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The Optimal Capacity of the Handling Facilities in Bitung Container Terminal

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Abstract

The Bitung container terminal as the international hub port experienced an increase in the growth of container flow and ship call from 2014 to 2019, wherein the average increase was 8% and 4%, respectively. In 2018, the increase of ship calls was significantly high about 25% compared with the ship call in 2017. One of the important port facilities, to support the loading and unloading activities for the container, is the container handling types of equipment that are used for container handling from ship to port, port to the container terminal, and in the container terminal itself. The aims of this study are to analyze the productivity performance of the container handling equipment in the Bitung container terminal by considering the growth of container flow and to determine the optimal capacity of the container handling capacity for the expected year in 2035. The container handling equipment that was investigated is a container crane (CC), rubber-tired gantry (RTG), and head track (HT). The combination of the qualitative and quantitative methods is used for analyzing the productivity, and the regression method is used for predicting the growth of the container. Also, the optimization method is used for determining the optimal capacity of the container handling equipment. The research results revealed the productivity of CC, RTG, and HT were 25 boxes/hour, 27 TEUS/hour, and 24 TEUS/hour, respectively. In addition, the optimal capacity of CC is one unit for the short term (2025) and mid-term (2035). The optimal capacity of RTG is two units for the short-term (2025) and mid-term (2035). For the HT, the optimal capacity is two units for the short-term (2025) and mid-term (2035).

Keywords: Sea tranportation; Container terminal; Container handling equippment; Optimization method

1. Introduction

Indonesia is one of big archipelago country in the world. By this condition, the mobilization of people and goods must require a proper mode of transportation that can connect effectively between islands. The transportation system has become a basic component of infrastructure that influences the pillars of developing a region. The transportation recently plays an important role in government policies and programs [1]. There are several considerations in choosing the transportation mode, namely, tariff, reliability, and alternative transportation connection, disadvantage, claim service, and the company's internal conditions [2]. In the case of the large quantities of goods, an effective and efficient mode of sea transportation is needed recently.

The sea transportation network consists of domestic and foreign sea transportation networks [3]. In domestic network, for the smoothness of the good distribution, sea transportation can open to access and connect island areas in both developed and isolated areas. For supporting the good distribution, a seaport and its facilities are required to expedite all ship activities such as anchorage, loading and unloading process. The smoothness of all ship activities in the port can impact on the increase of an opportunity for the trade relations both regional and international ways.

On the other hand, Indonesia Government has the long-term development plan (Rencana Pengembangan Jangka Panjang/RPJP) 2005-2025 wherein the development of sea transportation is directed to support economic activities and dynamic national distribution patterns. In particularly, the port development plan in the Sulawesi Island, several ports have been developing including international hub-port in Bitung, international port in Makassar, and national port in several area. For the international hub-port, Bitung regency was decided to be an international hub-port because its location close to the international market of Asia Pacific, and to support the bilateral relations between Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA). The national ports are developing include in the districts of Gorontalo, Anggrek, Kwandang, Tahuna, Manado, Tagulandang, Labuhan Uki, Kolonodale, Baubau, Kendari, Donggala, Tolitoli, Banggai, Luwuk, Poso, Kolaka, Pagimana, Ampana, Malili, Barru, Parepare, Bajoe, Bulukumba, Palopo, Mamuju, Selayar, Sinjai, Lirung, Belangbelang, Jeneponto, Siwa and Raha [4].

