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Supply chain performance analysis on modular construction shipbuilding

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Abstract. The Implementation of modular construction shipbuilding aims to accelerate ship production so that delivery time can be shortened. However, in its implementation, delay for completing and delivery the ship can still be found. The delay in delivery is influenced by the supply chain performance of the shipyard due to delays in design, material, and financial payments. This delay occurred due to the large number of sub-module and module construction works carried out in parallel. The works include hull construction, painting, outfitting and installation of equipments. This study aims to analyze the performance of the supply chain in shipyard that implementing modular construction system. In the initial stage, the study is conducted by defining the factors and parameters that affect supply chain performance in shipbuilding and determining factors that have the potential to cause delivery delays. The conceptual and technical approach is carried out by analyzing the causal relationship of the factors that have identified in the previous stage. Dominant factors that cause delays that occur in ship building are expected to find and observe using system dynamics approach. *Keywords:* *Supply chain performance, Modular construction, System dynamic.*

1. Introduction

According report from the (INSA) Association of Indonesian National Ship Owners determine the growth of Indonesian-flagged vessels in 2018 to reach 152 unions, up 1.68 % from the previous. Of that number, 19 units of tankers, tanker growth reached 3.42%. Small tankers 10,000 DWT increased 7 units while large tankers increased 12 units resulting in positive national shipyard growth.

Currently, in PT X Indonesia was accelerating production with modular system method to requested the (SSV)strategic sealift vessel by Philippines and KCR-60M (Indonesia – Navy). The construction of modular system method has two years from normal time (6 years), so that production effectively 4 years. Modular system method was implement concept from Product Oriented Work Breakdown (PWBS). Structure of PWBS uses the Full Outfitting Block System (FOBS) by PT.X Indonesia, but still needs some resistance in the shipyard, for example; The material is not ready to install, budget revision, lateness of material, lateness and revision of design.

This problem to handle to supply chain department, engineering department and financial planning department. Product-Oriented Work Breakdown Structure (PWBS) has been applied to large-type ships and series ships built in parallel, where the components are made massively, production is faster and more efficient. PT. X Indonesia has prepared ship construction with a modular system in



accordance with its technological readiness field [1]. Modulazation of ship is an implementation of the Product-Oriented Work Breakdown Structure concept, dividing to the production system of ships into a single integration system that is standard or equal (replacing each other) and a system combined with other systems complement each other. Modular systems lead to standardization applied to large type ships and series ships built in parallel, the components of which are mass produced, fast, efficient and massively.

Concluded that the concept of shipbuilding has shifted away from traditional method where ships were constructed on a slipway: modular construction has proved to be the most cost effective way to deliver modern warship. Integrated of modules means that only one major site is needed to assemble the various parts of the ship that been constructed elsewhere. This trends toward building a ship using mudules has dramatically change the dynamics of shipbuilding [2].

Identified cost reduction during refits and modernization as the primary motivator in early modular shipbuilding effort and he forecasted ship capabilities increasing as future technologies combine with existing function into smaller and lighter package [3].

Went further and they recognized that the shipbuilding industry plays an important role in increasing employment and productivity, especially when the market has fallen due to the influence of the global economic crisis. They introduced the modular outfitting concepts with the aim of optimizing the shipbuilding production process by increasing the portion of modular vessel outfitting as a way of shortening the duration of the shipbuilding process, reducing cost and increasing competitiveness without investing in new facilities, machines and tools [4]. Quoted modularity as a means to get at the same an improved functionality of the building for user operations and an increased speed of building production, changes and renewal, claiming that the potential decrease in building time would be about 50% or even to 75% [5]. Eventhough the construction of a modular system ship can increase shipbuilding process, it has to be supported by shipyard supply chain which collaborated with materials and outfittings.

Supply Chain is a network of companies working together to create and deliver a product to the end user. These companies include suppliers, factories, distributors, stores or retailers, as well as supporting companies such as logistics service companies [6]. Product design that takes into account supply chain management (SCM) is called design for SCM considering the flexibility of changing customer demand. Modularity or the number of components are different end products in mass customization. So it is suitable to be implemented at the shipyard. PT X Indonesia has implemented modular system since 2011 until now. Data of decreasing delay is shown in figure 1.

