, 2010). The sheer size of infrastructure transport projects often necessitates government involvement in terms of financing, developing, managing, and operating at different capacities and in different roles. However, private sector entities' participation has been on the rise lately (Grimsey and Lewis, 2002). Private sector involvement has not only potentially lessened financial constraints faced by the public sector, but it has also contributed to the advancement of new products and technology toward the development of sustainable roads and railways.

Numerous decisions will be made during the realization of a project from conception to commissioning. Some decisions occur within a single organization such as an owner's decision to adopt a procurement or contracting strategy, while other decisions involve more than one organization or actor such as quality assurance procedures during the construction phase. Decisions concerning the quality of the final product go through a chain of subordination comprising top level management that focus on the overall performance of the project to design and site managers that focus on the detailed specifications and implementation process. Generally, site managers often have wide responsibilities and certain issues are not transferred to a higher level in the hierarchy unless low-level managers ask for it (Bröchner et al., 2002). According to interview responses from client representatives, Bröchner et al. (2002) found that one of the essential skills that construction managers ought to possess is the ability to establish a cooperative relationship with exchange partners. Project managers mostly resolve potential conflicts by compromise and a mutual understanding that could lead to sub-optimal decisions for the client (Bröchner et al., 2002).

There is currently a large amount of studies concerning organization decision theories and decision-making processes in the construction sector (e.g., Shapira et al., 1994; Smith and Wyatt, 1994; Polydoropoulou and Roumboutsos, 2009; Jonsson, 2010). Polydoropoulou and Roumboutsos (2009) argue that project management in any organization reflects middle management status. Thus, they do not have ultimate decision-making authority except that they may pursue specific decisions based on their power of knowledge i.e. competence and experience during the project construction phase where project attributes are realized. Jonsson (2010) describes incentives and similar factors of importance for how a client's project manager can act during the implementation phase of a project. If superiors are unaware of an issue in the organization or a solution is working well for them, project managers tend to choose a conflict-free solution over conflict when disputes occur (Jonsson, 2010, p. 225). Furthermore, there is a wide variety of literature about trade-offs between construction project attributes such as cost, time, and quality. However, it seems that there are limited studies

concerning how the organizational decision-making process influences the level of quality sought at different stages of transport construction projects. Two important questions remain:

1. Is there a difference between decisions related to the quality of a project at the organizational level and those at the project level? This occurs when the quality assurance procedure is not adequate enough to ensure that the quality level during the construction phase is realized and standard specifications are maintained according to the level of quality that has been objectively set during the design and planning phase.

2. *Is there an unintended consequence of current quality assurance procedures of transport construction projects that is detrimental to quality improvement of future transport construction projects?* A transfer of quality assurance from client to contractor could enhance one or more attributes of transport projects in the short term, but it could also impact the client's workforce in terms of competence and skills. Currently in Sweden, contractors are responsible for carrying out all of the control and inspection tasks during the construction stage, while the client accepts or rejects the final inspection results of the completed project. The reason/s behind this kind of transfer is beyond the scope of this research.

The aim of this paper is to explore the aforementioned questions and how the decision-making process could influence the quality of infrastructure transport projects. Our intention is to combine existing decision-making theories and organizational theories related to quality attributes of construction projects in order to discuss some of the issues that could hinder or help efforts toward quality improvement methods of transport construction projects.

The nature of infrastructure transport projects and issues related to decisions about performance attributes such as quality are discussed in the following section. Section 3 summarizes some of the major organizational decision-making theories and how they relate to decisions made at the organization and project levels. Results of an online survey and its implications, as well as a broader discussion of quality-related strategies, are discussed in section 4 and 5. The last section contains conclusions and suggestions for further research areas.

2. Background

Before we start discussing the impact of decision-making on quality of construction infrastructure transport projects, we need to say something about the nature of construction projects and the role of the quality attributes in providing high performance projects. This would allow us to scrutinize some of the current practices in the construction sector and issues related to quality (and hence performance of the final product) that could be associated with the decision-making processes at the organization and project level. The focus will mainly be

on decisions made during the procurement and construction phases, where decisions about quality at the organizational and project level interact and sometimes override each other.

Transport projects belong to infrastructure investment types that are long-lasting. Furthermore, the nature of that kind of structure (lumpiness and indivisibility) would not be used in other forms of economic activity (Grimsey and Lewis, 2002). It takes a number of years to complete these projects, wherein project scope or ambition level could change due to uncertain expectations, project interfaces and geotechnical conditions, as well as technical standards (Flyvbjerg, 2004). Other aspects of transport projects are large scale in terms of size and their capital intensity in terms of development, operation and maintenance. These factors necessitate the involvement of many actors and stakeholders whose goals do not always coincide with those of the client or owners. The involvement of different stakeholders or actors in a project could span the life of a project or be very limited such as during the procurement or construction phase. The engagement of different actors in the development of transport projects presents opportunities and challenges stemming from congruent and divergent objectives of these actors. It is not unusual that two actors in a project have goals that produce opposite outcomes with regard to the main attributes of any project, including cost, time and quality (Polydoropoulou and Roumboutsos, 2009). One actor's gain may be another's loss. Furthermore, managers within an organization need to make trade-offs when leading the decision process, ultimately finding it difficult to achieve efficiency and consensus simultaneously (Roberto, 2004).

Failure to achieve project objectives cannot be solely blamed on the supply side of the contractual agreement of infrastructure projects (Winch, 2010). In order to increase the likelihood of the approval of a proposed project, organizations and promoters tend to overestimate the benefits of a project while underestimating its cost. Winch (2010) calls this maneuver "strategic misrepresentation" since it has organizational drivers. He distinguishes it from optimism bias, which has psychological drivers. Though both phenomena have direct implications on the cost attribute, the other two attributes of the "iron triangle"—quality and time—will also be positively or negatively affected.

The decision to pursue either approach (overestimation of benefit or underestimation of cost) or other subsequent decisions made during different phases of a construction project can be linked to models for decision-making in organizations that are discussed in numerous management related studies. Pollack-Johnson and Liberatore (2006) argue that the standard implicit assumption of time/cost trade-offs with constant quality may be unattainable or unrealistic. They have discussed a system of quality level curves that can be a useful management tool when making final project schedule decisions that explicitly incorporate quality attributes. Winch (2010) postulates four quality aspects in construction, namely: quality of inception; quality of specification; quality of realization; and quality of conformance. He also describes several quality management systems (Figure 1). Winch refers to total quality management (TQM) as the highest level of approach or "the motivation of continuous process improvement to achieve higher and higher levels of conformance to intention". Quality assurance is planned and systematic actions are necessary in order to

provide adequate confidence that a structure, system or component will perform satisfactorily and conform to project requirements.

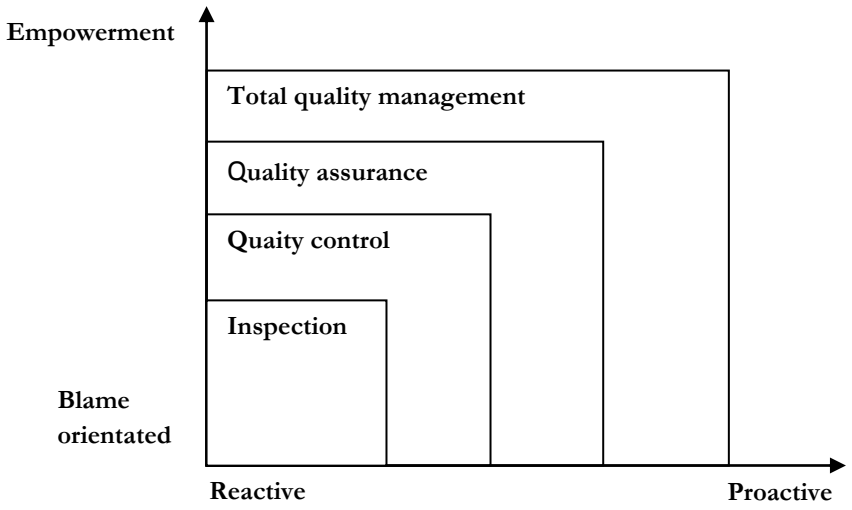

Figure 1: *Quality management regimes (source: Winch, 2010).*

Different procurement methods offered to the client in the construction industry have various degrees of flexibility in relation to quality control and quality assurance. The traditional design-bid-build is one extreme where the client often has the responsibility of the full range of activities related to the quality of the final product, for example inspection, test, and total control of both material and workmanship. The design and build procurement method allows the client of infrastructure projects to contract out some of these responsibilities of quality activities to the contractor and concentrate on the assessment and acceptance of the final product. Public-private partnership (PPP) and other long-term contracts make up the other extreme of procurement arrangements, where the focus on quality of the procured infrastructure projects shifts from client to contractor.

3. Research method

The uniqueness of each infrastructure project and the participation of many different actors at the planning and design stages of projects make it difficult to purposely ascertain the level of involvement of top management of the client organization in the decision process. However, it is possible to establish whether certain quality policies, such as the top management's decision to transfer quality assurance responsibilities from the client to the contractor and efficient implementation of project managers in these decisions, have produced the desired outcome of infrastructure projects.

In addition to the online questionnaire that is described in an earlier paper from the author (see Warsame, 2009a), a holistic approach based on theoretical discussion of decision-making theories and their impact on quality of construction projects addressed the aforementioned research questions. It is expected that the responses from the questionnaire will shed light on whether the top manager's decision of quality assurance transfer was an efficient decision that has led to the improvement of the quality of transport infrastructure projects.

During the construction and warranty period, certain decisions by project mangers, such as complete removal or repair of the defective parts and deductions from payments, could affect the quality level of a procured project. The composition of respondents may not allow us to fully capture different kinds of decisions; however, the high level of rework and repair would indicate the existence of a gap between efficient decisions at the organizational level and effective implementation of quality-related decisions at the project level.

4. Decision-making theories

Strategic decision-making concerns the relationship between an organization and its economic and social environment. Eisenhardt and Zbarachi (1992) suggest that decision-makers are boundedly rational, and decisions made could be influenced by the alternatives and choices afforded the decision-makers. Power and uncertainties also play a role in the decision process (Eisenhardt and Zbarachi, 1992). Failure to consider all of the variables involved in a project and an inability to assess the impact of its external factors contribute to poor decision-making (Drucker, 1954 cited in Roberto, 2004). Laroche (1995) discusses the role of decisions in organizations and how, for example, managers may influence the decision process. He uses the social representation concept that regards decisions and the decision-making process in organizations as a forms of common sense, socially built, and shared outcomes. Winch (2010) contends that project managers are intentionally rational decision-makers, responding to cues during a project life cycle and using a process he referred to as structured sense-making. Simon (1959) argues that when performance falls below the level of aspiration, the search for a new alternative of action is introduced, consequently adjusting the previous objective level until a new level of attainable goals is reached. If all of the actors in a project do not strictly adhere to the standards and specifications of the project, quality standards and expectations could be compromised. Thus, the search for an acceptable condition, by means of the structured sense-making described by Winch, could substitute the search for optimality.

A successful organizational performance strives for an efficient decision-making process and subsequent effective implementation of that decision (Roberto, 2004). In the construction business most contracts are incomplete, and thus achieving the mandatory performance of the contract has been a major management problem (Winch, 2010). Parkin (1996) claims that the complexity of major decisions involved multiple parties and lack of integration between organizational theories and decision theories, making it difficult to carry out research in this area. Nutt (1976) discusses six organizational decision-making models that are divided into

different categories based on whether key variables in the decision task are known and definable or cannot be defined nor fully comprehended, ultimately affecting a decision (see Table 1). Parkin (1996) contends that literature on decision-making can be broadly divided into three categories:

1. Axiomatically-based decision theories; derived from utility maximizing or optimizing models such as operation research, welfare economics, decision analysis, and multi-attribute utility theory. Nutt's first three models (Ttable 1) are good examples of this kind of decision-making theories.

2. Human judgment and behavioral-based decision theories mainly concentrate on describing judgmental aspect of decision-making and its limitations, as well as the role of personal beliefs in the decision process. According to Parkin (1996), these models are suitable at the individual and small-group decision level but offer little explanation to the decision-making process at the organization level. Nutt's fourth model falls into this category.

3. Conflict-resolution and contextual environment-based decision theories; interaction and interest accommodation of different stakeholders plays a major role in determining the major decision outcomes. Model five and six in Table 1 belong to this category.

Table 1: Organizational decision-making models (source: Nutt, 1976, pp.xx).

Organization decision-making models	**Decision criteria**	**Key assumptions**
1. Bureaucratic model	Maximum efficiency	Goals are known and the environment does not influence choices. Resources are adequate and tasks are predictable and repetitive. Master plan is a given tool to judge.
2. Normative decision theory	Maximum subjective expected utility	Goals are known with needed information obtainable and prediction feasible. Adequate resources are available.
3. Behavioral decision theory	Satisficing	Goals can be inferred through domain decisions. Uncertainties exist in all alternatives due to the environment. Resources interact with the decision process.
4. Group decision-making	Satisfice on objectives set by participants	Organizational goals guide group choices. Multidisciplinary choices are acceptable and implementation is achieved via participation. Co-optation makes the availability of needed resources and information possible.
5. Equilibrium-conflict resolution	Consensus	Goals must be defined. Conflict and time pressure cause the adoption of conspicuous alternatives. New alternatives are generated through further evaluation of existing ones. Decision premises and level of aspiration can change as a result of searching for alternatives.
6. Open system decision-making	Survival (agency's view) and acceptance (client's view)	Goals are unknown and unknowable. Strong interaction of the environment and decisions. Reacting better than planning.

5. Results and Discussions

A response rate of just over 52% (67 respondents) has been achieved. After a few questions related to the information of respondents, they were asked to assess past and current quality problems. According to the respondents, the quality of transport projects constructed in the last five years is either of the same level or even better than the quality level of projects built 20 years ago. Forty-three percent of respondents believe that the quality level is higher today, while 43% responded that the quality level has not changed during this period.

Responses from the survey suggest that respondents often accept project quality levels that are lower than those specified by the contractor but still falls within the acceptable limits. Repair and deductions from payment were more prevalent when quality deficiencies needed to be rectified though a complete removal was sometimes considered. Forty-three respondents (67%) indicated that quality problems discovered during the final inspection are either fixed by means of reparations without complete removal or contractors accepted payment deductions. If quality deficiencies are discovered during the warrant period, a complete removal or payment deductions are not the preferred options. Forty-two percent of respondents said that contractors very seldom remove the defected part or structure. Another 20% said that payment deductions seldom happen. The prevailing measure to rectify quality problems during the warranty period is reparation without complete removal. The use of tolerance limits is common in construction practices. However, frequent acceptance of satisfactory levels could influence future decisions on quality level (see Simon, 1995 and Winch, 2010).

The quality of construction projects rests on the shoulders of human resources such as site managers and project leaders. As respondents indicated, the quality problem in the completed structure depends largely on how well the project actors have done their job, the competence of the client, and the quality of the tender/bid documents. More than 80% of respondents indicated that quality problems of completed infrastructure projects are due to the low competence level of the client. Respondents also stated that quality problems are mainly caused by:

- Lack of communication between major actors and less involvement of personnel and management on the actual site.
- Planning mistakes and omissions in the design phase.
- Lack of competence, knowledge and experience.

