

Analysing the Factors that Enhance the Growth and Survival of Supply Chain Processes on Design Management and Procurement in Construction Firms

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ABSTRACT

The construction industry has faced challenges because of the interaction between design management and procurement in projects where the prime contractor is in charge of design management and design work is perhaps completed concurrently with construction. The actions taken by the parties will mostly dictate the type of plans the design management can create for the procurement and whether they are provided on time. Production success depends on the conditions established by design management and procurement as a whole. The article sought to improve operations by giving the target business a design management and procurement linkage through an efficient and effective supply chain strategy. An empirical analysis as well as a design science study were utilized to finish the study.

Based on the research's interviews, it was discovered that the target company's design management and procurement departments did not share a uniform procedure. Furthermore, there was no agreement on what should be included in the plans that were needed for the purchase, which prevented communication and cooperation. Given the issue at hand, there are numerous ways to practice things, therefore a growth direction has to be selected. The development of design and procurement packages was chosen, and enhanced cooperation amongst the involved parties was required. This study led to the development of a suggestion for enhancing the supply chain procedure between procurement and design management.

Keywords Construction industry, construction, business premises construction, procurement, design management, supply chain process

BACKGROUND OF THE STUDY

Many businesses in the construction sector have experienced difficulties with the process that links procurement and design management. There may not be a collaborative decision-making process or information flow. It's also possible for projects and staff to lack standard operating procedures and practices. Studying the interactions between the two sides and fostering cooperation are essential to improving the process, which will result in more successful projects and businesses. Several studies have highlighted the significance of the building construction project design process in order to enhance the performance of the construction sector, according to Appiah and Aboagye (2020). The procedure is extremely challenging to oversee, and it under extremely uncertain circumstances, thousands of judgments with multiple interdependencies are made. When taking into account the overall performance of the construction project, design management and procurement are tightly related.

A procurement package requires various types of plans from various field designers; the quantity of these plans and design fields varies based on the project and the field of the object being procured. Procurement can involve work, materials, or services, or a combination of them; the sequence in which various works are completed at a construction site will influence the sequence in which procurement packages are obtained; however, some procurement packages typically include similar plans from various design fields. Design management, on the other hand, has its own design packages that are utilized to control and manage designing; these are created to manage what plans should be prepared at specific project phases, as well as the scope and depth of planning ought to be explained as well.

Statement of the Problem

The efficiency of the supply chain between design management and procurement in construction companies is critically undermined by the absence of coordinated guidelines and timely information transfer. Specifically, in the target company, procurement struggles to issue accurate tenders due to delays and deficiencies in receiving necessary design plans. This misalignment results in significant performance and effectiveness issues within the supply chain. The lack of established processes and clear instructions for interaction between design management and procurement exacerbates these inefficiencies. Despite the significance of this issue, existing literature does not adequately address the coordination challenges between these functions in construction supply chains. This research seeks to investigate the underlying causes of these inefficiencies and develop a framework to improve the alignment and performance of the supply chain process between design management and procurement.

Objective of the Study

The objective of this work is to analyse the factors that enhance the growth and survival of supply chain process on design management and procurement in construction organizations.

The study sought to achieve the following specific objectives

- 1) To ascertain the problems and challenges in the supply chain process between design management and procurement.
- 2) To determine what kind of plans procurement needs from designers to be able to make proper invitations for tenders?
- 3) To examine the process by which design management can produce plans that serve procurement at the right time

Research questions

- 1) What are the problems and challenges in the supply chain process between design management and procurement?
- 2) What kind of plans procurement needs from designers to be able to make proper invitations for tenders? No purpose.
- 3) What is the process by which design management can produce plans that serve procurement at the right time? Too long and lacks specificities.

LITERATURE REVIEW

Introduction

This chapter contains a literature review of the supply chain process between procurement and design management in a construction company. The first subchapter presents general stakeholders of a construction project and the second subchapter introduces construction project phases, while subchapter introduces different project delivery methods for construction projects. Subchapter reviews generally design management while subchapter concentrates on reviewing subjects related to procurement. Subchapter presents the difference

between supply chain process and project process as well as introduces generally supply chain management and internal supply chain process of Construction Company.

Conceptual Literature Review

Concepts and Ideas of Supply Chain Management

The term “supply chain management” (SCM), according to Van der Vorst (2020) is relatively new. It first appeared in logistics literature in 1982 as an inventory management approach with an emphasis on the supply of raw materials (Oliver and Webber 2022). By 1990, academics first described SCM from a theoretical standpoint to clarify how it differed from more traditional approaches to managing the flow of materials and the associated flow of information (Cooper and Ellram 2023). The growing interest in SCM, according to Lummus and Vokurka (2019) is attributable to three (3) basic factors, thus, growing specialization or focus on core activities by many firms, intense competition from both local and international sources, and the realization by firms that maximizing performance of one department or function may lead to less than optimal performance for the whole company. Agreeing with this assertion, Cooper et al. (2020) in their research concluded that, the concept of SCM arose over the recognition that sub-optimization occurs if each organization in a supply chain attempts to optimize its own results rather than to integrate its goals and activities with other organization to optimize the results of the chain.

For any market driven organization to be able to compete effectively with its competitors it must sustain certain core competencies, such as process management, integration of knowledge, and diffusion of learning. Competitive position of a business arguably results from the assessment of what the firm offers with regards to value creation as compared to that of its competitors (Gorynia 2004). Indeed, basic measures of the competitive position of a firm are its market share and financial position. Additionally, factors such as product quality, customer loyalty, and reputations are also used as additional measures of business performance and competitive position of a firm (Gorynia, 2019). Consequently, Lee and Billington (2022) pointed out that, SCM can be used as a strategic weapon to develop a sustainable competitive advantage by reducing investment without sacrificing customer satisfaction.

Supply Chain Management and Business Performance

Performance Measurement

Generally, there have not been many studies regarding the practical part of performance managing (Jaakkola 2020). However, in 2019, Clark studied how managers actually judge marketing performance. Therefore, it is vital researchers account for the measures managers are using (Jaakkola 2019). It needs to however be noticed that performance is meaningful only when used in decision making (Lebas and Euske 2020). Also of importance is to what is performance compared (Clark 2020).

