

## Causal Loop Diagram Model of the Owner's Critical Role in the Success of Port Infrastructure Design-Build Projects

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### ABSTRACT

<b>Keywords:</b> Design-Build; Owner Role; Causal Loop Diagram; Port Infrastructure.	The research is expected to provide in-depth insight into how the role of the project owner affects the success of port infrastructure projects using a design-build approach, as well as provide a basis for increased efficiency and effectiveness in the implementation of the project. This research proposes a causal loop diagram model to provide an overview of the influence of the Owner's role in achieving the cost, time, and quality success of the Port Infrastructure Design-Build project. Research variables are obtained through in-depth literature studies and interviews with project owners and project practitioners experienced in design-build projects. Based on the literature study in this study, it has been formulated that the critical role of the owner is an essential factor of the owner in carrying out the project to achieve the goals that have been set.
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### Introduction

Design-Build (DB) project is a method of implementing construction projects where the work's executor is responsible for designing and building the project. In this method, the project owner deals with only one contractor or team responsible for the entire process, from planning to execution (Ling & Leong, 2002)

In the context of projects in general, a project owner (owner) can be defined as an organization or individual who owns a project and assigns tasks or works to other parties to complete and provides feedback for the completion of the work. The project owner is responsible for building the project and guaranteeing it will create significant organizational changes (Andersen, 2012).

Project success is defined as achieving predefined project objectives, such as time, cost, and quality, and delivering the desired business benefits (Alienta et al., 2023). The increasing popularity of Design-Build requires parties in the construction industry to understand each party's roles and responsibilities better to achieve project success (HUSIN, 2015). As the party initiating the project, the project owner is vital in determining the project objectives, needs, and expectations the Contractor must meet (Karyadinata, 2019). The owner is responsible for strategic decision-making, including DB contractor selection, budgeting, and risk management. The owner is vital in establishing cooperation with DB contractors; both parties interact and communicate

when designing and implementing the project. The owner is responsible for monitoring and supervising the project to ensure that the project runs according to the plan, budget, and schedule set (Zakiyya & Purnama, 2022).

Understanding the owner's role in managing a DB project can provide valuable insight into the factors that influence project success and help you gain a more comprehensive understanding of the owner's role at all stages of DB project completion. This research helps the project owner make better decisions to improve the owner's role and the future design-build project's success (Belferik et al., 2023).

This research focuses on the role of project owners in the success of Port infrastructure DB projects. With the increasing popularity of Design-Build, a deep understanding of the roles and responsibilities of each stakeholder has become crucial. This study aims to propose a Causal Loop Diagram model to illustrate the role of the project owner in achieving project success.

## **Research Methods**

The roles and responsibilities of the Owner in this study are based on the results of a literature study related to the vital role of the owner in Critical success factors that affect the success of the DB project and the role of the Owner in resolving the main obstacles to the implementation of the Design-Build project. A literature study or review allows one to define variables relevant to the research and how those predetermined variables are related.

Based on the results of an in-depth literature study of previous research, it is known that essential owner factors significantly affect the success of the Design-Build project. These findings were confirmed through interviews with experienced resource persons in Port infrastructure design-build projects. It concluded the critical success factors of Port infrastructure DB projects as owner role variables.

Semi-structured interviews are conducted with project owners and practitioners experienced in project management Design-Build. This semi-structured interview aims to gather information and perspectives from experts in the field, which can provide additional insight into the relevant variables and factors that influence project success. In addition, these interviews are also helpful in identifying variables that may not have been revealed in the literature study.

The data obtained from both sources is then collected into variables that are used to conceptualize the design of the Causal Loop Diagram model. This approach ensures that the variables cover aspects relevant to the owner's role in the Design-Build project and reflect current thinking.

Design conceptualization is done by creating a causal loop diagram (CLD) to show causal relationships and relationships between variables to represent the identified system. CLD will show how the relationship between these variables works to form a system that can describe the relationship between owner role variables that affect the project's success in the Design-Build project.