Considering the nature of infrastructure transport projects and the role of quality in the successful performance of these projects, the comprehensive assessment of quality control and quality assurance practices could invigorate the debate on methods of quality

improvement in infrastructure projects. The transfer of quality assurance may have produced the intended objectives in reducing clients' costs, while allowing contractors to deliver the desired quality with less interference, inspection and control from the client or their representative. At the organization level, cost and time are more highly regarded than quality attribute, while at the project level project mangers may decide on the level of acceptance and any necessary remedy of non-conformance.

An important question is to what extent these quality problems raised in the survey are a result of poor quality related decisions made by projects managers? Decisions that are inherently intended to enhance the performance of the project could negatively affect the quality level of the project due to inadequate trade-offs of project attributes or due to the improper selection of the decision-making process of quality assurance. A critical analysis of the nature of transport projects and how quality objectives are formulated and materialized requires a good understanding of the decisions and decision-making process during different phases of projects.

A successful infrastructure transport project must encompass both product and process integrity. Paquin et al. (2000) note that the success of many projects depends on the quality of the final product and service delivered to the client. The performance of any construction project is often measured in terms of cost, time and quality. These three attributes are extremely difficult to rank with regard to importance, influence on other attributes or impact on overall project success. However, the quality differs from the aforementioned two attributes of construction transport projects. Cost and time could be estimated somewhat close to the real project cost and completion date, while quality is difficult to measure or define precisely because of the nature of transport construction projects in terms of longevity, serviceability, and scarcity of complete technical data and information, which is contingent on the future usage of the project. In other words, quality is related to two properties that are hard to articulate with a high degree of certainty: a client's expectation and a client's perception of the final product. Nutt's description of closed and open decisions could generally fit the decision-making process of transport infrastructure projects. Cost and time attributes for infrastructure projects could be known to a certain degree (closed system decision), while the quantification of quality presents challenges that would require an open system decision.

In order to achieve project objectives that meet a client's expectations and end-user's satisfaction, a proper quality assurance method and practice must choose among many procurement strategies. Each one of them presents different approaches when handling this vital attribute of the performance of a project. We utilize Winch's (2010) depiction of approaches to conformance quality management (Figure 1) combined with Nutt's (1996) organizational decision-making models (Table 1) in order to envision how the quality level of transport projects are affected by the different decision paradigms (Figure 2).

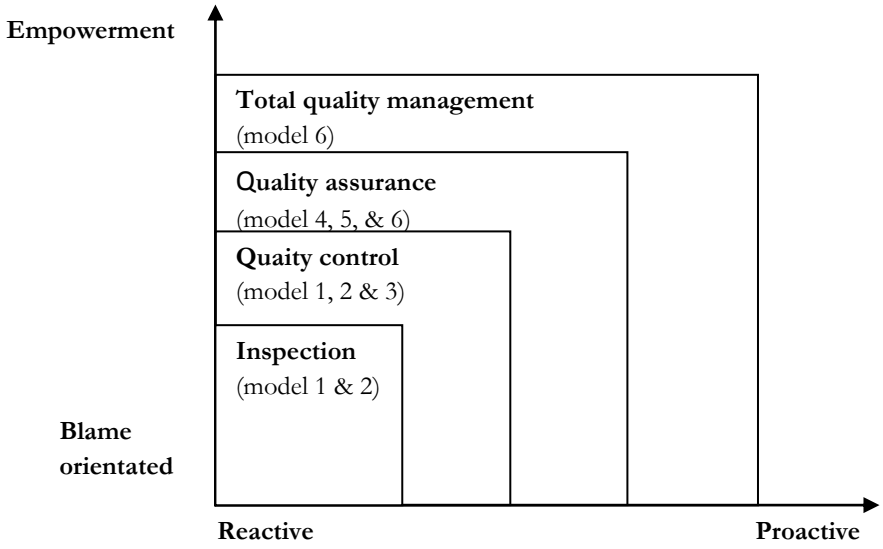

Figure 2: *Quality management regimes and organization decision models (source: adapted from Winch (2010)).*

When a client has total control of quality assurance procedures, a higher level of skills is essential since they are required to not only establish the desired quality level at the planning stage, but also control and inspect quality during various stages of a project. This strategy is prescriptive and thus may impose constraints on contractors. It could limit a contractor's ability to utilize an innovative product or technology that produces a similar or even better quality product if the client concerns of cost and time attributes exceed the benefits of any suggested changes. Models 1 and 2 of decision-making theories correspond to this strategy, where the client is in charge of quality inspection and control (see Figure 2). Winch (2010) notes that this strategy is expensive due to dedicated resources and non-conformance costs that arise from rejected components.

The situation is different when a transfer of quality assurance responsibilities from client to contractor is put in place. This strategy would allow contractors to construct the specified project with the desired flexibility in terms of technology and product, while meeting the overall objectives. A client's role is mainly to establish quality standards during the planning phase and to compare that with the quality of the final product. In other words, contractors construct and deliver the specified project without the client's interference; however, the project must meet the client's desired quality level and must fulfill its performance objectives. However, this strategy involves interaction between client and contractor that promotes group decisions in relation to technical standards and quality specifications during the delivery of the project. Models 4, 5 and 6 of organization decision-making theories fit the decision process of this strategy.

When a total transfer of quality assurance procedures including the planning and design phase is implemented, the client's role in project delivery is further reduced. In this strategy, the client's focal point of project success hinges on conforming to the desired quality level and the performance of the final product with respect to the original objectives. Process integrity and how quality assurance tasks are performed is not the client's main focus for this strategy. Product integrity and delivery of the project that satisfies the client's needs remain the primary objective of the procurement process. Furthermore, this strategy does not demand a high degree of client involvement during the construction stage (or even the planning stage depending on the type of procurement), and thus resources and skills dedicated to the project development and quality assurance could be less compared to the two previous strategies. Model 6 of organization decision-making theories corresponds to this strategy since it involves risks (cost, time and quality) associated with a long-term gestation process and the longevity of infrastructure transport projects.

According to the abovementioned explanation of the three strategies, models 4, 5 and 6 could best describe the current quality-related decision-making process of infrastructure transport projects in Sweden. It could be argued that the bureaucratic model and normative decision theory models (models 1 and 2) are the basis for most of the quality-related decisions, since the client formulates quality objectives through the design and technical specifications during the planning phase.

6. Conclusions

Clients and owners of transport projects have used different forms of procurement in order to mitigate their concerns on quality, time and cost attributes during the development and the whole life cycle of projects. Procurement strategies such as traditional construction with and without warrants, long-term relationship and alliances, build-operate-transfer schemes, and PPP play a major role in altering the trade-offs between project attributes.

A non-decline of the quality level of infrastructure projects after the transfer of quality assurance from client to contractors over 25 years ago suggests that the decision was not only an efficient one, but it has also been effectively implemented by concerned parties. However, lack of decisive quality improvement during this period and frequent acceptance of adequate quality levels rather than seeking optimal quality levels of the completed project may indicate that the decision to transfer was either inefficient or has not been appropriately implemented.

Quality assurance transfer decisions may have inadvertently impacted competence levels and the skills of a client's workforce since the knowledge and expertise shift to contractors. In addition, short-term decisions made by project managers at the project level could affect future decisions related to the quality level of projects carried out by the organization. If the quality level has been downgraded in the search for compromise and satisfaction rather than

optimality, it will not only set a motion for substandard quality but it could also cause stagnation of quality improvement goals.

Based on the above discussion and how quality could be affected by the different decision theories, the following approaches of quality improvement are proposed. These proposals are not thoroughly examined; however, they are a starting point in our discussion of quality improvement methods for transport infrastructure projects.

1. The return to the old quality control and inspection regime, where the client is responsible for quality assurance procedures. Direct monitoring from the client or consultant could be re-introduced. This policy would require re-training and re-building of competence and skills of the client workforce that has been affected by the transfer of quality assurance procedures.

2. The continuation of the current quality assurance system, where the contractor is responsible for quality assurance procedures and the client accepts or rejects the completed project based on their assessment. The perceived lack of quality improvement and quality problems associated with this policy could be alleviated in various ways. Extended warrants and long-term contracts are incentives for delivering superior quality projects. Since the goals and objectives of actors involved in the project are aligned in terms of project cost, low quality products and costs arising from rework and repair will be minimized or eliminated. Stringent pre-qualification and the contractor selection process could also improve the current quality assurance.

3. The use of other procurement strategies such as PPP would allow the client to shift risk associated with uncertainty of the quality of transport projects, which is very difficult to fully appraise due to the longevity, contextual environmental variables, and technical and specification complexity associated with infrastructure transport projects. Further research that incorporates these procurement approaches and appropriate decisions and the decision-making process of the quality attribute of transport projects is needed.

Two other issues that respondents pointed out and are relevant in order to broaden the discussion of quality improvement are:

- Improvement of specification and standards during the design stage in order to curtail quality problems associated with design changes and geotechnical glitches.

- Improvement of internal client processes such as competence, incentives and follow-ups.

Both these issues will be further discussed in the subsequent papers of the thesis.

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Paper 7

FRAME WORK FOR QUALITY IMPROVEMENT OF INFRASTRUCTURE PROJECTS[1]

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Abstract

In order to achieve high quality that not only gives acceptable return value to society but also satisfies the needs of all the stakeholders of infrastructure projects, comprehensive understanding of issues pertaining to the quality of the project is needed. The aim of this study is to provide an overview the most common procurement methods used in constructing infrastructure transport projects and analyze how these methods contribute to the desired quality of the final product in relation to client competence. An on-line survey of construction actors was carried out to ascertain quality level of Swedish infrastructure transport projects and determinant factors of quality problems. An equal number of respondents indicated that the quality of infrastructure projects has either increased or remained same level over the past twenty years. They also pointed out luck of client competence that is vital in realizing the desired quality level through proper procurement, monitoring and evaluation procedures. Public clients heavily rely on traditional design-build procurement that requires considerable client involvement of a project. Thus, the association of quality problems and luck of client competence may not be a mere coincidence but an overlooked outcome of current situation.

Keywords: Competence, infrastructure transport, procurement, quality, warranties

[1] Paper presented in 6th Nordic Conference on Construction Economics and Organization, Copenhagen.

INTRODUCTION

Transport infrastructure transport projects are essential to economic activity and growth of a society. They are characterized as havin long-life and long gestation processes as well as being capital intensive (Grimsey and Lewis, 2002; Ng and Loosemore, 2006). The sheer size of transport infrastructure projects often necessitates government involvement in terms of financing, developing, operating and maintaining them. Rienstra and Nijkamp (1997) outlined several arguments that explain government involvement in delivering infrastructure transport. One of the arguments is divergence of interest between public and private sector that makes transport infrastructure a product that cannot be easily delivered by the private sector (Rienstra and Nijkamp, 1997).

However, government involvement has been reduced for a lot of reasons while private sector participation has been on the rise lately (Grimsey and Lewis, 2002; Hodge and Greve, 2007). Private sector involvement in developing major infrastructure transport projects such as roads and railways were often motivated by the financial constraints faced by the public sector (Hodge and Greve, 2007). The private sector may provide more efficiently and faster delivery of infrastructure transport than public sector (Nilsson, 2009). Private sector efficiency allows government to share the associated risk of asset procurement and service delivery with the private sector (Cheung and Chan, 2010). Development of new products and technologies that lead to cost reduction and quality improvement contributed to increased private sector participation (Cheung and Chan, 2010) even though cost-cutting and desire of better quality are sometimes difficult to achieve both of them simultaneously (Estache eta al., 2009).

Lædre et al. (2006) and Tookey et al. (2001) argue that some of the causes of project success and failure can be traced back to the procurement method and how the owners selected that method. The owners or clients are the most critical to project success (Molenaar and Songer, 1996) and their characteristics such as expertise and experience are the moderating factors on the performance procurement system chosen (Luu et al., 2003). A UK government report (HM Treasury, 2008) claims that "*performance in the successful delivery of outcomes is strongly dependent on the skills of the client, not simply on the contract structure*".

The Swedish construction industry is facing a shortage of skilled workers and ageing of existing staff (FIA, 2005). Since quality performance and the effectiveness of any selected procurement method partially hinges on the competence of client's workforce, it is crucial to examine how different procurement methods could be affected by the scarcity of client competence, experience and expertise. The aim of this paper is to give an overview the most common procurement methods used in constructing infrastructure transport projects and analyze how these methods contribute to the desired quality of the final product in relation to client competence. Identifying some of factors that are associated with quality problems i.e. lack of competence and at what stage of the construction process that these factors are critical will allow us to contemplate which procurement method is appropriate to certain situations.

LITERATURE REVIEW

A survey conducted by the International Federation of Consulting Engineers (FIDIC, 2004) found that decreasing quality of construction is a worldwide phenomenon that is mainly caused by inappropriate mechanism of project delivery such as poor consultant and contractor selection, bad design, poor project supervision and inadequate material and workmanship. Other authors (Rienstra and Nijkamp, 1997; Jha and Iyer, 2007; Nguyen et al. 2004) identified several factors that have significant influence on the quality performance of a project however one common denominator of all these inadequacies or quality problems is the lack of client competence. Rienstra and Nijkamp (1997), Jha and Iyer (2007) claim that project manager's competence, top management support and interaction between project participants are external contributors that enhance the project quality performance from its existing level while owner's competence is an internal contributor in the sense that owners tend to retain the quality performance at the existing level itself.

A competent project manager and project team were highly ranked among the top five project success factors in a study carried out by Nguyen et al. (2004). Landin (2000) found that client incompetence often were blamed on flawed expectations and requirements placed on contractors. Respondents pointed out incompetent client were unaware of the requirement they should or did in fact place on the supplier and thus contractors were inclined towards not to following these requirements (Landin, 2000). The FIDIC (2004) finding also highlights the importance of client competence during the planning and design stage as well as during the tendering and construction stages. It emphasizes how the actors from the demand-side of the construction process such as client and engineer (consultant) could play a big role in improving the quality of construction.

During the operation and maintenance phase, assessment of the quality is challenging since the expected life of many infrastructure projects is quite long. Customer satisfaction surveys are sometimes used as a proxy for the quality level of a product. Though this approach can give an indication of quality level at certain point in time, it could be difficult to objectively assess the quality level of road infrastructure from end-users' point of view. A survey of Swedish Transportation Administration (STA, 2010) exemplifies the difficult of ascertaining reliable measurement of satisfaction level from road users. The survey found that drivers were not only dissatisfied with road conditions but also private and professional drivers have different opinion about the level of dissatisfaction. Many road administrations from the countries that participated in this study reported shrinking staff due to retirement and to the attractiveness of private sector employment. This report also has noted that new types of contracts require broader project management skills and practical experience and thus there is need for key competences such as operations, road surfacing and specialist engineers (STA, 2010).

RESEARCH METHOD

Cui et al. (2004) state that warrant contracting is usually used with performance-based specifications and is intended to replace stringent quality control and inspection regimes associated with traditional procurement. When quality deficiency is discovered three possible actions can be taken by project managers; complete removal of the defective product or structure, repair without complete removal, and deductions from payments if the quality is not exactly the required level but acceptable within certain limits.

An on-line questionnaire containing was administered in order to find general assessment of the quality problems today and the past (see Warsame, 2010a for more description of the survey). In order to establish the prevalence of quality problems in relation to different phases, respondents were asked their opinion about how often quality deficiency occurs and who discovers as well as what actions are taken when quality problems are discovered. A set of questions that was intended to give us a sense of understanding on whether warranty contracting has improved quality of construction projects after the client transferred quality assurance responsibility to the contractor were also included in the questionnaire.

