

Factor Affecting Shipbuilding Productivity

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FACTORS AFFECTING SHIPBUILDING PRODUCTIVITY

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ABSTRACT

Compensated Gross Tonnage (CGT) is the measure of work content that forms the basis of the shipyard productivity estimation. CGT is the best and most acknowledged productivity measurement. However, contemporary development of ship design, construction and maintenance projects requires the shipbuilder to adopt practices capable of involving the customer that are not normally necessary in technical works. Shipbuilder requires to commit proportionately more production input in terms of managerial, technical and administrative resources than would be the norm on a commercial vessel as the additional efforts to be taken into account in the CGT coefficient. This paper discussed the institutional management, administrative, and technical factors on the relation of shipbuilding productivity from the perspective of customers. Results of the survey indicate that documentation completeness (in the aspect of logistic, drawing design, work safety, facility and equipment), finishing time (in the aspect of drawing design) and documentation (in the aspect of docking assurance, documentation as shipping agent), and affordable price are among the most important factors. Moreover, the best works in productivity in the shipbuilder technical works are berth time, machine/shafting repair and maintenance, sea trial, outfitting and electrical related work. It is expected that these findings will provide guidance in attempts of improving the performance of the national shipbuilder industry, and will be useful to national and international shipping companies in seeking a best practices of shipbuilders.

Key words: shipbuilding, productivity, production inputs, management, customer factor.

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1. INTRODUCTION

The use of Compensated Gross Tonnage/ CGT as basic calculation of shipbuilding productivity has become prominent. On the other hand, there is no single consensus regarding the CGT's ability to project shipbuilders' productivity and competitiveness (Krishnan, 2012; Roslee, 2009; Craggs et al., 2004).[1] The measurement of Technical productivity (CGT) as

the basis for planning and projection of the national shipbuilder industry needs to be re-considered in the framework of industrial strength mapping. CGT as a basis of the calculation of productivity needs numerous improvement. Bertram (2003) stated that the productivity parameter typically rated based on CGT is less adequate for assessing the competitiveness of shipyards, in which the parameter should also consider the aspects of efficiency, cost and quality. In addition, the CGT is not able to calculate the type, size and design of the ship (Caprace, and Rigo, 2011), the complexity and disparity of productivity between the warships and commercial ships (Cragg et al. 2003).

Some research define productivity shipyards in different ways (e. g Bruce, 2006; Bertram, 2003). Xie (2012) emphasis on the characteristics of the operation, the target market, as well as the socio-political context factors. Other emphasize on learning process (Chen and Wang, 2016), technological change, consumer demand (Shin, et al, 2009; First Marine International, 2005). Lee, et al. (2001), Kaiser and Snyder (2013), Gómez (2012) describe the interdependence with other factors as the best way to make dock productivity calculations become more useful

The estimation of productivity by considering customer-driven factors was prompted by the fact that CGT is more likely to be comparative on the benchmark of comparison level, counting only the technical aspects of the ship and ignoring the factor of non production, management, technological innovation, and HR (Yu, et al., 2010). Various studies indicate that the factors of production inputs (e. g O'Mahony & Timmer, 2009; Schreyer, 2001; Lieber⁵⁴n & Demeester 1999) and managerial operation (e. g Kurosawa, 1991; Sumanth, 1984) determine the level of productivity of the shipbuilder and shipping companies on the dock preferences. This research reviews the use of the CGT as the basis of the shipyard productivity estimation, by encouraging the use of other shipbuilder measurement methods, and propos⁵³ alternatives that could enhance the value of CGT through evaluation by customers. This study attempts to analyze the factors affecting the productivity of the shipbuilder according to the perception of the customer.

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2. LITERATURE REVIEW

2.1. Shipbuilding Productivity

Definition of productivity varies widely, which implies in difference of measurement methods. Some refer production as a function of productivity by changing the input into the output such as labor and capital (O'Mahony and Timmer, 2009). Lee et al. (2014), Kaiser and Sneider (2013), Lee and Sarder (2011), ECORYS (2009), Shin and Shon (2000) propose a variety of characteristics as the components of input productivity which includes labor, materials, equipment, cost of capital/investment, work schedule, work design, working conditions, safety, cost probability, master planning, as well as supporting services and production processes. Lee et al. (2001) states that the shipbuilding productivity depends on the efficiency of limited management resources. In general productivity is the magnitude of the degree of transforming input into outputs (Shin and Shon, 2000) and the learning process accompanying the transformation process (Chen and Wang, 2016).