Causal loop diagrams help visualize how various variables in a system are related to each other causally. This diagram contains words and arrows (Ogunlana et al., 2003). Various relationships between variables forming the system will be seen at this stage. Each relevant variable will be connected with an arrow. The arrow's tail indicates causality/causation, and the arrow's tip or head indicates the effect/impact. Arrows connecting variables on their tails will be positive (+) to the variable in the direction of their head and negative (-) if vice versa.

## Results and Discussion

This research focuses on the role of project owners in the success of Design-Build projects, particularly in the context of Port infrastructure. This study aims to provide an overview of system conceptualization through a causal loop diagram model that can illustrate the role of the project owner in achieving the success of the Port infrastructure design-build project.

Research variables were identified through in-depth literature studies and interviews with project owners who have experience implementing Port infrastructure Design-Build projects. After collecting data from both sources, the variables obtained were used to conceptualize the Causal Loop Diagram model design based on cost, time, and quality success.

The success indicator of the Design-Build project in terms of cost is the conformity of the actual cost of the project with the planned budget (Lee, Jallan, & Ashuri, 2020). Owner role variables that affect cost success are related to scope. The owner needs to understand thoroughly the needs and scope of the project and have the ability to clearly define the scope and objectives of the project (Gransberg & Molenaar, 2019) and have similar project experience. Another owner's role in cost success is setting accurate project cost estimates (Songer & Molenaar, 1997; Zulch & Kitshoff, 2021). In the contractor selection phase, the owner needs to run a fair tender system (Hoseingholi & Jalal, 2017), allow sufficient time to study and prepare offers (Ginsberg & Molenaar, 2019), and compile comprehensive contract management. In the implementation phase of DB work, the owner needs to have good project management skills and minimize the occurrence of change orders. The variable role of the owner as a determining factor for cost success can be seen in Table 1.

**Table 1**  
**Variable Owner Role in Cost Success**

No	Owner's Role	Variable
1	Thorough understanding of the needs and scope of the project	<i>Understanding of project needs and scope</i>
2	Have the ability to define the scope of the project precisely	<i>Define the Project Scope</i>
3	Have experience with similar projects	<i>Owner Experience</i>
4	Accurately estimate project costs	<i>Accurate cost estimates</i>
5	Have good project management skills	<i>Owner Competencies</i>

No	Owner's Role	Variable
6	Running a fair tender system	<i>Fair tender system</i>
7	Allow enough time to study and prepare the offer	<i>Allocating Time to Prepare the Proposal</i>
8	Develop comprehensive contract management	<i>Comprehensive Contract Management</i>
9	Minimize the occurrence of change orders	<i>Change order management</i>

An indicator of the success of the Design-Build project in the aspect of time is the suitability of the implementation time with the planned duration (Lee et al., 2020). In time success, the critical role of the owner in the initial phase is to set the implementation schedule and duration of work accurately, ensuring land readiness (Kehinde & Atanda, 2022) and complete formal Licensing management from authorized agencies (Abotaleb et al., 2019) and have a particular organization as Project Management Office. Meanwhile, in the implementation phase, the critical role of the owner is to have good project management skills, have similar project experience, able to evaluate and assign design details according to scope with efficient time, implement effective approval mechanisms to evaluate and establish scope-appropriate design details; provide intense attention and input in the detailed design process; solve problems and respond quickly to eliminate project problems (Lee et al., 2020); implement good risk management; implementing an effective K3L program (Kehinde & Atanda, 2022); implement effective monitoring of contractor performance; implement suitable payment mechanisms and adequate funding during the project, establish communication and good coordination among stakeholders and minimize the occurrence of change orders. The variable role of the owner as a determining factor for time success can be seen in Table 2.