Measuring Business Performance

There are several points of departure that can be used to assess performance of a business (Jaakkola 2006). These include, among others, accounting perspective (assessment of financial measures of performance), marketing perspective (assessment of marketing inputs, too) and operations perspectives (assessment of effectiveness and efficiency) (Neely 2022). Apart from purely accounting-based assessment, all the assessment systems are increasingly using non-financial indicators to analyze according to Jaakkola (20020). For instance the Balanced Scorecard (BS), introduced by Kaplan and Norton (2022).

Theoretical Framework

Construction project stakeholders and management

In construction sector, project stakeholders can be defined as organizations, groups and individuals who are actively involved in the project. Stakeholders’ interests can be positively or negatively affected by the activities or results of the construction project. (Olander, 2007.) Project manager has to manage and dealt with other

groups of stakeholders. Identification of stakeholders and assessing stakeholders’ interests and expectations throughout every phase of the construction project lifecycle are necessary for successful project management. Also, stakeholders’ behavior and its effect on project outcome should be forecasted by the project manager. (Chinyio & Olomolaiye, 2020.)

Project stakeholders can be divided into two groups. The first group is often defined as internal stakeholder group and they are having a contractual relationship with the client or a subcontract from another internal stakeholder. They can be team members of the project or those who provide for the financing of it. The second group is usually defined as external stakeholder group and they are affected somehow by the project in significant way. Usually, they may have little choice about whether the project goes ahead and their opinion about the project can be negative or positive. Internal stakeholders can be divided forward into demand side and supply side, and external stakeholders into private and public as shown in the (Table 1) below. (Winch, 2007.)

Table 1. Example of project stakeholders (Customized based on reference: Winch, 2007.)

Project Stakeholders example			
Internal Stakeholders		External Stakeholders	
Demand Side	Supply Side	Private	Public
Client	Consulting engineers	Local residents	Regulatory agencies
Financiers	Prime contractors	Local landowners	Local government
Sponsor	Trade contractors	Environmentalists	National government
Client’s employees	Materials suppliers	Conservationists	
Client’s customers	Employees of the above	Archaeologists	
Client’s tenants			
Client’s suppliers			

Main stakeholders in construction projects can consist of owner/customer, user, construction project manager, prime contractor (Construction Company) and designers (Figure 3). Also, subcontractors, material suppliers, other consultants etc. can exist. These stakeholders’ roles and tasks can vary a lot depending on the chosen project model and contracts. This will lead to the discovery that project organizations are usually complex and multi-professional.

Construction project management includes a set of objectives which may be accomplished by implementing phases of operations subject to resource constraints. Constraints are usually concerning human workforce and financial resources. There can be conflicts between scope, cost, time and quality in the project and that is why the balance and location between these objects must be managed by the project manager. (Santos, 2019.) Compromises must be made, and risks must be evaluated and selected to be taken. Without taking risks there are no possibility to make any gains or benefit from the project. Project management consist much of sharing the risks between contractual parties.

The tasks of construction project management can consist of setting quality, scope, time and cost objectives for the project and monitoring their fulfillment. Designers must be selected and needed design contracts prepared. Needed decisions have to be made in time and construction permits acquired? Project management has to select delivery method for the project, organize competitive biddings and prepare contracts. Also, construction work must be controlled, and time targets monitored. Project management is responsible for necessary control actions to the project when the project objectives don’t meet the planned values. (Peltokorpi, 2019)

Controlling costs of the project among budgeted cost for work performed (BCWP) calculations is important for successful project management. BCWP is also called as earned value (EV). With EV calculations project manager can forecast cost, time and work performance during the project. Project manager looks to the future with the present data and sees what control actions have to be made if the project continues with the present cost, time and work realization or if the project continues as planned and scheduled control actions are not needed. Realized data is compared to the scheduled and planned data in a form of calculation and diagram. The primary data points for the calculations are budget at completion (BAC), budgeted cost for work scheduled (BCWS), actual cost of work performed (ACWP) and BCWP. (Karlos, Martinsuo & Kujala, 2020.)

Empirical Framework

Lean design management

Lean thinking strives to reduce order-to-delivery time by eliminating waste and creating value in an organization. Different industries have applied Lean principles in their procedures and manufacturing. Construction industry has also started to apply Lean thinking into production and business recently. However, there is still much room for improvement. With Lean ideas, different organizations can develop their business and processes towards better performance and provide better value for customer. While giving customers exactly what they want, the least amount of energy, time, effort, capital, equipment, materials and facility space is used. (Womack and Jones, 2008.)

Womack and Jones (2008) defined five basic principles for Lean. The first one is to **specify value**. Only ultimate customer can define value, and value is distorted by pre-existing organizations, for example engineers and other experts, who add complexity of no interest to the customer. The second principle is to identify the value stream. All the actions needed to bring a product to the customer create together the value stream, thus duplicate steps must be removed from the process. The third one is flow meaning that value-creating steps must be made to flow, and departments that execute a single-task process on large batches must be eliminated. The fourth principle is pull and it refers to that you must allow the customer to pull the product from you. You sell one and you make one. The last principle is to pursue perfection. The end doesn't exist for the process of reducing cost, time, space and mistakes, thus continuous improvement is the target. (Womack and Jones, 2020).

Appiah and Aboagye (2020) introduces some considerations on implementation of Lean construction principles in the design process. The share of non-value adding activities must be reduced while output value increased through systematic consideration of customer requirements. Some degree of flexibility in the end product must be allowed, thus output flexibility has to be increased. However, process variability should be reduced in the design work and cycle times must be reduced in order to make design work as effective as possible, though allowing the nature of the design work. The design process must be simplified by minimizing the number of steps, parts and linkages, while process transparency has to be increased in order to make sufficient communication of the process content possible. The focus should be on complete process in the design work and constructing continuous improvement into the process is essential. The flow improvement should be balanced with conversion improvement. (Tzortzopoulos and Formoso, 1999.)

There are different attributes which can be used in Lean design management at construction. Table 4 shows an example of attributes of Lean Design Management and contains research information about their use within different companies (Uusitalo & al., 2017). Attributes can be first divided into categories such as social process, methods and tools/technologies, and they all contain different possible practices which can be chosen for the use in design management. Social process category contains LPS, Big Room, Co-location, ICE and CPD. Methods category includes LOD, LBDM, TVD, SBD, CBA and real-time cost estimation.