As the international hub-port, Bitung's container terminal during 2014 until 2019 experienced the increase of average growth of the container flows and ship calls that were 8% and 4%, respectively. In 2018, the increase of the number of ship calls reached significant high of 25% compared with in 2017. There is several container handling equipment that are provided in the Bitung container terminal, namely a container crane (CC), rubber-tired gantry (RTG), and head track (HT). Those handling equipment are important facilities that can assist loading-unloading activities from ship to port, port to the container terminal, and in the container terminal itself. By the increase of the container flows and ship calls, the performance of the existing port facilities of the container handling equipment must be assessed in order to support the loading-unloading activities for the future. Therefore, this study aims to analyze the productivity performance of the container handling equipment in the Bitung container terminal by considering the growth of container flow and to determine the optimal capacity of the container handling capacity for the expected year in 2035. In this study, the performance of the container handling equipment was investigated. The combination of the qualitative and quantitative methods was used for analyzing the productivity, and the regression method was used for predicting the growth of the container. In addition, the optimization method was used for determining the optimal capacity of the container handling equipment.

2. Existing Condition of the Bitung Container Terminal

Bitung Container Terminal is the only container terminal in North Sulawesi Province. Astronomically, the coordinates of Bitung Container Terminal are 01° 23' 23" in North Latitude and 125°01' 43" in East Longitude [5]. Regarding the export-import and domestic goods, these are 70% and 30%, respectively. The destination countries for export and import commodities are Europe (Netherlands, England, and France), China, South Korea, Japan, USA, Malaysia, Vietnam, India, and Singapore. The flow of containers and ship calls in 2015 to 2020 is provided in Table 1 [6].

Table 1. The flow of containers and ship calls in Bitung Container Terminal 2015 – 2020.

Year	Loading-unloading (TEU)	CALL (UNIT)
2015	199122	243
2016	216531	246
2017	236963	240
2018	280763	299
2019	297168	320
2020	234122	307

The increase of the flow of containers affected on the capacity of Bitung Container Terminal wherein a container yard was decided to add. Then, new container yard was completely constructed in 2018. The location of new container yard in the area of Bitung Container Terminal is shown in Figure 1 [7].

Figure 1. The layout of Bitung Container Terminal.

3. Methods

The container in the loading and unloading activities is handled into three steps that are the containers from ship to port using the CC, from docks to stacking yard using the HT, and for arranging the container at stacking yards using the RTG. The productivity of the container handling equipment each step can be calculated by using the formula as follows:

$$Productivity = \frac{number\ of\ loading{-}unloading\ containers}{Effective\ time} \tag{1}$$

Furthermore, the number of the containers that will be served for the future can be predicted by using the multiple regression method wherein the independent variables are the number of population and Gross regional domestic product (GRDP). Also, the growth method was used. The dependent variable is the container number of loading-unloading.

$$y = a + bx_1 + cx_2 \quad (2)$$

where y is the container number, x_1 is the population, and x_2 is the Gross Regional Domestic Product (GRDP).

The growth method, the number of containers can be obtained as follows:

$$W = P_0 (1+i)^n \quad (3)$$

where W is the container number, P_0 is the current container number, i is the growth index, n is the projection year.

The optimal capacity of the container handling equipment is obtained by calculating the minimum total cost of the port operator costs and container's user costs. Then, the cost optimization of the service level can be described by the relation models between service cost and waiting cost wherein it is obtained by equaling the service cost and waiting cost [8].

3. Resutls and Discussion

3.1. Capacity and Productivity of the Container Handling Equipment

The handling activities of containers is divided into two steps, wherein for the first step, the containers are transported from the ship to the dock using the CC, dock to stacking yard using the HT, and at the container stacking using the RTG. Reversely, the containers are also handled from the staking yard to a ship. Therefore, the productivity of loading and unloading equipment at the Bitung Container Terminal is calculated by considering two steps. The average effective time of the handling equipment is 29 hours. Table 2 shows the ship service times of the berthing time (BT), effective time (ET), not operation time (NOT), idle time (IT), box crane hour (BCH) in Bitung Container Terminal for the last five years, 2016 – 2020.

Based on the data analysis, the productivity of each container handling equipment of the CC, RTG, and HT is for the loading/unloading activities are 50/50 TEUS/hour, 27/27 TEUS/hour, and 21/24 TEUS/hour. Then, the average productivity of each container handling equipment is shown in Table 3 [6].