**Table 2**  
**Owner Role Variables on Time Success**

No	Owner's Role	Variable
1	Establish the execution schedule and duration of work accurately	<i>Accurate time estimates</i>
2	Have good project management skills	<i>Owner Competencies</i>
3	Have experience with similar projects	<i>Owner Experience</i>
4	Able to evaluate and determine design details according to the scope with efficient time	<i>Approve design details</i>
5	Implement effective approval mechanisms to evaluate and establish scope-appropriate design details.	<i>Approval mechanisms</i>
6	Provide intense attention and input in the detailed design process	<i>Attention and input</i>
7	Solve problems and respond quickly to eliminate project problems	<i>Project issue Response</i>

No	Owner's Role	Variable
8	Implement good risk management	<i>Risk management</i>
9	Ensuring land readiness	<i>Appropriate Site</i>
10	Complete formal licensing arrangements from authorised agencies	<i>Project Permit</i>
11	Establish good coordination among stakeholders	<i>Stakeholder Management</i>
12	Implement an effective K3L program	<i>HSE program</i>
13	Implement effective monitoring of contractor performance	<i>Project monitoring</i>
14	Implement suitable payment mechanisms and adequate funding during the project.	<i>Adequate Funding</i>
15	Have a dedicated organization as a Project Management Office	<i>Project Management Office</i>
16	Establish good communication with related parties	<i>Communication</i>
17	Minimize the occurrence of change orders	<i>Change orders management</i>

Indicators of the success of the Design-Build project in the quality aspect are the conformity of the quality of work with the expectations and conditions that have been required. This is influenced by the role of the owner, namely, the owner has a particular organization as a Project Management Office, ensuring the project uses the suitable material; has a clear understanding of the technical functions of the materials used; implements effective consent mechanisms; implement an effective quality control system, (Kehinde & Atanda, 2022); have a clear understanding of the functional and technical performance of project outputs; ensuring projects are implemented with appropriate methods; implement risk management and implement an effective K3L program (Kehinde & Atanda, 2022) on the methods used and ensure contractors have carried out the necessary repairs (Lee et al., 2020) before the handover of work results. The variable role of the owner as a determining factor for quality success can be seen in Table 3.

**Table 3**  
**Variable Role of Owner in Quality Success**

No	Owner's Role	Variable
1	Ensure the project uses suitable materials	<i>Appropriate materials</i>
2	Have a clear understanding of the technical function of the material used	<i>Technical materials</i>
3	Implement effective consent mechanisms	<i>Approval mechanisms</i>
4	Implement an effective quality control system	<i>Quality Control</i>

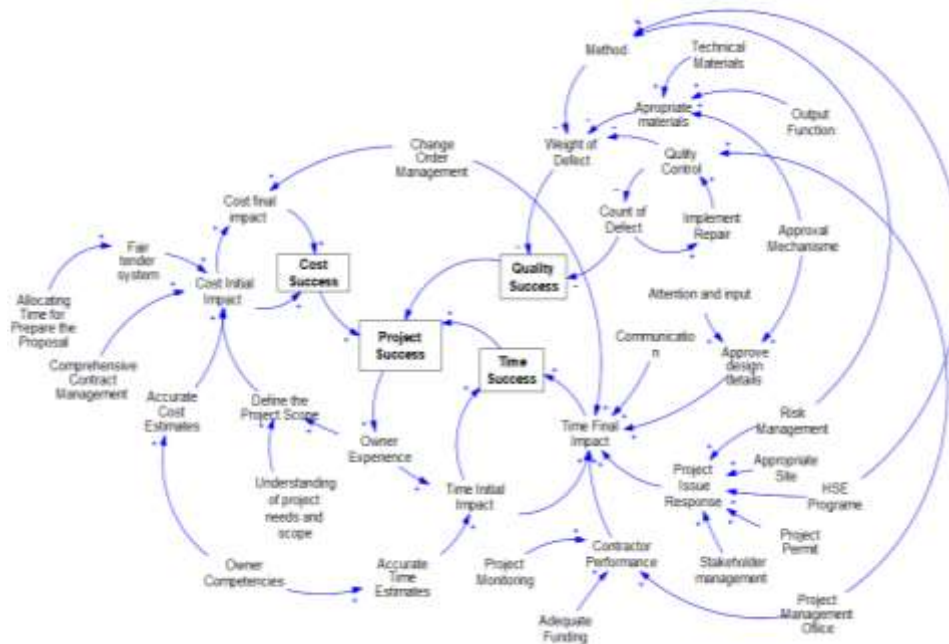
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No	Owner's Role	Variable
5	Have a dedicated organization as a Project Management Office	<i>Project Management Office</i>
6	Ensure that the contractor has implemented the necessary repairs	<i>Implement Repair</i>
7	Have a clear understanding of the functional and technical performance of project outputs.	<i>Output Function</i>
8	Ensure projects are executed in appropriate methods	<i>Method</i>
9	Apply an effective K3L program to the method used	<i>HSE program</i>
10	Apply good risk management to the methods used	<i>Risk management</i>