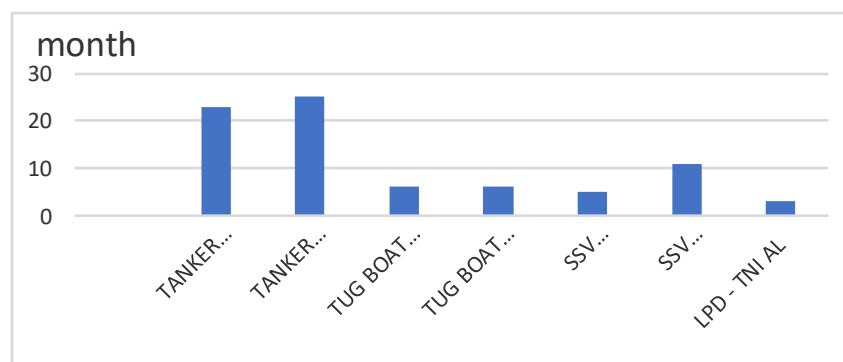


Figure 1. Data of ship delivery delays (units of months) in 2011 - 2018 PT. X Indonesia. (source PT. X Indonesia).

For the preparation of a modular system of developing shipbuilding, has impact on increasingly complex business management that requires detail calculation for the sustainability of a shipyard [7]. The ability of shipyards to bring materials depends on SCM shipyards, especially material procurement activities to reduce the risks that are not expected

in this business. The objective of this research is to analyze supply chain performance in modular shipbuilding.

2. Methodology

The method applied in the supply chain uses a conceptual and technical problem approach, namely the dynamic modeling approach based on systemic thinking and using perspectives based on information feedback and delays, to understand the dynamics of complex behaviors from physical systems, biological systems, and social systems, which occur in management modular shipbuilding system supply chain. PT X Indonesia is a shipyard that was chosen as the research work area. The methodology developed as follows:

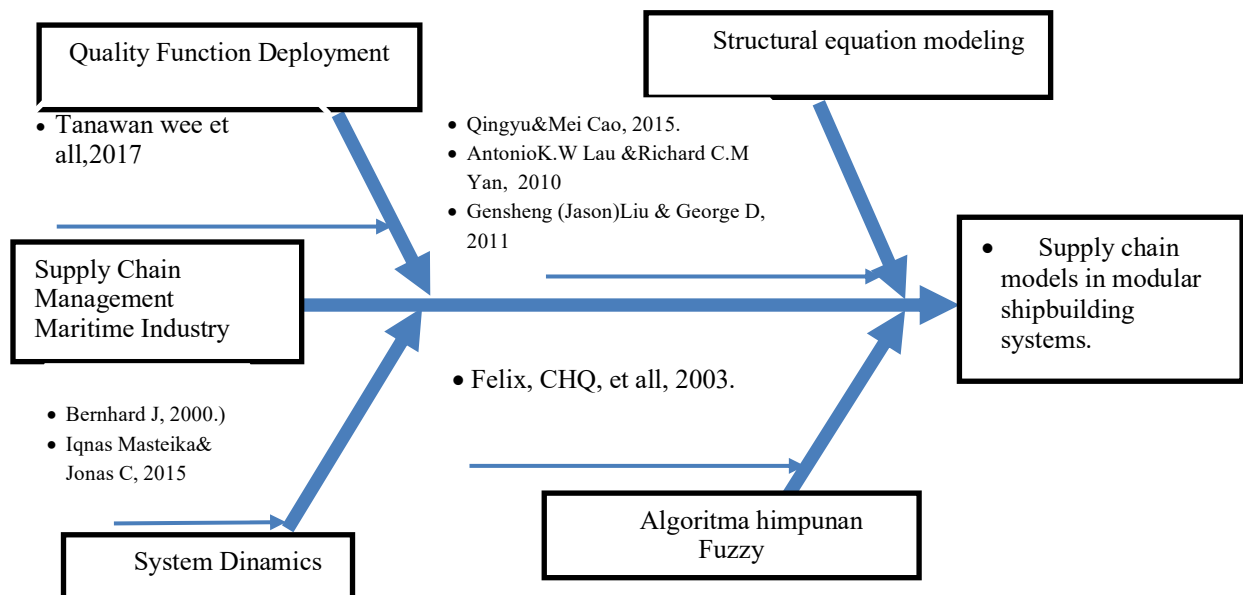


Figure 2. research methods conducted by previous experts in modeling the supply chain in the industry.