Table 2. The average time of ship services in Bitung Container Terminal.

Year	Berthing time (hour)	ET (hour)	NOT (hour)	IT (hour)	BCH (box/hour)
2016	85.30	53.23	16.78	15.29	22.70
2017	52.50	31.06	14.30	7.14	22.00
2018	52.91	29.39	13.09	10.43	21.00
2019	56.02	26.69	15.46	13.87	20.00
2020	45.20	24.48	13.12	7.59	25.00

Table 3. Average productivity of the container handling equipment.

Equipment type	Productivity (TEUs/hour)					
	Unloading (unit)		Loading (unit)		Average unloading (unit)	Average loading (unit)
	20 ft	40 ft	20 ft	40 ft		
CC	50	50	50	50	50	50
RTG	17.9	36.5	20.9	33.8	27	27
HT	24.2	24.2	20.9	20.9	24	20

For the capacity of the container handling equipment is affected by the working hours a day. The working hours per day of the container handling equipment in Bitung Container Terminal is considered 21 hours. Table 4 shows the capacity of each container handling equipment. The capacity of container handling equipment can be obtained by multiplying productivity with working hour.

Table 4. The capacity of each container handling equipment.

Equipment	Capacity (TEUs/day)		
	Loading	Unloading	Total loading-unloading
CC	1050	1050	2100
RTG	571	574	1145
HT	509	438	947

3.3. Projection of the container flows in Bitung Container Terminal

Here, the container flows in Bitung Container Terminal are predicted by using the population and GRDP in South Sulawesi Province. The population and GRDP of North Sulawesi Province are provided in Table 5 [9]. Regarding the loading and unloading projection scheme, the data were used during 2015-2020 including the situation of Covid-19 pandemic wherein the average growth is 2%. For the short-term, the projection of loading and unloading container flows until 2025 is shown in Table 6.

Table 5. Population in South Sulawesi Province 2015-2019.

Year	Population (x1000)	GRDP (Billion IDR)
2015	2412.1	70425.33
2016	2436.9	74764.66
2017	2461	79484.03
2018	2484.4	84258.55
2019	2507	89028.05

Table 6. The projection of loading-unloading container flows for the short-term.

Year	Loading-unloding (TEUs)
2021	238.804
2022	243.581
2023	248.452
2024	253.421
2025	258.490

For the medium-term projection until 2035, the simple linear regression considering the population and GRDP as the influential variables was used to obtain the container number. The number of containers (y) can be modeled by the relationship between the independent (x_1 and x_2) and dependent (y) variables as follows:

$$y = 111453.1+17.22736x_1+0.841043x_2 \tag{4}$$

where x_1 is the population) and x_2 is the GRDP. Projection of loading-unloading containers for medium-term using the yield growth method is shown in Table 7.

Table 7. The projection of the loading-unloading containers for the medium-term until 2035.

Year	Population (x1000)	GRDP (Billion IDR)	B/M (TEUS)	Projection Loading-unloading (year)	Projection Loading-unloading (month)
2021	2412.1	2.550	99.187	238.805	19.900
2022	2436.9	2.571	104.446	243.580	20.298
2023	2461.0	2.590	109.835	248.452	20.704
2024	2484.4	2.609	115.355	253.422	21.118
2025	2507.0	2.627	121.006	258.489	21.541
2026	2528.9	2.645	126.788	263.654	21.971
2027	2550.1	2.662	132.700	268.916	22.410
2028	2570.5	2.678	138.743	274.276	22.856
2029	2590.2	2.693	144.917	279.733	23.311
2030	2609.2	2.708	151.222	285.287	23.774
2031	2627.5	2.722	157.657	290.939	24.245
2032	2645.0	2.735	164.224	296.688	24.724
2033	2661.8	2.747	170.921	302.535	25.211
2034	2677.9	2.759	177.749	308.480	25.707
2035	2693.3	2.770	184.707	314.521	26.210

3.4. Operation Cost and User

3.4.1. The Cost of Container Handling Equipment and Port Operator

The cost of container handling equipment and port operator consist of direct employee cost and maintenance cost. The data of the direct employee cost and maintenance cost were obtained from PT. Pelabuhan Indonesia IV (Persero). The number of operators for the services of the CC, RTG, and HT is respectively three employees. Based on the data, the the direct employee cost and maintenance cost in Bitung Container Terminal are shown in Table 8 [10]

Table 8. Recapitulation of the cost of container handling equipment and port operator per year.