2.2. Customer Factor

Basically, productivity in sh⁴⁹builder industry is rated based on the concept of compensated gross tonnage (CGT) set up by the organization for Economic and Cooperative Development (OECD). The existence of CGT was driven by the need to create a universal measurement that is be able to be recognized and last for many years (Cragg et al., 2003). The coefficient of CGT is gradually expanded and enhanced taking into account the elements of the construction costs of the vessel, warship specifications and comparing performance between countries,

regions or companies. This expansion marks that the concept of CGT is still not perfectly formed, and there has been no single agreement is received completely. Hence, some international shipping consultants, such as the First Marine International submits another indicator as an alternative to the CGT as well as improve its shortcomings (Bruce, 2006). Some other alternative approaches have also developed such as customer factor and comparison with international practices (FMI, 2005). Customer factor is the result of First Marine International design in cooperation with the United States Department of Defense with an emphasis on the human aspects as the main constituent of productivity. First Marine International, in cooperation with the United States Department of Defense propose five measurement of shipbuilding productivity, such as normative productivity measurement, customer factor, complexity, ship specifications, shipbuilding productivity and international comparison (FMI, 2005). The aims are to find the benchmarking of alternative calculation of shipbuilding productivity, and to compare shipbuilder performance outside the CGT, and to identify any specific change of shipbuilder industry to increase shipbuilder performance.

FMI defines customer factor as the adoption of shipyards on practices that are not only fully commercial and more connected with customers. Customer factor tries to insert additional elements to be taken into account in the coefficients of the CGT. Basically, the customer is applied to the ship-based CGT coefficients to calculate the value of additional work, expressed by percentage of these following factors: engineering not associated with first-of-class design), administration, master plan, construction, industrial engineering, program management, material procurement and warehousing, production services and support, and quality assurance (FMI, 2008).

3. FACTORS AFFECTING SHIPBUILDING PRODUCTIVITY

Some productivity measurements that are commonly used, are the index number, the production function, distance function and DEA analysis (Xhaferi,2012). Colinand Pinto (2009), FMI (2005) Craggs et.al (2004) analyze that the input of the industrial engineering such as ship design, complexity and specification, ship type, proportion of outfit, compartment size, and the physical assets of the shipyards such as dock area, berth length, and dock capacity, has an impact on the shipbuilding productivity. All these aspects are based on the transformation of input, such as technical and physical assets, into outputs as the basic production in shipbuilder. Furthermore, the technology becomes a relevant factor used as a productivity dimension. Yu, Xiao, and Jiang (2010), Pires, Lamb, and Souza, (2009), Shin, et al (2009), Lamb, et al., (2006), propose changes to the shipyard technology, technological innovation, human capital innovation and resource efficiency, minimization of risk, product performance, product quality improvement dan quality assurance. Other analyses of Gómez, (2012), Gebhardt, and Jarvis (2003), Lamb and Hellesoy (2002), Lamb, et al., (2006), Moyst and Das (2005) add institutional factors and management as inputs in productivity such as the experience of managers, administration and managerial abilities, program management, vertical integration, ratio between production and non production workers, verification and assessment process, corporate mission and management framework that could affect security, production, quality and responsibility. The involvement of management factors due to the performance of productivity will likely improve profitability (FMI, 2008). Chen and Wang (2016) emphasize sustainability advantages in productivity as an obligation for the shipbuilder to survive. Other studies have also identified that the market factors and the external environment as company inputs are able to influence on shipbuilding productivity. In addition, there are also consideration regarding the characteristics of operation, target market and socio-political context factors, and costumer demand (Xie,2012; Shin, et al, 2009). Others emphasize productivity on the minimization of production cost (e. g Kolić, et al, 2011).

