Analysis of Necessity for Container Domestic Transhipment Services Inter-terminals: Case Study of Tanjung Perak Port Region

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Keywords: Benefit Cost Ratio, Container, Relocation Inter Terminals, Transhipment.

Abstract: Inter-terminal container domestic transhipment service in Port of Tanjung Perak has the additional stacking yard in Terminal of Mirah, inter-terminal relocation service, and 35% tariff reduction are provided. This service will indirectly impact shipping industry, which provides its own facilities such as depot and trucks for the relocation activities. The objectives of this research are (i) to analyse whether the service of domestic transhipment containers inter-terminals is needed or not in Perak port region, (ii) to evaluate the appropriateness of the existing location of container domestic transhipment stacking yard in Terminal of Mirah, and (iii) to identify the impact of implementing inter-terminal container domestic transhipment service to its fee at Port of Tanjung Perak. The results show that Inter-terminal container domestic transhipment service is only needed for discharged container transhipment in Terminal of Nilam and Berlian with YOR value of 61.9 % and 63.3 % respectively. The placement scenario of Transhipment CY shows that Terminal of Mirah has a faster service time up to 4.6 boxes/hour. BCR value in the perspective of ports is for about 1.67 while BCR value in total is up to 1.45 in which 35 % are relocated from transhipment CY of discharged containers. This service reduces the costs for container domestic transhipment up to 33 % in Port of Tanjung Perak.

1 INTRODUCTION

Pelabuhan Indonesia III has the potential to drive the national economy which has handled 72 domestic container shipping lines (Basuki et al., 2015). The flow of domestic transhipment containers at the Port of Tanjung Perak in 2016 was recorded at 33,374 TEUs, in 2017 it grew to 35,131 TEUs and in 2018 it reached 36,980 TEUs (Wijaya, 2019). Starting 15 January 2019, inter-terminal domestic transhipment container service in the Tanjung Perak Port area applies. Based on the survey result, there is an increase in container yard (CY) facilities for domestic transhipment containers and a 35% reduction in domestic transhipment container service tariffs.

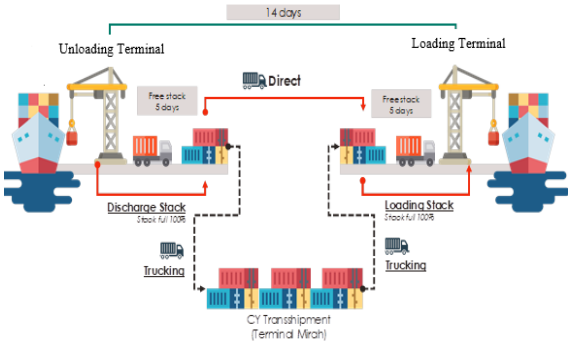

Figure 1: Service flow of domestic container transhipment.

There are two types of inter-terminal domestic container transhipment services, through domestic transhipment CY and without going through domestic transhipment CY or direct terminal unloading to the loading terminal. The types of service are differentiated based on the location of the unloading terminal and the time of the transhipment container (Wijaya, 2019).

The working area in this study includes the Tanjung Perak Port region. The area includes container terminals that serve domestic transhipment containers, namely Terminal of Mirah, Terminal of Berlian, Terminal of Nilam, Surabaya Container Terminal, and Terminal of Teluk Lamong. The Transhipment CY location is located in the stacking yard of Mirah Terminal, Jalan Prapat Kurung Selatan with a capacity of 55,955 TEUs / year. Figure 2 shows YOR for each terminal involved in domestic transhipment container service.

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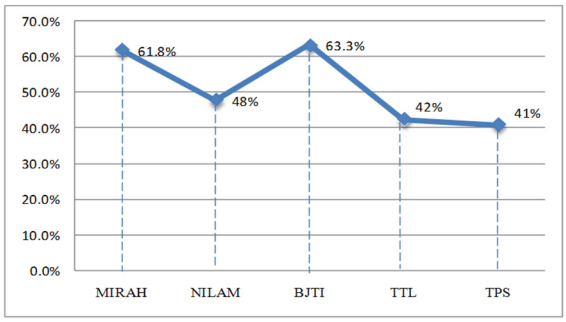


Figure 2: Yard Occupancy Ratio at Tanjung Perak Port Region, 2018.