Cost item	Amount (Million IDR)		
	CC	RTG	HT
Direct employee	666	1465.200	3596.400
Maintenance	75318.979992	75318.979992	24980.599872
Total	75984.979992	76784.179992	28676.999872
Cost per equipment	15196.995998	6980.379999	1058.407403

3.4.2. Waiting cost

The waiting cost is a cost due to unavailable for facility used wherein it includes the costs of good value in container and ship while waiting. The good value (GV) can be obtained by using the approach of average value of the export and import. Therefore, the cost of capital embedded (CE) of the goods per day is obtained by the GV multiplied with the interest rate (i), and it can be formulated as follows:

$$CE = (GV \text{ x } i)/365 \quad (5)$$

In 2020, the currency rate United States Dollar (USD) to Indonesia Rupiah (IDR) is about 14555.25 (IDR), and the capital interest is about 3.5 %. Based on the data in 2020, the number of export and import through the Bitung Container Terminal is 1361788 ton with the value of 767.287703 (Million USD) and 344941 ton with the value of 183.552579 (Million USD), respectively. Therefore, the GV of the export and import is obtained as follows:

$$GV_{export} = (\text{USD } 767287703 \text{ x IDR } 14555.25)/(1361788 \text{ ton})$$
$$= \text{IDR } 8201030 \text{ /ton}$$

$$GV_{import} = (\text{USD } 183552579 \text{x Rp } 14555.25/(344941 \text{ ton})$$
$$= \text{IDR } 7745258\text{/ton}$$

Meanwhile, the volume of export and import through the Bitung Container Terminal is 70% and 30%, respectively. Based on this ratio of volume, the GV of export and import is become as follows:

$$GV = (0.3 \text{ x IDR } 8201030) + (0.7 \text{ x IDR } 7745258)$$
$$= \text{IDR } 7881990\text{/ton}$$

Therefore, the CE per year can be obtained as follows:

$$CE = \text{IDR } 7973144 \text{ x } 3.5\%$$
$$= \text{IDR } 27586963\text{/ton-year}$$

Then, the waiting cost WC per year is obtained as follows:

$$WC = \text{IDR } 275869.63 \text{ x } 24 \text{ x } 1$$
$$WC = \text{IDR } 13241742$$

Furthermore, the direct fixed cost of ship due to the waiting service time consists of the capital cost and ship operation cost while waiting. Here, one of sample ship observed based on the high number of ship visits was the ship name of KM. Bali Ayu. Table 9 shows the direct fixed cost of a ship due to the waiting time.

Table 9. The direct fixed cost of a ship due to waiting time.

Item cost	Value (IDR Billion/year)
Depreciated cost	12540
Capital cost	11154
Insurance cost	4950
Crew cost	20641.155328
Total	49285.155328

3.5. Analysis of the need of Container Handling Equipment

The optimal of the need of container handling equipment is analyzed by considering the total minimum costs consisted of operator cost and user cost (container and ship) due to the waiting time. The need of container handling equipment is analyzed based on the existing condition (2020), short-term (2025), and mid-term (2035).

The optimal capacity for the existing condition based on the container flow in 2020 is 234122 TEUS. Regarding the unloading containers, the average number of containers is 19510 TEUS per month. For the short-term until 2025, the optimal capacity of the container flow is 258490 TEUS as well as the average number of unloading containers is 21541 TEUS per month. Meanwhile, the optimal capacity of the container flow in the mid-term until 2035 is 314521 TEUS wherein the average number of unloading containers is 26210 TEUS per month.

