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Literature review on shipyard productivity in Indonesia

Thaib Rizwan[1,2,*], Ayana Rizki[1], Umiralaska Salsabila[1], Muhammad Muhammad[1], Riyan Maulana[1], Makwiyah A Chaliluddin[1], Junaidi M. Affan[1], Razali Thaib[3], Suhendrianto Suhendrianto[4], Yusrizal Muchlis[5]

[1] *Fisheries Resource Utilization Department, Marine and Fisheries Faculty, Universitas Syiah Kuala, Banda Aceh, Indonesia.*
[2] *Fisheries and Ship Navigation Laboratory, Marine and Fisheries Faculty, Universitas Syiah Kuala, Banda Aceh, Indonesia.*
[3] *Department of Mechanical Engineering, Universitas Syiah Kuala, Banda Aceh, Aceh, Indonesia.*
[4] *Industrial Engineering Departments, Engineering Faculty, Universitas Syiah Kuala, Banda Aceh, Indonesia.*
[5] *Mechanical Engineering Department, Engineering Faculty, Abulyatama University, Aceh Besar, Indonesia.*

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ABSTRACT

The shipyard industry plays an important role in supporting fishing activities and efforts to fulfill animal protein for humans. It is an industry that has an orientation to produce a product in the form of a ship. There are two types of shipyards, which are offshore buildings and floating buildings - both are used to build new ships and repair old ships. Based on the level of technology used by the shipyard industry, it is divided into modern, traditional, and semi-modern shipyards. Its productivity can see the advantages and disadvantages of a shipyard to ensure this industry remains to exist. Several factors need to be taken into account to increase the shipyard productivity, including land or location, human resources, technology, and materials.

Preliminary

A shipyard is a building on the seashore or water shore that constructs new ships and maintains and repair old ships (Soekarno *et al*., 2019). One of the problems faced by the traditional shipyard industry today is the lack of production capacity to build new ships and repairmen facilities. It is also an industry that has different operational characteristics from other industries. Customers determine what they want, and shipyard builders make the unit based on the customer's needs (Lai *et al*., 2020). Research conducted by Sukisno *et al*. (2019) stated that the shipyard industry is a capital-intensive industry with great investment value to build production facilities and requires serious planning, handling, and management to survive and create a healthy industry. Therefore, investment is an essential factor in supporting a shipyard industry. Based on the type of ownership, a productive shipyard industry can help local economic growth. According to Bodul *et al*. (2020), the shipyard industry is a labor-intensive industry that connects to related manufacturers and the service industry's large capacity. It is also considered a specific industry because it recruits workers from the locals and contributes to the people's economic growth and welfare around the shipyard location.

The development and implementation of technology can maintain the traditional shipyard industry's productivity. Productivity defines as a measurement of productive efficiency and as a comparison between *output* and *input* processes. The measurement level of productivity is often used to measure the losses and the profits of a shipyard industry. Productivity measurement is also used as an evaluation indicator for shipyard performance. According to Kim *et al*. (2015), evaluation of shipyard production capability is essential for calculating the production costs and the possibility to reduce them. The productivity of the shipyard industry determines the competitiveness of the industry. The shipyard industry needs to increase its productivity to be able to compete with other traditional shipyard industries. According to Khoryanton *et al*. (2020), the most influencing factors on the competitiveness of the

* Corresponding author.
Email address: rizwanthaib@unsyiah.ac.id

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shipyards industry are related to shipping, such as price, quality, and goods availability.

Table 1. Classification, indicators and examples shipyard building that exist in Indonesia.