The conceptual model describes the interaction between variables and sub-variables obtained from the results of literature reviews and interviews with experts. Model conceptualization includes causal loop diagrams to identify variables and sub-variables that interact and affect each other in the system.

Design conceptualization is carried out to show causal relationships and relationships between variables to represent the identified system. CLD will show how the relationship between these variables works to form a system that can describe the relationship between owner role variables that affect the project's success in the Port infrastructure Design-Build project.

Each relevant variable will be connected with an arrow. The arrow's tail indicates causality/causation, and the arrow's tip or head indicates the effect/impact. Arrows connecting variables on their tails will be positive (+) to the variable in the direction of their head and negative (-) if vice versa. Figure 1 conceptualizes the CLD model using variables from literature studies and interviews verified by experts. Verification of the model is carried out by confirming the model's construction so that the model's structure can approach the accurate picture of natural conditions.



**Figure 1 Causal Loop Model Conceptualization Owner Role Diagram**

The causal loop diagram in Figure 1 shows the relationship between owner role variables and the success of the Port infrastructure design-build project. The model is formed from 3 (three) main sub-models, namely cost success, time success, and quality success.

Cost success is influenced by the variable role of the owner in planning the initial project budget (cost initial impact) and final project cost (cost final impact). In the Port Infrastructure Design-Build project, the project's final cost is influenced by the owner's role in managing changes in the contract (change order management) during the execution of the work. The owner's role in the initial budget preparation process includes accurately setting cost budget estimates and appropriately defining the project scope. Meanwhile, the owner's role in carrying out a fair tender mechanism and comprehensive contract management influences the initial price.

The owner's role variables influence time success in determining the initial duration of work (time initial impact) and the duration of the end of work (time final impact). The owner's role influences the determination of the initial duration of the project in setting the implementation time accurately and having a similar project experience. The final duration of the project is influenced by the owner's role in carrying out change order management, effective communication, determination of design details according to the scope with efficient time, and the ability of the owner to respond quickly to eliminate project problems. It is influenced by the performance of contractors monitored through effective monitoring mechanisms.

Based on the success aspect of the quality of the work, the Port infrastructure Design-Build project is influenced by the level of defect (weight of defect) that occurs during the work and the number of occurrences of each level of defect (count of defect).

The owner's role influences the weight of defects in ensuring the use of appropriate materials, implementing appropriate methods, and applying a sound quality control system. Meanwhile, the number of defects is influenced by the owner's role in carrying out quality control and ensuring that the contractor has carried out repairs to defects that occur.

## **Conclusion**

Based on the literature study in this study, it has been formulated that the critical role of the owner is an essential factor of the owner in carrying out the project to achieve the goals that have been set. The achievement of this goal is interpreted as the conformity of actual costs with budget calculations, the suitability of implementation time with the planned duration, and the suitability of the quality of work results with the expectations and conditions that have been required.

The success of a Design-Build project and the owner's role factors that influence it are dynamic reciprocal relationships in the phases of the project life cycle. In this study, the Causal Loop Diagram model was used to model the dynamic and complex relationship between the variables of the owner role and the success of the Port Infrastructure Design-Build project. Conceptualizing the Causal Loop Diagram model will help the owner of the Design-Build project improve the ability to manage the project effectively and efficiently so that the owner can ensure that the Design-Build project implemented will run smoothly and achieve the expected goals. This will ultimately positively impact the owner's reputation and credibility and open up opportunities for success for new and more complex projects. This model can be developed as a basic concept for building a dynamic system simulation model that can be used to ensure that the managerial strategies applied and decisions made are aligned with the project objectives, thus creating a work process that is supportive of the achievement of the overall success of the Design-Build project.



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