In Figure 2. several research methods conducted by previous experts in modeling supply chains in the industry. But no one has yet developed a supply chain that synergizes with the modular construction shipbuilding at shipyards. The novelty in this research to develop the supply chain model using System dynamics. The model will be developed with complex factors as a solution to solve all problems in modular construction shipbuilding.

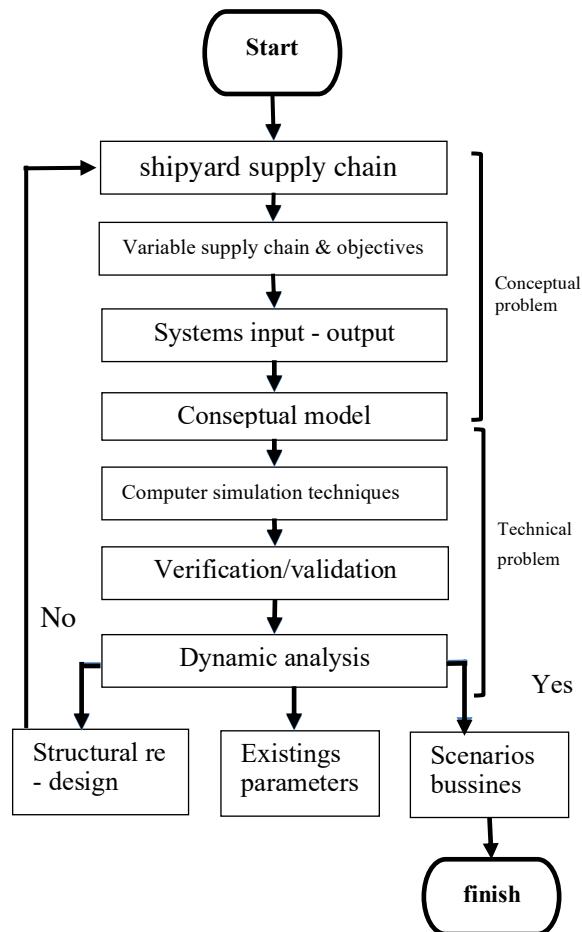


Figure 3. Flow Chart of Shipyard Supply Chain Research (source: Naim and Towill in [8]).

The identification of the modular system shipbuilding chain management model is carried out through literature and interviews with stakeholders, practitioners and policy makers involved in the supply system procedures for input, production and delivery of the modular system as shown in Figure 3. Data collected consists of primary data through observation, interviews with respondents in the Supply Chain department, hull construction, machinery outfitting and electrical outfitting secondary data obtained from literature, books, scientific journals, and various related publications.

The Strategy of supply chain ship construction system is a complex system with various constraints, it needs a dynamic approach as a solution to solve all complex problems in order to be able to minimize obstacles that occur in the production process of the chain starting from the input supply, production and delivery stages. the system is integrated between various actors in each supply chain activity.

3. Discussion

3.1. Modular ship system production

The ship's modular production process emphasizes the construction of ships with the number of starting points of the modules used in parallel construction. Supply chain performance must also adjust parallel development systems to more quickly fill materials, component equipment and outfitting.

In the implementation of PWBS to increase production massively in batch production system, which produces the same blocks in one batch and is assigned to different shipyards. There is one shipyard to assemble (hull erection) into another ships from ship blocks that have been made at other supporting. The production system accelerates the construction of ships because during the erection

process all blocks are ready. However, with this production system work in berth building areas such as welding, outfitting installation, and painting is no different from building ships with small blocks in general, it's just not necessary to wait for the blocks to be assembled. Quality between blocks has a different, because it is done by a variety of shipyards.

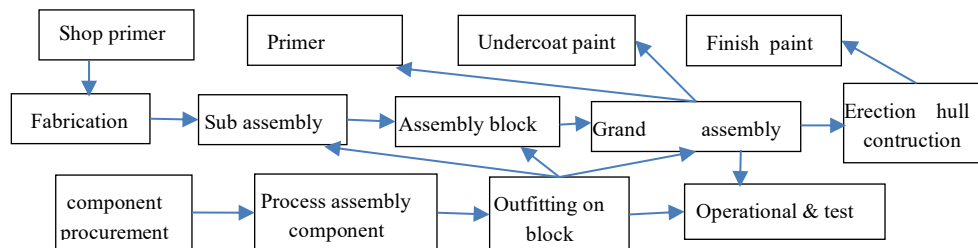


Figure 4. Modular vessel production system process flow In the production process.