No	Shipyard Classification	Indicator	Example	Reference
1	Traditional	• The whole ship design is determined by the ship owner • The material used is dominated by wood • Generally using the traditional method in making the ship., influenced by the experience of the workers • Using simple tool. • There is no special company that can handle the job • Producing small size ship (0-30 GT) • Minimal the implementation of technology, dominated by human labor	• Bagan Siapi-api Traditional Shipyard • Bintan Traditional Shipyard • Lampulo Traditional Shipyard • Rokan Hilir Traditional Shipyard	• Nofrizal *et al.* (2014) • Prayetno *et al.* (2016) • Guidance (2017) • Kholis *et al.* (2020)
2	Semi Modern	• Is a transitional shipyard phase from traditional shipyard to modern shipyard. • Using Fiber material • Has a PWBWS (Product *Oriented Work Breakdown Structure*) concept, such as: The first classification is Hull construction, outfitting, painting. The second classification is the division based on the intermediate product (interim *product*), the third classification is a classification based on three aspects of production. It is to facilitate the production control. • Shipyard semi-modern shipstill classified into industry dockyard ship because lack of technology.	• Shipyard Dok Pembinaan UPT BTPI • Shipyard Fan Marine Shipyard (FMS) • Shipyard Karya TeknikUtama (KTU)	• Johansen (2019) • Ariyoko *et al.* (2019) • Manov *et al.* (2019)
3	Modern	• Most workshops are 100 m to 250 m long. • The production concept uses a modular concept based on the customer demand. • Construction of the shipyard is very expensive. • Shipbuilding materials use steel plates. • Shipyard ship forward has planned production of the long-term with the structure of the hierarchy. • Facility - facilities used in the process of assembling the ship such as, the vehicle platform, crane, and jack hydraulic needed to position and align the beam is accurate. Theodolites, laser level, plumb-bobs and measuring tape are often used as measurement systems.	• PT Dok Kodja Bahari (DKB) • PT PAL Indonesia • PT Krakatau Shipyard • PT Bandar Abadi Shipyard	• Carames *et al.* (2018) • Mokhtar *et al.* (2016) • Pratama *et al.* (2019) • Sending *et al.* (2020) • Jeong *et al.* (2017) • Porath *et al.* (2016)

Productivity

In general, productivity is often defined as the relationship between the system's *output* and the number of *input* factors used by the system to produce the *output*. In this case, the *output* could be due to the process, whether a product or service. Meanwhile, the *input* factors consist of every human and physical resource used in a process. To increase productivity, producing more goods and better quality from the same sources, or the same goods from different sources, is needed (Pekuri *et al.*, 2011). Increased productivity refers to increasing the goods production ratio or related to the services based on the used resources. According to Syverson (2011), productivity is product efficiency, such as the amount of *output* obtained from a particular set of inputs.

Productivity does not reflect how much *output* is given, but it reflects how efficiently the resources are used to carry out the production activities (Gordon *et al*., 2015). Measuring a productive system's capacity is complex because it considers the factors, such as management policies, availability of supplies, equipment, production taxes, human resource factors, and variability (Pachecho, 2014).

The productivity level can be measured collectively or evaluated industrially (through employee salary trends, labor growth, and optimization of technology use in production activities) (Kumar *et al*., 2016). Productivity is the ratio of the *output* from the *input* in an organized process, such as production effectivity, efficiency in resource utilization, and the product's quality (Castelle, 2017). Productivity is generally defined as the ratio of output volume to the volume of *input used* (FAO, 2017). The higher level of productivity, the better performance, and quality of the product produced at the *output* (Hanaysha, 2016). Quantitatively, productivity is the ratio between output and input used per time unit (hour, day, month, and year). Productivity is generally defined as the ratio between output volume and the volume of input (Kyaw *et al*., 2016).

Shipyard

The shipyard industry is characterized by the mode of production ETO (*Engineering to-Order*) and usually a project-based industry. Shipyards are required to handle several projects simultaneously to be able to compete in the market. Generally, shipyard projects are extensive and complex, where the number of activities can reach up to ten thousand and the cross-work model is commonly happening in the shipyards (Li *et al*., 2018). The shipyard industry is classified as one of the main drivers to encourage the shipping sector's development and increase regional income. However, the shipyard industry faces challenges and weaknesses, such as lack of skilled personnel, high costs for management and operation projects, and intense competition from regional areas due to low labor costs. There has been no aggressive strategy and proactive movement to ensure improvements; hence the industry is still fragmented. Two important criteria that must be considered as characteristics of shipyards to remain competitive are higher productivity and lower costs during the production process (Soh *et al*., 2019).

A shipyard is a place to build or repair ships, so it must have land or area and *water form* or coastline. Based on its activities, shipyards can be divided into new building yards, repair yards, and new building and repair yards. The orientation of the new building is a type of shipyard that builds new ships based on the owner's orders. Repairing orientation is a type of shipyard that works to repair or maintenance the ship. New building orientation and repair are multifunctional shipyards, such as building new ships and maintenance/repairing and modifying ships. The shipyard is an industry where material transformation processes occur (wood, steel, *fiberglass*, among others) into *output* in the form of ships or other offshore buildings (Saputra, 2017).