Table 1 Literature Review of Shipbuilder Components Productivity

Author (year)	Identified Components
Pires, Lamb, and Souza, (2009) Kaiser, and Snyder, (2013)	The level of mastering technology, efficiency, work conditions Materials and workforces, ship design (rig) and specification, shipbuilder ability, the influence of construction time on cost, Contract costs, shipbuilding productivity, and the fluctuation of exchange rate effects on cost and workforces
Lee, and Sarder, (2011)	Workforces and expertise, science and technology, intermediate goods and services, raw materials, energy, capital and finance
ECORYS(2009)	Ship type, proportion of outfit, average compartments size, cost performance, work content, ship design, and the correlation between customer and productivity
Craggs, John, <i>et al</i> (2004)	Cost, risks, first-of-class performance drop-off, the probability of cost and schedule overrun increase ships` complexity, general technique, administrative, master planning, industrial engineering, management program, materials and equipment supply, supporting productions and services, quality assurance
First Marine International (2005) Lamb and Hellesoy (2002)	Vertical integration, ship type, and the ratio between production workers and non-production workers influence on productivity
Lee <i>et al</i> (2014). Yu, Xiao, and Jiang (2010)	The management of production, resources efficiency, work planning process, and work cycle The capacity of shipbuilder growth, for instance innovation in technology, and capital contribute for shipbuilder capacity
Shin, and Sohn, (2000)	Production plan, work plan, verification based on simulation, workforces optimizing, cost, total consumption of man-hour in hull production and outfitting, time, materials, products performance and quality, design method, operating devices process, quality assurance and evaluation.
Lamb, <i>et al</i> (2006)	Technical and managerial conditions, shipbuilder planning, process of increasing shipbuilder, technology involvement, and ship investment
Xie Y. (2012)	Operation characteristics, markets target, and social political context influence on shipbuilding productivity
Shin, <i>et al</i> (2009) Gómez, (2012) Moyst, and Das, (2005)	The changing of ship technology, and customer demand The correlation with non-production factor, management, and innovation Managers` experience in design and construction influence on construction schedule and environment characters (The frequency of design changing in design and rework)
Colin, and Pinto (2009).	Turn-over indicators, such as inputs, physical assets such as dock area, berth length, and ⁴ ing capacity influence productivity
Gebhardt, and Jarvis (2003)	Company`s mission and management framework which balance security, production, quality, and responsibility
Das, B., and Tejpal, N. (2008)	Tugboat shipbuilder: The availability of materials and equipment, changing and picture mistakes, material cost and workforces, and finishing time of the ship

4. RESEARCH DESIGN

This study is explanatory research, aimed to describe and explain systematically regarding the characteristics of particular phenomenon. This case study is conducted in PT. Janata Marina Indah as shipbuilder company, located in Semarang Tanjung Emas port. This kind of study is chosen because of its compatible for research which emphasis in exploring factual condition of the field (McCutcheon and Meredith,1993). Case study is more likely to have high value rather than theoretical study, additionally it is be able to generalize from a single case (Gerring, 2004).

Purposive random sampling technique is used in this study. The data is obtained from questionnaire distributed to 44 ships owner, managers, surveyor, and supervisor from ship industry. All of them rely on PT Janata Marina Indah Semarang for developing and repairing their ship. The questionnaire is replicated from the previous questionnaire used by PT. Janata Marina Indah to evaluate the performances of ship development and maintaining services.

The questionnaire is evaluated by using Likert scale, with a score of each question 1-3 with a qualitative range less, moderate and high. Data-based questionnaires were analyzed quantitatively using the index number for the calculation of productivity (Xhaferi, 2012) and Spearman correlation. Research on productivity by using index numbers is well known in engineering (e.g Gündüz, Nielsen & Özdemir, 2012; Sambasivan, & Soon, 2007; Odeh, & Battaineh, 2002; Faridi, & El-Sayegh, 2006; Enshassi, Al-Najjar, & Kumaraswamy, 2009; Fugar, & Agyakwah-Baah, 2010; Yang, & Wei, 2010; Motaleb & Kishk, 2010; Pourrostam, & Ismail, 2012). The analysis of index numbers is able to simply describe the public perception of the rest of respondents while keeping the priority/urgency of the importance of each indicator/component that is asked to the respondents. However, the identification of the respondents common perception can be done by using the modes, but less precise, because it ignores the answers of the respondents other than the most answers. In addition, the value of the mode less represent the entire perception of the respondent. This study examine a wide range of costumers from the shipping company (commercial, warships, within the country and abroad) in PT. Janata Marina Indah Semarang. The aim is to ascertain their preferences on national shipbuilders in the following years. This study is expected to contribute regarding the dynamics of competition on the shipbuilding industries of national and international factors by taking into account the customer as the basis for calculation.