This service can reduce the use of depots and shipping trucks from the number of containers transhipment domestic between terminals (Nur & Hadi, 2013). In addition to the imposition of new tariffs set at each unloading terminal and loading terminal, based on field survey, service users must pay for container relocation services operated by PT Berkah Multi Cargo with package rates that have been set. This will have an impact on the cost and time of service for containers (Triatmodjo, 2009). In this regard, this study was prepared to analyse whether the service of domestic transhipment containers inter-terminals is needed or not in Perak port region. So that later it is expected that this research can be used as a reference in determining strategies/policies related to domestic transhipment container services in the Tanjung Perak Port area. The results of this study can be used to determine whether inter-terminal domestic transhipment container services are needed in the Tanjung Perak Port area based on cost and time service analysis.

2 RESEARCH METHODOLOGY

The concept of the research to be carried out is to compare the distribution services of inter-terminal transhipment containers, namely the service of existing (relocation container through transhipment CY in Terminal of Mirah) and the absence of transhipment CY services (relocation container through depot). For the terminals reviewed, 5 (five) terminals are involved in domestic transhipment container service with 3 types of container distribution for each service. The existing service are (i) Unloading Stack-Transhipment CY-Load Stack,

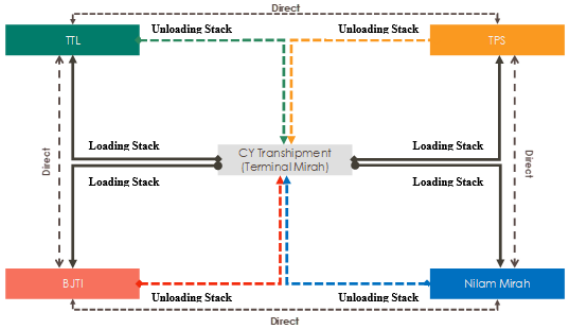


Figure 3: Container distribution services.

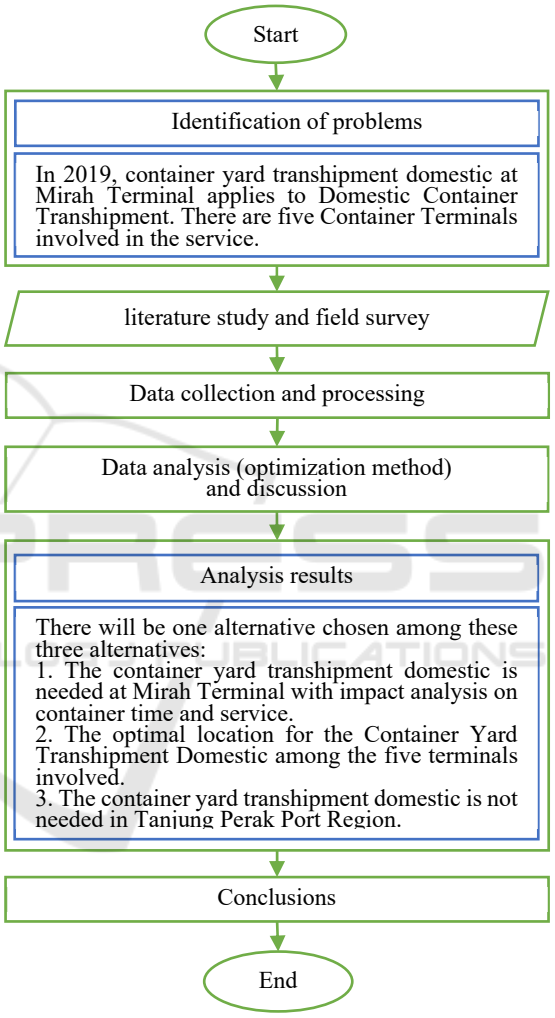


Figure 4: Tool design flow chart.

(ii) Unloading Truck Losing-Transhipment CY-Load Stack, and (iii) Unloading Stack-Load Stack for services there are Transhipment CY. The service of relocation container through depot without Transhipment CY in Mirah, namely: (i) Unloading Stack-Depot Shipping-Load stack, (ii) Unloading Truck Losing-Depot Shipping-Load stack, and (iii)

Unloading Stack-Load Stack. This research will be conducted using the flow depicting in Figure 4.

