Jurnal Siasat Bisnis Vol.27 No. 2, 2023, 135-155

Jurnal
SIASAT BISNIS

Journal homepage: https://www.journal.uii.ac.id/jsb

Using interpretive structural modelling and quality cost model to solve project completion delay in shipyard case study in PT X

Ngurah Ayu Happy Susilawati*, Desi Adhariani
Master Program in Accounting, Faculty of Economics and Business, Universitas Indonesia, Depok, Indonesia
*Correspondents e-mail: ngurah.ayu@ui.ac.id

Article Info

Article history:
Received : 2023-06-06
Accepted : 2023-08-28
Published: 2023-08-30

JEL Classification Code:
M11, M19, M49

Author's email:
desi.adhariani@ui.ac.id

DOI: 10.20885/jsb.vol27.iss2.art2

Abstract

Purpose – This research proposes an alternative method to solve completion delay issue and optimized the strategy using ISM technical method and Quality Cost Model application.

Design/methodology/approach – Data was acquired from 120 questions from company key persons that involved in project for last 5 years. The instruments processed using ISM analysis to measure the relationship among causes, then using Quality Cost Model to solve.

Findings – This research shows that factors of late payment from client, delays in bank credit processing, bad weather, and design changes by owners are the root causes of delays. Further analysis using the Theory of Constraint (TOC) shows that financial constraint issues influence the decreased throughput and increase operating cost. Further management use five sequential steps to improve the management and P-A-F models as one of strategic cost management tools applied to the root causes to determine the optimum cost strategy to solve the problem.

Research limitations/implications – This research was conducted using a case study method, and the conclusion related to problem and root cause may not be applied totally to other companies, but the framework may be applicable. Future research can investigate other issue using TOC framework, combine TOC with other models to conduct root cause analysis, and the COQ model implementation in shipyard management.

Practical implications – This research demonstrates that management can use Interpretative Structural Modelling (ISM) analysis to determine the root cause, then analyse and overcome the issues using TOC framework. COQ model approach to sharpening the decision, and prioritize the resources allocation.

Originality/value – This research combine ISM, TOC, and PAF Quality Cost Model approach for decision making which can be a management tool in strategic cost management.

Keywords: root cause analysis, ISM, quality cost model, strategic cost management, shipyard management

Introduction

In a competitive business environment, companies must maintain the quality of their products and service to survive, achieve customer satisfaction, and expand new markets. Service quality can influence client satisfaction, from four aspects, those are reliability, responsiveness, assurance, and tangibility. Delivering service on time is one aspect of reliability, which is considered as a most

P ISSN 0853-7666 I E ISSN 2528-7001

important dimension of service quality (Sunindijo *et al.*, 2014). The company's ability to maintain its service quality lead to business success.

Higher quality leads to higher production costs which mean a higher price. The quality cost concept sees the cost from a comprehensive perspective to measure the company's sacrifice to achieve quality. An optimum strategy for maintaining quality enables the company to increase its profit and competitive advantage. Companies need to implement priorities in managing their quality costs effectively with quality cost management, otherwise, resources may be misallocated.

Company X, a medium-scale shipyard, works on orders to build new ships based on a government and private sector contract. The custom order is treated as a project-based order and managed by a project manager. Technically, the production process is grouped into three major parts, namely the design work, material procurement, and construction (Basuki *et al.*, 2012) within a range of 3-12 months of the production process. The contract mentions technical and financial aspects such as payment terms, bank guarantee, insurance, warranty, and penalties for completion delay and non-conformance. Further, the contract may involve other parties, such as an independent surveyor, classification, and government agent as permit issuance.

The main issue in the company is delays in project completion. Historically, most orders have been delayed and subject to fines of up to 5% of the contract value which will reduce the company's profits, poor performance record, and less reliability. Various management preventive and corrective actions have not shown significant results, so it is necessary to analyze deeper into the root cause so management can make the right strategic policies, then evaluate them ongoing.

In the long run, low-service quality will become an obstacle for companies to develop and expand into new markets which tend to demand higher quality and timeliness. Improving quality can increase firm value because profitability will increase as customer demand increases and production costs decrease (Hansen & Mowen, 2018). Increasing the prevention cost lowers the cost of failure in a much larger number (Eraslan & Önal, 2021). The total quality cost will be decreased, if not the prevention costs reached a saturation point, and exceed the saving. The cost of quality is zero when the product meets the target value, and the cost of quality increases symmetrically for products that deviate from the target (Hansen & Mowen, 2018).

In the industrial field, some research proposed and implement some methods to determine potential root causes and their causal effect in quality matter using engineering perspective, such as Failure Mode and Effect Analysis (FMEA) method (McDermott *et al.*, 2009; Wu *et al.*, 2021) which further combined with fuzzy logic to improve the FMEA method (Cardiel-Ortega & Baeza-Serrato, 2023), hybridization of Cause and Effect Diagram (CED) and Interpretive Structural Modelling (ISM) (Abellana, 2020), Root Cause Failure Analysis (RCFA) (Huff & Lynaugh, 2001) and Automated Root Cause Analysis (ARCA) (E Oliveira *et al.*, 2023). Those researches described appropriate techniques to determine root causes and then prioritize the actions based on the logical or technical matter to solve the quality problem. Financial aspects are not taken into primary consideration, which leads to an unoptimized solution or higher production cost.

This research intended to solve completion delay issue, by considering both engineering and financial sides and optimized the strategy. This research proposes a comprehensive technique using the ISM as a root cause analysis tool in manufacturing and Quality Cost model application to balance engineering and financial perspectives. ISM analysis is used to determine the priority among quality costs. The PAF quality cost model can be applied, then treated as performance indicators for each activity (Tambunan, 2022). This approach is intended to address the complexities of strategic quality management.

Literature Review

Theory of Constraint and Operational Measures

Theory of Constraint (TOC) is a management tool that assumes that any controllable system is constrained by some constraints in achieving other of its goals (Jacobs & Chase, 2020; M. C. Gupta & Boyd, 2008; Simatupang *et al.*, 2004). According to TOC, there is always at least a single constraint, and TOC implements a focus process to identify the constraint and restructure the rest of the organization around it.(Orouji, 2016), primarily concerned with the reduction of constraints focuses on the enhancement of systems (Nave, 2002).

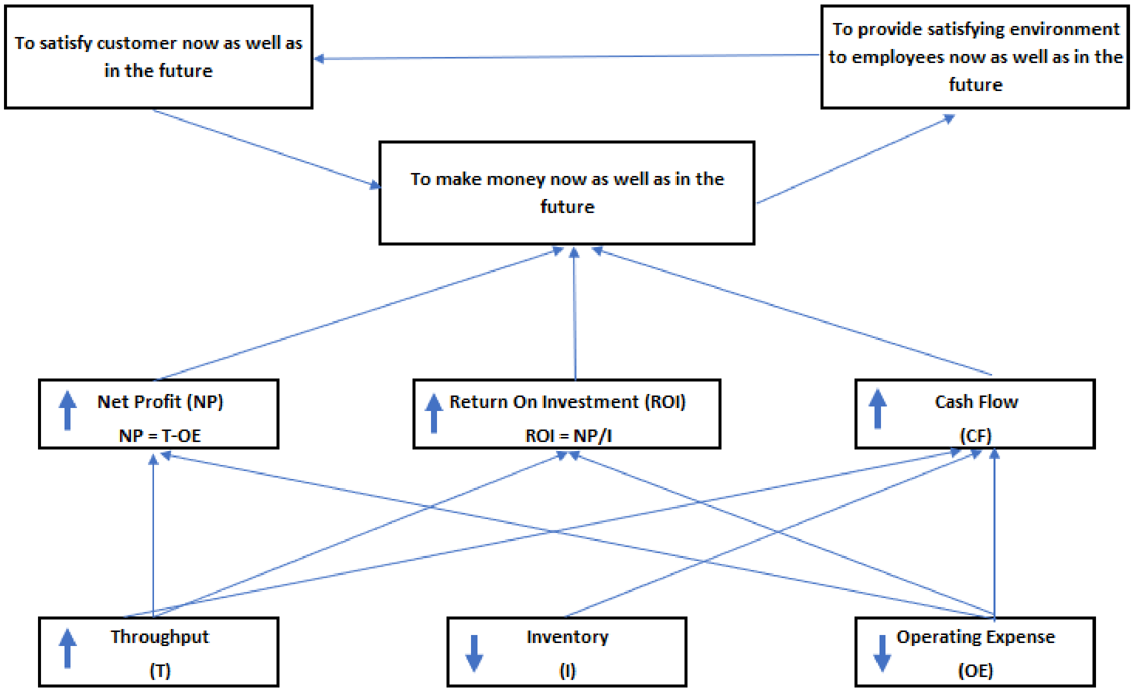

Figure 1. Integrated TOC Framework (M. Gupta *et al.*, 2002)

A system, in this context, is characterized as a sequence of interrelated processes. A fitting comparison for a system is the chain, which comprises a collection of interdependent links that collaborate to achieve a common objective. The constraint, in this context, is a vulnerable link that hinders the system's overall performance. The main focus of TOC as a management improvement method further compared with other method such as Six Sigma which is all about reducing differences, while lean methods are about reducing waste, and TOC is mainly about getting rid of obstacles. Further, the management can choose the application based on its typical using five sequential steps, namely: (1). Identification of the constraint, (2). Exploitation of the constraint, (3). Subordination of other processes to the constraint, (4). Elevation of the constraint, and (5). Repetition of the cycle.. (Nave, 2002) The overall system's performance is reassessed through the identification of new constraint processes, their exploitation, subordination, and subsequent evaluation. This method, which focuses on constraints, yields positive effects on the production flow time throughout the system.(Orouji, 2016).