Slipways and *dry-docks* are typical elements of a shipyard that can be combined into one shipyard. Shipyards show similarities globally due to the shipping standardization that contributes to shipyards' standard layout (Hettema *et al*., 2019). The shipyard industry's existence is one of the most important fishing industry places, specifically to support and organize fishing vessel system. Shipyard fisheries business can strive if there is a demand from consumers, and the producers can fulfill the consumer's needs. The shipyard business's sustainability is influenced by several factors, such as the availability and price of raw materials, demand, competition with outsiders, and regulations governing the shipyard business (Rizwan *et al*., 2020).

A shipyard is also a place to build or repair ships; hence it needs a place at the coastline. Based on shipyard activities, it can be divided into several parts, first, special shipyards, which is special workshops and construction of new ships and repairs several new ships based on the orders from their clients. Second, shipyard repair, a type of shipyard that works for ship maintenance and ship repair. The third is a multifunctional shipyard that builds, maintain/repair, and modify a ship (Warsilan, 2018). Maintenance activity at the shipyard such as replacement of ship engines and electrical components (electric aircraft, pumps, *rudder*, *bushing*, propeller, and shaft). Maintenance of ships can be defined as activities required maintaining management and materials to certain conditions (Ashari *et al*., 2019). A shipyard is an industrial production facility where certain *inputs* are used to design, develop, build, repair, or dismantle a ship (Nugroho *et al*., 2017).

Shipyard industry based on its ownership is divided into three sectors: the first sector is semi-governmental organizations, which focus on shipyard building and ship repair together with other mechanical works, the second sector is shipyard owned by government organizations where ships and fleets are maintained with a particular budget that has been planned, and the last sector is private shipyard building (Kyaw *et al*., 2016). The shipyard is also defined as one of the most critical elements in the shipping industry to build and repair ships. In the maritime industry itself, ship repair is the second most crucial aspect; around 40% of the operating costs in a marine shipping organization are associated with maintenance (Zaman, 2019). Shipyard building is an upstream industry that plays an essential role in the maritime system by providing various types of a new ship. Several countries attach great importance to and encourage the development of the shipyard building industry, the mixed manufacturing industry, promoting the steel industry's development, machining, and painting (Chao, 2019).

A shipyard can be defined as a place designed to accommodate the shipbuilding and repairing work process. Shipyards are usually built on a large land area because the final product is extensive and accompanied by supporting facilities to carry out activities related to new construction or repair of ships (Sukisno *et al.*, 2019). Basically, the shipping industry can be divided into two major activities, which are ship building and ship repairing. The two main activities always require a series of processes, including calculating materials, labor, production equipment, infrastructures, costs, and the work environment. In addition, a series of ongoing processes also involve interactions between units in shipyards, supporting industries, external agencies, and the natural environment (Budiyanto *et al.*, 2016). Important factors in the shipyard industry are cost, processing time, and quality of production. Despite all these important factors, cost remains one of the main factors in shipbuilding. Shipyard industry competitiveness is directly related to the capabilities of the company, industry, and region. Evaluation of the shipyard industry is necessary to increase the competitiveness of the shipyard industry. The comparison system is an evaluation method that can be used to evaluate the shipyard industry's performance. Basically, there are three-step processes that evaluate individual shipyard build-up and best practices, estimate shipyard productivity, and compare the use of best practices and productivity among shipyards to identify areas of improvement (Chhabra, 2015).

The shipyard business starts with the construction of a shipyard on a largescale investment. In most cases, shipyard production capacity is determined by the availability of resources, land area and especially the degree of proximity of individual factories and work stages. In the shipping sector, material handling costs comprise a sizable portion due to many heavy steel materials and semi-final products (Choi *et al.*, 2016). In the global market, global demand and economic activity influence the shipyard industry. Basically, whenever the economy warms up, international trade increases and sea transport increases will positively affect the trend of many industries, including the shipyard industry, where new ship orders increase in a short period (Ferreira *et al.*, 2018). Ship inspection is a critical process to avoid making mistakes by shipyard workers, reducing the ship's quality in the shipyard building process. The inspection management is still conducted manually, such as checking documents in sheets of paper and scanned files. The paper is kept in the cupboard, and the scanned files are saved separately on the computer. An additional tool is needed to help inspection management, such as computer software. If the Inspection Management is running well, then the shipyard quality management will also run well because Inspection Management is part of implementing the quality management process (Putra *et al.*, 2016).