There are 3 zones in the integration of modular systems, the painting zone, the hull block construction zone and the outfitting zone which are interrelated which are different from the previous development system. The outfitting process begins at the sub assembly, assembly stage, until the grand assembly. While the primary shop painting process is carried out before the forming and cutting stages are carried out at the fabrication. Whereas primary painting and primary undercoat are carried out in the grand assembly workshop until the finish erection hull.

Ship building with a modular system requires the engineering process of distributing modules and considering the stability of the modules. in addition, if necessary a floatation process can be carried out to facilitate the erection process if the shipyard has limited material handling.

3.2. Supply chain system in Modular shipbuilding system

Analysis of shipyard supply management is still little, especially regarding SCM for shipyards that have been implemented in shipbuilding with a modular system, but more implementation in manufacturing companies which has a high product variety such as electronics, toy and plastics industries [9].

The development of information technology is able to achieve better supply chain efficiency from market changes and consumer needs. The supply chain is in the form of product supply activities, including supply of materials and parts, development and assembly, storing and monitoring reserves, receiving and managing orders, distribution through all channels, shipping to consumers and information systems to monitor all of these activities. SCM is responsible for the coordination and integration of all activities on an ongoing basis. It connects all players who play a part in it, one department, one organization, and all external players, including suppliers, people responsible for shipping, third party companies, and information system providers [10].

Supply chain performance is said to be good in terms of delivery if it is able to bring the material in time, quantity and quality according to needs and production schedules and transformation changes. In principle of ship construction with a modular system is an implementation of the grand block joining in PWBS. a modular system combining several blocks into a ring block or a complete module with equipment and outfitting (E/O) and final painting, has been tested, and in some cases, that modules must be able to float with good stability by installing temporary waterproof impermeable insulation. Module development is carried out in the workshop area so that work in the building berth area becomes shorter. Modular system technology requires a design process that considers the division of modules and the stability of the modules being floated.

The general objectives of the Modular Ship Design concept are [11]:

- Reduced design and construction cost (modular system of production process leading in ship standardization)
- Reduced design and construction time.

- Greater flexibility for updates later in the ship's life (temporary for missions or general update).
- Shorter and cheaper maintenance periods.
- Reduced maintenance cost.

However, modularization comes at price:

- Higher initial design effort.
- Reduced design freedom (possibly retarding technological progress).
- Usually higher weight.
- Usually increased space requirement.

Modular systems affect the dynamic process of the supply chain shipyard system in terms of:

- The lead time for procurement of FOBS system goods is only carried out one starting point to 6 points with material procurement and parallel processing.
- Efficiency of goods in the purchase of goods with the amount of one item and in large quantities, shipping costs and administrative costs the same, so as to reduce these costs.
- Scheduling procurement of goods must be more flexible to adjust the design part of the plan.
- Purchasing equipment and outfitting (E / O) with a non-retail package system.
- Availability of material based on 6 starting points according to the division of the ship building zone.

According to the division of the ship building zone. By looking at the efficiency of supply chain performance [12]

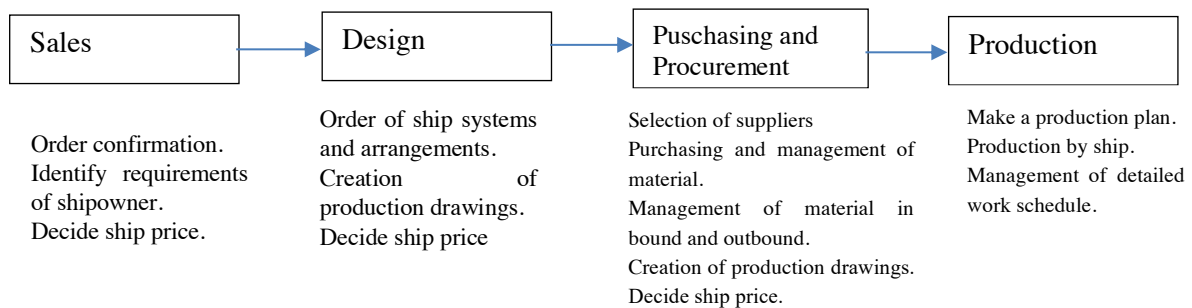


Figure 5. Shipyard supply chain supply process (source: SeungHoon Nam a, at all. 2017).