Improving performance from TOC perspectives are measured by throughput, inventory, and operating expense, which are represented with some financial indicator such as Net Profit, Return on Investment, and Cashflow. (M. Gupta *et al.*, 2002). Figure 1 show how the process of improvement guarantees that operational decisions are made to enhance throughput, while simultaneously reducing inventory and operating expenses.

Market demand is the main factor affecting throughput. Removing constraints in throughput can increase sales and boost company profits, as long as the market is not saturated. The main objective is to identify the constraints that hinder the company's ability to achieve optimal throughput. These constraints may be related to production, sales, or distribution channels (M. C. Gupta & Boyd, 2008).

Reducing inventory is crucial for businesses to increase profitability. Inventory ties up a lot of capital that doesn't generate revenue. By reducing inventory, businesses can free up capital to increase throughput. The theory of constraints defines inventory as all investments related to throughput, including production facilities, equipment, raw materials, parts, and finished products that haven't been sold. For example, reducing wait times in the production line can increase throughput and decrease inventory simultaneously (M. C. Gupta & Boyd, 2008).

TOC application looked at different business areas and found four main categories: distribution & logistics systems, project management, manufacturing, and general management. Currently, TOC combined with other math models to find important issues.(Melendez *et al.*, 2018), such as TOPSIS method and Monte Carlo simulation (Stopka *et al.*, 2023).

Strategic Cost Management

Strategic cost management refers to the application of cost management strategies aimed at enhancing a company's strategic position while effectively managing its costs. This approach involves the integration of cost-related data into the decision-making process to support the overall organizational strategy. To develop a strong strategic position, it is important to separate costs that support it from those that could harm it. Then, focus on reducing the costs that could harm the company's position.

Effective strategic management is a crucial factor in the success of any company or organization. The rise of competition in the global market, advancements in technology, and changes in business processes have made management more dynamic and significant than ever before. It is imperative for managers to maintain a competitive attitude, and the company's competitive strategy is vital for this purpose. A strategic mindset enables managers to anticipate changes in demand and customer needs, and accordingly design products and production processes. In such a scenario, flexibility is imperative. (Rounaghi *et al.*, 2021).

Strategy costs should be measured and optimized before executed. Quality costing can focus management attention and strategy to solve failure sources and their costs (Jafari & Rodchua, 2014). The strategy can be optimized using certain quality model. The most Quality Cost model used is Prevention-Appraisal-Failure Model (PAF Model) (Eraslan & Önal, 2021; Jafari & Rodchua, 2014; Schiffauerova & Thompson, 2006), with suppositions that investment in prevention and appraisal activities will reduce failure costs, further investment in prevention activities will reduce appraisal costs (Modhiya & Desai, 2016).

Figure 2 shows the relationship among categories. There is a positive relationship between prevention costs and quality level. Through increasing prevention costs, failure costs will be reduced. This will improve quality which in turn will positively affect the level of customer satisfaction and brand image and will lead to increased performance (Ghunaim & Jaaron, 2021).

Figure 2. Graphical Representation of Prevention, Failure and Total Costs (Santhoshn & Melwynrego, n.d.).

Process Design and Process Control

The process design phase involves the strategic planning of resources, tasks, and training required for the successful manufacture of a new product. The engineer should have manufacturing experience to understand the available process options and potential design flaws that may lead to suboptimal production processes (Schroeder *et al.*, 2021). It is recommended to conduct concurrent engineering, in which both process and product design are done in parallel to enhance the production process before finalizing the product design. Its main advantages are reducing misalignment and shortening project completion times in various industries. In the implementation, process control may use information technology to track and control a physical process (Heizer et al., 2019).

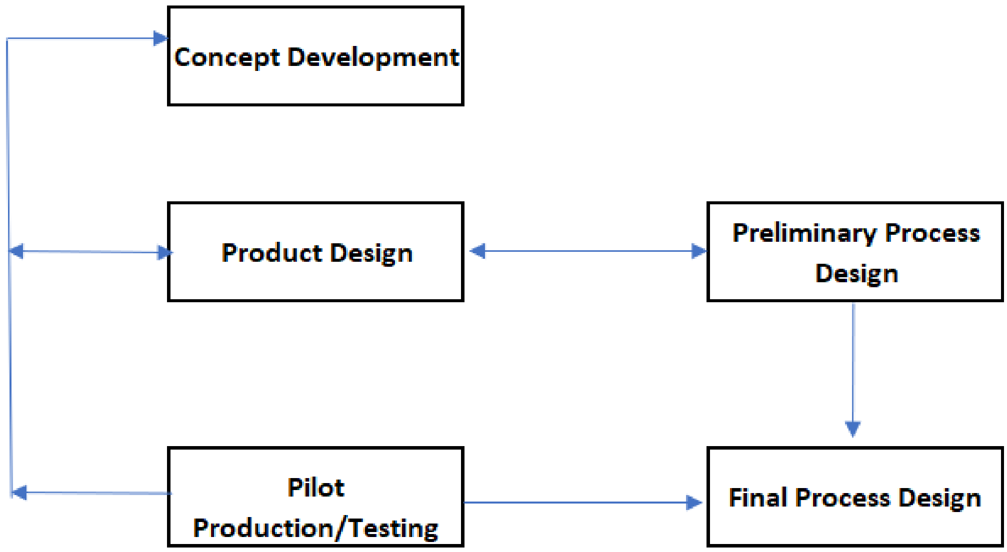

Figure 3. Parallel Process Design and Product Design (Schroeder *et al.*, 2021)

Hypotheses

Shipbuilding is a unique process which combines construction and manufacturing business nature, although most nature is a construction. The completion delay issue in construction often happened (Abeysinghe & Jayathilaka, 2022; Assaf & Al-Hejji, 2006; Shahhossein *et al.*, 2017), especially in shipbuilding (Gazali & Baroroh, 2022; Harlan & Resda, 2019; Prihandono, 2017). Prior literature mentioned the cause of completion delay were shortage skilled subcontractors or suppliers, financial difficulties of contractors, poor planning and scheduling (Abeysinghe & Jayathilaka, 2022), delay in progress payments, late in reviewing and approving design documents, change orders by owner during construction (Assaf & Al-Hejji, 2006), poor cash flow, inadequate financial resources, and volatility in financial markets (Shahhossein *et al.*, 2017), delays to deliver engineering drawings and equipment, unpredictable events such as bad weather, absenteeism, and staff turnover (Mello *et al.*, 2015). Every company have certain variables cause completion delay issue that should be identified, analyzed, and determined the root cause. The question will be formulized as Q1: What are the root causes of completion delay of shipbuilding in Company X?

To overcome the issue, management need to design focused strategic plan, which are answered in Further Q2: What are management strategies to solve the root causes

PAF Quality Cost Model is a tool of the strategic cost management which can measure the activity to achieve desired quality target. Referring PAF model, the completion delay cost was classified as failure cost (Modhiya & Desai, 2016). The company strategy to solve the failure was prevention and appraisal activities. Any difference from target quality value will result in quality costs or losses, so a product must be precise to specification (Ghunaim & Jaaron, 2021). Futher, the next question the Q3: How do the quality cost model can be applied to problem solving? Figure 4 show the relationship among questions.