The rest of the questions of the survey (15 questions) were statements that are intended to ascertain important attributes such as competence of construction actors, project characteristics etc. that may have contributed quality problems or lack of quality improvement. Respondents were also asked to comment on each question and statement in order to solicit their candid view about the quality of infrastructure projects.

FRAME WORK FOR QUALITY IMPROVEMENT

Construction quality

Brockmann (2009) argues that construction projects such as buildings or infrastructure are typically quasi-credence goods meaning that their qualities are ex-ante intangible but ex-post tangible. His argument is based on the classification of three types of quality (Darbi and Karni, 1973); *search qualities* which are known before purchase, *experience qualities* which are known costlessly only after purchase, and *credence qualities* which are expensive to assess even after purchase. Construction goods do not exhibit search qualities since the quality of construction goods cannot be determined at the time of signing contract (Brockmann, 2009). However, once the contract is carried out and the project is completed ex-post search qualities could become tangible. Similarly, construction goods also differ from experience goods since experience qualities are based on a high frequency of contracting between the same client and contractor (Brockmann, 2009). The nature of construction business and government regulations as well as competition rules does not foster repetitive interaction among actors in construction sector. On the contrary, Vassallo (2007) argues that quality of most of infrastructure projects are observable after their use and

classified them as "experience goods". He claims that infrastructure quality is verifiable though the cost of measuring quality is not usually low.

It could be argued that since different procurement methods provide construction clients an opportunity to influence design and construction qualities, a client's internal capacity and available resources such as design and inspection teams as well as his competence and skills play a major role determining whether the desired product has the characteristics of search, experience, or credence qualities. If a client or his representative has the capability to carry out all the necessary quality control and quality assurance activities, this will ensure that the quality of the project becomes not only observable but verifiable during the construction until the operation phase starts or even during the warrant period. When client and contractor have also long term relationship high frequency contracting that is a necessary condition for experience qualities (Brockmann, 2009) could be materialized.

The quality and long term performance of the infrastructure is subject to many external and stochastic factors such as the level of usage of infrastructure, efficiency of intended operation, weather, and frequency of planned and unplanned maintenance. Thus, the quality of realization during operation and maintenance is may be what makes construction goods to be treated as quasi-credence goods.

Client competence

A client organization with highly skilled and sufficiently experienced workforce is most likely capable to ascertain many project risk factors than client organization with less endowed human capital resources. There are distinctive competencies that are highly required when client is employing a specific procurement method. The traditional procurement (Design-Bid-Build) where client has multiple contracts with different actors for the provision of infrastructure projects is a good starting point to identify most relevant responsibilities of client. Client is expected to have enough manpower resources with appropriate skills and expertise in different areas such as financial, technical and contracting management. Some of the notable client competences are; ability to define project scope and objectives, establish design criteria and performance requirement, carry out preliminary survey and geotechnical investigations, ensure constructability of design, perform control and inspection of quality performance, and prepare possible mitigation actions and procedures when performance objectives are not met.

Competences that are needed for risk sharing activities where the client uses a procurement strategy such as design-build and performance-based contracts with warranties are much similar to the above list except that client is oblige to prepare request for proposals (RFPs) for DB contracts instead of complete design of the project. Xia and Chan (2010) found previous experience with DB related projects is among the key competences that DB clients in China should possess. Competences that are needed for risk transferring activities where client engages procurement strategies such as design-build-finance-operate (DBFO) with or without

maintenance and other forms of PPPs are now more related to management, financial, legal, and commercial activities.

A resourceful client organization could use these extraordinary technical competencies and expertise to transform experience qualities to search qualities or even credence qualities to experience qualities. This transition between types of qualities would have certain implication on how client selects appropriate procurement methods. Thus, the above representation could improve understanding the impact of different procurement methods on client's workforces and their skill development. The most common procurement methods and how they defer in terms of quality aspect will be discussed next.

PROCUREMENT METHODS

Procurement methods are often classified based on how construction activities such as design, construction, and operation and management are delegated among actors in the project. Different financing options of infrastructure projects also influence this classification. Love et al. (2008) classified the following four procurement systems; traditional (separated), design and construct (integrated), management (packaged), and collaborative (relational). Our short description of procurement methods is similar to Love et al., (2008) classification and will be described below.

Traditional procurement (separated)

Traditional procurement method of design-bid-build (DBB) with negotiated or separated competitive bidding fits this type of classification. DBB procurement method is prescriptive by nature where owners with in-house designers or with appointed consultant prepare the project design and tender documents. Quality control (QC) and quality assurance (QA) activities are either carried out altogether by the contractor or sometimes the client is responsible for quality assurance while contractor is responsible for quality control process. In Sweden, 25 years ago, the client (Swedish Transportation Administration) has transferred quality control and quality assurance to the contractors and accepts only the final project if it meets the expected quality level of performance.

Mandell and Nilsson (2010) studied some 1400 road construction and renewal projects procured by the Swedish road administration between 2000 and 2009. The large majority of these projects were procured in the form of unit price contracts or DBB. Pietroforte and Miller (2002) noted that DBB was the most dominant form of infrastructure procurement after the Second World War in the US although during the last decade Design and Build (DB) has grown steadily in both private and public sector. Gransberg et al. (2007) indicate that unit price contracts dominate procurement of projects in the transport sector in US. One shortcoming of DBB approach is that it does not take into account the increasing operation

and maintenance costs of the ageing infrastructure (Pietroforte and Miller, 2002). Furthermore, DBB procurement focuses the price of the project rather than quality.

Management (packaged)

Construction management (CM), Management contracting, and Design and mange belong to this category. Basically, an owner enters agreement with a construction firm that carries out leadership, administration and management of specified services (Koppinen and Lahdenperä, 2004b). According to Koppinen and Lahdenperä (2004b), CM is seldom used in road construction because of the relatively small number of contractors involve in road construction that is easily manageable by clients.

Design and build procurement (integrated)

In order to address certain problems associated with DBB and improve the performance of construction projects, integrated design-build (DB) procurement and its variants such as design-build-operate/maintenance (DBO/M) have been promoted to be an appropriate alternative procurement strategy. DB is an integrated procurement system where the client contracts with a single contracting organization to carry out both design and construction responsibilities with or without inclusion of operation and maintenance contracts. One common feature of these types of contracts is that client is responsible for entirely and directly financing the project (see Pietroforte and Miller, 2002). DB would allow contractors to tender the most economical design that meets the requirements of the client and use materials and innovation techniques that produces desirable outcome for the client. However, DB procurement method demands different skills and competences than the traditional procurement (DBB) that public servants are accustomed (Koppinen and Lahdenperä, 2004b). A distinct criterion for DB contracts is the requests for proposal (RFPs) along the price and technical proposals. The RFPs contains owners' objectives and needs with respect to quality and the design/builders are required to interpret those requirements and submit their proposals (Gransberg and Molenaar, 2004).

There is no definite agreement on whether the overall quality achieved under DB procurement is better than DBB. Koppinen and Lahdenperä (2004a) claim that client's expectation of design quality does not differ between DB and DBB though contractors under DB tend to choose only the necessary design that leads to savings. One major problem found by Gransberg and Molenaar (2004) is that owners of public projects who have used DB procurement often executed with DBB mentality because majority of RFPs contained a DBB construction quality control plan requirement. Xia and Chan (2009) argue that the use of DB procurement does not mean that an inexperienced client can simply leave all the project and responsibility to the DB contractor. Design-Build procurement is much easier for a client with sufficient design and past construction experience (Xia and Chan, 2009).

Public-Private-Partnerships and its variants (relational)

A further categorization of procurement methods is based on how financing of the project is formulated. This category is an extension of integrated design-build variations except that the private sector is now financially involved in the provision of a project. Design-Build-Finance-Operate or BOT, as it is known outside the US (Pietroforte and Miller, 2002), Build-Own-Operate-Transfer (BOOT), and Build-Own-Operate (BOO) belong to this group. These procurement methods have longer contract period than the typical integrated procurement methods financed by the publicly sector. Jefferies and McGeorge (2009) argue that there is no clear-cut definition between public-private-partnerships (PPPs) and BOOT except that one can observe an increase in the number of stakeholders of PPP projects. Design-Build-Finance-Operate (DBFO) or Build-Operate-Transfer (BOT) is another example of PPPs arrangement.

Though the use of PPPs for procurement of public infrastructure projects is not something new to most of the developed and developing countries, comprehensive performance assessment of the projects undertaken with PPPs has been difficult due to the divergence between the duration of PPPs contracts and the longevity of infrastructure projects. Infrastructure projects could last decades or centuries while PPPs contracts are often in the range of 30 years. Thus, it is difficult to have a full assessment of infrastructure projects that are constructed under PPPs arrangements. Procurement of infrastructure projects with PPP involves many parties with conflicting objectives and thus requires extensive client competence and expertise (Cheung and Chan, 2010). Estache et al. (2009) claims that the private operator may heavily invest in cost reduction technologies without taking into consideration their impact on the quality of the project. Realized quality could be better or worse under private contracting depending on the impact of any cost reduction technologies employed by the private actors (Estache et al., 2009). PPP arrangements to surface transport infrastructure are complex with many pitfalls and thus require strong client competence and expertise (OECD, 2008). The report suggests that public sector experience with the design and build procurement provides adequate knowledge and capacity that is needed to handle complex PPPs arrangements. Based on international experiences, Swedish Transport Adminstration report (STA, 2008) accentuates the importance of highly competent client organization for efficient and successful PPP projects. According to the report (STA, 2008), the only infrastructure project that has been built with PPPs arrangements so far is Arlanda railway link (Arlandabanan).

RESULTS AND DISCUSSION

Sixty three respondents that translate to a 53% response rate completed the survey. According to the respondents, quality of construction projects constructed in last five years is either at the same level or even better than the quality level of projects built twenty years ago. Same numbers of respondent (44%) believe that quality level is higher today or has not changed during this period.

Responses from client side were almost inconclusive when asked who finds out quality problems during construction (client or contractor). A possible explanation for this inconclusiveness could be that the client has little opportunity to discover quality problems during this phase since quality assurance responsibilities were transferred to the contractor. Respondents indicate that clients' complain is limited to few isolated projects (41%) though 32% of them pointed out that client complain about quality problems is present in majority of the projects. With regard to quality problems discovered during the final inspection, 44% of the respondents say that few isolated projects encountered quality problems while 26% of them indicated that majority of the projects experienced quality problems.

A combined 41 respondents (64%) indicated that quality problems discovered during the final inspection get fixed by means of reparations without complete removal or contractors accepted payment deductions. The situation is somewhat different when it comes to quality problems during warranty period or shortly after it expires. Majority of respondents (42) indicate that clients very seldom discover or complain about quality during this period. If quality deficiencies are discovered during the warrant period, a complete removal or payment deductions are not the preferred options. 25 respondents or 42% of them say that very seldom contractors remove the defected part or structure. Another 20% (20 respondents) say that payment deductions do happen very seldom. The prevailing measure to rectify quality problem during warranty period is reparation without complete removal. These responses give an indication on how project managers and client representatives react when they discover quality problems but the underlying fact is that these kinds of decisions require higher competence and experience that is in short supply in the client organization's workforce as the following responses suggest.

Responses from the questions related to competence of client with regard to quality problems of infrastructure projects were very strongly negative. Respondents indicated that client's lack of competence is major factor of quality problems of infrastructure projects. Approximately 82% of respondents partially or totally agree when we stated that the quality problem in the finished structure is highly dependent on the client's competence. Similarly, 72% of them indicated that tendering documents contributed quality problems of final product. Respondents also pointed out (80%) that designers of the project play a major role on the quality problems experienced in the finished project.

The above finding provides an opportunity to investigate the role of client competence on different procurement methods and how much skills, expertise and competence of client workforces and client experience is demanded by each type of procurement method.

A prognosis from FIA (FIA, 2005) points out that one third of the construction industry's workforce will retire between 2005 and 2015. The study also shows that the construction industry has a higher proportion of older people and a smaller proportion of younger employees compared to the total employment. In Finland, employees' retirement and reduction of client staff are reported to be behind diminishing client experience and competence (Koppinen and Lahdenperä, 2004b). The implication of human capital scarcity is that public clients face an uphill battle in attracting new talented and competent graduates as well as retaining them in a competitive market. Some of the respondents in our survey also raised this issue of ageing client workforce, non-replacement policy of retired staff and their concern of new skilled workers not joining the public transport sector.

Love et al. (1998) state that no one procurement method is likely to be better than others for any project although one procurement method could be more appropriate or suitable than others for an individual project. In Sweden, traditional procurement (Design-Bid-Build) or unit price contract has been the most dominant contract form used for the delivery of transport infrastructure projects (Mandell and Nilsson, 2010; Trafikverket, 2008). The question is whether this heavy reliance of DBB method in the Swedish infrastructure transport is supported by undisputed higher performance achievement compared to other procurement methods or the Swedish Road and Railway administration has chosen it for other reasons.

Several possible explanations have been offered as to why a clients or owners keep using repeatedly the same procurement method especially the dominance of the traditional procurement method. Familiarity of DBB within the industry and its ability to satisfy public accountability, client control over the project's outcome and cost certainty makes easy and attractive method for public sector to rely on more often than other procurement methods (Love et al., 2008, Koppinen and Lahdenperä, 2004a). Avoidance of uncertainty is another explanation. Lædre et al (2006) claim that owners select a well known procurement route since unknown procurement method could introduce new uncertainty. When owners attain experiences from the use of certain procurement procedure and management routines, it will encourage them to keep using this combination in their next project (Lædre et al., 2006). Koppinen and Lahdenperä, (2004b) suggest that DBB procurement are generally considered to be suitable when client wants to settle upon a design before construction commitments, take advantage of existing designs or the client has the only experience necessary for this kind of project. Lædre et al (2006) state that public owners are not motivated to be creative when selecting the procurement route because creative thinking is seldom rewarded while project failure will be criticized. Thus, it is convenient to use the same procurement system. One important question that could be raised about the heave reliance of public sector on DBB

procurement method is "can the benefits and confidence that a continuous use of DBB offers to the public sector be sustainable for a long period of time?

While cost effectiveness, strong client control of the project, and flexibility are some of the benefits associated with DBB, one cannot overlook the downside of the use of DBB procurement for several reasons. First, if the client's lack of competence (as our survey indicates) is due to a shortage of skilled and experience workforce then the use of DBB could exacerbate the situation since DBB requires higher client involvement. Secondly, the use of DBB contracts has been seen as one of the factors that contributed to the lower productivity and lagging performance of the Swedish construction industry (Mandell and Nilsson, 2010; Nilsson, 1999). Thus, a lack of client competence and its negative impact on quality of infrastructure projects will worsen the situation and inflict further distress to the sagging industry's productivity.

The frequent use of DBB procurement raises other concerns on top of its susceptibility for human capital shortages. In the US, economic factors and change of procurement laws will cause an increase of public client's use of other procurement methods such as DB, DBO and BOT (Pietroforte and Miller, 2002). Similarly, Lædre et al. (2006) state that, since April 2000, UK government requires projects should be procured by public-financing-initiative (PFI), prime contracting, or design-build. In Sweden, limited projects have so far been procured with other procurement method than traditional DBB method. However, the use of performance-based contracts such as DB (with short-term warranties) and DBOM (with long-term warranties) is painted as good move toward public sector readiness to embrace PPPs arrangements (STA, 2008).