According to Ju *et al.* (2020), the shipbuilding production plan is divided into long-term, medium-term, and short-term levels, and detailed functions of the *input* or *output* of the production plan process for each level. The database structure and production plan systems are developed in long-term production planning based on the required production planning level. According to Mansor *et al.* (2015), it is vital for the government and stakeholders in the local shipyards to optimize shipyard building implementation and increase its quality towards greater competitiveness. The increase of shipyard building activities can be a promising way to increase productivity, making shipyards more competitive. To optimally increase the shipyard building activities, advanced technology in tracking systems in inventory management and logistics handling is needed.

According to Guo (2019), the advanced shipyard building industry is based on digital technology and advanced technology, integrated with the process, logistics, information flow, and improved ship systems and standard systems. Several studies have defined shipyard productivity in different ways. Chen *et al.* (2016) emphasize the characteristics of operations, target markets, and factors in the socio-political context and other emphases on the process, technological change, and consumer demand. Sulaiman *et al.* (2017) describe several other interrelated factors that lead to better productivity for the shipyard industry. According to Soetardjo *et al.* (2018), calculating land geometry is necessary before shipyard building. The land geometry is the most basic input data for shipyard layout design and determines the size and shape in which each production module is located. Avikshit (2018) also states that the shipyard industry must employ a worker with higher capabilities and years of experience in the shipyard industry to ensure better working conditions for each level of work. According to Al Amri (2018), the shipyard layout determines the more efficient material flow, efficient material handling, better production, better planning processes, and work organization.

One of the advantages of increasing shipyard productivity is increasing competitiveness in the shipyard industry. Of course, this must be aligned with technological developments in the shipyard industry. The shipping industry must adapt and be more flexible in changing methods or new products designed to meet demand. If there is no improvement, competitors will take advantage of it (Firmansyah *et al*., 2018). According to Ford *et al.* (2020), using new technology in the shipyard is a potentially effective way to generate considerable savings in ship building. However, the use of technology must also be aligned with the quality of human resource capabilities.

Modern Shipyard

A shipyard is an entity involved in shipbuilding, ship repair, ship modification, and other similar marine-related works. Managing this activity requires special skills and knowledge. The modern shipbuilding industry must have certain facilities to support the performance of the shipyard, using facilities such as slipways, graving docks, and floating docks. This industry also uses the airbags method as the launching or docking process of a ship, which uses a rubber balloon filled with air. The current modern shipbuilding industry concept adopts a modular construction approach, which means that modules can be built at a specific location and then can be brought to the construction site for the final line up and then combined. In this approach, the shipyard only focuses on building the core area of the ship rather than the whole process - from design to launch process (Abdullah *et al*., 2016).

Most modern shipyards' workshops are between 100 m and 250 m in length; therefore, it requires appropriate communication technology, such as wireless communication. A device network or repeaters located in a place with access to data and electricity networks is needed to cover the entire workshop with wireless communication. In the modern shipyard industry, ships are generally built using a construction method that divides them into several parts. Considering that many elements are built simultaneously, various components that form a block need to be managed at the same time early throughout the shipyard. In addition, accurate and efficient logistics planning among various shipyard production areas (for example, workshops, warehouses, stockpiling areas, and docks) are the factors that need to be considered (Caramés*et al*., 2018).

The modern shipyard industry has a better management system compared to the traditional shipyard. Well organized documentation aims to have specific documents with relevant information for each assembly phase. The documentation must be completed and ready at least one month before the beginning of the assembly process - prepare the process, material supplies, and work requirements. Production planning is a key prerequisite for an efficient shipbuilding process. It is important to recognize and monitor key activities such as deadlines for ordering and delivering materials related to shipping dynamics equipment, as well as planning and predicting workloads related to planning adequate human resources (Matulja *et al*., 2018). Almost all modern shipyard building industries use the modular construction concept in shipbuilding. Modular construction is derived from one of the shipping industry theories, which is the lean production theory. *Lean production* theory is a production practice that considers the entire expenditure of resources to obtain economic benefits without any loss or waste. There are several differences between modular construction and traditional shipbuilding, which are the modular construction focuses on customer demand, while traditional shipbuilding focuses on production or ships. The purpose of modular construction is to minimize the residual use of materials and add value based on customer's demand; meanwhile, traditional ship building aims to reduce the budget and increase effectiveness. The modular construction model is more time-efficient than traditional shipbuilding (Mokhtar *et al*., 2016).