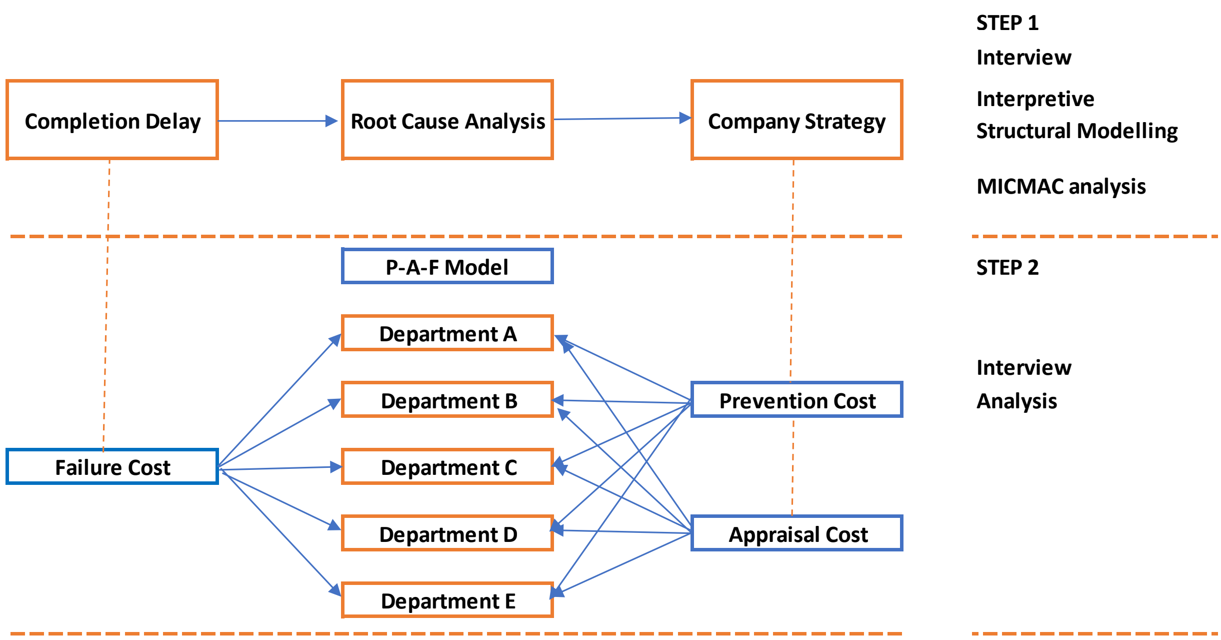

Figure 4. Conceptual Framework

Research Methods

This case study used a qualitative and quantitative approach in case study. The principle of case study is found in the duality of being situationally grounded, but at the same time, seeking a sense of generality (Ketokivi & Choi, 2014). This study designed as a theory-generating case study due to limitation of literature and theory to understand the phenomenon. It used multiple project case look for both similarities and differences across projects cases and proceed toward theoretical generalizations.

The qualitative research explores the possible variable influenced the issue and may detect other hidden variables. The qualitative research is used to gathering, evaluating, and interpreting non-numerical data, using behavior and opinion observation to discover on patterns in data sets, like changes over time, and attempt to discover potential links among variables (Saha, 2022). Quantitative research techniques rely on numerical, objective, and trustworthy data, then assessed using mathematical and statistical techniques (Saha, 2022). It creates and tests associations between variables in investigating the truth by historical data. It involves the development of research questions and testing hypotheses (Olalere, 2011). The mixed method research, which blends qualitative and quantitative methods, has gained enormous appeal in the field of accounting research in recent years (Saha, 2022) and give more comprehensive discussions. Although quantitative methods used broadly on accounting research, the qualitative approach has a sizable use in order to develop novel theories that could subsequently be tested by quantitative methods (Bonner *et al.*, 2006).

The object of the research is PT X, a middle size shipyard which located in Jakarta as the research object. The research methods conducted through three stages. First stage, a brief literature review on the construction delay issue in shipyard business, quality cost model, and strategic cost management. In-depth interviews were used to gather information from respondents about the relevant potential causes for completion delay in 5 recent years. Interview was conducted to 6 members of the management team of different divisions in semi-structured form to obtain diverse perspectives so as to strengthen the validation of the results of analysis. The respondents are Director, Project Manager, Engineering Manager, Finance Manager, Logistic Manager and Marketing Manager.

All valid potential causes were listed in Questionnaire A for completion delay causes then answered by respondents to give opinion about causal relationship among factors, and analyzed using Interpretative Structural Modelling (ISM). ISM is a method for identifying causal relationships among variables (Shrivas & Singla, 2022). The complexity of ISM increase along the number of variables involved, so some variable limitation is applied for ISM model development for complex long range planning (Attri & Dev, 2013). This approach can be used to improve management decision making in different areas (Bolaños *et al.*, 2005). ISM can detect the transitive relationships between the causes, by stated, "If A is related to B and B is related to C, then A is related to C". This feature is appropriate for root cause analysis (Abellana, 2020). The assessment uses a linguistic scale, namely V, A, X, and O.

Table 1 shows the using linguistic rating to represent causal expression between variables. The interaction among 16 completion delay causes were seen through 120 questions. The data tabulated and processed using Interpretative Structural Modelling (ISM) to identify the root causes. The ISM method is an effective tool for complex decision making (Abellana, 2020). Further, the result showed the strategic target area should be focused by management.

Table 1. Linguistic Rating Used

Linguistic Scale	Does faktor A cause factor B?	Does faktor A cause factor B?
V	Yes	No
A	No	Yes
X	Yes	Yes
O	No	No

In the second stage, the research determined strategies to solve root causes and any quality cost under P-A-F category related to the strategy. The determination involves prioritization which is important because analyzing every quality cost is time consuming and inefficient (Basak *et al.*, 2015).

Results and Discussion

Completion Delay Analysis

The case study focused on latest shipbuilding projects within 5 years. Potential causes for delay issue in the new building was obtained by conducting interviews with key persons who experienced in each section and industry. Table 2 shows 16 potential causes obtained and their interactions assessed through Questionnaire A in Appendix 1.

Table 2. Potential Causes for Completion Delay

No	Delay Causes	References
A1	Late payment from owner	(Abeysinghe & Jayathilaka, 2022; Assaf & Al-Hejji, 2006; Shahhossein *et al.*, 2017)
A2	Late project financing	(Assaf & Al-Hejji, 2006)
A3	Low labor productivity	(Araújo-Rey & Sebastián, 2021)
A4	Bad weather	(Assaf & Al-Hejji, 2006)
A5	Order changes during production	(Abeysinghe & Jayathilaka, 2022; Assaf & Al-Hejji, 2006)
A6	Material delay	(Assaf & Al-Hejji, 2006)
A7	Wrong material estimation	(Mello et al., 2015)
A8	Insufficient cash flow	(Abeysinghe & Jayathilaka, 2022; Shahhossein *et al.*, 2017)
A9	Late payment to supplier	(Prihandono, 2017)
A10	Lack of planning	(Abeysinghe & Jayathilaka, 2022; Mello *et al.*, 2015)
A11	Lack of control	
A12	Bad relationship with client	(Abeysinghe & Jayathilaka, 2022)
A13	Bad relationship with surveyor	(Abeysinghe & Jayathilaka, 2022)
A14	Work progress has not been achieved	(Mello *et al.*, 2015)
A15	Long custom clearance process	(Prihandono, 2017)
A16	Insufficient labor	(Abeysinghe & Jayathilaka, 2022)

In consideration of the contextual relationship of each factor and the potential existence of a relationship between any two factors (a and b), it is necessary to question the associated direction of the relationship. To denote the direction of relationship between two factors (a and b), the following four symbols are utilized as Table 1: Based on the recap data processing of the results of questionnaire A, the SSIM matrix was formed in Table 3.

Table 3. Matrix SSIM – Completion Delay

	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1	A	X	A	A	X	A	V	X	X	X	X	X	X	O	A
A2		O	O	O	V	O	V	V	O	O	A	O	X	O	O
A3			A	A	A	A	A	A	A	A	O	A	X	O	X
A4				O	V	O	O	O	O	O	O	O	V	O	O
A5					V	X	V	V	V	V	X	X	V	O	V
A6						X	V	V	X	O	V	V	V	A	O
A7							V	O	X	A	V	V	V	O	O
A8								V	A	A	V	V	X	O	V
A9									A	O	V	V	V	O	O
A10										V	V	V	V	V	V
A11											V	V	V	O	O
A12												O	A	A	A
A13													A	A	A
A14															O

The subsequent phase in the ISM approach involves the creation of an initial reachability matrix derived from the SSIM. This is achieved by replacing the four SSIM symbols (namely V, A, X, or O) with binary digits of 1 or 0 in the initial reachability matrix. The guidelines for this substitution are outlined as follows: (a) In the event that the (a, b) entry in the SSIM is V, the (a, b) entry in the reachability matrix will be assigned a value of 1, while the (b, a) entry will be assigned a value of 0. (b) If the (a, b) entry in the SSIM is A, the (a, b) entry in the matrix will be assigned a value of 0, while the (b, a) entry will be assigned a value of 1. (c) In the case where the (a, b) entry in the SSIM is X, the (a, b) entry in the matrix will be assigned a value of 1, and the (b, a) entry will also be assigned a value of 1. (d) Finally, if the (a, b) entry in the SSIM is O, the (a, b) entry in the matrix will be assigned a value of 0, and the (b, a) entry will also be assigned a value of 0. The result of Innitial Reachbility Matrix in Table 4?