Figure 6. shows a simplified supply chain flow where the shipyard supply chain process is derived from the analysis of the shipyard target. This representation consists of four stages: sales, design, purchasing and procurement, and production. From the theory above, it can be developed in East Java shipyard supply, as follows.

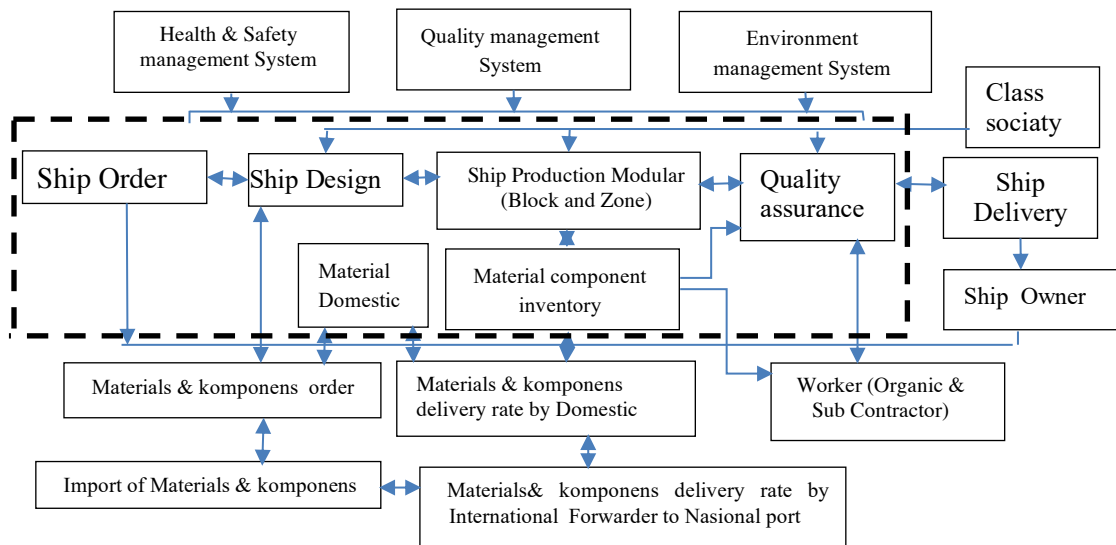


Figure 6. Conceptual model of shipyard supply chain strategy

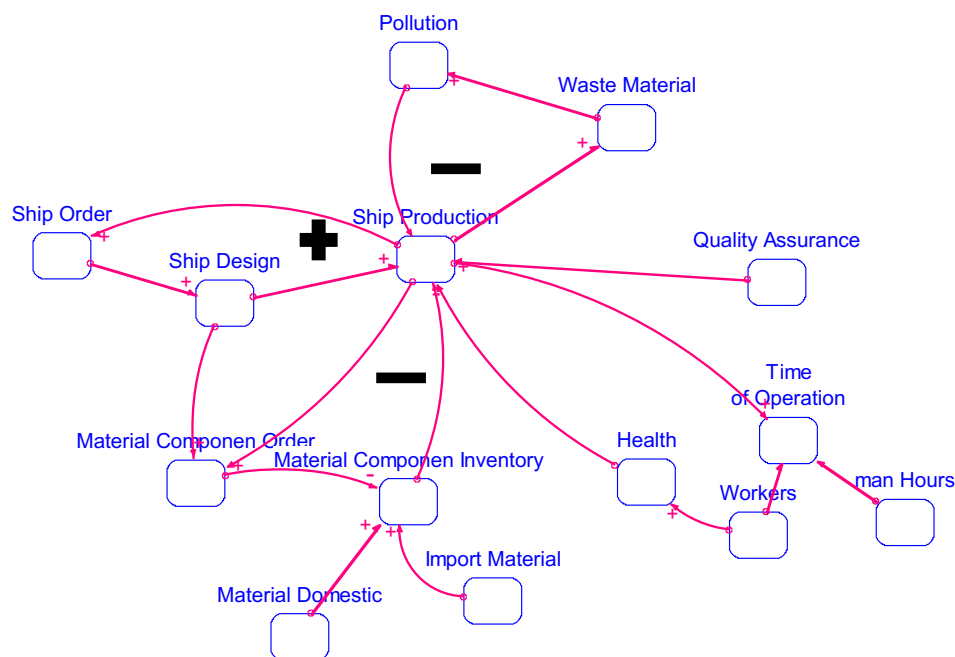


Figure 7. Dynamic Model of Shipyard Supply Chain for shipbuilding modular systems.