The use of warranty contracting has given some leeway for the public sector to deal with quality problems that could arise from contractors not complying with the specifications and the design (Cui et al., 2004; FHWA, 2007). Federal Highway Authority report (FHWA, 2007) state that warranties offered an alternative way to assure performance when State highway agencies faced staff and budget shortage and still needed to increase the quality and life-cycle performance of pavement. Warranties guarantee that contractors are responsible to repair and replace defects both during the construction and warranty period (Cui et al., 2004). One of the main features of warranties is that quality is measured based on actual product performance over time rather than construction materials and workmanship (Guo et al., 2005). In other words, contractor has the incentive to use any construction methods and products as long as they meet client's specified quality performance. The finding of our survey seems to support that contractors with warranty obligations have actually succeeded to produce the desired quality performance of infrastructure projects. More than seventy percent of respondents have indicated that only few or no infrastructure projects encountered quality problems during the warranty period or after the warranty expired (after 1 to 3 years).

CONCLUSIONS

The success and failure of infrastructure project to achieve their performance objectives in terms of end-users' needs and societies' economic benefits are determined by number of factors including the procurement strategy. The choice of an appropriate method to procure a specific infrastructure project depends on many factors and client competence is one of the most important of them. The client is not only the owner of the project and the initiator of the concept but also represents the end-user and thus responsible for determining their needs objectively, interpreting them accurately and selecting design and construction teams that can deliver successfully the desired product. All these activities and responsibilities require a very strong client competence with skills, expertise and experiences necessary to carry out their technical, financial and management duties.

As our survey and other previous studies mentioned in this paper indicate, lack of client competence is one of the factors that contribute quality problems of infrastructure projects. Traditional procurement method, which is the most common method used by the Swedish Transportation Administration (STA), demands the highest client involvement in the project compare to other procurement methods. In light of shortage of skilled and experienced workforce in the public sector and the heavy reliance of the sector on this traditional procurement, it is plausible to assume that the association of quality problems and luck of client competence is not a mere coincidence but an overlooked outcome of current situation.

Many benefits that are associated with traditional procurement method such as client's control of the project, design flexibility and familiarity of the sector with this method and public sector's achievement of quality standards through warranties cannot be disregarded. However, the need to have enough public sector staff with good skills and competencies is very crucial to improve that quality of infrastructure transport projects. Strong and broader client competence would enable the public agency staff to properly identify the needs of the customers that are necessary inputs to determine the performance requirement and the objectives of the project. Increased client competence would ensure that many unknown quality attributes are transformed to known elements and know-unknowns will be shared or transferred accordingly. On one hand, product with quality attributes similar to manufacture goods (search goods) could benefit a procurement method that relies more on standardization and the use of more prefabricated products. On the other hand, product with experience and credence qualities would benefit more on the use of procurement methods that foster frequent and long-term relationships such as performance-based contracts and PPPs arrangements. Furthermore, other procurement methods such as relational (PPPs), integrated (DB), and performance-based contracts (DBOM) require strong client competence, skills and expertise that match those possessed by the commercial and business-oriented private sector.

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Paper 8

Procurement type and quality in infrastructure projects

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Abstract

One of the major goals of any project is to achieve the highest possible quality level without adversely affecting the anticipated cost and schedule. The final quality of a project is determined by a number of factors and there is no simple deterministic relation between these underlying factors and the level of quality. A fundamental question is whether quality can be increased by choosing a particular procurement method or the risk for low quality is higher with certain procurement method. Despite the existence of large literature in this area, there has not been clearly formulated that quality is independent from the choice of procurement type. We argue that given the right conditions all procurement methods can give good results, and given the wrong conditions all of them can lead to low quality.

The aim of this paper is to try to synthesize both theoretical and empirical results about the performance of different procurement method and present arguments that make this statement convincing. The theoretical framework used in this paper is general contract theory and transaction cost theory while the result from questionnaire carried out within the project provided important empirical background.

Two questions that are central to the debate of the choice of procurement method in relation to quality of the final project are who should do the detailed design and should construction and operations be bundled. A client with low technical competence may choose design-build procurement method as the client then only has to specify the characteristics of final product. This same client can also contact with technical consultant and make the detailed design together that would allow client to use design-bid-build procurement method. The main conclusion is that there is no quick fix when it comes to improving quality in infrastructure projects and there is no a procurement method that guarantees a better quality than another.

Keywords: Construction**,** infrastructure projects, procurement methods, quality

1. Introduction

Cost, time and quality are the three main dimensions when project results are evaluated. In this article the focus is only on the last of these three: How can quality be increased and what can be done to avoid quality problems? As discussed in Warsame (2011) quality in relation to construction projects can be given different meanings. A first distinction is between quality of product and quality of process. Another important distinction is between quality as an absolute concept in relation to certain standards and quality as a relative concept where quality is related to what the client had ordered and what the client reasonably could expect, given the price they are willing to pay. In this paper quality is used in this relative sense.

The final quality of an infrastructure project is determined by a number of factors. The diagram below (from Warsame 2011) gives an overview of these factors. In this article the focus is on the second stage in the diagram which includes the choice of procurement types: Can quality be increased by choosing a particular procurement method and are the risks for low quality higher with certain procurement methods?

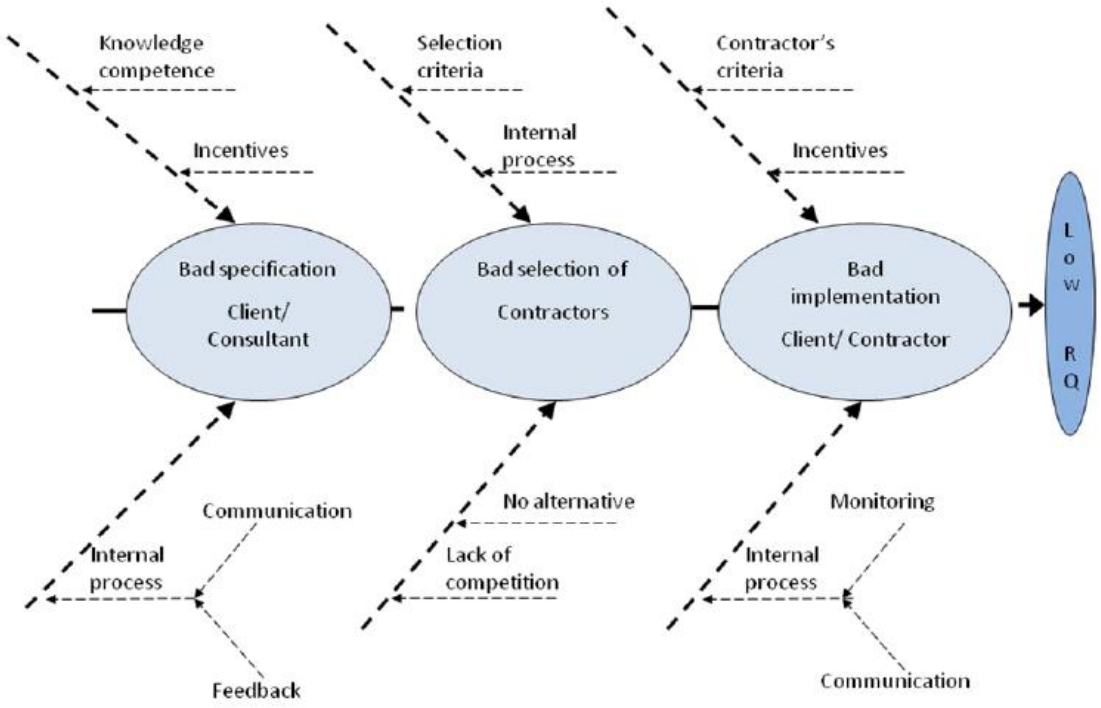


Figure 1: *Model for explaining quality problems (RQ = relative quality)*

The thesis that will be argued for in this paper is that the answers to both these questions are NO: Given the right conditions all procurement methods can give good results, and given the wrong conditions all of them can lead to low quality.

The structure of the article is as follows. In the next section the methodology and theoretical framework of the paper is presented, and then different procurement types are presented in a structured way. They are structure around two central questions: "Who should do the detailed design?" and "Should construction and operation be bundled?" These two questions are then discussed from a quality perspective in section 4 and 5. Other aspects related to procurement types are analyzed in section 6. In section 7 our conclusions are related to conclusions in some other literature on choice of procurement type.

2. Method and conceptual framework

Method

The paper tries to synthesize both theoretical and empirical results about the performance of different procurement types. There is a very large literature in this area but we hope that the selection made covers the most important arguments and results. One background is also the questionnaire presented in Warsame (2011) where one result was very weak support for statements that quality problems were less in specific procurement types.

Our aim is to try to present theoretical and empirical arguments that make the statements presented above convincing. Future debates will determine to what extent we have succeeded,

From a broader methodological/Popperian perspective the propositions presented can be seen as "conjectures" that, according to our view, have so far not been refuted.

Conceptual framework

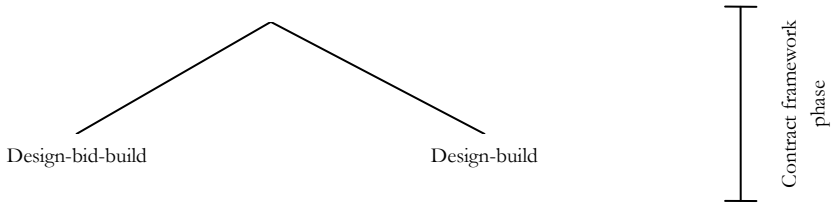
The theoretical framework used is general contract theory and transaction cost theory, where assumptions about rationality and self-interest are made and where incentive problems, asymmetric information, principal agent problems and moral hazard are central concepts. The concepts and ideas from these theories will be presented a little more in detail in sections 4 and 5 below when they are used.

3. Procurement types

Procurement types can be structured and classified in a number of ways. Here the starting point is the stepwise structure in Borg (2011).

In the first step the methods are divided after *who does the design* and two broad categories are then identified: *Design Bid Build (DBB) contracts* where the client is responsible for the design and *Design-Build (DB) contracts* where the contractor is responsible for the detailed design. This is illustrated in figure 2

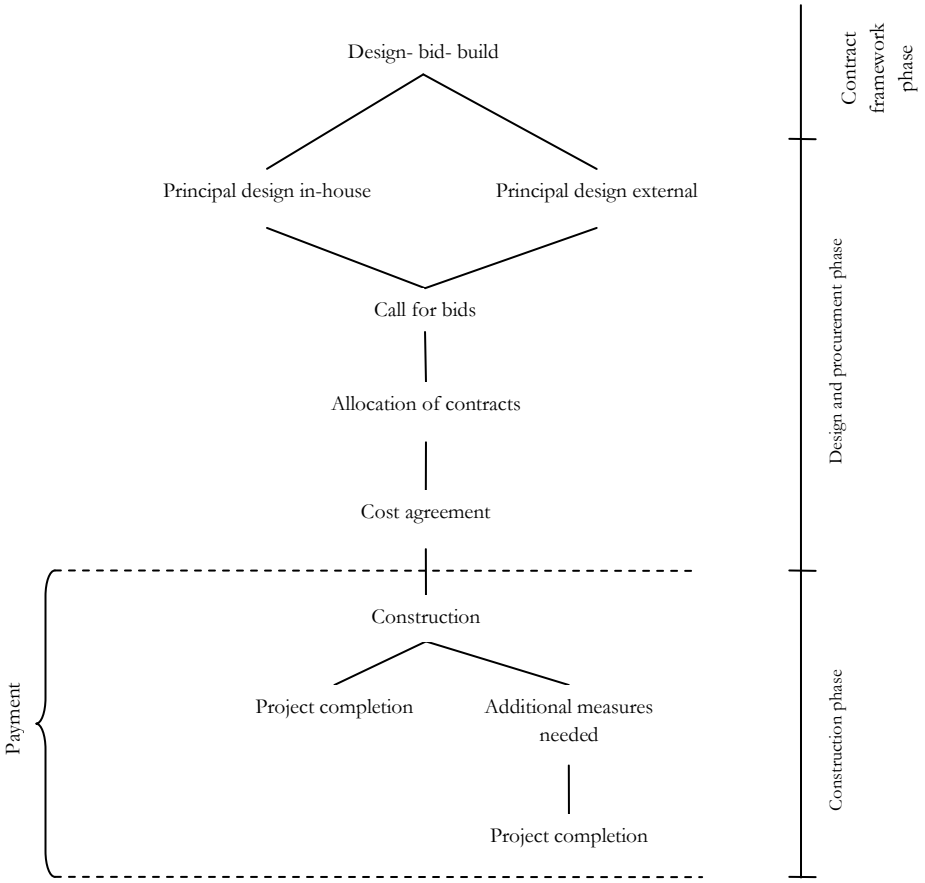
Figure 2: *Initial decision when procuring a contract in the infrastructure sector.*



Within each of these two types the client can hire a Construction Management company that helps and takes over the responsibility for some of the tasks that otherwise is done by the client. This will be commented upon below, but the use of a Construction Manager does not change the difference described above concerning the role of client and contractor.

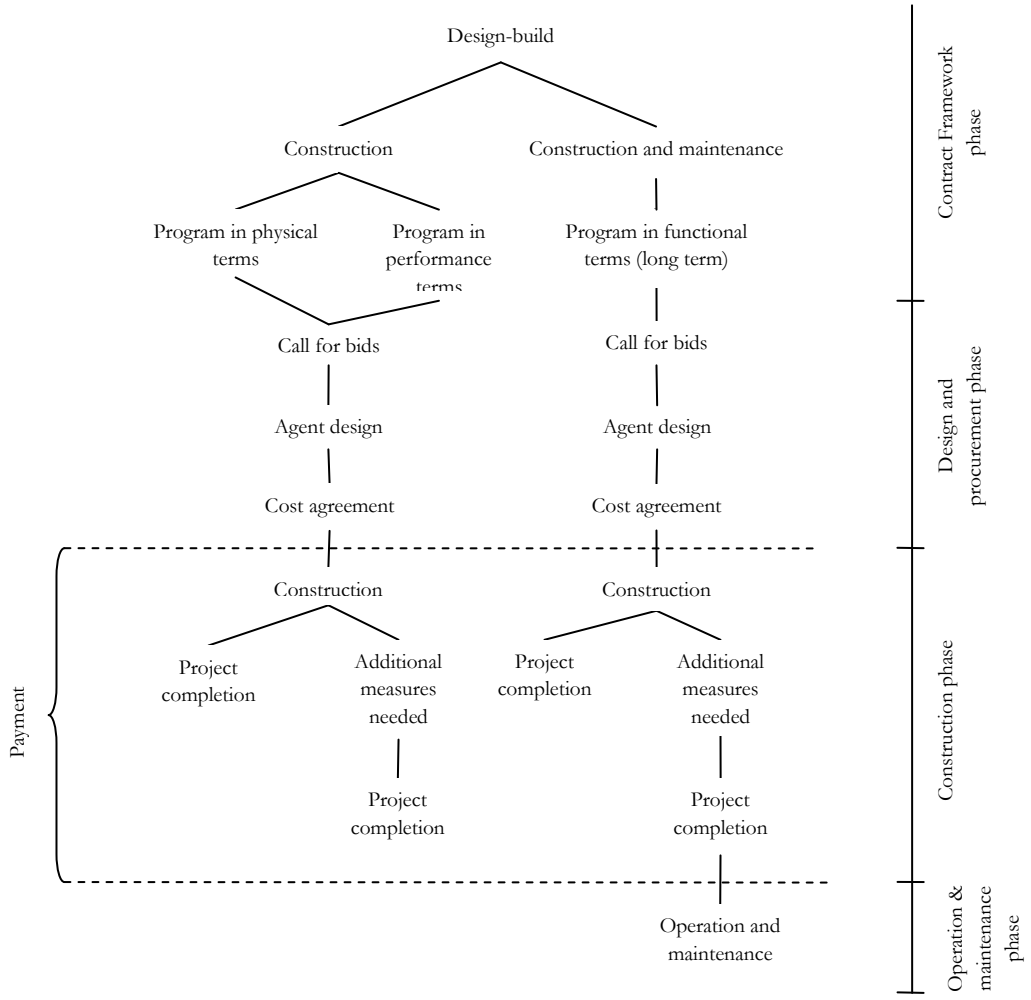
The Design-bid-build can further be subdivided according to *whether the design is made in-house or not*. The total process in a DBB-project is described in Figure 3 below:

Figure 3: *The design-bid-build process*



Within the Design-Build procurement, further subdivisions are motivated dependent on *what the contract covers for activities*: Does it only concern the construction phase, or does it also concern operation and maintenance of the object, e.g. a road. In Figure 4 such a subdivision is presented.