Table 4. Initial Reachability Matrix (RM) – Completion Delay

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	0	0
A2	1	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0
A3	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1
A4	1	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0
A5	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1
A6	1	0	1	0	0	1	1	1	1	1	0	1	1	1	0	0
A7	1	0	1	0	1	1	1	1	0	1	0	1	1	1	0	0
A8	0	0	1	0	0	0	0	1	1	0	0	1	1	1	0	1
A9	1	0	1	0	0	0	0	0	1	0	0	1	1	1	0	0
A10	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1
A11	1	0	1	0	0	0	1	1	0	0	1	1	1	1	0	0
A12	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0
A13	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0
A14	1	1	1	0	0	0	0	1	0	0	0	1	1	1	0	0
A15	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0
A16	1	0	1	0	0	0	0	0	0	0	0	1	1	1	0	1

Table 5 describe the relationship between variables by showing the reachability and antecedent relationships that intersect at intersections. The reachability set comprises the factor itself and any other factor that it may affect, while the antecedent set comprises the factor itself and any other factor that may affect it. Subsequently, the intersection of these sets is determined for all factors, and the levels of different factors are established. The factors that share the same reachability and intersection sets are positioned at the top level in the ISM hierarchy. These top-level factors are those that will not elevate other factors above their own level in the hierarchy. Once the top-level factor is identified, it is excluded from consideration, and the same process is repeated to identify the factors in the subsequent level. This process is repeated until the level of each factor is determined. These levels are instrumental in constructing the ISM diagram.

Table 5. Reachability, Antecedent, and Intersection per variabel

Variable	Reachability Set	Antecedent Set	Intersection Set
A1	A1 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16	A1	A1
A2	A2 A6 A7 A8 A9 A10 A12 A13 A14 A15 A16	A2	A2
A3	A3 A14 A16	A1 A3	A3
A4	A4 A6 A7 A8 A9 A10 A12 A13 A14 A15 A16	A4	A4
A5	A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16	A5	A5
A6	A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16	A1 A2 A4 A5 A6	A6
A7	A7 A8 A9 A10 A11 A12 A13 A14 A15 A16	A1 A2 A4 A5 A6 A7	A7
A8	A8 A9 A12 A13 A14 A16	A1 A2 A4 A5 A6 A7 A8	A8
A9	A9 A12 A13 A14	A1 A2 A4 A5 A6 A7 A8 A9	A9
A10	A10 A11 A12 A13 A14 A15 A16	A1 A2 A4 A5 A6 A7 A10	A10
A11	A11 A12 A13 A14	A1 A5 A6 A7 A10 A11	A11
A12	A12	A1 A2 A4 A5 A6 A7 A8 A9 A10 A11 A12	A12
A13	A13	A1 A2 A4 A5 A6 A7 A8 A9 A10 A11 A13	A13
A14	A14	A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A14	A14
A15	A15	A1 A5 A6 A7 A10 A11 A15	A15
A16	A16	A1 A2 A3 A5 A6 A7 A8 A10 A16	A16

Based on the table iteration is carried out to compile the ISM diagram to provide a visual picture of the relationship between variables as shown in Figure 5. It shows that the factors of late payment from client (A1), delays in bank credit processing (A2), bad weather (A4), and design changes by owners (A5) are the root causes of delays.

The specific relationship among variables in level 8, show that late payment from owner (A1) also can cause order changes during production (A5). This situation shows client's legitimation to push order changes, which leads to extra work and higher delay risk. A1 also cause A2 by lengthening the bank analysis process since it increases the credit risk. A1 and A2 are related directly to the financial aspect of project or company, means that the company need to review its working capital and cash management. A4 able to cause A5 by design modification as a response to bad weather incidents.

Based on Table 4 processed using the concept transitivity, then the final reachability matrix is obtained. The affordability of the matrix to provide the 'driving power' (power of influence) and the 'power of dependency' of every enabler. Thus, in the last reachability matrix table, in which the driving force for A1 (Late payment from owner) is the total number of values entered in the row, namely 13. Meanwhile, the value of 'dependence power' for A1 (the number of entries in column) is 4. Similarly, the values of 'driving force' and 'dependence power' calculated for all remaining enablers, as shown in Table 6.

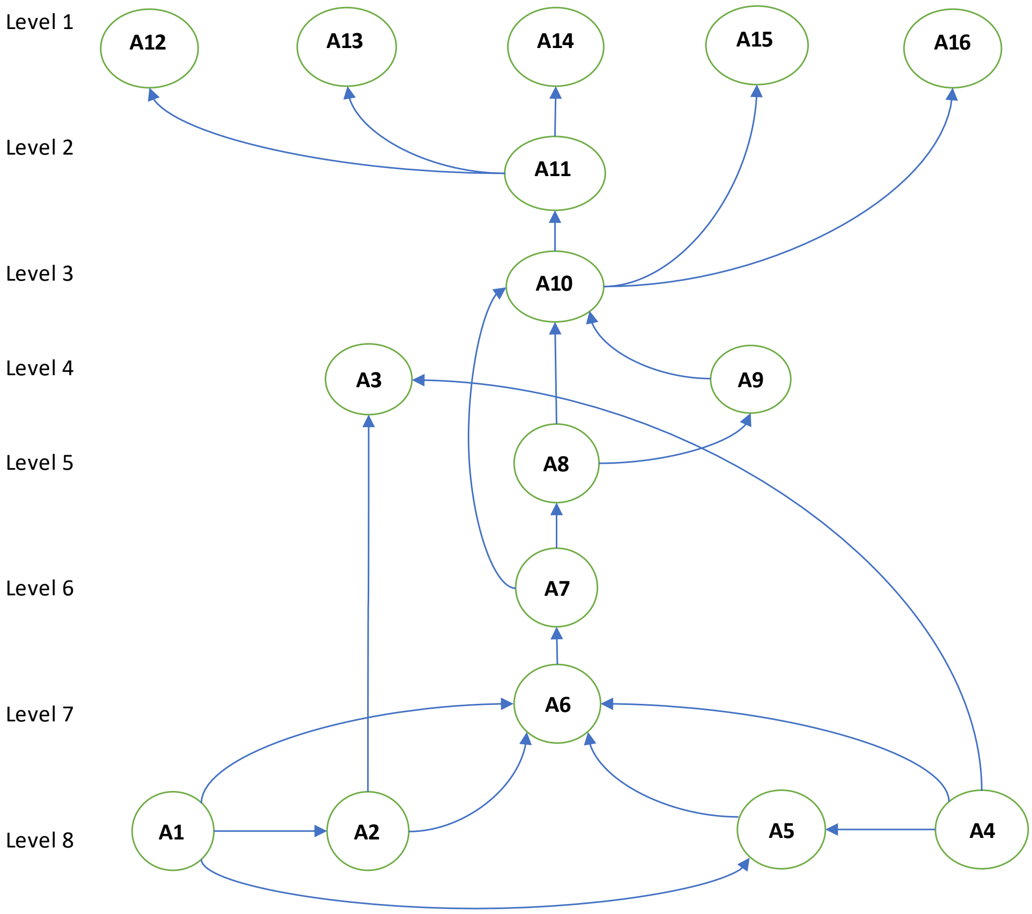

Figure 5. ISM Diagram – Completion Delay

Table 6 shows how strong the driving power and dependence level of each variable are in driving completion delays so that it can be used to know the characteristic of each factors. The root causes characteristic is the factor with the highest driving force and the lowest level of dependence.