Procurement

Finding a satisfactory definition of procurement has been challenging, as many sources have disputed its definition in general. Even many words like procurement, purchasing and acquisition have been used to describe the same thing. For example, coherent boundary between the terms procurement and purchasing have

not been found in the literature (Münch, 2015, page 42). It has been discovered that some sources comprehend that purchasing is a subset of procurement and based on transactions happening in the end of procurement process (Münch, 2015, page 43). Nevertheless, in this Master's thesis these terms are used to describe mostly the same thing because purchasing can be also understand as only direct buying from external sources, which is not always the purpose of company's procurement department. The procurement department can be understood, for example, as a company's organization unit which is responsible for all operational and strategic, procuring-relevant planning, activities, processes, strategies and interfaces (Münch, 2015).

However, there are different definitions for the term procurement. Novack and Simco (2021) define procurement as "the act of buying goods and services for a firm" or "the activity of obtaining goods and services for the firm" and state that "procurement is a complex process that is difficult at times to define, understand and manage". Mak (2014), in turn, defines procurement as "a careful, usually documented process resulting in delivery of goods or services to be delivered within a set time period". Rowlinson & McDermott (2005, page 3) instruct that procurement has been also described as "the framework within which construction is brought about, acquired or obtained". Probably, it would be good to define the term procurement also as "managing the outsourced resources of the organization" (Surakka, 2018, page 18); (Kolhonen & al., 1997, page 5). As a conclusion, procurement is a big universal term for managing and leveraging external resources as well as the supply chain.

Procurement in the construction industry

The purpose of procurement department in a construction company is to purchase services and materials of the right quality, in right quantity and at the right price. The time for purchasing must be also right and the purchasing source. The aim is to seek to obtain the highest quality subcontractors and materials at lowest possible price for the construction project. The procurement department supports the project team in performing their responsibilities within the project's scheduling goals and budgetary. Procurement department's engineers determine the best services, bulk materials and commodities, select the suppliers of materials or service, negotiate the lowest price and best terms for contracts, and make contracts ensuring that the right amount of the service or material is received at the appropriate time. In order to purchase services competitively and rationally, suppliers are evaluated based on the quality, price, availability, performance, reliability and service support. Also, financial backgrounds of the possible subcontractors or material suppliers are reviewed in order to prevent unnecessary risks. (Benton and McHenry, 2010, pages 28-29.) Procurement is an overlapping function between design and construction phases, and because of this, procurement risks may have cascading effect on project schedule and cost overruns. Therefore, management of procurement risk is important to avoid injurious effect on the success of project. Multiple items from multiple suppliers as well as several subcontracts with multiple subcontractors are required for a construction project under multiple contracts, terms and conditions and risks exposure. (Dixit, 2020.) Thus, evaluating and managing procurements and their risks are essential.

Benton and McHenry (2020) describe some several main objectives for procurement department. The project team must be supported in implementing their responsibilities within the project's scheduling targets and budgetary goals. Inventory investment must be kept to a minimum meaning that just-in-time purchase concepts should be implemented. It is recommended that maximum integration with upstream and downstream supply chain members would be achieved and patterns of administration for procuring subcontracts, materials, services and equipment must be prepared. It is important that services are purchased and procured competitively, and good relationships with suppliers and subcontractors are developed and maintained. However, reliable alternative subcontractors and suppliers should be developed too, and background checks on current and potential subcontractors and suppliers must be carried out. It would be essential to establish and update database of current and potential subcontractors and suppliers. Nevertheless, subcontractors and suppliers must be prequalified, selected and evaluated in the process. Thus, the scope of work for each active project has to be studied, invitation for tenders reviewed and evaluated, successful and unsuccessful tenders informed, contract and associated details prepared and negotiations with potential subcontractor candidates must be held. Procurement orders, contracts, and subcontractors for engineering and construction have to be

prepared, as well as delivery and transportation scheduled with construction site management. (Benton and McHenry, 2020).

RESEARCH METHODOLOGY

Introduction

This chapter explains the procedure, methods and techniques used in carrying out the research. It deals with the population and sampling techniques used, data collection procedure, research design, and data analysis

Study Design

The survey included the direct administration of interview guide. Interviews were constructed based on literature review, data search from company's databases, internal meetings with thesis advisor and company's management as well as understanding of the problem. The purpose of interviews was to investigate company's present practices related to the supply chain process between design management and procurement, and as well discover the challenges related to the subject and possibly find out or receive development proposals from the interviewees. A frame for interview questions was formed and interview questions were created by the author. The interview questions were designed so that the scope was not to guide the interviewees to the answer and all questions were commented by company's few employees and thesis advisor, which were from their title a procurement manager, a head of developer contracting, a procurement engineer and a project engineer, before starting interview phase. All these people were excluded from the interviews.

The interview frame was divided into questions related to interviewee's background, company's present practices, challenges and problems as well as development propositions. Interviews were conducted anonymously in Finnish, and they were recorded in the interview sessions. Later recorded interviews were analyzed and translated into English by the author, and only author utilized and listened them before deleting them. Permission for recording was asked from every interviewee. The interviewees were selected beforehand from different departments in the meeting with company's advisor, procurement manager and head of developer contracting, and they were contacted by the author. All interviews were voluntary and there was the opportunity to refuse. Interviewees were from procurement department, design management department, development department and production department. 20 employees were interviewed during interview phase and Table 6 shows job title, department and experience on topic of interviewees and interview times of interviews.

Sources of Data

The study benefited from secondary data. The secondary data was sourced with the help of a well-structured and organized interview guide.

Methods of Data Collection

The study uses interview guide as the data collection instrument. The interview guide were distributed all to 200 respondents and responses solicited through recording and transcription The answered interview guide were retrieved from the respondents as there was high assurance of confidentiality and privacy. However the interview guide was use to solicit for response from the respondent for the qualitative aspect of the study

Data Analysis

Qualitative methods of analysis were employed in analyzing the data collected. The qualitative data analysis involved an analysis of production output and sales level collected from the study area to assess the company's performance regarding applying supply chain management practices to business processes. It also includes content an analysis of data or information collected during interviews in the form of notes jotted down during reconnaissance survey and in-depth interviews with key personnel

Analysis and results

The recorded interviews were analyzed and translated from Finnish into English afterwards by the Author because interviewing in English was considered not to be the best way to get properly answers and satisfying data. The answers to interview questions were written open from every interview and they are considered in the following analyses presented below.