The construction of a modern shipyard industry is costly; therefore, the facilities provided must be well-planned- from site selection to material flow. Modern shipyard planning must be based on the goal and objectives to ensure long-term shipyard development. The shipyard is best located in the port area to facilitate the material supply and human resources, thus increasing shipyard performance. It is also necessary to determine the type of shipyard building. The shipyard service preference is based on several factors such as ship size, docking costs, and effective and efficient operation (Pratama *et al*., 2019). The modern shipyard industry requires integrated logistics planning due to the handling of high complexity shipbuilding. For example, this complexity produces a highly complex structure of a ship with several components and steels. In the modern shipyard industry, apart from specialized shipbuilding production facilities (such as panel assembly lines, dry docks, among others), the transportation system is an important factor; for example, the facility goliath cranes support the current shipbuilding process. Modern shipyards handle the production process of large and heavy ships compared to traditional and semi-modern shipyards. Synchronizing all shipyard resources based on the production program is necessary to ensure an efficient and competitive shipbuilding process (Sender *et al*., 2020).

In modern shipyards, semi-finished products are made by cutting and assembling steel plates. The cutting and assembly process takes place in an independent workshop within the shipyard. Therefore, the shipyard production system can be divided into a unit production system that carries out a specific process. Each unit production system is linked to the physical logistics flow of products and information flow for the production process. As a result, the shipyard production system can be defined as a unit production system, logistics flow, and information flow. Sophisticated planning is essential to manage such a complex production system systematically. The advanced shipyard has a production plan with a hierarchical structure (Jeong *et al*., 2017).

The modern shipbuilding industry is an industry that has a reasonably high production complexity. In order to increase productivity and reduce production complexity, block construction techniques are widely adopted by the modern shipbuilding industry for medium to large size ships — every block is composed of panels, structural profiles, machines, pipes, and other parts. The blocks are built separately and then taken to the building-dock, where they are placed, aligned, and welded to form a ship. The modern shipyard industry produces large quantities of large ships every year; therefore, facilities are essential. Facilities used in the ship assembly process, such as platform vehicles, cranes, and hydraulic jacks, are required to position and align the beams accurately. Theodolites, laser level, plumb-bobs, and measuring tape are often used as measurement systems (Porath *et al.,* 2016).

Traditional Shipyard

The function of the traditional shipyard in Indonesia is divided into several classifications: wooden shipbuilding, fishing boat building, passenger and wooden shipbuilding, and dry cargo shipbuilding. In the traditional shipyard industry, customers play an essential role in making decisions about ship design. The initial design involved developing and refining the ship's main characteristics with higher precision than the concept designing stage. These characteristics include the main ship's dimensions, the selection of materials such as wood and wood, determining the size and type of propulsion generator (Ohbuchi *et al*., 2017).

A traditional shipyard is a community's shipyard with a construction system using traditional methods, traditional tools, and wood as the primary material. There is no company structure in a traditional ship yard because an individual system runs the business. The traditional shipyard industry's fundamental challenges are the decreasing demand for ship orders, the ship repair process tends to be carried out by the community, and the reduced raw material for wood. It also has high operational costs result in the increasing construction ship price, limited equipment availability a traditional shipyards (hence challenging to reach the size of the ship that has been determined by the buyer), and a high error at of up to 25% losses risk. These challenges can be resolved if there is an improvement in ship building technology. If necessary, technology transfer must be carried out from a ship yard with the highest ship production technology level to another shipyard with lower ship production technology (Firmansyah *et al*., 2018).