5. VARIABLE IDENTIFICATION

In this study, the dimensions of shipbuilding productivity reflects an increase in services quality offered by the shipbuilder, changes in business environment and managerial, primarily in Indonesia, competencies in terms of commercial ships or warships and shipbuilder industry competition internationally. Based on the literature review, there are 3 variables i.e., production inputs, management/institutional, and engineering work productivity with 18 determinant factors in the dimension of shipbuilding productivity, including 54 identified components chosen for further analysis as given by Table. 2.

The production input variable contains 5 factors (work facilities and equipment, warehousing, logistics, drawing design, and work safety), 5 management factors (quotation, management letters, docking assurance, general services, and docking report), and 8 factors of technical productivity (tank, Electrical, outfitting, hull, blasting and painting, machining and shafting, berth and sea trial). The analysis is mapped by using productivity system, organized by First Marine International (2005) in term of approximation method and the dimensions of productivity. The customer factor is calculated by taking into account stakeholders assessment, shipbuilder customers, managers` internal observation of the shipbuilders performance (FMI,2005). The stakeholders assessment especially customer is needed for performance and continuity of shipbuilders in the future (Craggs, *et al*, 2004).

Table 2 Selection Factors of Shipbuilding productivity

Component	Reference
INPUT PRODUCTION FACTOR	
Work facilities and equipment	Das, B., and Tejpal, N. (2008)
Finishing time	Lamb, et al (2006)
Work quality	Shin, and Sohn, (2000)
Register (documentation of task result and trial)	
Warehousing	Kaiser, and Snyder, (2013)
Punctuality (acceptance and transfer)	ECORYS(2009)
Work quality (identification and security)	
Register (documentation of task result and trial)	
Drawing design	Shin, and Sohn, (2000)
Finishing time	Das, B., and Tejpal, N. (2008)

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Work quality according to requirements from the construction Register (documentation and control)	
Logistics Punctuality of arrival The quality of purchased goods Documentation completeness	Kaiser, and Snyder, (2013) Bertram, V. (2003).
Safety Preventing action The quality on minimizing accidents Register and documentation	Pires., Lamb, and Souza, (2009)
MANAGEMENT FACTOR	
Quotation Information speed Information accuracy Affordable price	Kaiser and Snyder, (2013) Lee, W., and Sarder, M. D. (2011)
Documentation as shipping agent Finishing time Documentation completeness Register (documentation of task result and testing)	Lee et al (2014). Gebhardt, and Jarvis (2003)
Docking assurance Finishing time Maintenance quality Register (documentation of task result and testing)	Shin, and Sohn, (2000) Lamb and Hellesoy (2002) Yu, Xiao, and Jiang (2010)
General services (accommodation, sanitary, information, and communication) Finishing time Work quality Register (documentation of task result and testing)	Pires., Lamb, and Souza, (2009) Kaiser, and Snyder, (2013) Lamb and Hellesoy (2002)
Docking report Finishing time of report The accuracy of finishing report Completeness of shipping document	Craggs, John, et al (2004) Lamb and Hellesoy (2002)
PRODUCTIVITY ITEMS	
Tank cleansing Finishing time Work quality Register (documentation of task result and testing)	First Marine International (2005) ECORYS(2009)
Electrical Finishing time Work quality Register (documentation of task result and testing)	First Marine International (2005) ECORYS (2009)
Outfitting Finishing time Work quality Register (documentation of task result and testing)	First Marine International (2005) ECORYS (2009)
Hull Finishing time (replating and welding) Work quality (replating and welding) Register (documentation of task result and testing)	First Marine International (2005) ECORYS (2009)
Blasting and painting Finishing time Work quality Register (documentation of task result and testing)	First Marine International (2005) ECORYS (2009)
Machine maintenance/repairation and shafting Finishing time Work quality Register (documentation of task result and testing)	First Marine International (2005) ECORYS (2009)
Berth (2)	Pires., Lamb, and Souza, (2009)

Berth speed (X1) Berth quality (X2) Berth services (X3)	
Sea Trial Suitability of time and planning The quality of ship condition Register (documentation of task result and testing)	First Marine International (2005) ECORYS (2009)

6. RESULTS

Index number formula is used to determine rank factor affected productivity and productivity rank of technical work that obtained the highest value from that factors. Analysis of relative importance index (RII) is conducted to obtain general perceptions from the respondents regarding the research variables, and to describe respondents' perception upon the questions (Ferdinand, 2006; Odeh & Battaineh, 2002).