Company's present practices

Existing policies and process between design management and procurement

Ten interviewees directly reported that there was no common process description or guidelines considering the supply chain process between design management and procurement. The rest of the interviewees suspected that there was none or did not know if there was. It was considered that there are loose processes for design management and procurement activities but clear holistic description of the whole process between design management and procurement is missing as design management and procurement function separately from each other. The need for a process description emerged during the interviews. The interviewees were also aware that they may have silos in departments and the process is case-specific at the moment as well there are few common processes and the project staff grabs the project itself and starts applying the practices considered to be the best. Activities were performed differently between different projects based on the habits experienced by the individuals as good.

It was recognized that different methods were used in different projects considering the process and there was no common method in use. For example, one method was that procurement packages had been used to control the design work and no separate design packages had been made. Another method tried was that the design package and procurement package models had been sometimes presented but clear procedures and instructions may not have existed. Third example was that design and procurement packages have been same package entities. Nevertheless, it was told that the whole chain process starts with making a general schedule for the construction and based on it a procurement plan and schedule are created and after these the design schedule is created. The design schedule is created with help of a procurement plan where the need times for the plans are specified and is drawn up in every project, but there are already differences in the meaning of that term that is, at what stage it is drawn up and on what basis. It would be important to harmonize practices and procedures so that the process does not overly vary in project implementation between different projects and be unclear. The supply chain process between design management and procurement is complicated enough already by its nature, thus it would be necessary to create a process description about it.

Some of the interviewees felt that procurement often comes too late aboard for the project planning and may not be early enough involved in the project to set schedules and more, in order that plans would be of the right level at the right time. From this it can be concluded that resource allocation is not working properly enough considering the project planning. Table 7 compiles discoveries and statements considering analysis about existing policies and process between design management and procurement.

Table 1. Existing policies and process between design management and procurement

Discoveries	Statements
There was no common process description or guidelines considering the supply chain process between design management and procurement.	(INTVW 2) "The aim is to have common policies, but at the moment there is no common process" (INTVW 4) "There are loose processes for design management and procurement activities but there is no clear holistic description of the whole process between design management and procurement" (INTVW 10) "Process descriptions about design management and procurement are not synchronized and, in my view, design management and procurement function separately from each other"

The need for a process description emerged.	(INTVW 8) “There are no written common policies and there is a need for them and guidelines considering the supply chain process between design management and procurement, and a division of responsibility is also needed”
Activities were performed differently between different projects based on the habits experienced by the individuals as good.	(INTVW 4) “the process is not controlled and comprehensive, but based on the parties’ own views” (INTVW 6) “there are probably as many ways to act now as there are project managers”
It was recognized that different methods were used in different projects.	(INTVW 19) “Procurement packages have been used to control the design work and no separate design packages have been made, however probably we should go in this direction that design packages would be used to control design work” (INTVW 14) “The design package and procurement package models have been sometimes presented but clear procedures and instructions may not have existed” (INTVW 3) “The design schedule, design packages and procurement schedule as well as procurement packages are used in the current project. Efforts have been made to make the procurement packages equate the design packages, and design package has been created based on procurement package.” (INTVW 8) “There are not always separated design packages and procurement packages, but sometimes they are same package entities”
Resource allocation is not working properly enough considering the project planning.	(INTVW 17) “Procurement often comes too late aboard for the project planning” (INTVW 10) “Procurement may not be early enough involved in the project to set schedules and more, in order that plans would be of the right level at the right time. Sometimes too much planning has been done, thus you must go back in the design and do it twice”

Creating the design schedule and its content as well as parties involved

There were many different methods to create the content of design schedule depending on whether the design packages were used or the procurement packages or some other titles, thus currently there are many different design schedule methods in use. Some of the interviewees considered that the aim is to have procurement packages in the design schedule and title distribution is similar to procurement package distribution in the design schedule. While some others thought that design packages should be created, and it would be the right development direction, and design packages and procurement packages have been used together in some projects, but not nearly always. It was mentioned as well that procurement packages have been used as information for design packages and thus design packages include afterwards procurement packages. In detailed design phase, design packages which are based on the need times for the plans of procurements have been sometimes used. It was notified that the use of design packages has become more refined in lifecycle projects than in other projects yet. One alternative method for creating design schedule was expressed as creating three different level schedules to support each other including upper level schedule, procurement/drawing schedule and separated building frame phase schedule.

It was brought out that the design schedule should be created based on general schedule and procurement schedule, and it is necessary that all parties like production, procurement and design management are involved. Most of the interviewees thought that project manager creates the design schedule and procurement as well as production must be involved and consulted. Thirteen interviewees told already at this stage of the interview that the use of design packages in the design schedule should be taken into use more generally in projects.

Table 8 compiles discoveries and statements considering analysis about creating the design schedule and its content as well as parties involved.

Table 2. Creating the design schedule and its content as well as parties involved

Discoveries	Statements
Currently there are many different design schedule methods in use.	(INTVW 1) “The aim is to have procurement packages in the design schedule” (INTVW 3) “Title distribution is similar to procurement package distribution in the design schedule” (INTVW 4) “Design packages should be created, and it would be the right development direction” (INTVW 5) “Design packages and procurement packages have been used together in some projects, but not nearly always”
The design schedule should be created based on general schedule and procurement schedule.	(INTVW 20) “The design schedule should be created based on general schedule and procurement schedule, and it is necessary that all parties like production, procurement and design management are involved”
Design management, procurement and production should be involved creating design schedule.	(INTVW 18) “Project manager creates the design schedule and procurement as well as production must be involved and consulted” (INTVW 13) “But at worst, it has been done by one person from his/her point of view”

Creating the procurement strategy and plan as well as parties involved

The procurement plan had been always created in projects, but creating or forming the procurement strategy was generally at weaker level or it hadn’t been done at all. It was discovered also that procurement formats have not been considered enough at the beginning of the project before the start of production. Nevertheless, sometimes procurement formats have been pondered when considering certain procurement packages, for example, in case of production subassembly, the needed level for main designers planning has been taken into account and needed plans for procurement.

As regards creating the procurement strategy, it was mentioned that a procurement strategy should be made for the project at a fairly early stage and principles for procuring agreed as well as critical, urgent and economically significant procurements identified. The distribution of procurements must be formed, and procurement formats decided. One must know how to approach each procurement entity or package.