Figure 4: *The design-build process*



From this division two crucial issues can be identified in relation to the question of how procurement type affects quality, and these will be discussed in the following sections. The two main issues are:

- Concerning design: Should the client or the contractor be responsible for the detailed design (se figure 2). This is discussed in section 4 below.

- Concerning the scope of the contract: Should the procurement only include the construction phase or should it also include operation and maintenance (see figure 4 above). This is discussed in section 5 below.

Some other aspects, including the use of partnering and incentive systems are commented on in section 5.

4. Design responsibility and quality

The tendency in many countries seems to be to move away from making the design in-house to using external consultants. There can be several explanations for this, e.g. that fluctuations in the number of projects make it difficult to employ an in-house work force, and that this problem can be increased when the work-force becomes more specialized. It might also be more difficult to create strong incentives in an in-house organization. In Warsame (2009) there is a more general discussion of the trend away from both in-house technical specialists and in-house construction work force among developers and authorities responsible for infrastructure.

Independent of the reason for this development, the discussion here will focus on a comparison between the case where the client hires a technical consultant to do the detailed design and the case where the contractor works together with a technical consultant and do the detailed design. Notice that the arguments against the client/developer having their own staff also are relevant for the question whether the *contractor* has an in-house staff or not. This means that it might be the same companies and individuals that make the detailed design independent of whether the client or the contractor is responsible for the design. The question of the skills of the technical consultants doing the work should then not be an argument that points in a specific direction when it comes to who should be responsible for the detailed design.

In the classical work on economic organization in the widest sense, Milgrom and Roberts (1992) describe the general problems in an economy in terms of achieving *coordination* and creating *incentives*. These aspects seem highly relevant for the choice of who should do the design.

- From a *coordination* perspective, the rational choice would be to let the contractor be responsible for the detailed design as the design then can be adjusted to the technical competence of the contractor and the design can be carried out with more knowledge about the following construction process.

- From an *incentive* perspective, the rational choice would be to let the client be responsible for the design. If the technical consultant work for the contractor there should be pressure on the consultant to choose cheaper solutions within the limits set by the standards laid down by the client. It might be difficult to know the exact quality of all technical alternatives and there can be expected to be some incompleteness or vagueness in the client´s standards, and this opens the door for the contractor to influence the design in the direction of cheaper solutions with somewhat lower quality.

A counterargument against this is that stronger incentives for the contractor to choose the "right" solution might be created if the contractor also is responsible for operation and maintenance. This will be discussed more in detail in section 5 below and for now it assumed that the contract only concerns the construction phase.

The implication of the arguments above is, of course, that things might go wrong in both alternatives. If the client is responsible for the detailed design, and do not have enough knowledge of the production phase, there will arise a need for redesign and costly adjustments. The overall quality might also suffer if the design is not adjusted to the skills of the contractor. On the other hand, if the contractor is responsible for the design, there might be a risk that alternatives with lower cost and quality are chosen if the specifications of the client are imperfect.

A client who is aware of these potential problems can however mitigate them, at least partly. If the client is responsible for the detailed design they - and/or the technical consultant - may build up knowledge of the construction phase in order to reduce the risk for coordination failures. If the detailed design is made by the contractor, the client may be more careful with the specifications, or for some components where quality is difficult to evaluate ex-post, the client might simply say that this is the component that should be used. Such detailed specifications might also be necessary if the client uses a certain brand in other parts of their system and want to reduce operating costs by having getting economies of scale, e.g. concerning spare parts. Koppinen and Lahdenperä (2004b) also underline that the client might need to spend considerable resources for monitoring in DBB-projects to mitigate moral hazard problems when the contractor is responsible for design. As shown in Figure 1, the final quality will also depend on the implementation stage and even if design and procurement is carried out in the best possible way, quality might be bad because of problems in this final stage.

If the reputation of the contractor is important for the choice of contractor in forthcoming projects, it might also be risky for the contractor to choose a cheaper low quality alternative as this might reduce the probability of future work for the client.

We also see here that the line between the alternative procurement types becomes vaguer. A knowledgeable client may, even if they are responsible for the detailed design, leave some room for adjustments of the design after the contractor is chosen in order to take advantage of the comparative skills of the chosen contractor. On the other hand, if the client´s specifications become more and more detailed, then the room for the contractor in the design stage might be rather small, even if they formally are responsible for the design.

As argued in Borg (2011), the choice between using Design-Bid-Built and Design-Build might be determined by factors that are independent of how the different alternatives affect coordination and incentives for the actors. Three examples are:

- The importance of creating competition. The number of companies that are willing to bid for a job where the detailed design already is done might be higher as the risk in such a case is lower and the need for competence is narrower.

- There might be several technical solutions that are possible and only a few firms that are good at each technique. If the client specifies the technique, then only a small number of companies are left and the lower competition might increase the price. If the detailed

technique is not specified by the client, more companies might be willing to bid which could be expected to reduce the price.

- Time: Especially in larger projects it might take more time if the detailed design is made first and contractors selected afterwards. If the contractor is responsible for the design the work can start as soon as the design of the initial part is ready, and the initial construction works can be carried out while the design is still going on for the later stages.

In complex projects where the design needs to be adjusted during the project as more information becomes available, it may also be more practical with a DB-contract.

5. Quality and the integrating of construction and operation/maintenance

The potential of bundled contracts

In recent years a number of theoretical studies have pointed out that bundling construction and operation/maintenance can lead to higher efficiency, as is done in e.g. different forms of Public Private Partnering-projects (PPP). No distinction will here be made between different forms of contracts where construction and operation/maintenance are bundled, e.g. differences in how the project is financed and how the contractor is paid.

The core in articles like Bennett and Iossa (2006); and Martimort and Pouyet (2008) is that this type of bundling leads to higher efficiency because coordination between construction and maintenance can be improved. The design can in a better way take into account consequences during the operation/maintenance stage and this reduces life-cycle cost. Better knowledge of how the construction works have been carried out can also lead to operation/maintenance measures that are better adjusted to how the facility was built.

Another important feature of these long term bundled contracts is that they, at least partly, are formulated in performance terms. The client sets up a number of performance criteria that the facility should fulfill over time and the payment to the contractor is dependent on that these conditions are fulfilled.

The potential from a quality perspective of contracts that bundle construction and maintenance are clear: The responsibility for supplying the quality that is stipulated in the contact is completely in the hands of the contractor and their payment is dependent on that they produce a service with this quality.

Problems with bundled long term contracts

As argued in e.g. Lind & Borg (2010) there are a number of general problems with realizing this potential in bundled contracts, e.g. how contractors can collect and transfer knowledge within their organization about how operation and maintenance costs are related to how the

facility was constructed. Here the focus will, however, be on issues more directly related to the quality of the object.

The *first* main problem is the possibility of describing the quality that the client wants in a way that is possible to measure in a rather objective way. Robinson and Scott (2009) point out that the description of services in PFI/PPP projects typically lists a large number of characteristics and that this still has not been enough to get the contractor to produce what the client really wanted. The quality of the facility, in some dimensions, was not the expected one because it was difficult to write a contract that was complete enough. Their general message is that describing service quality is very difficult and that a lot of resources must be put into specifying service quality. Guo et al. (2005) also points out measurement problems in a contract with functional demands.

A *second* contractual aspect that can be problematic in performance based contracts is the verifiability of the specified characteristics. Lind and Mattsson (2009), evaluating an experiment with performance based bridge maintenance, show that there were often disagreements between client and contractor about whether the characteristics specified in the contract were fulfilled or not.

In general one can say that writing "complete" long term contracts is a very challenging task and that there are bound to be mistakes or lapses that can lead to lower quality than expected in the objects, see e.g. Milgrom and Roberts (1992) for a discussion on conditions for complete contracts and why they are difficult to fulfill.

A *third* general problem with long-term bundled contracts is what happens over time. The theoretical studies typically assume that there is a completely binding contract and that the contractor has a real long-term responsibility for the object. There are several problematic assumptions behind statements like these:

The first assumption is that there will be no renegotiations of the contract. Engel et al (2009) show that renegotiations have been common with PPP projects in Latin America. Even if they focus on payments and cost-overruns, the same problem might occur concerning certain quality aspects. A contractor with good political connections may be able to renegotiate and get the client to accept a lower quality than the one originally stipulated.

A second assumption is that the contractor will not sell the project. In recent years a number of infrastructure funds that are buying PPP-projects have been started (see e.g. Inderst 2010). Initially the project is owned by a construction company, but when the project is completed it is sold to an investor. This might seem logical from a comparative advantage perspective as the construction company has their advantages in the initial stages of the project. If the contractor plans to sell the project, the incentives for the contractor to choose techniques that minimize life-cycle costs are reduced as there will be asymmetric information between the contractor and the new investor. The contractor might build with lower quality in dimensions that are difficult to evaluate from a buyer, and this creates higher operating and maintenance costs later on.

It could be argued that this does not matter as the new owner of the project will be responsible for supplying the specified quality. It would simply be a transfer of resources to the initial contractor from the buyer who overpays for the project, not knowing that they will have to spend more resources on operation/maintenance because of the low-cost alternatives chosen by the original contractor. As has been seen in the period before the recent financial crises, overpaying for property is not uncommon and it cannot be assumed that the initial contractor thinks that all buyers will be rational and well-informed. Studies have shown that when an actor gets under financial pressure they tend to reduce quality (see Matsa 2011 for an example from the retail sector). One can therefore imagine a scenario where a bundled construction and maintenance contract, e.g. a PPP-project, is sold to a more speculative investor at a high price and with high leverage, and where this investor reduces operation and maintenance cost - and quality - in order to avoid bankruptcy. If such a bankruptcy would occur, it would most likely put the direct responsibility back in the hands of the client.

General evaluation

We are not saying that bundled long term contracts cannot work. A client with a combination of skill and luck might find the right contractor for such jobs - a contractor that is dependent on their reputation and therefore do not use the possibilities given by an incomplete contract, and do not sell to less serious or less knowledgeable investors. It is important to underline the role of luck here, as it is impossible to predict how a contractor will act in the long term. New owners or managers may take over a "serious" company and manage it in different ways than expected.

It can also be argued that the potential advantages of a bundled contract can be gained in a none-bundled contract if the client builds up knowledge about the relation between construction and operation/maintenance. Karim (2011) e.g. presents life-cycle calculation of highway barriers based on data from the Swedish Transport Authority. Results from studies like that can be used by the client to stipulate what kind of barriers the contractor in the construction phase should choose. Lind & Borg (2010) argues that in the infrastructure sector where government authorities have been responsible for construction and operation/maintenance over maybe 100 years, these authorities have much better opportunity to build up such knowledge compared to a private contractor that traditionally has worked only in construction projects and with little resources for research about the long term consequences of different construction techniques.

6. Other aspects of the procurement

This paper started from the hypothesis that the choice of who should be doing the design and whether construction and operation/maintenance should be bundled or not are the two most crucial dimensions in the choice of procurement type. In the debates about procurement types several other aspects have also been discussed (see e.g. Ashworth 2008, chap 11) and two of these will be commented upon here.

Partnering

Eriksson (2011) describes different dimensions of partnering – width, depth, duration and intensity - but for the purpose of this paper, partnering in general can be seen as a closer cooperation between client and contractor where e.g. adjustments in the project specifications can be made during the project. In another paper (Eriksson, 2010), based on a questionnaire to clients in Sweden, one result was that clients seemed to be more satisfied with the quality in partnering projects compared to non-partnering projects.

Closer cooperation between client and contractor is, however, possible in all the different types of procurement that has been discussed above. For DBB there can be partnering relations both between the client and the technical consultant and between the client and the contractor. Nyström (2007) analyze partnering in rather long term operation and maintenance contracts, and it is also possible to work with partnering in PPP-contracts (see e.g. Andersson 2008 for a discussion about on how complete the PPP-contracts are in different countries).

From a quality perspective, working with common goals and structures that reduces the risk for moral hazard should be an advantage independent of the procurement type and Eriksson's result mentioned above is in line with this.

Economic incentives

Economic incentives are possible in all kinds of contracts, e.g. related to the completion time, or through cost-sharing contracts. Designing incentives are, however a complicated matter, and strong economic incentives and qualities that are difficult to observe creates risk, but it is hard to see that this risk is higher in a specific procurement type.

7. Concluding discussion

The thesis in this paper – that quality is independent of choice of procurement type – has, as far as we know, not been formulated as clear and straightforward as here, but there are statement that are very much are in line with our views. Many authors discuss in what

situations a certain procurement type is best, but typically the statements are vague and very guarded, which is what we should expect given the thesis formulated above.

Ashworth (2008) writes

> "Individual experiences, prejudices, vested interests, familiarity, the need and desire for improvement are all factors that have helped reshape procurement in the construction industry." (p 298)

> "The arguments for engaging either a consultant or a constructor as the client´s main advisor or representative are to a large extent linked with tradition, fashion, loyalty and the satisfaction or disappointment with a previous project." (p 295)

This means that one client might go from procurement type A to procurement type B in order to increase quality, while another for the same reason moves in the opposite direction. And this should not be surprising if the direct relation between procurement type and quality is weak.

In a similar way, Laedre et al (2006), for example, writes "A client's choice of procurement method, among other factors, could be influenced by the client's familiarity and prior experience with that method as well as the level of client involvement required by the selected method". The same point is made in HM Treasury (2008). Molenaar and Songer, (1998) underlines the role of public agency's staff and experience to the success of projects procured in DB delivery method, which implies that during some circumstances this method might work well but not do so in other situations.

The thesis in this article can be formulated in other ways. The most general one is to say that there is no quick fix when it comes to improving quality in infrastructure projects. There is no procurement method that guarantees a better quality than another.