Table 6. Final Reachibility Matrix

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	Driver Power	Dep
A1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	0	0	13	14
A2	1	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	11	3
A3	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	4	13
A4	1	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	11	1
A5	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	14	4
A6	1	0	1	0	0	1	1	1	1	1	0	1	1	1	0	0	13	8
A7	1	0	1	0	1	1	1	1	0	1	0	1	1	1	0	0	14	8
A8	0	0	1	0	0	0	0	1	1	0	0	1	1	1	0	1	7	10
A9	1	0	1	0	0	0	0	0	1	0	0	1	1	1	0	0	6	8
A10	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	13	7
A11	1	0	1	0	0	0	1	1	0	0	1	1	1	1	0	0	8	6
A12	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	4	14
A13	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	4	14
A14	1	1	1	0	0	0	0	1	0	0	0	1	1	1	0	0	7	14
A15	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	5	6
A16	1	0	1	0	0	0	0	0	0	0	0	1	1	1	0	1	6	9

Matrice d'Impacts croises-multiplication appliqúe an classment (MICMAC Analysis) is a way to study the power of different factors which means cross-impact matrix multiplication applied to classification (Attri & Dev, 2013). The goal of this analysis is to discover which factors are important and which ones depend on others. The MICMAC principle uses matrix multiplication to identify key factors in different categories. There are four categories: autonomous factors, linkage factors, dependent factors, and independent factors, as shown in Figure 6.

Some factors are called "autonomous" because they are not strongly connected to the system and have little influence on it. Other factors, called "linkage" factors, have a lot of influence on the system and are connected to many other factors. There are also "dependent" factors, which have little influence but are strongly affected by other factors, and "independent" factors, which have a lot of influence but aren't affected much by other factors. The most important factor, called the "key factor," is usually an independent or linkage factor. Figure 6 shows that Variable A2, A5, and A4 is located in independent quadrant with the characteristics of having high driving power and low dependence. Meanwhile variable A1 is in the linkage quadrant, with the characteristics of having high driving power and high dependence.

At the end of ISM analysis, comparing the result in Figure 5 that conclude variable A1, A2, A5, and A4 are the root causes of completion delay issues and Figure 6 that show those variables are key factors because located in independent and linkage quadrant.

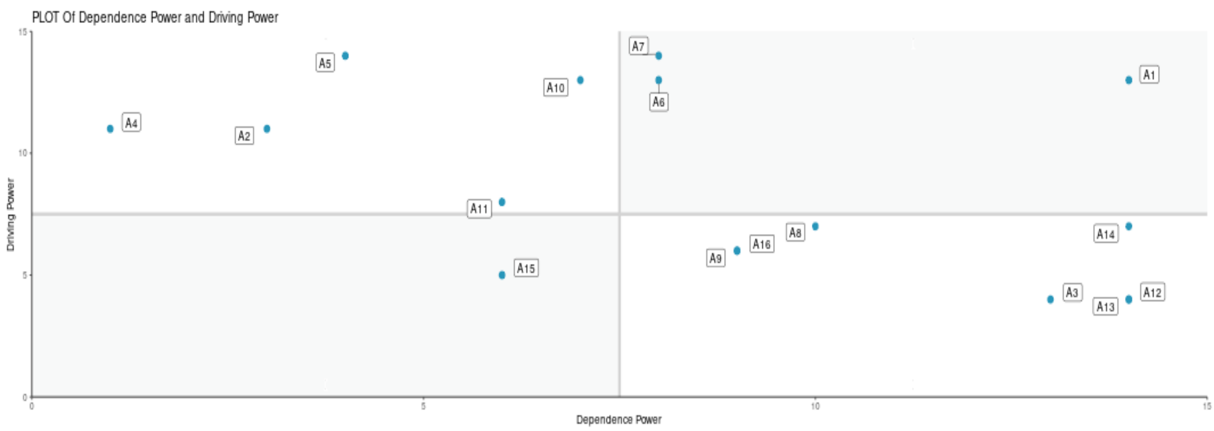

Figure 6. MICMAC Diagram – Completion Delay

Management Strategy

The basic step using TOC framework is identification of the constraint.(M. C. Gupta & Boyd, 2008) ISM analysis shows that financial aspect is one of the major constraints which represented by variable A1 and A2. Other constrains are the technical aspect namely A3 and A5 related to order change request (A3) and bad weather(A5). Based on TOC operational measure, financial constraint may influence the throughput and operating expense. The delayed delivery is a reflection of decreased throughput, and the higher operating expense may be caused by higher production costs, and penalties. The drawing changing request and bad weather related to higher operating expense and decreased throughput. Issue in throughput and operating cost will decrease net profit, ROI, and negative cashflow simultaneously.

The financial issue seldom discussed in production management. Few researchers in operations management have included financial factors in their inventory or production decisions. However, there is a lot of literature on inventory control, capacity expansion, and supply chain management. Most models for these decisions assume that the company can always finance its optimal production or inventory level without considering financial limitations. In reality, many companies face financial constraints and rely heavily on external capital. Debt is a common occurrence across all firms. (Xu & Birge, 2004).

The next step using TOC framework, management should exploit the financial and technical constrain. Overcome the financial constraint, management need to concern about the contract items related to payment terms, documents and procedures from the owner. The optimal scenario entails the presence of a substantial down payment and a multitude of payment options. Conversely, the absence of such provisions may result in the potential for project delays. Billing requirements and documents also important. Some contracts require a bank payment guarantee in the amount of the payment. The company need to prepare adequate non-cash loan facilities or counter guarantees.

The third step is subordination of other processes to the constraint. Usually the billing process done by marketing department and the document supported by finance department. The down payment collection began after signing the contract, but the progress term billing would be carried out after work progress pass the threshold. If the progress of work is late, then the billing process will also be late. Management needs to revise the target in accordance to billing milestone target. So that work target will be achieved, billing runs on time, and the risk of delays can be avoided. The delay in financing process is crucial. The company should ensure the facility and its consequences within tender period. Management must choose banking partners that responsive and fast credit process, especially in terms of project financing. Procurement strategy also can be used as alternatives to overcome the constraint by using certain timing and volume (Priya *et al.*, 2023).

The design change factor can be managed by extra work clause in contract. The consequences of extra work are extra charges and longer contract duration for the company. An agreement is needed with the owner at the beginning of the contract regarding the finalization of the design. Using the concurrent engineering process as described in **Figure 3** may avoid misalignment and shortening project completion times (Heizer *et al.*, 2019) The design process can be divided per production stage, and approval is requested from the owner in stages as well. So that the process of finalizing the design of each stage can be done more carefully. Phased agreements also provide room for both parties if any changes are needed.

The weather factor is one of the determining factors. So that during the tender, the company can choose order with enough duration to anticipate year-end weather. Work method modification is an option by can be done. Company can add the closed area to avoid the risk of heavy rain. Local weather forecasts may be advantages.

Weather events such as high waves, continuous rain, strong wind, also affect the delivery process and increase the risk for ship delivery. Companies can anticipate the delivery by using bulk cargo, or build ships in closer areas and sheltered from monsoons and year-end winds.

Further, the management may decide to elevate the constraint. However, elevating the constraint is not always necessary. It is a strategic decision in project management whether to do so or not (Ronen & Pass, 2008). The strategies should consider cost and benefit measurement. Each strategy will have traceable and hidden cost consequences.

The other interesting issue related to relationship mapping among variables in level 8, show that late payment from owner (A1) also can cause order changes during production (A5) Figure 5. This situation shows client's legitimation to push order changes, which leads to extra work and higher delay risk. As an external shareholders, client will generate risks related with financial ability, changing needs, claims, and possession of site (Ibrahim, 2015) Most cases, clients want the team to deliver the project as fast as possible because the longer it takes to implement, the longer their money sits idle without generating any returns. Unless, the projects start before client needs are fully defined. (Pinto, 2020). The management need to emphasize the project scope and scope management. The project scope everything about a project, includes all the work and results of a project. It lists all the tasks, resources used, and final products, including quality standards. Scope management is the way to control a project's goals from start to finish. It includes planning, defining, doing, and ending the project. It's the foundation for all project work and is the result of planning before starting the project.

Quality Cost Model

The quality cost model that will be used is the PAF model, with consideration of its simplicity. Prevention costs are related with the design, implementation, and maintenance of quality management system, or any action is taken to investigate, prevent, or reduce the risk of nonconformity or defect (Modhiya & Desai, 2016). Quality planning involves designing, implementing, and managing the quality system, auditing the course, supplier surveys, and process improvements.

Based on the PAF model, project delays are a form of failure that can be measured by Failure Cost, which needs to be prevented by Prevention Cost, and tested by Appraisal Cost. Payment delays categorized as internal failure costs, whose cost measurements involve traceable and hidden costs (Basak *et al.*, 2015), similar with bank process delay, bad weather, and design changes. Based on company strategy (S1, S2, S3, and S4) it is possible to determine quality costs and measurement.