Table 3. Creating the procurement strategy and plan as well as parties involved

Discoveries	Statements
The procurement plan had been always created in projects but creating or forming the procurement strategy was generally at weaker level.	(INTVW 1) “A proper procurement strategy has not always been done, however luckily it is now being done in our new project. Procurement packages will be created for the procurement plan and strategy for forming procurement packages is being done in this project” (INTVW 4) “The procurement strategy is not made even though it should be made in the early stages, and individual decisions are made but the contents of the packages are not holistically reviewed as they should. Again, only the individual’s way of doing is emphasized and there is no process of how to do it”

<p>Procurement formats have not been considered enough at the beginning of the project.</p>	<p>(INTVW 10) “Procurement formats have not been considered enough at the beginning of the project before the start of production, by whom have design responsibilities and do suppliers have also”</p>
<p>Procurement strategy should be made at a fairly early stage and principles for procuring agreed as well as critical, urgent and economically significant procurements identified.</p>	<p>(INTVW 6) “Basically, a procurement strategy is made for the project at a fairly early stage and principles for procuring are agreed as well as critical, urgent and economically significant procurements are identified. The distribution of procurements must be formed, and procurement formats decided, for example in case of production subassembly”</p> <p>(INTVW 13) “The work begins with the fact that the procurement strategy is considered in every part of the whole, whether it is made on paper clean is not always done, but it has been gone through with construction manager and with the person in charge of design management. You need to know how to approach each procurement entity or package”</p>

Coordination or cross checking of design schedule, design packages and procurement packages

Two different views emerged in the interviews on this issue. Nine interviewees reported that no coordination or cross checking of design schedule, design packages and procurement packages has been made or coordination has not been made properly. Couple interviewees didn’t know, and eight interviewees reported that coordination has been made at some level, nevertheless some of them had not used design packages and procurement packages but had managed design work on a pure procurement basis. Design schedule and procurement schedule had been combined into same schedule at one project and in some projects the design packages had been created based on distribution of procurements (procurement packages), thus an effort has been made to have content as parallel as possible. Coordination or cross checking is probably the biggest problem currently. However, some suggestions were already discovered that parties shall prepare preliminary design and procurement schedules themselves and afterwards collaborate and coordinate schedules and packages. Table 10 compiles discoveries and statements considering analysis about coordination or cross checking of design schedule, design packages and procurement packages.

Table 10. Coordination or cross checking of design schedule, design packages and procurement packages

Discoveries	Statements
<p>No coordination or cross checking of design schedule, design packages and procurement packages had been made or coordination had not been made properly.</p>	<p>(INTVW 1) “The intention is that the design packages contain the documents required by the procurement packages”, (INTVW 2) “nevertheless, the design packages and procurement packages have been used separately and there is no coordination or cross checking made”</p>
<p>When design work had been managed on a pure procurement basis, it had led to problems.</p>	<p>(INTVW 16) “The procurement packages have been also used as design titles in the design schedule and therefore there have sometimes been conflicts between design and procurement priorities. For example, the relationship with building services engineering (HVAC and electrical engineering) and ceiling subcontract, when suspended ceiling procurement is not so urgent or rushed but building services engineering is in a hurry, thus the structures for the suspended ceiling would have to be designed ready in case of that”</p>

<p>Coordination or cross checking is probably the biggest problem currently.</p>	<p>(INTVW 11) “This is probably the biggest problem right now, because it requires a lot of work and is complex entity and things have to be linked together and blown up into smaller pieces. Determining design packages and procurement packages requires skillful resources early in the project and identifying ulterior things and making decisions. Critical procurements should be identified and determine. The difficulty is that not all the necessary information may yet be available, and one does not want to create semi-finished schedules well in advance, in order that they do not look bad later in someone’s opinion. Nevertheless, the procurement package is a customer for the design package and must define its own content and requirements“</p>
<p>It was suggested that parties shall prepare preliminary design and procurement schedules themselves and afterwards collaborate and coordinate schedules and packages.</p>	<p>(INTVW 18) “The parties shall prepare and make preliminary design and procurement schedules themselves. After that they gather together and check if they are cohesive and parallel and make the necessary changes together. Reviews or inspections of packages should be also kept later with designers involved in order to guarantee a realistic plan for the entity. Nevertheless, a unified view within own company is essential before involving designers”</p>

Standardized levels of development considering building information modeling

Standardized levels of development for building information modeling does not exist currently according to ten interviewees, and others did not know if they exist, but they are in a development process at the moment. It was found that in the master plan design phase, it is possible to carry out a rougher design on common building information modeling requirements’ level of developments which are refined to more accurate levels into the detailed design phase but currently there is no stage in the supply chain where it has been verified that one has designed according to the required levels of development, thus it would be necessary that someone would be responsible for this issue and would do the verifying during the design work. It was mentioned that there would be a need for standardization of information structure and content in general in Finland, which could be to rely on in a design contract. Finland lacks such and therefore the level of modeling is often bad in Finland and leads to a variation in the type and level of building information models in different projects. Nevertheless, it was discovered during the interviewing that some projects have developed project-specific instructions for building information modeling and determined levels of development, but it has been challenging.

Almost all of the interviewees found standardizing levels of development useful. The biggest benefits identified were getting quantities out of the model for procurement, provided they could be trusted, and using the model to illustrate contract boundaries in the negotiations. However, the company has transcription for quantity takeoff in the Housing segment and based on that Business Premises segment is going to make its own transcription for quantity takeoff. Table 12 compiles discoveries and statements considering analysis about standardized levels of development considering building information modeling.

Table 4. Standardized levels of development considering building information modeling

Discoveries	Statements
<p>Standardized levels of development for building information modeling does not exist currently in the Business Premises segment.</p>	<p>(INTVW 20) “These are currently being prepared for the Business Premises segment because the current operating model and common building information modeling requirements’ levels of development do not directly help this issue with design management. However, on the housing segment side, levels of development have been standardized already. The information designation and naming conventions for the information model</p>