A second alternative way to formulate the thesis is to say that there are no simple deterministic relations between underlying factors and the quality that will result in a project. This means that it is not possible to say that in situation S1 the probability of getting high quality is better if you choose procurement method P1. In the literature one can find statements that each procurement method has advantages and disadvantages and that they are suitably for different situations. We can agree with the first part of the statement, but the second part does not follow, if rather general situations are referred to. An example can clarify this.

It has been argued that if a client has low technical competence, then choosing DB-procurement would be better as the client then only has to specify the characteristics of the final product. The first counterargument is that if you do not have technical competence it will be very difficult to specify all relevant characteristics of the object. The second counterargument would be that the client could just as well contact a technical consultant and make the detail design together with them, and then use a DBB-procurement. A client that has

good relation with a technical consultant would probably choose the second alternative while a client with good experience from working with a specific contractor would choose the first option.

To end on a more positive note, in a companion paper to this (Warsame & Lind, 2011) there are discussions about what a client can do to improve quality. The main thesis is that knowledge and incentives are the crucial factors. The client has to build up a system for knowledge management, which of course must include knowledge about necessary conditions for making a certain procurement type work, and create an organizational culture where there is a continuous feedback from earlier projects and incentives for the employees to do "the right thing". Whether infrastructure projects are procured with traditional DBB, DB, or PPP-structures a skilled and experienced client workforce could overcome the challenges in each of the methods and contribute to the delivery of successful projects. And that success will depend on how knowledge that is gained from the design, construction and operation phase is captured, stored and shared among the clients' workforce. Hence, a proper knowledge management through the whole process might facilitate public client workforce to share the experience and lessons learned from previous projects

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Paper 9

What can the client do to improve the quality of transport infrastructure projects?

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Abstract

Public sector clients play different roles in the provision of transport infrastructure projects. They are responsible to identify the needs of end-users, determine performance objectives of projects and ensure that the most appropriate procurement method that minimizes risks and optimizes outcomes is chosen. Public sector client could also have a major influence on the actions and behavior of other actors in the sector that ultimately improve the overall performance and productivity of construction sector.

The purpose of this paper is to present and argue for a number of statements about what is important in order to improve quality in new infrastructure projects. The paper tries to synthesize both theoretical and empirical results concerning organizational performance, especially the role of client competence for the quality of the project. Results from the questionnaire carried out within the project but presented elsewhere and extensive literature review are mainly utilized.

We argued that knowledge and incentives are two crucial dimensions for getting high quality. The internal process of client organization such as design type, procurement method, and construction procedures could be influenced by client's internal resource capacity. Thus, a more structured and proper knowledge management will not only minimize the loss of tacit knowledge and enhance public sector's internal process capacity but will also reduce reliance on specific procurement method without economic and technical justifications. Furthermore, certain strategies such as incentive schemes, second opinion practices, post-review reporting for accountability and transparency purposes could improve public sector's knowledge assets. It is expected that only a public sector client with skilled and experience workforce supplemented with appropriate knowledge management can succeed to fulfill their societal responsibilities.

Keywords: Client competence, knowledge management, infrastructure, internal process, quality

1. INTRODUCTION

1.1 Background, purpose and main ideas

Time, cost and quality are three crucial parameters in a construction project. Delays, cost-overruns and quality problems have plagued construction projects. In an earlier paper (Warsame, 2011a) it was found that according to both clients and contractors involved in transportation infrastructure investment in Sweden quality has not fallen over time, but improving quality is always an important issue. As the concept of quality also has been discussed in that paper it just stated that quality here is a relative concept. Bad quality is when the quality is lower than could be expected given what was contracted.

What is typical in the kind of projects that is discussed in this paper is that there is a public client responsible for very large investments. In Sweden, the Swedish Traffic Administration is responsible for both roads and railways and has an operating budget of 50 billion SEK for 2010 (around 5 billion €).

The purpose of this paper is to present and argue for a number of statements about what is important in order to improve quality in new construction in projects of this type. The main points are:

1. First we want to repeat the obvious point that *there are no "quick-fixes"*. Improving quality is a long term goal and depends on a number of interacting factors that has to be in focus continuously over time.

2. *It is up to the client to make sure that quality is good*. This starting point is discussed more in detail in section 2 below. In many sectors of the economy it is not expected that the buyer of a product should have a lot of knowledge, e.g. when a household buys a new car. In these cases the market works in such a way that it is possible to find a car with good quality without being an expert. As argued in section 2 below, this should not be relied on in the area of infrastructural investment.

3. The two crucial dimensions for getting high quality are *knowledge* and *incentives*. The famous Swedish builder Olle Engkvist wrote the following in a book from 1949 (translated by us):

> "That a low-quality building ever is constructed depends on that the builder either lacks one or several of the necessary qualifications for the trade, or that the profit motive is so dominating that it overshadows all other interests." (Engkvist 1949, p 9)

In a governmental organization, it does not have to be the profit motive that creates problems, and the term can be exchanged for ulterior motives in general.

4. *Knowledge management* is very important in an organization. A central question is therefore how the client systematically can build up and maintain the necessary knowledge? This is in focus in section 3.

5. The second crucial point is to create incentives for individuals. The goal should be *to create a structure where an individual's decision today affects the future for the individual*. Doing a good job should increase career opportunities and make higher future incomes possible. The recent financial crisis has shown that it is almost impossible to create short term incentives for "good" behavior (see e.g. Quigley 2008) and the focus in the discussion is therefore on long-term incentives. Some pre-conditions for creating the right incentives are discussed in section 4.

6. The knowledge and incentive structure is also embodied in *internal work processes*, and in section 5 some examples of ways to design such processes in order to increase quality are presented.

In Warsame (2011a) the following "Fishbone structure" for explaining quality problems is presented.

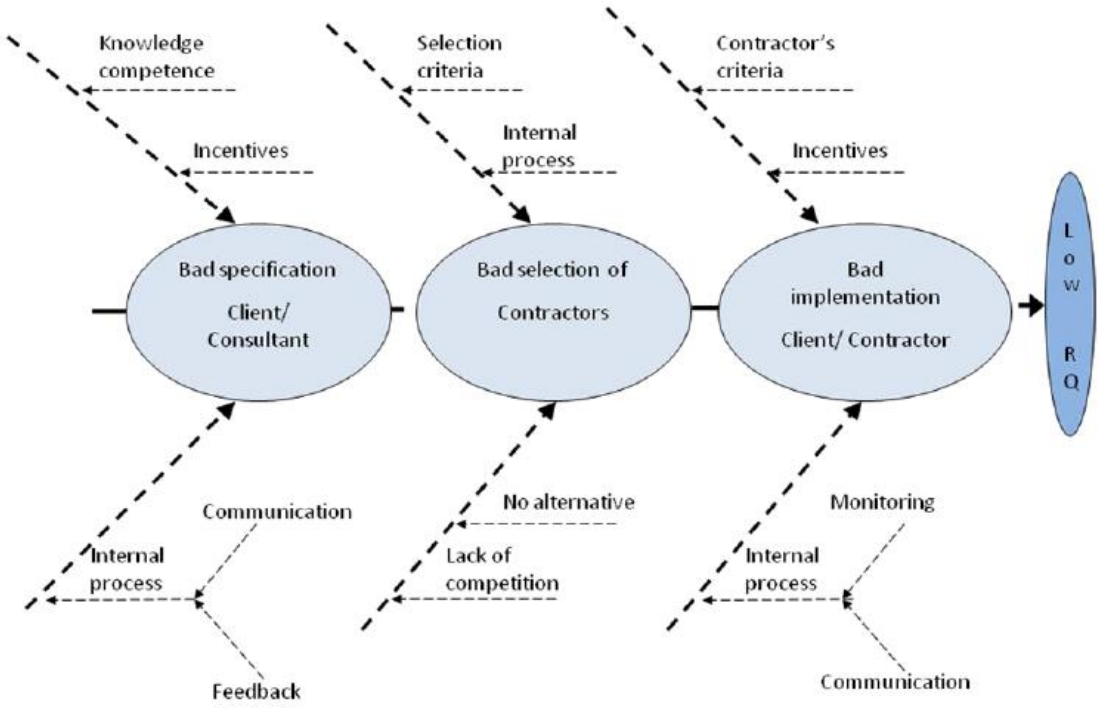

Figure 1: *Model for explaining quality problems (RQ = relative quality)*

This paper is based on the hypothesis that *knowledge and incentives are crucial in all these three stages* – for the right specification, the right selection of procurement method and during

the implementation stage where the client has to control that contractor delivers what was contracted.

1.2 Method and limitations

The paper tries to synthesize both theoretical and empirical results concerning organizational performance, including the results from the questionnaire carried out within the project and presented in Warsame (2011a). One of the main results in that questionnaire was the role of client competence for the quality of the project.

The paper is of course rather speculative. A statement like "If you do X, quality will increase" is difficult to verify empirically as quality is dependent on so many factors that it is empirically is very difficult to identify the specific role of a certain factor. In each case the resulting quality is the result of the interaction of a large number of factors as illustrated in Figure 1 above. Our aim is, however, to try to present a theoretical and empirical argument that makes the statements presented above and clarified below convincing. Future debates will determine to what extent we have succeeded, and what the weak points are that need to be developed more. The aim is not to be original but only to try to present a convincing set of proposals.

The paper is written in a Swedish context but the proposals are general. To what extent various organizations already embody these principles are not discussed in the paper. It is not a proposal saying. "This is what you should *change* in order to improve quality" but a proposal saying "This is what an organization *should look like* if it wants to have higher and higher quality."

From a broader methodological/Popperian perspective the propositions presented can be seen as "conjectures" that, according to our view, have so far not been refuted.

2. WHY QUALITY IS UP TO THE CLIENT?

It is possible for a non-expert to know the quality of a car rather well, but it will be argued here that a traffic authority cannot rely on "the market" if they want to build a road with a certain quality.

The car is typically produced in a large volume in a plant with rather strict control of the production process. The company has produced cars over a number of years. As the life of a car is rather short it is possible to collect information rather quickly about the quality of a certain brand, and a certain model. In a country like Sweden where cars have to be inspected every year a lot of third party data are published on faults in all car models. The result of this is that the household do not have to be an expert, or even consult an expert when they buy a

new car, as there is this third-party information on different brands. (That the situation is different with an old used car is another story, see e.g. Akerlof , 1970). Tests of new cars are also regularly published in both general and specialized newspapers.

A section of a road is typically:

- Produced "in the field" where surveillance can differ considerably and where external factors can affect the quality of a specific construction.
- Produced by a group of people that change more or less from project to project. If company A does a good job in project p1 in region r1, it does not mean that company A will do a good job in project p2 in regionr2 as a different group of persons then will produce the road. Big construction companies are typically to some extent decentralized (see e.g. Leiringer et al 2009).
- A good where it takes a relatively long time to find out if there are quality problems – and even if company A did the job then it might not be the case that company A today are as bad as they were maybe 10 years ago when the road was constructed.

This is not the right place to develop these arguments further but in the rest of the paper it is assumed that the market feed-back mechanisms in infrastructure construction projects are too weak to be relied upon. The client must then use more direct methods to assure that a certain quality will be delivered.

This view of the role of public client has been underlined by several authors, even if the theoretical background to their statements isn´t so clear. The procurement of these assets, and proper operation and maintenance as well as their continuous performance improvement, requires a client workforce with strong competence, skills and experience. Ward et al. (1991) stresses that client's stock of experience and advice received are crucial to addressing his objectives, concerns, and client perceptions of the nature of the project as well as formulating client's expectations of the procurement method. Public clients need to maintain enough skilled and competent workers and management in order to manage risks and safeguard public interest of construction projects (Manley, 2006; APCC 2002). Public sector clients could also have a major influence on the actions and behavior of other actors in the sector as well as overall performance and productivity improvement of construction sector. It is expected that only a public sector client with skilled and experience workforce augmented with appropriate knowledge management and incentives can succeed to fulfill these responsibilities.

Manley (2006) also points out that the project-based production of construction industry and lowest-cost tender selection constrain the industry's performance and quality expectations. The temporary and unique nature of construction project and the absence of systematic transfer knowledge could reduce the possibility that employees utilize the lessons and experience learned from previous project in a timely fashion (Carrillo and Chinowsky, 2006). CIOB report (2010) stresses that public client who needs these on-off works must be educated and informed sufficiently. In addition to these innate industry problems, shortages of skilled

workers due to retirement and decreasing number of new employees joining the public sector have been reported in Sweden and elsewhere. One third of the Swedish construction industry workforce will retire by 2015 (FIA, 2005). Construction organizations have encountered challenges to intentionally attract or train employees in knowledge creation purpose (Kululanga and McCaffer, 2001). Novak and Hammer (2009) study states that public sector employment no longer holds the attraction and prestige that it once held and is unable to compete with private sector for young talented employees. Diminishing client experience and competence were also said to be caused by shortage of public client staff in Finland (Koppinen and Lahdenperä, 2004). When one or few individuals who possess critical knowledge retire or depart, it creates a knowledge insufficiency within the public client organization (Novak and Hammer, 2009). Inexperienced and insufficient staff resources contribute to poor procurement and project management (APCC, 2002).

In the following sections necessary conditions related to knowledge and incentives for getting the expected quality will be discussed.

3. KNOWLEDGE MANAGEMENT

3.1 General definition and general types of knowledge

Carrillo (2004) argues that the use of knowledge in construction organizations always existed but what is new is the increased awareness of how knowledge should be properly managed. What is knowledge and how it differs from information or data has often been debated and is beyond the scope of this paper, but it suffices to say that knowledge is a valuable organizational resource that has become widely recognized and accepted in the business community (Pathirage et al., 2007). Similarly, there are numerous definitions of knowledge management and for the purpose of this paper we use the definition of Scarborough et al. (1999) cited in Al-Ghassani et al. (2004) that combines both the process and outcome perspectives of knowledge management. It states that *knowledge management is any process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance in organizations*. The significance of knowledge management and its role on successful innovation process in the sector is not also something new to the Swedish Road Administration (now part of the Swedish Transport Administration, Trafikverket). An agency report (SNRA, 2003) emphasizes the importance of capturing existing knowledge, creating knowledge, and the use of knowledge through implementation.

According to Nonaka and Takeuchi (1995), knowledge can be classified explicit and tacit. Explicit knowledge is described as knowledge that can be precisely and formally articulated. It is easily codified in different format that would allow for documentation, transfer, sharing and communication. Tacit Knowledge is a knowledge that comprises experience and work

knowledge that resides only with the individual and difficult to formally articulate. Pathirage et al. (2007) claim that tacit knowledge based on skills, experience and talent of people is considered to be relatively unexplored and underutilized when compared to the work on explicit knowledge. Information technology (IT) tools often address the explicit knowledge while non IT-tools address the tacit knowledge.