Related with the analysis of optimal capacity in the Bitung Container Terminal, the need of the number of container handling equipment also was analyzed. Therefore, the number of container handling equipment for the short-term and mid-term was determined in the relation with the total cost of waiting cost and operator cost as shown in Fig. 2 to 7 accordingly.

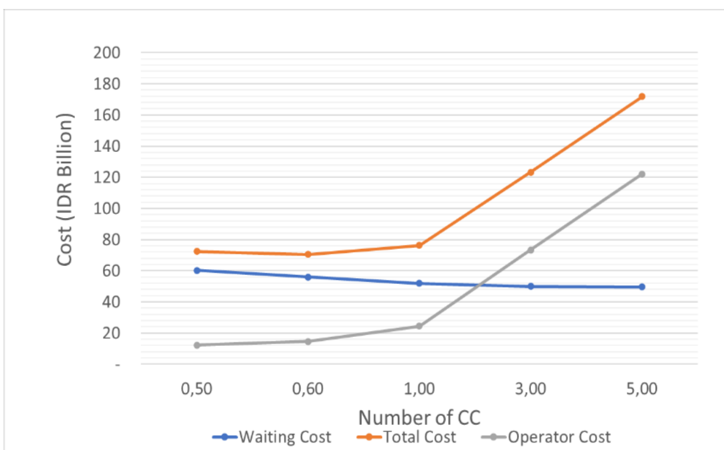

Figure 2. The total cost of the CC for short-term.

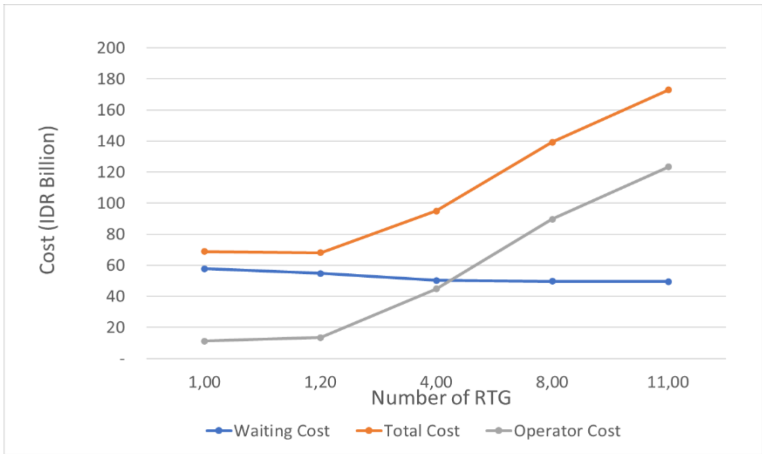

Figure 3. The total cost of the RTG for short-term.

Figure 4. The total cost of the HT for short-term.

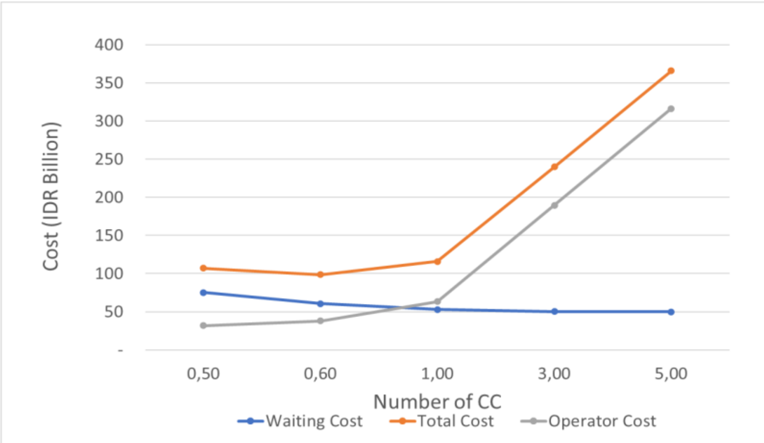

Figure 5. The total cost of the CC for mid-term.