The sum of respondents with certain answer (frequency) will be multiplied by the score (a set score for each option). Each score of answer option (frequency is multiplied is summed to obtain the total score. The total score is divided by the sum of total respondents, therefore the average score of each option according to respondents perception is able to be obtained. The data analysis uses index number to comprehend the degree of respondents perceptions on research variable. By summing up scores from each index factor. The formula used is as follows (Odeh & Battaineh, 2002):

$$I = \frac{\sum_{i=1}^3 WiXi}{\sum_{i=1}^3 Xi}$$

In which :

I = relative importance index

i = scale response categories = 1, 2, 3 for less, moderate, or high

Wi = weighting score of scales/response $i = 1, 2, 3$, alternately

Xi = frequency of scale response categories i

The score of index is formed in average index score of respondents perception which is categorized in a scales range. Therefore, it can be concluded through priority/rank as given by Table 3 an Table 4.

Table 3 Index Number of Relative Priority and Productivity Items

Factor/Item	Component	Production Input		Management		Productivity	Qualitative Scaled range
		Index	Rank	Index	Index	Rank	
Work facilities and equipment	Finishing time	2,11	13				Moderate
	Work quality	2,09	14				Moderate
	Register (documentation of task result and testing)	2,34	5				High
Warehousing	Punctuality (acceptance and transfer)	2,09	15				Moderate
	Work quality (identification and security)	2,34	6				High

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	Register (documentation of task result and testing)	2,27	7		Moderate
Drawing Design	Finishing time	2,36	3		High
	Work quality according to requirements from the construction	2,25	8		Moderate
	Register (documentation and control)	2,41	2		High
Logistics	Punctuality of arrival	2,16	11		Moderate
	The quality of purchased goods	2,25	9		Moderate
	Completeness of shipping document	2,41	1		High
Work Safety	Preventing actions	2,16	12		Moderate
	The quality on minimizing accidents	2,20	10		Moderate
	Register and Documentation	2,36	4		High
Quotation	Information speed		2,39	9	High
	Information accuracy		2,41	8	High
	Affordable prices		2,48	4	High
Documentation as shipping agent	Finishing time		2,41	6	High
	Document completeness		2,43	5	High
	Register (documentation of task result and testing)		2,50	2	High
Docking assurance	Finishing time		2,50	1	High
	Maintenance quality		2,41	7	High
	Register (documentation of task result and testing)		2,48	3	High
General services (accommodation, sanitary, information, and communication)	Finishing time		2,18	14	Moderate
	Work quality		1,98	15	Moderate
	Register (documentation of task result and testing)		2,32	11	Moderate
Docking Report	Report finishing time		2,39	10	High
	The accuracy of finishing report		2,32	13	Moderate
	Completeness of shipping document		2,32	12	Moderate
Tank Cleansing	Finishing time		2,45	8	High
	Work quality		2,16	22	Moderate
	Register (documentation of task result and testing)		2,32	17	Moderate
Electrical	Finishing time		2,25	21	Moderate
	Work quality		2,36	15	High
	Register (documentation of task result and testing)		2,48	5	High
Outfitting	Finishing time		2,36	14	High
	Work quality		2,39	11	High
	Register (documentation of task result and testing)		2,45	7	High
Hull	Finishing time (replating and welding)		1,84	24	Moderate
	Work quality (replating)		2,27	20	Moderate

	and welding)			
	Register (documentation of task result and testing)	2,48	6	High
Blasting and painting	Finishing time	2,39	12	Moderate
	Work quality	2,09	23	Moderate
	Register (documentation of task result and testing)	2,45	9	High
Machine maintenance/repair and shafting	Finishing time	2,57	2	High
	Work quality	2,41	10	High
	Register (documentation of task result and testing)	2,55	4	High
Berth	Berth speed	2,66	1	High
	Berth quality	2,30	18	Moderate
	Berth services	2,30	19	Moderate
Sea Trial	Suitability of time and planning	2,36	16	High
	The quality of ship condition	2,39	13	High
	Register (documentation of task result and testing)	2,57	3	High