This distinction of knowledge has shaped the strategies of knowledge management followed by different organizations (Carrillo and Chinowsky, 2006). Gore and Gore (1999) suggest a strategy of organization's knowledge management that combines the use of current explicit knowledge, capturing new explicit knowledge and externalization of tacit knowledge. Egbu and Robinson (2005), based on Nonaka and Takeuchi's theory of knowledge creation, also describe four distinct modes of interaction between tacit and explicit knowledge; socialization, externalization, internalization and combination (see Figure 2 below). A designer's explanation of design concepts to client is tacit to tacit interaction and it takes place through the process of *socialization* (2nd quadrant). Apprenticeship and mentoring schemes between senior engineers mentoring junior engineer is another example of tacit to tacit interaction. Such experiential knowledge is nurtured through shared experience and continuous interaction (Egbu and Robinson, 2005). Next the designer uses manuals on design standards and interprets these explicit documents to a unique design that could satisfy the needs and the requirements of clients. This knowledge transformation from explicit to tacit is termed *internalization* (3rd quadrant). When the architect/designer translates a design concept into sketches in order to explain to the client, the architect transforms tacit knowledge to explicit and is called *externalization* (1st quadrant). Another example of externalization process is when a junior engineer transforms the tacit knowledge that he or she gained from senior engineer through the socialization interaction to explicit knowledge. The 4th quadrant represents the *combination* process where explicit to explicit interaction takes place. Knowledge is created through integrating and processing of different documents such as design briefing and sketches, performance and standard specifications, estimates and contract requirements.

Socialization and externalization interactions between client's workforces could be affected by shortage of skilled and experienced workers of public client sector. Retirement of experience workers or scarcity of new skilled and talented employees due to competition from private sector could have severe consequences on socialization and externalization processes since they both involve sharing and transfer of tacit knowledge that is embedded in individuals. Both socialization and externalization are required to create an ever growing body of organizational routines (Osterloh and Frey, 2000). Quality circles and task forces that are widely used to enhance total quality and continuous improvement are examples of externalization process of creating firm specific routines (Osterloh and Frey, 2000).

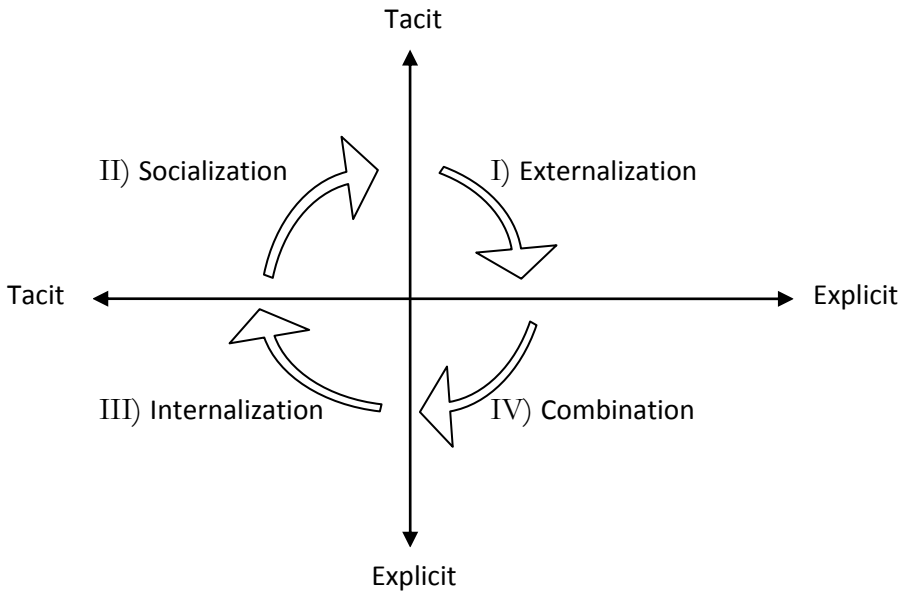

Figure 2: Knowledge conversion modes (Nonaka and Takeuchi, 1995).

3.2 Knowledge management in the construction industry

Egbu and Robinson (2005) emphasize the need for the construction sector to deal effectively with its skills shortage in order to overcome challenges of today's knowledge economy. Gau (2011) contends that knowledge management in public sector is more difficult than private sector. Public sector's strict division of labor and large number of routines in the sector may hinder knowledge sharing and creation in public organizations. Kululanga and McCaffer (2001) assert that when employees perform organizational tasks routinely and are unable to improve their organizational business process, such employees lack the cognitive capacity that necessitate them to create, acquire and share knowledge.

Construction organization can acquire knowledge internally by tapping knowledge from its staff, conducting internal benchmarking and learning from experience (Kululanga and McCaffer, 2001). The industry is characterized by a wealth of experiential knowledge that resides in the heads of experienced senior engineers. If they retire or leave the organizations, this tacit knowledge potentially follows with them (Sheehan et al., 2005). Imagine if an experienced bridge inspector with immense tacit knowledge in his/her head is about to retire and a new inspector who suppose to take over that responsibility has not been provided opportunity to be mentored by the senior staff or the tacit knowledge has not been transformed into explicit knowledge that would allow the junior staff to learn from the past experience. Socialization and externalization interactions such as mentoring of younger employees by experience professionals and systematic documentation of lessons learned from past projects promote the extraction of tacit knowledge from individuals mind and its transformation to explicit knowledge that could be easily shared among employees in the organization.

The above discussion would lead to conjure that public sector client organization like any other organization benefits from both tacit and explicit knowledge. An organization with good knowledge creation environment but without a proper service for knowledge capturing and sharing mechanism will be ineffective as an organization with proper tools to manage knowledge but lacking knowledge creation atmosphere (Kululanga and McCaffer, 2001). Incorrect or ineffective use of explicit knowledge such as standards and specifications during the design phase of infrastructure projects could affect the quality of final product. Similarly, if lessons learned and experience gained from previous projects are not captured and shared among project teams, then public client employees could repeat similar mistakes that hampered quality improvement. In other words, any expectation gap between the *design quality*, where the use of explicit knowledge mostly dominates and *quality realization* during the construction phase, where tacit knowledge (experience and skills of project manager) dominates, could be reduced through effective knowledge management within the public sector client.

A *European Guide to Good Practices in Knowledge Management* (CEN, 2004) describes five core knowledge activities that are most widely used by organizations in Europe: identify, create, store, share and use. In 2003, Swedish National Road Administration has put forward a 10 year research development program (2004-2013) that was intended to promote access to knowledge about and in the surrounding world (SNRA, 2003). The main components of that program were how:

- useful knowledge is achieved (research)
- knowledge is used to develop different activities (development)
- results are presented in different activities (demonstration)
- results are put to general use (implementation)

It seems that the seeds of knowledge management and innovation within the public agency especially the road transportation have been planted long time ago. However, the focus was more on development of explicit knowledge that is more easily codified and shared among team members but not the tacit knowledge that is hard to capture. Since each individual worker controls his or her tacit knowledge, a better understanding of internal process routines that accounts for who is doing what and how is very essential to the overall performance of the public organization in situations where person leaves the organization. Existing knowledge should be maintained and updated through proper knowledge management policies and procedures. Creating knowledge is generative learning whilst acquiring is adaptive learning (Kululanga and McCaffe, 2001).

3.3 What does it mean in practice?

From a knowledge management perspective the following components can be identified, and are, as we see it, all necessary conditions for an authority to be able to reach high quality.

1. The building up of long term explicit knowledge through research: The authority needs research in order to improve their knowledge. It has to be active in procuring and/or doing their research on issues of long term importance. The Swedish Traffic Board procures result from a large number of researchers every year. The board needs to be active in this area, what cooperation between private and public actors, An interesting example is the CDU-center that is financed by the leading authorities and has a continuous publication of results (see http://cdu.infra.kth.se).

2. *The building up of an knowledge through tests* - in order to become more sure about how a certain system would work various solutions has be tested in practice, and this is one part of a knowledge management system.

3. The *building up of knowledge through cooperation with foreign experts and consultants.* Pooling knowledge is of course rational and something that is going on a larger and smaller scale.

4. *The building up of a systematic management of the organization's own experience.* We will come back to this later when we talk about internal processes. As the typical transport authority handles a large number of procurements and projects it is important to underline the need for continuous monitoring of how different projects worked out.

These four knowledge creation processes must be discussed and developed together with different stakeholders. *Storing, spreading and accessing knowledge* are in the next stage crucial aspects - and in a longer perspective there are of course many feed-back loops, but it is mandatory for a successful organization to be able to create, store and spread knowledge about for example different construction techniques. The Canadian Transport Development Center (see www.tc.gc.ca/eng/innovation/tdc-menu.htm) can be seen as one part of such an integrated knowledge system.

The *tacit knowledge and experience* is, per definition, more difficult to document, and this is an area where knowledge management is much more difficult. Creating systems for developing and spreading tacit knowledge demands other types of forums, e.g. in the form of mentors or the conscious creation of teams and project groups. It is also a matter of personnel policy, where the authority more or less has to handpick persons with the right background that they need in the organization. Several authors have underlined the important of a *"knowledge sharing culture"*, see for example Carillo (2004) and Fong (2005). This will be returned to below in the section about incentives; is there incentive to build up, use and share tacit knowledge within the organization?

When proper knowledge management, that facilitates the creation of new knowledge, capturing of existing knowledge, storing, sharing, and use of knowledge is in place, it is expected that that different skills and competencies of public client organization's workforce

are not only maintained to competitive position but are also continuously improving. Training programs such as courses and mentorship opportunities play a major role in facilitating capturing and sharing of tacit knowledge. They would beef-up the skills of young professionals and allow experienced professionals to leave behind their knowledge when they retire. These policies could also break the knowledge barrier between different departments and divisions in the public client organization. The creation of the Swedish Transport Administration (STA) from two different administrations (road and railway) with diverse routines and knowledge systems, as well as the geographical dispersion of various STA activities create large challenges from a knowledge management perspective and there could be a need for a specific knowledge management center that works will all the issues discussed above.

4. INCENTIVES FOR INDIVIDUALS

This section follows the same structure as the last section. First a general discussion about incentives, then a focus on the construction industry and finally our views and recommendations are presented.

4.1 The importance of incentives

Many organizations have recognized that the success of knowledge management depends on people and their behavior (Sheehan et al., 2005). Some of the potential benefits of knowledge management are improved decision-making and management learning as well as improved efficiency of people and operations (Mohdzin and Egbu, 2008). A major part of this knowledge is tacit, which is often difficult to transfer from an individual level to the organizational level. Employees must be sufficiently motivated to share knowledge through incentives (Egbu, 2004). Teerajetgul and Charoenngram (2006) emphasize how incentives or reward could significantly affect internalization of the knowledge creation process. They state that the vision and aspiration of the construction managers in applying creativity in on-site knowledge practices plays crucial role on the strength of knowledge management. Osterloh and Frey (2000) argue that transfer prices and commands are unsuitable for motivation when the transfer of tacit knowledge within or between teams is crucial. The question is how to create incentives for individuals to share and reveal relevant knowledge and information that could be useful in improving the performance of projects? Osterloh and Frey (2000) suggest that organizational forms that emphasize participation and personal relationship are needed. However, the answer for the above question also requires a deeper discussion of economic theories behind incentives.

Milgrom & Roberts book "Economics, Organization and Management" from the early 1990s is an attempt to understand what determines how efficient organizations work. Organizations

here cover everything from government authorities to private companies. In many ways the book is an attempt to synthesize management theory and economic theory, but the base is clearly in economic theory (microeconomic theory, contract theory, and transaction cost theory). In this section we take this basic theoretical framework and apply it to the question about quality improvements in the infrastructure sector, with a focus on how the client can improve the workings of their own organization.

One central starting point in Milgrom & Roberts´ Economic Approach is that the basic unit for understanding how organizations work is the individual. One has to understand the incentives of individuals in different parts of the organization in order to understand how the organization works.

Incentives can be of many different kinds. There might be internal incentives where people do certain things just because they want to do a good job and sustain a certain image of themselves. Ellingsen & Johannesson (2008) discuss this from this perspective of why people e.g. give tips to taxi-drivers when travelling in a foreign country, where they never will meet that driver again. Incentives can also concern career opportunities: if I do certain things today it increases the probability to come to a higher position and get more money, a more interesting job and/or more power in the future. Of course, incentives can also concern short run gains including both economic bonuses and positive feedback from colleagues and superiors.

There is a large literature concerning short term economic incentives, e.g. in the form of bonuses. One main theme is the difficulty in designing such incentives in such a way that they have the right effect. One central problem is measuring all relevant aspects of the performance (see e.g. Milgrom & Roberts, 1992, p. 369). In the rest of this paper short term bonus systems will not be discussed as it is very difficult to see how they can be used to improve quality in construction projects. The discussions on incentives below therefore focus on more long term incentive systems.

4.2 Precondition 1: Knowing who did what

An important precondition for creating stronger incentives is that it is possible to know who did what. Carrillo (2004) argues that peer recognition of employee's contribution and acknowledgement of individual's achievement such as manager of the year award has a more sustainable impact than financial reward. Herzberg (1968) argues that recognition for achievement is one of the motivator factors that are intrinsic to the job and have a long-term affect on employees' attitudes, contrary to what Herzberg termed hygiene factors such as supervision and fringe benefits.

It is in this respect interesting to compare e.g. what information is presented when a movie is ready and what information is presented when a construction project is ready. At the end of the movie, hundreds of names are presented giving information about who did everything

from directing, producing, and playing, to being the driver, and the assistant to the actors. This information is available "forever".

But assume that after a few years someone wants to know who did what in a construction project. Who was the architect, the technical designer, the project manager but also who was doing all the work on site - who was responsible for installing the electric system and who painted the walls inside the building?

An important precondition for creating stronger incentives during all the different stages from planning to construction would then be *a systematic recording of who did what in a project*. That everything is publicly presented has made it possible to create a database like IMDb (Internet Movie Database, www.imdb.com) where there is information about 80000 individuals in the movie sector.

There is a clear general trend in this direction in the form of demand for more detailed CVs, but in a CV an individual can rather easily hide that they were part of a failed project or a project with quality problems. Credit information is also systematically collected and available from private companies for a fee. Carrillo (2005) also points out that using skills database within an organization, especially in a particular domain, convinces client that such organization has expertise in that area.

An authority like the Swedish Transportation Authority could build up such a database over "who did what" both concerning their own staff and demand of contractors and sub contractors that they compile information about who did what in different projects - who was responsible and who did the actual job. The incentive effect would of course be strongest if such a database were publicly available and could be used by everyone, e.g. employers evaluating different applicants for a job and a client evaluating possible contractors.

An important implication of Milgrom and Robert´s approach is that the basic unit, when data about contractors and subcontractors are registered, should be the individual and not the company - even if it of course should be registered what company the individual worked for in the specific project. Companies can go bankrupt and new companies can be started, and without data about the individual, it is easy to hide responsibilities by starting new companies.

Dixit (2002) argues that an important feature of most public sector agencies is costly ex post auditing of agencies, since the agent can observe some outcome better than the principal, and that requires the principle to devise reward schemes and costly outcome verification schemes. He recommends the use of costly verification concept of principal-agent theory rather than the standard moral hazard and adverse selection schemes if one is attempting to design optimal audit procedure. The general feature of this optimal scheme is that; on receiving the agent's report, the principal may either accept it or find out the truth using a costly audit. With such revelation, the principal can optimize his objective, subject to the agent's incentive compatibility and participation constraints (Dixit, 2002). In the situation of an authority like STA, a comprehensive post-review report for each completed project could not only be useful tool for pre-qualification of contractors in the future but also an assessment tool for public

client's staff that are carried out that project. The Swedish National Audit Office has in several reports asked for improvement in this respect (Riksrevisionen 2010, 2011). However, an internal incentive system based on the performance of each completed project should not be detrimental to collaboration and teamwork aspirations. STA could establish a reward system based on a post-review project report and make sure that individual career goals and public sector's primary objective of enduring infrastructure projects are aligned.