	<p>should be agreed properly with designers in order that data could be standardized for building components and examination over projects would be enabled”</p>
<p>In the master plan design phase, it is possible to carry out a rougher design on common building information modeling requirements’ level of developments which are refined to more accurate levels into the detailed design phase.</p>	<p>(INTVW 20) “In the master plan design phase, it is possible to carry out a rougher design on common building information modeling requirements’ level of developments which are refined to more accurate levels into the detailed design phase. Unfortunately, at the moment there is no stage in the supply chain where it has been verified that one has acted or de-signed according to the required levels of development”</p>
<p>There would be a need for standardization of information structure and content in general in Finland, which could be to rely on in a design contract.</p>	<p>(INTVW 20) “There would be a need for standardization of information structure and content in general in Finland, which could be to rely on in a design contract. Finland lacks such and therefore the level of modeling is often bad in Finland”</p> <p>(INTVW 13) “In practice, there are no standardized levels of development, but even for persons that make design contracts it is not clear what levels of development means and for what they are used. This leads to a variation in the type and level of information models in different projects”</p>
<p>The biggest benefits identified were getting quantities out of the model for procurement, provided they could be trusted, and using the model to illustrate contract boundaries in the negotiations.</p>	<p>(INTVW 8) “It would be very useful, in order to be able to include required BIM levels of development into design contracts and procurement would get decent quantities for procurements”</p> <p>(INTVW 10) “Using the building information model would be very useful, but first we need to be able to define what do we want from the building information model and that requires the participation of several people”</p> <p>(INTVW 17) “It would be useful also for designers to know what levels of development is required with each building component when designing and building information modeling”</p>

It was discovered that partly delays in supplying plans for the procurement occurs because of the inability of design management and procurement to describe what level of plans are needed. The procurement must be involved in influencing design management and be active as well as express what plans and what levels are needed. The supplying of plans for the procurement have been tried to be controlled with various inspections or reviews about the plans but nevertheless these have been accomplished too little and it would be extremely good way to keep such reviews together with designers and procurement. Lastly, it was stated that managing the supplying of plans requires extremely hard control, and the design management and the procurement should continuously interact considering procurements and design management so that the design management and the procurement work as a supply chain. Connecting the procurement strategy to the chain is still a challenge, which requires in particular tight continuous interaction and implementation of the process. Table 14

compiles discoveries and statements considering analysis about availability of design documents and plans for the procurement currently considering time and content.

Table 5. Availability of design documents and plans for the procurement currently considering time and content

Discoveries	Statements
It is very usual that plans are not generally supplied by the designers to the procurement at right time as agreed earlier.	(INTVW 13) “Without lying, almost 100% of the plans do not come when agreed. It is more the practice that they are late or if they arrive on time, they are too weak from their level or some plans are missing”
It easily becomes dominant way that plans are promised and not taken seriously.	(INTVW 13) “If the focus of the design is elsewhere, it is usually compromised from plans to be provided for the procurement if other planning is urgent for example production and plans related to permissions, and agreed things begin to be delayed on a regular basis. It easily becomes dominant way that plans are promised and not taken seriously, and even the procurement no longer insists the right level of plans halfway through the project but the approach is so that can one deliver at least something, thus I will compose the rest of it”
Buffers are used extensively in the supply of plans for the procurement.	(INTVW 19) “To put it bluntly, at the moment you cannot rely at all on designers to supply plans for the procurement. There is always the design schedule, but the plans are mainly either late, wrong at their level or bad at every project. Buffers are used often in the delivery schedule of plans due to the supply chain process cannot be trusted”

Synthesis of the main findings

Based on the interviews the topic of this master’s thesis has been a challenge and a problem in the construction industry in general for years. Some of the interviewees had previously worked for other construction companies and shared their thoughts from that time too. The problem has been discussed in construction companies for years. Nevertheless, solutions have not been properly found or utilized in everyday activities. The literature framework serves as a basis for developing a solution and connecting things, and for understanding the overall picture.

According to the data search, some guidance can be found on the subject from the company’s current new management system database and older databases. However, guidance is scattered into different locations and is somewhat unclear. Because the information is distributed into different places, it is difficult to find. Thus, the instructions cannot be followed correctly either. Nevertheless, the foundations for good data management exists as long as data discovery is developed, and data is centralized only into company’s new management system database. The design management and procurement have their own guidelines for the processes but the guidance considering their relationship and interfaces doesn’t exist properly. It is instructed that the design schedule must be created for the project and design packages as well as procurement packages must be determined and created. However, design packages and procurement packages are currently separate entities in the instructions and their connection is not expressed. Collaboration between design management, procurement and production is brought out in some instructions but the ways to collaborate is not provided or explained. Currently, the guidance in the management system database is provided at very general level and more specific guidance is needed, especially in the interfaces of design management and procurement.

As a conclusion, the target company doesn't have currently common processes between design management and procurement among different projects when prime contractor is responsible for design management. Design management and procurement function separately from each other and there is a need for common policies and process description. The answers from interview question 1 (company's present practices) supported this issue as it was directly reported that different methods are currently in use and common process description is needed. The interviews revealed that process descriptions are still underway and there are no common practices yet. Currently, project managers have their own established manners or even rather poor manners considering the process. Without common policies, it is difficult to develop anything at all when there is no comparable data. Some projects are going well, and some are worse. There would be a need for some common process description and approach that could be developed further. Thus, creating always a new way of working on the project at the beginning of the project is not anymore needed as there would be common process. Sure, there are variables and projects are different, but there are anyway some similarities. The interviews brought out that a bold alignment from upper management would be needed to start promoting certain kind of policy with this issue between design management and procurement. Meaning that it must be chosen whether to use both design packages and procurement packages together or not in the supply chain process.

The design management and procurement don't have a common understanding about what plans and what level of designing is needed for each procurement entity. This refers to interview question 3 (company's present practices) as creating a procurement strategy and determining procurement formats is generally at weaker level. A common understanding of the strategy for each procurement package should be found in collaboration or otherwise designers supply the procurement with incomplete or wrong kind of plans, or they are delivered late. It was suggested that procurement should also list what plans and documents are needed for the procurement package and what level of planning is required to help design management's and designers' work. However, synchronizing design packages and procurement packages in collaboration would be essential and they are not synchronized at the moment properly. They have been treated generally as separate entities and there is a need for coordination work which can be complex. One big problem is that design work cannot be managed on a procurement basis properly. The design work requires a different implementation order than procurement and construction site's tasks because some things have to be planned as a whole and some things have to be planned already earlier to be able to plan a certain things. Therefore, design packages and procurement packages must be coordinated in order to make both sensible from their content and allow proper timing of all actions and supplying of plans. One difficult aspect to this issue is also that the owner's decision making must be bound to the design schedule somehow. Due to this, design packages and procurement packages must be taken into use and utilized together by coordination.