The traditional shipbuilding industry generally produces wooden ships that have a small capacity compared to modern steel ships. Compared to the modern shipyard, most of the production is to assemble block by block with large engines and cranes. However, traditional ships are one hundred percent made from human work. Workers are not well trained in a formal technical school but only learn skills from senior workers. Traditional shipyards do not have a special place for their production process, sometimes on the riverbank, on the beach, or behind the house. Geographic factors and material resources usually influence the location of a traditional shipyard. Most of the traditional ships are produced from wood. The shipyard location is located not far from the timber factory, where logs are cut to the required size to reduce the operational costs. The craftsman will order the quantity of wood from the wood mill based on the customer's specifications. Shipyard sizes are usually not as large as modern shipyards because they do not produce traditional ships massively (Wekke *et al*., 2019).

Shipyard building is considered a tradition in Indonesia, where handcrafted wooden boats are built using techniques passed down from ancestors.

Traditional shipbuilding techniques are passed down without standard calculations and are built against the logic of modern shipbuilding, where the hull would be built before the ship's frame. The workforce in the traditional shipbuilding industry includes the foreman as the head of shipbuilding. About 2 to 4 helpers depend on the size of the ship being built. The foreman or chief craftsman entirely carries out the implementation of the work. Meanwhile, the auxiliary workers only do the work when the foreman asks them. The foreman or assistant worker skills in the shipyard building process are obtained from generation to generation without training. As a result, the productivity level is deficient because of the work's control by the foreman's hands. In addition, the foremen shipyard age is over 50 years (Praharsi *et al*., 2019). According to Putra *et al.* (2015), the traditional shipyard industry's problem is that the ships built do not have a line plan, and it is only based on the experience. The equipment used is still simple. These things cause productivity at the shipyard to be hampered. Kambase (2020), in his research, also mentioned that currently, lack of capacity, outdated maintenance equipment, lack of equipment, inadequately skilled workforce are some of the main challenges facing ship maintenance and repair services worker at Shipyards.

A shipyard is a building on the seashore or water shore that constructs new ships and maintains and repair old ships (Soekarno *et al*., 2019). One of the problems faced by the traditional shipyard industry today is the lack of production capacity to build new ships and repairmen facilities. It is also an industry that has different operational characteristics from other industries. Customers determine what they want, and shipyard builders make the unit based on the customer's needs (Lai *et al*., 2020).

Semi-Modern Shipyard

Shipbuilding technology continues to develop to increase the productivity and competitiveness of shipyards. The semi-modern shipbuilding uses technology between modern and traditional. There are various types of ships handled in semi-modern shipyards, from wooden ships to steel ships. The shipbuilding industry is categorized asa semi-modern shipyard if it meets the following criteria: technology availability approved technologies, and financial structure shipyard. Many shipyards in a transition phase from traditional to semi-modern or modern production processes face difficulties in the promotion sector due to the limited cash flow, unreliable delivery times, and passive marketing strategies (Johansen, 2019).

The transition process of the traditional shipyard industry into a semi-modern shipyard industry requires revitalization and evaluation as a reference for the development process. Revitalization, shipyard clusters, and production technologies need to be studied and evaluated to serve as clear references in developing a globally competitive shipyard industry and require supporting industries in it. Regarding the technology as a support, revitalization in shipyards can be an important opportunity to focus on a standard shipyard concept based on the type of ship that is the superior product and related to the orientation product of shipyards mapping application technology. This concept suggests that the shipyard needs to be evaluated for its technological readiness (Stanivuk *et al*., 2020). The semi-modern shipyard industry is still classified as a traditional shipyard industry in terms of technology. Programmatic technology transfer efforts are only carried out by the modern shipyard industry, resulting in a lack of innovation. Judging from the product cycle, many are old and in the process of declining function. A useful application of management technology and evaluation of assets must be carried out regularly (Manov *et al*., 2019).

The semi-modern shipyard industry label is obtained from the measurement of technological components, including the estimated degree of sophistication that indicates each technology component's sophistication in the shipyard. *State of art* assessment is the complexity level of each technology component. The contribution of components is determined by the values obtained from the limits of the degree of sophistication and the state of art rating and an assessment of the contribution of components (Utomo *et al*., 2019). The semi-modern shipyard industry implements PWBS (*Product Oriented Work Breakdown Structure)* concept, the same as the modern shipyard industry. PWBS concept divides ship production process into three types of work: the first classification is hull construction, outfitting, and painting; the second classification is based on the intermediate product (*interim product*) - for example, the intermediate product in the *fabrication*, *assembly*, and workshop; and the third classification is based on three aspects of production - this is intended to facilitate production control. The first production aspect is the *zone*, and this is a means to simplify the planning process. Two other aspects of production are the problem area and *stage*, which means dividing the work process from material to when the ship is handed over to the *owner* (Ariyoko *et al*., 2019).