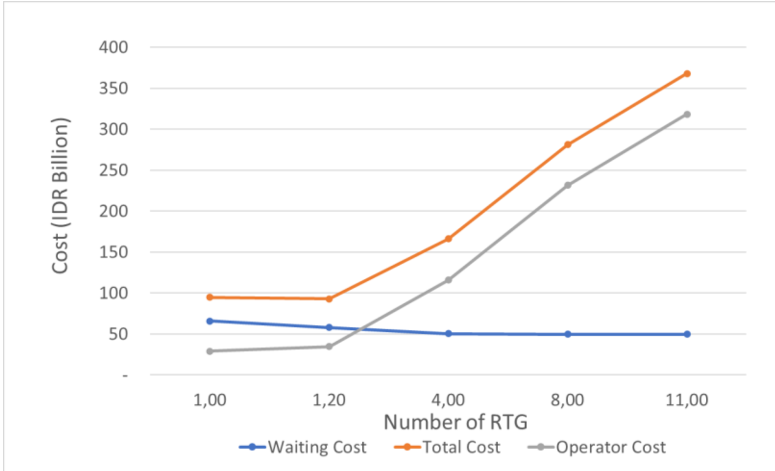

Figure 6. The total cost of the RTG for mid-term.

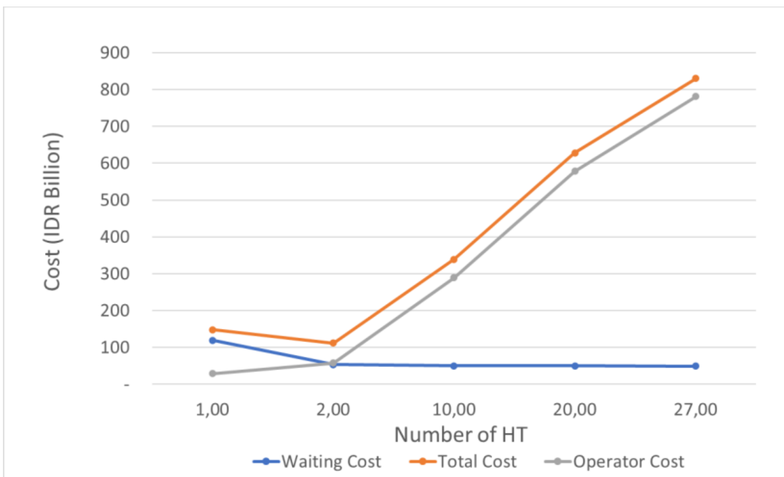

Figure 7. The total cost of the HT for mid-term.

Based on figures above, the optimum number of container handling equipment is determined as shown in Table 11. The need of container handling equipment for all terms shows low, and it is caused by the assumption of the good value that is relatively small. Also, the container flows tended to decrease during the Covid 9 pandemic.

Table 11. The optimum number of container handling equipment.

Equipment	Existing (unit)	Term (unit)		
		2020	Short-term	Mid-term
CC	5	1	1	3
RTG	11	2	2	2
HT	27	3	2	2

4. Conclusions

The productivity of the CC is 25 box/hour or 50 TEUs/hour. For the RTG and HT, their productivities are 27 TEUs/hour, and 20-24 TEUs/hour, respectively. The working time per day is about 21 hours, therefore, the productivity per day of CC, RTG, and HT is 2100 TEUs, 1145 TEUs, and 947 TEUs, respectively.

Furthermore, the need of the container handling equipment related with the optimal capacity is determined. For the short-term, the need of CC, RTG, and HT is 1 unit, 2 unit, and 2 unit, respectively. Then, for the mid-term, the need of CC, RTG, and HT is 1 unit, 2 unit, and 2 unit, respectively.

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