Based on the interviews, the use of design packages and procurement packages would be the right process to start developing activities and collaboration with good interaction is required between design management and procurement. The answers from the interview question 1 (development propositions) supported this issue as the importance of design packages and procurement packages was recognized considering the question about what is the process by which design management can produce plans for procurement at right time. A common understanding about the content of design packages and procurement packages as well as their coordination work process is essential.

DISCUSSION

As a result of this thesis, a solution proposition for improving the supply chain process between design management and procurement was developed based on the literature review and research implemented in the form of mapping the company's current state and interviews. Design management and procurement have been both studied earlier, but their deeper connection in the supply chain process has been paid less attention. Especially, the prime contractor's procurement perspective and connection to design management have been lacking research. Nevertheless, this thesis takes a stand on this issue. The literature review supported well in finding a solution proposition to the problem in question and structuring the author's thoughts, as well as forming an understanding of the key issues related to the work. Based on the literature review, a theoretical

framework was created between design management and procurement in the construction company's internal supply chain, which serves as background information for the solution proposition.

There is no one right solution to the problem and process under consideration, and things can be practiced in many ways. However, a coherent common approach needs to be established in the company in order to develop operations in general and to study the success and suitability of processes. Based on thesis research, it was decided to develop the use of design and procurement packages in the supply chain in order to serve the procurement better with produced plans at right time with correct content and level of planning. The proposed solution builds on the literature and previous research on the subject, but the proposed solution introduces a new perspective on the connection of the procurement strategy including procurement formats to the design needs and required level of planning as well as management of the internal supply chain as a whole. The improved supply chain process proposition fits well with the current goal of aligning the supply chain process between design management and procurement.

The coordination of design and procurement packages through procurement strategy and formats (the link between design management and procurement) has proven to be a new thing and solution, which neither Kruus & al. (2006) SUKE-model has presented nor was found in the literature. The problem with the use of design packages alone or the SUKEmodel is precisely that the procurement distribution is made too freely concerning the design packages which produce plans for different procurements. The procurement strategy and formats are not properly taken into account concerning the forming of design packages, thus coordination work is missing. Which leads to the fact that procurement still gets the wrong level of plans and usually late, when critical decisions are made too late between the owner and the design management from a procurement and production perspective. The challenge is also to identify critical decisions for the coordination process on behalf of the design management to the owner, which are based on the needs of the procurement and the production in the chain concerning plans. The process of coordinating design and procurement packages adds novelty to the thesis, as the interviews also revealed that design and procurement packages have generally been kept too separate entities in the construction industry and their coordination has not been understood to implement through procurement strategy and formats.

Another novel thing is BIM aspect, as in general, the level of building information models is still weak in Finland, and the determination of LODs is a fairly new thing in design management. This was manifested in the fact that based on interviews even some of those responsible for design management did not understand what things and how can be influenced by the LODs in BIM. Thus, in this supply chain process between design management and procurement, proper determination of LODs adds value to the right content of plans and the level of planning. Uusitalo & al. (2019) described applying LODs for project's building components, but this thesis went more deeper into strategic process itself and emphasized the significance and influence of procurement strategy and formats into determination of the required LODs for building components.

The third novel thing is the thesis' focus on the interface between design management and procurement. In general, existing research on the subject nearly always focuses strongly on either design management activities or procurement activities, thus the description and consideration of the actions between the parties has remained slight, which continues to create problems in the industry in this chain. For example, Bølviken & al. (2010) article described developing collaborative design management on such projects where design is partly carried out in parallel with construction, but the deeper connection between design management and procurement was not brought out as the article concentrated on design management aspects. For another example, Koniel (2019) Master's Thesis concentrated strongly on developing design management activities to eliminate detailed design waste, but interface and activities between design management and procurement was not considered. The developed process description about the supply chain between design management and procurement in this thesis improves performed actions and the smoothness as well as comprehensibility of the process.

Proposition for improving the supply chain process

The developed proposition for improving the supply chain process between design management and procurement is presented and described. The process between design management and procurement is first

illustrated and later the improved operating model between the design packages and the procurement packages is presented. The theoretical framework developed based on the literature review acts as a support and background information for the proposition. The proposition is constructed based on the literature review, research about present state of the target company’s practices and development targets as well as meetings about the subject in the target company.

There are many ways to practice things related to the subject and one right solution does not exist for this problem in question. However, it is necessary to choose a direction in which the development will be taken in order to harmonize the work between the projects and thus evaluate and develop things forward. The use of design packages and procurement packages was chosen to be developed based on the research, and target company’s general desire. The design management and the procurement serve the needs of the production in the supply chain, which is why it is important to create the conditions for production to succeed. It is important that the design management can supply the procurement with complete right level plans at right time in the chain produced by the external designers, thus collaboration including good interaction between design management and procurement is required.

Process description about the supply chain between design management and procurement

The whole process requires proper resource allocation in the very early phase of the project, and time for project planning must be reserved before starting the project and detailed design work. Project manager, procurement engineer and construction manager are required in the planning of the project, even though if individuals are not final in the project, the project directions including design schedule and packages, procurement strategy and formats as well as procurement schedule and packages, and also general schedule must still be planned.

In general, the starting points for master plan design and detailed design phases are that master plan design phase must be implemented with starter design packages utilizing “Push” principle. This means that design management produces the main drawings in accordance with the objectives planned for the building based on the objectives of the owner, whereas detailed design phase must be implemented with design packages and procurement packages including procurement formats utilizing “Pull” principle. This in turn means that in project planning phase general schedule is created by construction manager, and based on that procurement schedule and plan including procurement packages and formats is created by procurement engineer as well as design schedule for detailed design phase including design packages is created by project manager. Starter design packages contain all the initial design data required for the detailed design phase design work. They must produce master drawings (space concepts, model room, building specification, floor plans and sections etc.) in the master plan design phase. Figure 22 illustrates the difference between master plan design phase and detailed design phase considering the design management point of view and their content.