Shipyard Productivity

The factors that can affect productivity in the shipyard industry, according to Anwar *et al.* (2020), are land, technology, human resources (HR), shipyard management systems, capital, and materials. The land is one of the main factors that influence the shipyard industry's productivity and is one of the main assets for companies to develop their business. Land plays a vital role in manufacturing industries and industries that require land/factory/warehouse/field support. Several criteria determine a land for the traditional shipyard industry, such as: land location (bay or watershed/*DAS* – *Daerah Aliran Sungai*), meteorological prediction, geophysical and oceanographic aspects, environmental aspects, and infrastructure (Widiastuti *et al.*, 2019). Technologies can maintain productivity and increase the competitiveness of a shipyard industry; however, some aspects of technology transfer programs are ignored. Before implementing the technology transfer, it is essential to identify what technologies needed to be transferred and why changes are necessary. This identification will identify the shipyard's current competitiveness and the performance of the components of the shipyards' hardware and software technologies. The decisions will be made based on this identification. If a software technology component is well-performing, *the output* will be conversely. Meanwhile, if the technology component of software 21 shows poor performance, then the hardware technology component's investment tends to increase the cost per unit of *output* (Firmansyah *et al.*, 2017).

The existence of technology in the shipyard industry is beneficial in facilitating the production process. Technology is a physical facility required in the production process, such as instruments, machinery, and others. Production equipment is divided into two parts; there are *hand tolls* and *power tolls*. *Hand tolls* are working equipment that operates using human power, while *power tolls* are working tools that operate using electricity. In shipyards, hand tolls and power tolls are combined to produce the right product (Guterres *et al.*, 2020). A rapid shipyard industry development requires human resources with high skill in finishing the shipbuilding process. Labor plays an essential role in achieving the company's production goals. In addition to using funds to build shipping infrastructures such as shipyards, the sustainability of shipbuilding is highly dependent on the availability of human and natural resources (Anele, 2017).

The material greatly determines the productivity of the ship building industry. Most of the shipbuilding industry uses wood and FRP (Fiberglass-reinforced Plastic) materials. Wood is a primary natural resource, and it has been around for billions of years. Wood material in the construction sector is mainly used to build fishing boats or other types of vessels. Wooden ships require raw materials from mature wood that are ready to use. Nowadays, many fishing boats have constructions composed of composite materials, namely FRP (Fiberglass-reinforced Plastic). The number of fishing boats that use FRP indicates that this type of material has also gained a place in the shipping world (Ariesta *et al.*, 2018). According to Xueetal (2020), increasing the ship yard industry's productivity must be accompanied by efforts to increase the efficiency of ship building. Increasing the ship building efficiency focuses on three aspects: the first is to reduce the number of ship building jobs using technology or increasing the efficiency of ship building by simplifying the production process; second, maximize the efficiency of the production process by focusing on increasing the efficiency of ship building production through the development and implementation of advanced production technology and special production; and third, reducing ship building costs by restructuring management, reducing overall ship building costs, and increasing the efficiency of ship building management activities. According to Habibie *et al.* (2015), the shipyard industry needs to increase its competitiveness, especially among the domestic shipyard industry. To increase shipyard productivity, working together with various parties is needed, starting from the shipyard owner until the government agencies. Research of Saraswati *et al.* (2018) shows that government support for national shipyards will open up new opportunities for companies to obtain more shipbuilding demands; therefore, an increase in shipyard productivity is also needed. Increasing shipyard productivity requires innovation in various fields. According to Nugroho *et al.* (2017), shipping company innovations such as improving technology, human resources, and fleet quality are needed to increase the shipyard industry's productivity.

Conclusion

It is necessary to increase the shipyard industry's productivity to ensure that the ship yard industry can compete with other ship yards industries. Therefore, shipyards industries need to create innovation in various fields, including land/ location, human resources (shipyard workforce), technology, and materials used for ship building.

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