The developed model consists of the integration of three important streams in the logistics of chain activities, material flow, money flow, and information flow. Integration is intended to capture the mechanism and operating behavior of material flow and PWBS (modular) system equipment components. Through the examination of behavior models, the assessment of material flow operations and equipment components shown by ship quality, delivery delays, and financial indicators, and the design of shipyard supply policies to improve compliance with company performance requirements. Information technology in logistics or materials is based on synchronizing the activities of various organizations in the logistics chain and sharing information between supply chain actors.

3.3. Shipyard supply chain dynamic capabilities

The dynamic capabilities of the supply chain have more dynamic changes according to changes in customers, markets or significant influences of non-governmental organizations. The dynamic ability of supply management theory to gain new abilities in knowledge and discovery of competitive advantage. Diverse customer desires and intense competition are driving companies to be more innovative in creating innovative products - new products become an important issue in innovative products. The ability to manage ship building projects requires dynamic supply chain system performance in the flow of materials and components related to modular system shipbuilding. The ability to manage the supply chain is influenced by the collaboration between functions in the shipyard as well as the involvement of suppliers supplying components, systems or modules that are ready to be assembled in ship production and design processes and determining suitable materials. The role of supplier input for material savings, quality improvement and compatibility of materials with design and reduction of design time and production installation time. Suppliers for complex and critical items are involved from the start if they have the expertise to provide meaningful input.

Modular production pays attention to design flexibility to customer demand. Modularity of the same number of components or modules can be used to make different end products. The number of components in a modular product will have a better bargaining position because the number of components purchased each type will be more. Companies get lower prices each unit due to higher economies scale on the part of suppliers. Usually the customer (owner) determines the specifications selected then the shipyard will produce the ship in accordance with the specifications ordered by the owner.

Quality assurance involves the design, production process, product material procurement process until the product is handed over to the ship owner. Quality assurance will check the selection of supporting shipbuilding sub contractors, because ship production with a modular system uses a batch production system. The construction of the same blocks in one batch is done by different shipyards and the shipyard is assembled into a hull erection of several ship blocks that have been made from other supporting shipyards. Integration of supply chain performance requires speed and accuracy on uniform products in shipyard company performance systems.

Conditions in the shipyard, problems that affect ship delivery time delays during the production process take place due to increasing currency spikes or increasing component price. Because of that changes, the budget has to be revised by the bureaucracy for long time. As a result, there were delay in the process of purchasing, shipping material and ship building process. 70 % of the ship construction budgets is in the form of material if there is inefficiency in material management so there is a risk of delay in claiming ship delivery. Vendor consistency in price and timeliness of bringing materials according to schedule has a bearing on the timeliness of production. Delay in drawing revision slows the assembly process, because the speed and accuracy of the design drawings affect the material supply in bringing the material according to the working drawing specifications. Factors that become obstacles in the shipyard are evaluated and as Improvement of shipyard supply chain management performance improvement.

The modular chain supply system works in an integrated manner to carry out continuous evaluations towards improvement by optimally increasing shipyard readiness. improvement and development steps that are optimal and productive, among others:

- Flexibility of material procurement time is adjusted to the ship building schedule.
- Cost flexibility quickly and precisely using banking or independent services.
- Service flexibility using vendors together to minimize owner-certified compliance.
- Flexibility in material availability means starting time for procurement of material and equipment (imported goods) of at least 2 months so that the trial goods and post-purchase is carried out properly.

4. Conclusions

Modular shipbuilding Construction systems with a high degree of parallel demand for shipyard supply chain performance more dynamically creating innovation equipment and collaborating with suppliers. Implemented by a shipyard in Indonesia (PT.X), although there are still obstacles during the production process that need to be minimized. Dominant factors in shipbuilding delays are as follows:

- Budgeted changes due to an increase in currency spikes or component prices have resulted in a long-term revision of the bureaucratic budget, resulting in delays in purchasing, shipping goods, production processes, delivery time and the risk of late claims.
- Vendor consistency in terms of price and timeliness in bringing materials according to the shipyard schedule also contributes to the timeliness of production.
- Delay in sending the design results and revising the drawing will slow the assembly process and affect the material supply according to the working drawing specifications.

Acknowledgements

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