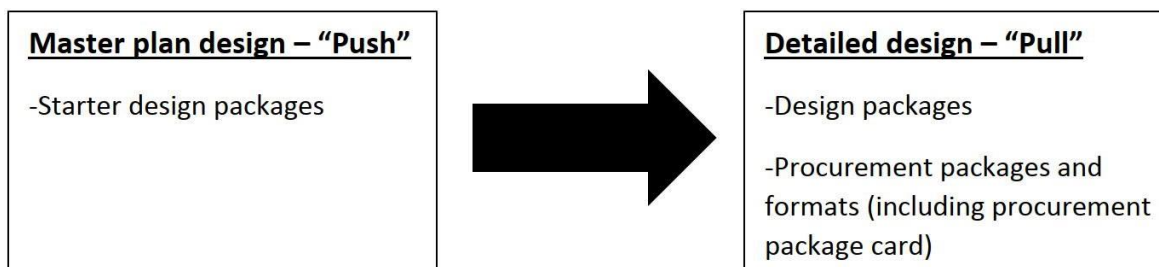


Figure 22. The difference of contents between master plan design and detailed design phases

Considering the BIM aspects, the LODs must be definitely determined for the building components and for the project in question early, or standardized LODs must be used if available. LODs must be tied to design contracts by project managers because otherwise designers will not follow them. BIM LODs must be determined for a rougher level for the master plan design phase so that drafts are not modeled too accurately. This saves time and unnecessary work as plans often change a lot at the drafting stage and even afterwards. For the detailed design phase, more accurate LODs must be defined. BIM coordinator must support the design management and take care of these aspects together with the design management. The entire design

management must be a BIM and data-driven, involving the BIM coordinator to support the design management and verify that the LODs are implemented as agreed in the design. Otherwise, the quantities obtained from the BIM, cannot be relied on by the procurement. It would be important that the procurement could utilize reliable quantities from the BIM in contracts, and afterwards when subcontract's tasks are completed at construction site, it could be checked from the updated BIM in the final settlement of subcontract how the quantities have changed in the BIM. This would prevent fraud in terms of additional invoicing when the quantities would be comparable to the quantities at the time of awarding the subcontract. Nevertheless, the determination of LODs gives the right kind of quantities for the procurement with the right units for subcontracts, ergo, the quantities of the BIM would be presented in the same units and formats as the procurement must use in the subcontracts. How far one wants to take LOD accuracy in any building component depends only on the company and the project's own needs. Procurement format also plays an important role in this matter, how precisely and to what extent things are planned in the BIM. Even if an entity is procured as a production subassembly, the subcontractor's building information modeling must be specified with defining LODs for the contract if the model is to be used properly for example during the building's lifecycle. However, new common LODs would be needed for the construction industry in Finland, which could be relied on in the design agreements. If prime contractors always set their own LODs, the designers get confused, and new design settings for each project create an almost unreasonable challenge and difficulty for the modeling work.

A process flowchart between the design management and the procurement was developed and constructed for the artefact proposition to solve the problem in question (Figure 23). The process starts with proper resource allocation for the project planning and with determination of LODs for BIM. After this, construction manager creates a general schedule for the construction project and schedules the site tasks so that they can be completed as planned. The whole supply chain is based on the need to create the conditions for the construction site to succeed and the phases of the chain are all that way based on the created general schedule.

Thus, next phase in the process is that the procurement plan and schedule are drawn up on that basis. The procurement strategy is essential to create for the project and procurement packages. Therefore, the procurements must be determined and distributed into different procurement packages. Defining procurement formats and the needed level of planning, at least for critical procurement packages, is essential in the process. Rougher plans can be used to query different solution options and get potential savings from them, as well as to reserve supplier capacity with some kind of quantity data, even if the plans are not of the detailed design level. Procurement performed with detailed plans (one of the procurement formats) is not always needed with each procurement package, thus the mere role of the buyer is irrelevant considering the procurement. Due to this, different procurement formats must be selected for each package and that way the required level of planning determined. This requires collaboration between the procurement and design management to achieve a common understanding about the strategy with each procurement package, and this has a direct effect on coordination work of design and procurement packages. Defining procurement formats also opens up a discussion between the design management and the procurement so that the project manager can point out which issues and packages would require alternative solutions. Thus, in that case procurement format can be, for example, procurement performed with normative designs. As a result, preliminary procurement packages (at least critical packages) are formed with defined procurement formats and after that procurement plan and schedule are created. A procurement package card should be created for every package in order to support the coordination work of design and procurement packages as well as the design management's and designers' work. The procurement package card can express the required plans and their level of planning regarding the procurement package in question. The procurement package card should contain the name of the procurement package and procurement format, the content of the procurement package including contract boundaries, the schedule of the procurement package, the required plans and initial data from designers as well as the needed time for the plans considering the procurement. Standardizing procurement package cards from recurring procurement packages would ease the workload when the card could only be updated for each project. Nevertheless, standardizing these procurement packages cards is limited outside of the scope of this Master's thesis. Appendix 3 shows an example of procurement package card template.

The initial design schedule is created on the basis of the general schedule and the procurement plan and schedule. A standardized design package division can be used in the process if one exists in the company or the design packages can be formed for the project. What is important about design packages is their timing and content. The design package produces plans for multiple procurement packages and thus includes design entities that have dependencies in the design process, what things need to be already decided and designed in order to be able to design the plans required by the procurement packages allocated to the design package in question. As a result of the completed design package, the agreed plans are delivered at the time agreed for the procurement.

CONCLUSIONS

The Design Science Research method suited well for this thesis purposes as it provided knowledge through the systematic literature review, allowed connecting empirical research part to the developed theoretical framework and finally enabled the creation of an artifact which came out in a form of solution proposition for the problem in question. Through the method, a comprehensive understanding of the problem was achieved which enabled the examination of different contexts related to the issue. A satisfactory solution was obtained for the problem even it would not be optimal, thus the study clearly benefitted from the use of the Design Science Research method. The topic of this thesis is very complex and has been problematic issue for the business premises construction industry for a long time, thus the author's own systematic research plan developed on the basis of the method served very well as a basis and indicator of direction during the research, although the topic was difficult and there is no one right solution to the problem.

This thesis studied how the supply chain process between design management and procurement could be improved in projects where the prime contractor is responsible for design management and design work is implemented possibly concurrently with construction. The challenge is to supply plans for the procurement from the designers and design management at the right time and with the right content. The connection of design and procurement packages is emphasized in this matter and the basis for their coordination is established from the procurement strategy and formats of each procurement package. Determining procurement strategy and formats for procurement packages in the project planning stage must be implemented in collaboration between design management and procurement in order that the parties form a common view and understanding of the issues. How things will be procured and in what order what plans are needed and what level of planning is required. Thus, collaboration and good interaction between design management and procurement is essential for being able to improve the supply chain process.

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