The priority index factor is arranged in each components, which is divide into three variables such as input, management, and productivity. Qualitative assessment of the range scale is formed from the derivate of the above formula. Number : 1, is the lowest scale or theoretical minimum range scale (c.f. Odeh and Battaineh, 2002). Qualitative range scale is calculated by using the formula as follows (Ferdinand, 2006):

$$rs = \frac{mWi - 1}{ni}$$

In which:

RS = Range scale

mWi = maximum weight of response score $i = 3$.

ni = the sum of scale response categories = 3 in which 1, 2, 3 for less, moderate, or high

$$rs = \frac{3 - 1}{3}$$

$$rs = 0,667$$

In general, Table 3 shows the accumulation of respondents answer by emphasizing on each components. Based on the table above, it is clear to see that all component factors are not including to the low scale (1,00-1,667). The answer of respondent to input production variable shows actual range 2,09 – 2,41. Actual range for management factor is about 1,98 – 2,50. However, productivity variable has actual range between 1,84 – 2,66. Analysis of each priority index factor is given by Table 4.

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Table 4 Priority Index and Main Factor Ranked of Shipbuilding productivity

Input Production			Management			Productivity		
Factor	Index	Rank	Factor	Index	Rank	Item	Index	Rank
Drawing design	2,34*	1	Docking assurance	2,46*	1	Machine maintenance/repair and shafting	2,51*	1
Logistics	2,27*	2	Documentation as shipping agent	2,45*	2	Sea Trial	2,44*	2
Work Safety	2,24*	3	Quotation	2,42*	3	Berth	2,42*	3
Warehousing	2,23*	4	Docking Report	2,34*	4	Outfitting	2,40*	4
Work facilities and equipment	2,18*	5	General services (accommodation, sanitary, information, and communication)	2,16**	5	Electrical	2,36*	5
						Blasting and painting	2,31**	6
						Tank cleansing	2,31**	7
						Hull	2,20**	8

*high, ** moderate The highest index score is obtained by drawing design factor of input production variable, docking assurance of management variable, and machine maintenance/repair and shafting of productivity variable. In the input production variable, the highest index score is only obtained by drawing design factor, however other factors obtain moderate score. In contrast, on the management variable there is only general services factor which obtain moderate score (2,14). There are 8 factors in productivity variable, 5 of those obtain score which is relatively high, and the rest of three (blasting and painting, tank cleansing, and hull) obtain moderate score for about 2,31; 2,31 and; 2,20 alternately. The range scale which is produced this index number becomes priority measure in repairs and significantly affect the organizations.

Nonparametric test by using Rank Spearman correlation is used to test the correlation between dependent variable (input production and management) and independent variable (productivity of technical working). Spearman correlation test is chosen to analyse any factors in technics, because all of the research variables used ordinal scale (e.g Odeh and Battaineh, 2002).

Table 5 Spearman Correlation

		Technical Productivity
Spearman's rho	Production Input	,842(**) ,000
	Management	,880(**) ,000

** Correlation is significant at the 0.01 level (2-tailed), N = 44

The correlation coefficient shows significant correlation between production input and management with technical productivity. Each dependent variable (production input and management) has correlation coefficient for about 0,842 and 0,880 alternately and significant at 0,001 (1%). Based on this results, it can be stated that production input variable and management have significant correlation to bring success on technical work and increase productivity of national shipbuilding industry.

7. DISCUSSION

This study found several factors that play pivotal roles to the productivity of national shipbuilding industry. Based on the index number score, there are several factors that be able to obtain high productivity as given by Table 6.

Table 6 Index of Repairs Priority and Managerial Implication Per Factor

Production Input			Management			Productivity		
Factor	Scales range	Implication	Factor	Scales range	Implication	Item	Scales range	Implication
Work facilities and equipment	Moderate	Increase customer involvement	General services (accommodation, sanitary, information, and communication)	Moderate	Increase non technical service quality, such as responsibility and empathy	Hull	Moderate	Increase repair time and quality
Warehousing	Moderate	Increase customer involvement	Docking Report	High	Maintained	Tank cleansing	Moderate	Increase quality and work progress report to customers
Work Safety	Moderate	Increase customer involvement	Quotation	High	Maintained	Blasting and painting	Moderate	Increase quality
Logistics	Moderate	Increase customer involvement	Documentation as shipping agent	High	Maintained	Machine maintenance/repair and shafting	High	Maintained
Drawing design	High	Maintained	Docking assurance	High	Maintained	Electrical	High	Maintained
						Outfitting	High	Maintained
						Berth	High	Maintained
						Sea Trial	High	Maintained