Table 7 shows a PAF cost structure sample. Company strategy to ensure the owner's payment promptly (S1) will cost invoice and document preparation (PC11), bank guarantee preparation (PC12), and owner review (AC11), in order to avoid completion delay (FC00) and payment delay (FC11).

Table 7. PAF Model Proposed

No	Strategy	PAF Cost	Measurement
		Prevention Cost	
PC11	S1	Invoice and document preparation cost	Labor cost
PC12	S1	Bank guarantee preparation cost	Bank fee
PC21	S2	Document preparation for bank guarantee	Activity cost
PC22	S2	Standby loan provision cost	Bank fee
PC23	S2	Standby loan administration cost	Bank fee
PC41	S4	Re-arrange work process	Labor Cost
PC42	S4	Insurance for delivery	Insurance cost
PC43	S4	Faster shipping cost	Shipping cost
PC51	S5	Customer requirement review	Labor cost
PC52	S5	Design confirmation per phase	Activity cost
		Appraisal Cost	
AC11	S1	Invoice and document review cost	Review cost per document
AC21	S2	Bank review cost	Review cost per document
		Failure Cost	
FC00	S0	Project late fees	penalties
FC11	S1	Payment delay	Cost of fund per delay
FC21	S2	Bank cancellation/rejection	Process cost
FC41	S4	Extra delivery cost	Shipping cost
FC51	S5	Design re-drawing	Activity cost

According to Figure 2, in executing each strategy the management should concern about the optimum point that reflects the timely completion at minimum quality cost. It is an equal amount between the prevention plus appraisal cost, and failure cost. Using this equation, the management can make the decision in executing the strategy, related to its budget efficiently. The management can determine the failure cost first, before decide the effort.

Table 8 show an illustration of failure cost calculation, result Rp 154.520.547 that will be avoided. Figure 6 shows the estimated cost to avoid the failure, and stated as the budget limit to execute the prevention and appraisal strategy. Comparing Figure 5 and Figure 6, the management can decide to execute the strategy easily. This simple calculation can be done easily by management. The management can refresh the variable and or the assumptions used recently by company historical data or other technical tools. Further, PAF cost model components can be applied and used as performance indicator for related department.

Table 8. Failure Cost Estimation

Item	Amount
Contract value	Rp 12,000,000,000.
Payment invoiced	Rp 5.000.000.000
Late Penalties (1/$_{000}$ x days x contract value)	Rp 12,000,000 per late day
Cost of fund	12% p.a
Estimated payment delay	21 days
Estimated completion delay	10 days
Failure Cost Estimation	
Completion delay (FC00)	Rp 120.000.000 (10x12.000.000)
Payment delay (FC11)	Rp 34.520.547 (21/365x12%x5.000.000.000)
Estimated Failure Cost	Rp 154.520.547

Table 9. Prevention and Appraisal Cost Estimation

Item	Amount
Overtime for document preparation	Rp 1.000,000/day
Document preparation days	10 days
Overtime for bank guarantee preparation	Rp 500,000/day
Bank guarantee preparation days	5 days
Owner review	Rp 7.000.000/docs
Prevention and Appraisal Cost Estimation	
Invoice and document preparation (PC11)	Rp 10.000.000 (10x1.000.000)
Bank guarantee preparation cost	Rp 2.500.000 (5x500.000)
Invoice and document review cost	Rp 7.000.000
Estimated Prevention and Appraisal Cost	Rp 19.500.000

Conclusion

According to the finding of this research, the root cause of completion delays in company X caused by both financial and technical factors which are interrelated and described in Figure 5. Factor of late payment from client (A1) and delays in bank credit processing (A2) are financial related matters. Meanwhile bad weather (A4), and design changes by owners (A5) are technical related matters. Two of the root causes are related to financial aspects, may indicate financial problem symptoms. The phenomenon is relevant with the industry characteristic that need high capital investment (Hossain & Zakaria, 2017).

The management should re-evaluate the project feasibility and cashflow projection, then accept projects that feasible, positive cashflow, and or sufficient financing. Firms that have limited access to capital face higher costs when trying to secure external financing during capacity expansion periods. This leads to an increase in upward adjustment costs. When activity decreases, these firms may suffer a greater decrease in the present value of revenue generated by a marginal capacity. This is because they have higher opportunity costs of capital and therefore higher discount rates compared to firms with better access to capital (Rounaghi *et al.*, 2021).Without financial assurance, the completion delay risk will be higher, and the projected profit will be diminished.

The other finding is that the root caused are client related, internal related and environmental related factors. Factor of late payment from client (A1) and design changes by owners (A5) are client related and have causal relationship. Further it indicates critical issue of client relationship and company lower position against the client.

The equality among parties in the construction contract should be noticed As an external shareholders, client will generate risks related with financial ability, changing needs, claims, and possession of site (Ibrahim, 2015). The superiority of client may cause many design changes and on the other hand postponed the progress payment. This action may end to shipyard loss, or dispute. The management suggested to analyze the client characteristic more, and negotiate contract carefully. More payment thresholds will be helpful.

Theoretical Implication

This research contributes adding literature about delay completion causes in shipyard business, especially in medium scale shipyard. First, this research support prior researches about the causes (Abeysinghe & Jayathilaka, 2022; Assaf & Al-Hejji, 2006; Shahhossein *et al.*, 2017) which show that late payment from client, delays in bank credit processing, bad weather, and design changes by owners, are important factor in completion delay. Second, this research support prior research about TOC as a management tool that assumes that any controllable system is constrained by some constraints in achieving other of its goals (Jacobs & Chase, 2020; M. C. Gupta & Boyd, 2008; Simatupang *et al.*, 2004). Third, this research support that the process design and product design need to be done in parallel to shortening project completion time in shipbuilding (Heizer *et al.*, 2019).

Practical Implication

This research determined that financial factors and client related issues are important in causing delay in the shipbuilding process. The management can focus the attention and resources to avoid the delay then the completion delay issues solved by using five sequential steps for management improvement under TOC framework (Nave, 2002).

Beside this issue, the company may face other quality challenges, in which COQ approach as an strategic cost management, can help to make effective strategy to solve the issue. The process is started with problem identification, root cause analysis, strategy making, then execution. The focus to root cause cost related will ease the management to make decision, because evaluate every cost is time consuming and inefficient. Quality costs can focus on areas that have poor performance or need improvement.(Basak *et al.*, 2015).

Future Research

This research was conducted using a case study method, in which the data and discussions specific to single company. The conclusion related to problem and root cause may not be applied totally to other company, but the framework may be applicable. Future research can investigate other issue using TOC framework, combine TOC with other models to conduct root cause analysis, and the COQ model implementation in shipyard management.

References

Abellana, D. P. (2020). A proposed hybrid root cause analysis technique for quality management. *International Journal of Quality & Reliability Management*, *38*(3), 704–721. https://doi.org/10.1108/IJQRM-11-2019-0356

Abeysinghe, N., & Jayathilaka, R. (2022). Factors influencing the timely completion of construction projects in Sri Lanka. *PLOS ONE*, *17*(12), e0278318. https://doi.org/10.1371/journal.pone.0278318

Araújo-Rey, C., & Sebastián, M. A. (2021). An Approach to the Analysis of Causes of Delays in Industrial Construction Projects through Planning and Statistical Computing. *Sustainability*, *13*(7), 3975. https://doi.org/10.3390/su13073975

Assaf, S. A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management*, *24*(4), 349–357. https://doi.org/10.1016/j.ijproman.2005.11.010

Attri, R., & Dev, N. (2013). *Interpretive Structural Modelling (ISM) approach: An Overview.*

Basak, P. C., Viswanadhan, K. G., & Sailaja. (2015). Costs of Quality: Exploratory Analysis of Hidden Elements and Prioritization using Analytic Hierarchy Process. *International Journal* *of Supply and Operations Management*, *1*(4). http://www.ijsom.com/article_2338_d191eaa93a29b9e14288d8feb3a422d3.pdf

Basuki, M., Manfaat, D., Nugroho, S., & Dinariyana, A. (2012). IMPROVEMENT OF THE PROCESS OF NEW BUSINESS OF SHIP BUILDING INDUSTRY. *Journal of Economics, Business, and Accountancy | Ventura*, *15*(2), 187. https://doi.org/10.14414/jebav.v15i2.74

Bolaños, R., Fontela, E., Nenclares, A., & Pastor, P. (2005). Using interpretive structural modelling in strategic decision‐making groups. *Management Decision*, *43*(6), 877–895. https://doi.org/10.1108/00251740510603619