4.3 Precondition 2: Repeated games

One of the strongest ways to create incentives is through "repeated games" (see e.g. Dixit, 2002). If you do a good job, the probability of getting hired again and getting a better and better paid assignment increases - and the opposite if you do a bad job. In a number of sectors of the economy this type of incentive mechanism is the dominating one. The movie industry is an obvious example mentioned above. Lindahl & Leiringer (2011) analyze project management in the event industry, and there teams are put together for each specific event, and one central criteria is that the persons did a good job at an earlier event and is trusted by the one responsible for setting up the event.

Looking at infrastructure construction from the perspective of repeated games it is possible to see several problems.

The first concerns the relation between the client and the contractor in the public sector. In a comparison between procurement by private and public clients in the housing sector, one result was that the private clients preselected 2-3 companies according to their earlier experience and knowledge of the companies (see e.g. Belfrage & Lind 2011). If the client was dissatisfied with a company, then this company was deleted from the list. The public client worked under the Law of Public Procurement and had open tenders and they had to follow strict criteria both in the prequalification stage and when choosing contractor. This means that earlier experiences that were not well-documented could not be used. It is not possible, or at least very difficult, for a public client to promise a company that they will get more work, without competitive procurement, except for a rather short period. There are disagreements about what you can and cannot do under the Law of Public Procurement, but in practice this law seriously limits the power of incentives based on the repeated games model.

One result of this is, however, that one strategy for a public client that wants to improve quality is that they should try to stretch the Law of Public Procurement as much as possible, e.g. by using more qualitative criteria and giving more weight to earlier successful experience. Eriksson (2010), in a study of strategies and views of clients, finds a correlation between using "soft" criteria and higher quality in the project.

In the contracts, the client can also stipulate which persons should be involved from the contractor side and limit the use of subcontractors that are not long term collaborators of the contractor. The client can at the same time work in a systematic way also to get new

contractors, by adjusting the criteria in different procurement, sometimes focusing on the need to choose reliable long term partners, sometimes focusing on making it easy for new firms to enter. This would be economically beneficial for the client in the long term as it increases competition, even if it is not the cheapest in the short term.

The second problem from the perspective of repeated games is that on the client side the staff on all levels is hired by standard employment contracts with fixed wage. The level of employment protection is high in countries like Sweden which means that the direct difference for the employee between making a good job or not from the perspective of long term quality is small. The question is then how incentives can be strengthened *within* a public authority. This will be discussed in the next section.

4.4 Incentives in a public administration

As mentioned above, a precondition for creating incentives is knowledge about who did what. In a public authority, the incentives are rather long term, related to promotions and getting better jobs in other organizations. This is also the case in most large private companies where pay is fixed and employment protection is similar to the one in the public sector,

The purpose of this section is primarily to give examples of how things should not work and how they might work. It is, as mentioned above, not a part of this project to find out how close the actual authorities are to the cases described below. Evaluating the relevance of the arguments and suggestions is up to each authority.

The following is a stylized example of a structure where incentives for quality are not so strong (the example is partly inspired by the discussion in Jonsson 2010 appendix 1).

> Election time is closing in and it is very important for the government to show both that they are starting up projects and finalizing projects that are important for winning the elections. Projects then have to start up quickly without enough preparations. The civil servants working with the cases, somewhat disillusioned from earlier cases, also knows that there will be a number of changes and adjustments later in the project, so there is no point in putting in maximum effort concerning the design in an early. Civil servants that might have protested against certain "bad" decisions earlier are seen as troublesome and causing delays have more problems to get promotions. Most employees remain quiet and shrug their shoulders knowing that problems will come later.

The importance of things working smoothly and of avoiding conflicts can also affect the work during the construction stage, e.g. saying yes to proposals from the contractor even if there is a risk of lower quality. Warsame (2011b) described different “decision styles” and several of these underline the importance of consensus and avoiding conflicts, and this can lead to client representatives accepting lower qualities and/or higher risks for quality problems than actually was contracted. The person representing the client might accept some short-cuts taken by

contractors and subcontractors as the person knows that his or hers boss will not be happy if there are many conflicts and complaints against the contractor as the result might be that the project be delayed. However, respondents from the questionnaire (Warsame, 2011a) rejected the statement that project leaders from contractors and clients turn their back on quality problems in order to avoid cost overruns and delays. One of the organizational decision models discussed in Nutt (1976), equilibrium-conflict resolution model, describes how conflict and time pressure could cause the adoption of conspicuous alternatives. He argues that decision premises and level of aspiration can change as a result of alternatives. Bröchner et al., (2002) argue project managers' compromises and culture of conflict avoidance could lead sub-optimal decisions for the client. All these things can be described as part of a "company culture" and *creating the right culture is important for the long term quality of the projects*. The culture in the authority, together with their competence, will affect the incentives for consultants, contractors and subcontractors, that - to simplify somewhat - do what is necessary to survive in the market, but often not much more.

In a public authority, the politically chosen board, and leading politicians on all levels, is of course in the end responsible for how the authorities work. These "final" decision makers send out signals about what they approve of and do not approve of, and their behavior will affect the company culture in the authority. But, of course, also public employees on all levels have a responsibility towards the taxpayer and citizens to contribute to an efficient use of resources in the public sector. In their comparative study, Svensson et al. (2004) found that guidelines for whistle blowing procedure and formal resolution process barely exist in both corporate and public sectors in Sweden. They suggest that there is a strong association between the guidelines to support whistleblowers and the organizational sector that one belongs. Only 7.4% from public sector compare to 27.5% of corporate sector have these guidelines. They conclude that guidelines to support whistleblowers are much less frequent in the public sector organizations than in the corporate sector organization.

4.5 What does it mean in practice?

As mentioned in the last section, the board and leading politicians have a general responsibility for sending signals to the organization concerning what are the important goals. This does not concern only what is written in various documents, but how they act when various decision are made, including hiring and firing of top managers.

A central responsibility for the authority themselves is, as argued above, to build up a system where different individuals role in projects are documented and accessible. The information that is collected and stored should also play an important role for later decisions about individual´s careers and which contractors that will be hired. All this can be seen as one part of creating a company culture where efficiency and transparency are central values.

However, assessment of quality goals and verification of a project performance that has yet to be constructed may pose an enormous challenge. Quality of infrastructure projects only

becomes known during the construction or after a project is completed and utilized, which is why knowledge management is hence important as argued above and why a special unit working with knowledge management can be important.

5. APPLICATIONS: INTERNAL PROCESSES

5.1 Introduction

Provision of transport infrastructure projects involves many stakeholders (client, consultant and contractor) with different objectives and expectations. Similar divergences could exist within an organization such as public sector client where different departments are responsible for different tasks; pre-design, tendering, construction, operation and maintenance. Thus, the skills and knowledge that exist within each department reflects different phases of construction project. Construction is sometimes described as knowledge-intensive activity because of the design and tendering process that require specific skills and professional while other times is described as labor-intensive because of construction phase activities that require a lot of craftsmen and various specialized workforce.

There are many explanations why large infrastructure projects fail to achieve their performance objectives in terms of time, cost, and quality. Failure arising from client internal process such as insufficient resources, optimism biases, lack of client competence that results bad design and wrong procurement methods, political and legal interferences of decision-making process are among the many mentioned in the literature. A proper knowledge management in public sector client will not only ensure that both knowledge and labor intensive needs and concerns are addressed but it will also boost the way tacit knowledge, which is an essential tool for continuous improvement of project performance, is handled in the sector.

However, it is important to look closely at each stage of the process, and the risk and possibilities in each of these. In order to achieve project performance objectives in terms of time, cost, and quality, public sector client follows certain procedures such as selection of design consultant, tendering, pre-qualification and selection of contractor. The following sections that focus on different stages in the construction process can be seen as an application of the more general ideas presented above concerning knowledge management and incentives.

5.2 Design stage

The design stage is carried out in different ways in different procurement types, but here the focus is on the dominating form where at least the basic design is carried out by the client and a technical consultant. Applying the ideas presented above could e.g. mean:

- Establishing long term co-operation with a number of consultancy firms. Lind (2011) sketches a model for competition that in this case would mean that e.g. that the client in certain regions work with a certain firm and that this is seen as a long term cooperation evaluated with specific criteria and compared with other regions where there is a long term cooperation with other firms. In certain types of projects new firms are tested and get the chance to enter into more long-term cooperation.

- Follow ups on company and individual levels as discussed above.

- As shown in Warsame (2011a) problems with the design documents are one of the factors that create quality problems. A system used in several countries is to demand that there is a "second opinion" before larger projects is carried out. The Norwegian government established mandatory external quality assurance of all public investment projects with an expected budget above 60 Million Euro (Magnussen and Olsson, 2006). Though the use of quality assurance in this context could be somehow misleading since this process is not directly focused on the quality aspect of projects but the cost, this kind of second opinion, or independent expert, exemplifies the importance of second opinion in order to meet the demand of better management and control of major public investment projects. In order to improve efficiency and reduce corruption, China's state-owned enterprises tendering for jobs with a value larger than a certain sum are required by law to go through a tender valuation process conducted by an independent specialist committee (Yung and Lai, 2008).

Similar systems can also be implemented for smaller projects but then in a simpler and cheaper way. From an incentives perspective, knowing that someone else will make a review, and that the result of this review will be documented, is important.

More resources spent in these initial stages can be a good investment from the perspective of quality, cost and time.

5.3 Tendering and Procurement phase

One result from several studies is that procuring on the lowest price increases the risk for quality problems. This is not a new observation. Engkvist, quoted in the introduction, also wrote the following (1949, p 27):

> "The question of price was and is often the one that is given priority. It is believed that quality could be controlled. But there is a wide gulf between good and bad quality, and it cannot be bridged by control. If the builder is bad, the work will be bad, even if there is strict control. If he is good, and for this will and knowledge is necessary - the work will be good - even without control."

The first issue this raises is how tendering should be carried out. In another paper (Warsame et al 2011), procurement methods are analyzed and there it is argued that there is no simple relation between procurement method and quality. One cannot say that choosing one specific

method always lead to higher quality. Therefore the focus will be on the general features of the procurement process. Doloi (2009) summarized some of the most important pre-qualification contractor selection criteria that were identified by various researchers. Experience, organizational capability, and past performance of the contractor were among those emerged to be crucial for project success and deemed to be highly correlated with contractor's performance.

Selection of a procurement method is a daunt task for even the most experienced client or contractor because of unknown benefits and risks for each method (CIOB, 2010). Love et al. (2010) state that the selection of project strategy for capital works projects such as infrastructure consist two components. An Analysis component where priorities for project objectives and client attitude to risk are assessed and established and a Choice component where possible options are considered, evaluated and the most appropriate option is selected. While it is common that the decision to choose the appropriate procurement method for public infrastructure projects is solely made by the public agency such as STA, some countries impose their public agencies to seek consultation and approval of selected procurement method from independent experts, or designated professional committees. In Canada, Ministry of Transportation of Ontario has established a *Contract Innovation Office* that works with regional teams in determining which procurement model to use for their infrastructure projects. In this way it would also be possible to systematically experiment and evaluate different procurement methods, as e.g. in the studies in Nyström (2008) about partnering and Lind and Mattsson (2010) on the use of functional characteristics.

5.4 Monitoring during construction phase

Different procurement methods stipulate who is responsible for carrying out activities related to quality assurance and quality control of the project. Furthermore, any selected procurement method would have an impact on the level of interaction among various actors in a construction project and subsequent gain or loss of knowledge, skills and experience for the public client organization's workforce. Novak and Hammer (2009) noted that outsourcing of tasks often leads to a loss of competence to perform those tasks. It is in this phase of the construction project that the competences of client's workforce are extremely needed. The level of client workforce involvement during the construction stage could vary depending on the type of procurement method but their commitment to achieve specified quality level while utilizing skills, experience and lessons learned from previous project remains the same. When the client is responsible for both the control and the assurance of quality it is expected that the interaction and the level of communication between project members to increase. Consequently, conflicts and litigation could arise due to differences of expectations, procedures, standards and specification, and design changes. When the contractor is responsible for quality assurance, as in the case of Swedish Transportation Authority, client involvement may be reduced but strong knowledge and wealthy of experience are still essential in order to ensure that performance objectives of the project is achieved while

acceptance of deficient product is eliminated or minimized. As discussed above, a number of incentive problems may also arise in this stage as there might be felt to be a trade-off between quality and delays.

Senaratne and Sexton (2009) argue that most of the knowledge captured and shared between projects teams during problem-solving activities connected with project is tacit knowledge. This knowledge is internalized and codified in project documentation in ad hoc manner (Senaratne and Sexton, 2009). Post –project reviews provide an opportunity for people involved in a project to exchange ideas and information related to success and failure actions during the project or during a particular phase of the project (Carrillo et al., 2010). Post-project reviews also facilitate capturing tacit knowledge that would have been lost after construction team disbanded at the end of project and make it explicit for other to use it in future projects (Carrillo et al., 2010).

The quotation from Engkvist above underlines the limits of monitoring. The general arguments presented above from Milgrom and Roberts (1992) indicate that the importance of monitoring depends on the possibility to introduce sanctions on the contractor: With stronger sanctions less monitoring is needed. The more the contractor - and the specific individuals - is dependent on a good reputation the less monitoring is needed. If quality problems can lead to a costly break down of a long-term cooperation, the risk for the contractor is high if they do not produce a high quality work. But the question becomes more complex when we look at the individual level as their incentives depend on their specific situation, and this would imply that a systematic monitoring by the client always is important.

As mentioned above the incentives within the client organization is also important: What are the incentives of those who monitor and the incentives of those who monitor those who monitor etc.?

6. SUMMARY AND CONCLUSIONS

Public client organizations play different roles in a construction project, but typically they act as the owner and the party who instigated a project for the benefit of society with the intention to create value for money. Since they represent the end-users of the completed facility, they provide the needs and objectives of the project to the rest of project team and ensure that expected project is completed with desired performance in terms of specified time, budget and quality.

In order to ensure that a desired project performance is achieved and provide better infrastructure projects, the public client organization must be equipped with high skills and experience. There are several suggested policies that could improve how public client organizations manage their knowledge and increase the efficiency of their internal process of

project management and procurement. Construction industry is a knowledge-intensive industry and most of the knowledge especially tacit knowledge resides in individual employee's head. Furthermore, the successes of any construction organization like STA depends on the success of their projects that in turn will depend how individuals involved in each project were motivated and carried out their duties. There are strategies intended to shore up individual's performance through proper incentives and also to create a more transparent system similar that have been used in other sectors such as movie production. Short-term incentives schemes such as bonuses may have little consequence on individual's attitude toward team performance while peer recognition of employee's achievement has more profound effect on individual's career goals.

Similar motivation goals could be achieved, if after the completion of a project, the authority is required to make publically available the list of all individuals who have participated in the construction of that project. In order to implement such strategy and create stronger incentives it requires that public client to compile comprehensive information system and database that would allow establishing who did what. Public client can also demand from other actors in the industry to disclose information about individuals who will be participating in a project. Such systematic recording will also be helpful in a situation where an employee encounters a problem and is trying to locate someone who has dealt a similar problem in the past.

To ensure that public transport funded projects meet value for money criteria, the use of second opinion from independent expert and committee has been implemented in Norway. Similar approach that focuses on quality can be introduced as a first and rather simple step in our transport infrastructure projects.

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