7.1. Production Input

Index number analysis shows productivity achievement obtained today and highly preferences of customers to PT. Janata Marina Indah which have yet involved many function from production input. It is depicted from the low level of several factors in the production input variable. Factor of work facilities and equipment, warehousing, work safety, and logistics obtain moderate score from the customers, because the customers are less likely to involve in knowing the management of production input in the shipbuilder. In addition production input is difficult to assess directly by the customers, owing to the fact that it is manifested in real terms within the technical work. However, high score of index number is obtained by the factor of register and documentation, as well as drawing design which directly related to shipbuilder customers. Therefore, it confirms the possibility of lack in form of benchmarking productivity in the customer factor. This correction is related that customers have to be involved as high as possible in term of shipbuilder, including transparency in internal aspects, management, and organizational management. On the other hand, specific aspects stay restricted from the customer such as management of facilities and equipment, logistics, warehousing, and funds.

The results of Spearman correlation test show that there is positive correlation and significance in production input variable and management with productivity on national shipbuilding industry. It shows that the better the production input and organizational management had a positive and significance in term of increasing shipbuilding productivity. These results support the argument of

Colinand Pinto (2009), FMI (2005) Craggs *et.al* (2004) which analyze industrial engineering input related to shipbuilding productivity, such as drawing design, complexity and specification, ship type, outfitting proportion, compartment size, and physical assets; dock, berth length, and dock capacity. All these aspects are starting point on the technical input transformation and physical aspect to become output as basic production in shipbuilder.

7.2. Management

Among the five factors in the management variable, there is just one factor which obtain moderate score (general services/ accommodation, sanitary, information, and communication). It confirms the importance of institutional factor, managerial, and non-technical administrative as productivity factor. Enhancement is conducted through service quality such as responsivity and empathy in serving shipbuilder customer. However the characteristics of shipbuilder operation is more likely to focus on technical work aspect and ignore general services. However, the company is expected to increase its non-technical services, which also related to benchmarking customer factor involving customers` knowledge. Therefore, customer involvement is highly possible through personal relationship and emotional aspect built not just technical, but also well administrative service such as mailing, documentation, docking report, and general services to the customers. It confirms the research by Kaiser, and Snyder, (2013), Lee, W., and Sarder, M. D. (2011) regarding the urgency of contract funding, Lee *et al* (2014) concerning production management, Lamb, et al (2006) about the condition of the managerial, Gómez, (2012), and Das Moyst, Gebhardt (2005), and Jarvis (2003) regarding the company's management and mission.

8. CONCLUSION AND IMPLICATIONS

Based on the analysis among factors in production input variable, completeness of logistics document is a major component that is the most influential to productivity according the customers. In addition, register and documentation, finishing time of drawing design, register, work safety, documentation of task results, and testing of work facilities and equipment

became the most significant factors of technical work in shipbuilding productivity. However, the most significant factor in production input is drawing design.

Component of management which affect technical work is finishing time of docking assurance, register (documentation of task result and testing), documentation as ship agent, affordable price and completeness of shipping documents. The most influential factor affect to the shipbuilding productivity is docking assurance, organizing documents, quotation, and docking report.

The best component in technical shipbuilding productivity is berth speed, finishing time of maintenance/repairs and shafting including the register, sea trial, and electrical.

The implications of this study are theoretically able to broaden the knowledge regarding the application of customer factor as methodology and approach in assessing shipbuilding productivity. However, practically this study affects to ensure the continuity of national shipbuilding industry in term of competitiveness in the future. It also reduces the dependence of repairing and constructing ship in foreign country which drains nations` foreign exchange. In addition, to encourage national shipping company to construct and repair the ship locally by mapping strength and weakness of national shipping industry compare to foreign company. By such comparative analysis, will hopefully encourage the ship owners to broaden their knowledge regarding enhancement of national shipbuilding industry. Therefore, the owners repair their ship domestically because of several similiar aspects which have the same quality compare to the foreign shipbuilder company.

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