Bonner, S. E., Hesford, J. W., Van Der Stede, W. A., & Young, S. M. (2006). The most influential journals in academic accounting. *Accounting, Organizations and Society*, *31*(7), 663–685. https://doi.org/10.1016/j.aos.2005.06.003

Cardiel-Ortega, J. J., & Baeza-Serrato, R. (2023). Failure Mode and Effect Analysis with a Fuzzy Logic Approach. *Systems*, *11*(7), 348. https://doi.org/10.3390/systems11070348

E Oliveira, E., Miguéis, V. L., & Borges, J. L. (2023). Automatic root cause analysis in manufacturing: An overview & conceptualization. *Journal of Intelligent Manufacturing*, *34*(5), 2061–2078. https://doi.org/10.1007/s10845-022-01914-3

Eraslan, S., & Önal, S. (2021). Kalite Maliyetleri ve Bir Üretim İşletmesinde Uygulaması. *OPUS Uluslararası Toplum Araştırmaları Dergisi*, *17*(35), 1626–1643. https://doi.org/10.26466/opus.824779

Gazali, G. S., & Baroroh, I. (2022). Risk Analysis of the Causes of Delay in Ship Construction (Case Study of KM CL 9E Ship Construction). *BERKALA SAINSTEK*, *10*(4), 235. https://doi.org/10.19184/bst.v10i4.32674

Ghunaim, N. M., & Jaaron, A. A. M. (2021). The Influence of Cost of Quality on the Performance of Food Manufacturing Companies: An Empirical Study. *The TQM Journal*, *34*(4), 788–806. https://doi.org/10.1108/TQM-01-2021-0026

Gupta, M. C., & Boyd, L. H. (2008). Theory of constraints: A theory for operations management. *International Journal of Operations & Production Management*, *28*(10), 991–1012. https://doi.org/10.1108/01443570810903122

Gupta, M., Ko, H.-J., & Min, H. (2002). TOC-based performance measures and five focusing steps in a job-shop manufacturing environment. *International Journal of Production Research*, *40*(4), 907–930. https://doi.org/10.1080/00207540110097185

Hansen, D. R., & Mowen, M. (2018). *Cornerstones of cost management* (Fourth edition). Cengage Learning.

Harlan, F. B., & Resda, D. P. (2019). Mitigation of Delay Risk in Ship Construction Project With Lean Approach. *Advances in Social Science, Education and Humanities Research*, *377*.

Heizer, J., Render, B., & Munson, C. (2019). *Operations Management* (13th ed). Pearson Education Canada.

Hossain, K. A., & Zakaria, N. M. G. (2017). A Study on Global Shipbuilding Growth, Trend and Future Forecast. *Procedia Engineering*, *194*, 247–253. https://doi.org/10.1016/j.proeng.2017.08.142

Huff, D. S., & Lynaugh, K. M. (2001). Utilization of Root Cause Failure Analysis in the Investigation of Marine Deck Fitting Failures. *Naval Engineers Journal*, *113*(1), 93–100. https://doi.org/10.1111/j.1559-3584.2001.tb00015.x

Ibrahim, H. (2015). *Risk analysis for mega commercial projects* [American University in Cairo (AUC)]. https://fount.aucegypt.edu/etds/1218?utm_source=fount.aucegypt.edu%2Fetds%2F1218&utm_medium=PDF&utm_campaign=PDFCoverPages

Jacobs, F. R., & Chase, R. (2020). *Operations and Supply Chain Management* (16th ed.). McGraw-Hill Education.

Jafari, A., & Rodchua, S. (2014). Survey research on quality costs and problems in the construction environment. *Total Quality Management & Business Excellence*, *25*(3–4), 222–234. https://doi.org/10.1080/14783363.2013.824715

Ketokivi, M., & Choi, T. (2014). Renaissance of case research as a scientific method. *Journal of Operations Management*, *32*(5), 232–240. https://doi.org/10.1016/j.jom.2014.03.004

McDermott, R. E., Mikulak, R. J., & Beauregard, M. R. (2009). *The basics of FMEA* (2nd ed). Productivity Press.

Melendez, J. R., ZOGHBE Nuñez, Y. A., MALVACIAS Escalona, A. M., ALMEIDA, G. A., & LAYANA Ruiz, J. (2018). Theory of Constraints: A systematic review from the management context. *Revista Espacious*, *39*. https://www.revistaespacios.com/a18v39n48/a18v39n48p01.pdf

Mello, M. H., Strandhagen, J. O., & Alfnes, E. (2015). The role of coordination in avoiding project delays in an engineer-to-order supply chain. *Journal of Manufacturing Technology Management*, *26*(3), 429–454. https://doi.org/10.1108/JMTM-03-2013-0021

Modhiya, S., & Desai, D. (2016). A Review on Cost of Quality Methodology and Hidden Costs in Manufacturing Industries. *REST Journal on Emerging Trends in Modelling and Manufacturing*, *2*(4).

Nave, D. (2002). How To Compare Six Sigma, Lean and the Theory of Constraints A framework for choosing what's best for your organization. *QUALITY PROGRESS*. https://nzbef.org.nz/wp-content/uploads/2019/05/Guide-How-To-Compare-Six-Sigma-Lean-and-TOC.pdf

Olalere, T. (2011). Methodology in Accounting Research: A Critique of Taxonomy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1921192

Orouji, M. (2016). Theory of constraints: A state-of-art review. *Accounting*, 45–52. https://doi.org/10.5267/j.ac.2015.12.004

Pinto, J. K. (2020). *Project management: Achieving competitive advantage* (Fifth edition, global edition). Pearson.

Prihandono, M. (2017). *ANALISIS RISIKO PADA PEMBANGUNAN KAPAL (STUDI KASUS PADA PEMBANGUNAN KAPAL TANKER PERTAMINA 3500 DWT DI PT DUMAS TANJUNG PERAK SHIPYARDS* [Institut Sepuluh November]. https://repository.its.ac.id/46587/1/9114201504-Master_Theses.pdf

Priya, B., Biswas, I., Thürer, M., & Avittathur, B. (2023). How to finance the supply chain when you are small? Clearance sale and loan payment timing in financially constrained supply chains. *International Journal of Production Economics*, *263*, 108934. https://doi.org/10.1016/j.ijpe.2023.108934

Ronen, B., & Pass, S. (2008). *Focused operations management: Achieving more with existing resources*. Wiley.

Rounaghi, M. M., Jarrar, H., & Dana, L.-P. (2021). Implementation of strategic cost management in manufacturing companies: Overcoming costs stickiness and increasing corporate sustainability. *Future Business Journal*, *7*(1), 31. https://doi.org/10.1186/s43093-021-00079-4

Saha, R. (2022). Quantitative and Qualitative Approaches to Accounting Research. *International Journal of Multidisciplinary Research & Reviews*, *1*(2), 1–6. https://doi.org/10.56815/IJMRR.V1.I2.2022/1-6

Santhoshn, S., & Melwynrego, A. (n.d.). Evaluation of defect correlations with quality, delivery and cost. *International Journal of Mechanical and Materials Engineering*, 2018.

Schiffauerova, A., & Thompson, V. (2006). A review of research on cost of quality models and best practices. *International Journal of Quality & Reliability Management*, *23*(6), 647–669. https://doi.org/10.1108/02656710610672470

Schroeder, R., Rungtusanatham, M. J., & Goldstein, S. (2021). *Operations Management in the Supply Chain, Decision and Case* (8th ed.). McGraw-Hill Education.

Shahhossein, V., Afshar, M. R., & Amiri, O. (2017). The Root Causes of Construction Project Failure. *Scientia Iranica*, *0*(0), 0–0. https://doi.org/10.24200/sci.2017.4178

Shrivas, A., & Singla, H. K. (2022). Analysis of interaction among the factors affecting delay in construction projects using interpretive structural modelling approach. *International Journal of Construction Management*, *22*(8), 1455–1463. https://doi.org/10.1080/15623599.2020.1728486

Simatupang, T. M., Wright, A. C., & Sridharan, R. (2004). Applying the theory of constraints to supply chain collaboration. *Supply Chain Management: An International Journal*, *9*(1), 57–70. https://doi.org/10.1108/13598540410517584

Stopka, O., Zitrický, V., Ľupták, V., & Stopková, M. (2023). Application of specific tools of the Theory of Constraints – a case study. *Cognitive Sustainability*, *2*(1). https://doi.org/10.55343/cogsust.48

Sunindijo, R. Y., Hadikusumo, B. H. W., & Phangchunun, T. (2014). Modelling service quality in the construction industry. *International Journal of Business Performance Management*, *15*(3), 262. https://doi.org/10.1504/IJBPM.2014.063026

Tambunan, T. (2022). A conceptual framework of quality cost chain in strategic cost management. *The TQM Journal*. https://doi.org/10.1108/TQM-09-2021-0281

Wu, Z., Liu, W., & Nie, W. (2021). Literature review and prospect of the development and application of FMEA in manufacturing industry. *The International Journal of Advanced Manufacturing Technology*, *112*(5–6), 1409–1436. https://doi.org/10.1007/s00170-020-06425-0

Xu, X., & Birge, J. R. (2004). Operational Decisions, Capital Structure, and Managerial Compensation: A News Vendor Perspective. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.652564

Appendix 1. Questionnaire A

Questionnaire A
Completion Delay

Dear Sir/Madam,
As part of my research about Completion Delay Causes in your company, please give your opinion regarding the relationship between factors as listed below. The following questions will be used for analytical use only and your answer will be confidential.
Put a check mark (√) to the relationship that most suitable according your knowledge and experience in column V, A, X, or O. **Assessment only given once per row**.
V = Factor A causes factor B
A = Factor B causes factor A
X = Factor A causes factor B and Factor B causes factor A
O = Factor A and factor B are not related each other

No		Factor A	Relationship type				Factor B	
			V	A	X	O		
1	A1	Late payment from Owner					Late Project Financing	A2
2	A1	Late payment from Owner					Low labor productivity	A3
3	A1	Late payment from Owner					Bad weather	A4
4	A1	Late payment from Owner					Order changes during production	A5
5	A1	Late payment from Owner					Material delay	A6
6	A1	Late payment from Owner					Wrong material estimation	A7
7	A1	Late payment from Owner					Insufficient cash flow	A8
8	A1	Late payment from Owner					Late payment to supplier	A9
9	A1	Late payment from Owner					Lack of planning	A10
10	A1	Late payment from Owner					Lack of control	A11
11	A1	Late payment from Owner					Bad relationship with client	A12
12	A1	Late payment from Owner					Bad relationship with surveyor	A13
13	A1	Late payment from Owner					Work progress has not been achieved	A14
14	A1	Late payment from Owner					Long custom clearance process	A15
15	A1	Late payment from Owner					Insufficient labor	A16
16	A2	Late Project Financing					Low labor productivity	A3
17	A2	Late Project Financing					Bad weather	A4
18	A2	Late Project Financing					Order changes during production	A5
19	A2	Late Project Financing					Material delay	A6
20	A2	Late Project Financing					Wrong material estimation	A7
21	A2	Late Project Financing					Insufficient cash flow	A8
22	A2	Late Project Financing					Late payment to supplier	A9
23	A2	Late Project Financing					Lack of planning	A10
24	A2	Late Project Financing					Lack of control	A11
25	A2	Late Project Financing					Bad relationship with client	A12
26	A2	Late Project Financing					Bad relationship with surveyor	A13
27	A2	Late Project Financing					Work progress has not been achieved	A14
28	A2	Late Project Financing					Long custom clearance process	A15
29	A2	Late Project Financing					Insufficient labor	A16
30	A3	Low labor productivity					Bad weather	A4
31	A3	Low labor productivity					Order changes during production	A5
32	A3	Low labor productivity					Material delay	A6
33	A3	Low labor productivity					Wrong material estimation	A7
34	A3	Low labor productivity					Insufficient cash flow	A8
35	A3	Low labor productivity					Late payment to supplier	A9

36	A3	Low labor productivity	Lack of planning	A10
37	A3	Low labor productivity	Lack of control	A11
38	A3	Low labor productivity	Bad relationship with client	A12
39	A3	Low labor productivity	Bad relationship with surveyor	A13
40	A3	Low labor productivity	Work progress has not been achieved	A14
41	A3	Low labor productivity	Long custom clearance process	A15
42	A3	Low labor productivity	Insufficient labor	A16
43	A4	Bad weather	Order changes during production	A5
44	A4	Bad weather	Material delay	A6
45	A4	Bad weather	Wrong material estimation	A7
46	A4	Bad weather	Insufficient cash flow	A8
47	A4	Bad weather	Late payment to supplier	A9
48	A4	Bad weather	Lack of planning	A10
49	A4	Bad weather	Lack of control	A11
50	A4	Bad weather	Bad relationship with client	A12
51	A4	Bad weather	Bad relationship with surveyor	A13
52	A4	Bad weather	Work progress has not been achieved	A14
53	A4	Bad weather	Long custom clearance process	A15
54	A4	Bad weather	Insufficient labor	A16
55	A5	Order changes during production	Material delay	A6
56	A5	Order changes during production	Wrong material estimation	A7
57	A5	Order changes during production	Insufficient cash flow	A8
58	A5	Order changes during production	Late payment to supplier	A9
59	A5	Order changes during production	Lack of planning	A10
60	A5	Order changes during production	Lack of control	A11
61	A5	Order changes during production	Bad relationship with client	A12
62	A5	Order changes during production	Bad relationship with surveyor	A13
63	A5	Order changes during production	Work progress has not been achieved	A14
64	A5	Order changes during production	Long custom clearance process	A15
65	A5	Order changes during production	Insufficient labor	A16
66	A6	Material delay	Wrong material estimation	A7
67	A6	Material delay	Insufficient cash flow	A8
68	A6	Material delay	Late payment to supplier	A9
69	A6	Material delay	Lack of planning	A10
70	A6	Material delay	Lack of control	A11
71	A6	Material delay	Bad relationship with client	A12
72	A6	Material delay	Bad relationship with surveyor	A13
73	A6	Material delay	Work progress has not been achieved	A14
74	A6	Material delay	Long custom clearance process	A15
75	A6	Material delay	Insufficient labor	A16
76	A7	Wrong material estimation	Insufficient cash flow	A8
77	A7	Wrong material estimation	Late payment to supplier	A9
78	A7	Wrong material estimation	Lack of planning	A10
79	A7	Wrong material estimation	Lack of control	A11
80	A7	Wrong material estimation	Bad relationship with client	A12
81	A7	Wrong material estimation	Bad relationship with surveyor	A13
82	A7	Wrong material estimation	Work progress has not been achieved	A14
83	A7	Wrong material estimation	Long custom clearance process	A15
84	A7	Wrong material estimation	Insufficient labor	A16
85	A8	Insufficient cash flow	Late payment to supplier	A9
86	A8	Insufficient cash flow	Lack of planning	A10
87	A8	Insufficient cash flow	Lack of control	A11
88	A8	Insufficient cash flow	Bad relationship with client	A12
89	A8	Insufficient cash flow	Bad relationship with surveyor	A13

90	A8	Insufficient cash flow	Work progress has not been achieved	A14
91	A8	Insufficient cash flow	Long custom clearance process	A15
92	A8	Insufficient cash flow	Insufficient labor	A16
93	A9	Late payment to supplier	Lack of planning	A10
94	A9	Late payment to supplier	Lack of control	A11
95	A9	Late payment to supplier	Bad relationship with client	A12
96	A9	Late payment to supplier	Bad relationship with surveyor	A13
97	A9	Late payment to supplier	Work progress has not been achieved	A14
98	A9	Late payment to supplier	Long custom clearance process	A15
99	A9	Late payment to supplier	Insufficient labor	A16
100	A10	Lack of planning	Lack of control	A11
101	A10	Lack of planning	Bad relationship with client	A12
102	A10	Lack of planning	Bad relationship with surveyor	A13
103	A10	Lack of planning	Work progress has not been achieved	A14
104	A10	Lack of planning	Long custom clearance process	A15
105	A10	Lack of planning	Insufficient labor	A16
106	A11	Lack of control	Bad relationship with client	A12
107	A11	Lack of control	Bad relationship with surveyor	A13
108	A11	Lack of control	Work progress has not been achieved	A14
109	A11	Lack of control	Long custom clearance process	A15
110	A11	Lack of control	Insufficient labor	A16
111	A12	Bad relationship with client	Bad relationship with surveyor	A13
112	A12	Bad relationship with client	Work progress has not been achieved	A14
113	A12	Bad relationship with client	Long custom clearance process	A15
114	A12	Bad relationship with client	Insufficient labor	A16
115	A13	Bad relationship with surveyor	Work progress has not been achieved	A14
116	A13	Bad relationship with surveyor	Long custom clearance process	A15
117	A13	Bad relationship with surveyor	Insufficient labor	A16
118	A14	Work progress has not been achieved	Long custom clearance process	A15
119	A14	Work progress has not been achieved	Insufficient labor	A16
120	A15	Long custom clearance process	Insufficient labor	A16

End of the Questionnaire