3 STUDY AND ANALYSIS

In this study and analysis, a simulation will be conducted to obtain the right service analysis results with the final BCR value from the side of the service provider and service user.

3.1 Simulation Model for Transhipment Container Service Demand in Unloading Terminal

Container service requests are analysed using moving average method because the number of containers unloaded at each terminal from January to April 2019 has a dynamic data pattern (See Figure 5 and 6).

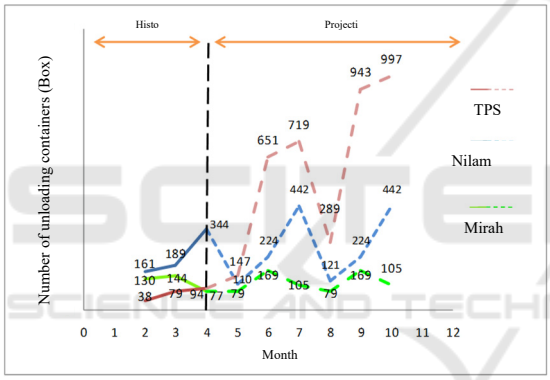


Figure 5. Number of container projection (TPS, Nilam, Mirah).

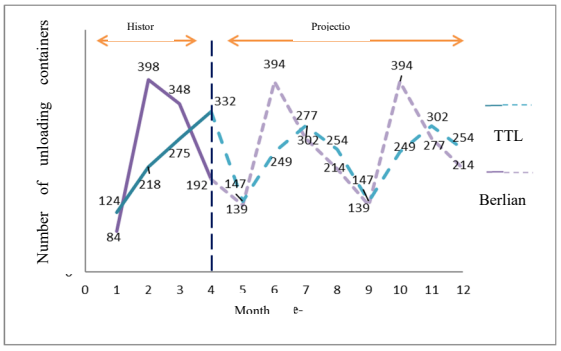


Figure 6. Number of container projection (Teluk Lamong, Berlian).

Input model simulation is the number of containers unloaded by taking into account the percentage of container size and the loading terminal probability (Putra, 2016). This study using probability theory to determine the loading terminal which is the priority destination for container relocation from the unloading terminal (Carlo et al., 2014). The result of the probability calculation is the number of containers relocating to the loading terminal, calculated using the following procedure.

a. Number of relocation containers

The number of relocated containers is obtained using Equation 1 below.

$$Pr = Pbi_{ij} \,.\, k_{ij} \quad (1)$$

Pr = Number of containers relocated (Box/ Month)
i = Unloading Terminal
j = Load Terminal
k = Percentage of Relocation

b. YOR analysis in the unloading terminal

Calculations for the stacking field utility uses the following equation (Directorate General of Sea Transportation, 2017):

$$YOR' = \frac{TG - TG'}{TY} \quad (2)$$

YOR = YOR after there is a transhipment container
TG = Capacity reached (Box)
TG' = Capacity reached after container transhipment (Box)
TY = Installed capacity (m^2)

c. Cost calculation through transhipment CY

Fares between terminals to the loading terminal (Nilam, Mirah, Berlian) are consecutively calculated using Equation 3, 4, and 5.

$$Ba = Tb_1 + ((Prt \,.\, M_1) \,.\, (((Lp_1\text{-}5) \,.\, T_2) + (5 \,.\, T_1)) + ((Prt \,.\, M_2) \,.\, Lp_1 \,.\, T_1)) + Tm \quad (3)$$

$$Ba = Tb_2 + ((Prt \,.\, M_1) \,.\, (((Lp_1\text{-}5) \,.\, T_2) + (5 \,.\, T_1)) + ((Prt \,.\, M_2) \,.\, Lp_1 \,.\, T_1)) + Tm \quad (4)$$

$$Ba = Tb_3 + ((Prt \,.\, M_1) \,.\, (((Lp_1\text{-}5) \,.\, T_2) + (5 \,.\, T_1)) + ((Prt \,.\, M_2) \,.\, Lp_1 \,.\, T_1)) + Tm \quad (5)$$

Ba = Cost through domestic transhipment CY
Prt = Number of container relocation through transhipment CY (Box)

Tb_1 = Rates at the unloading terminal (Nilam, Mirah, Berlian)
Tb_2 = Tariff at the unloading terminal (Teluk Lamong)
Tb_3 = Rates at the unloading terminal (TPS)
Lp_1 = Stacking time in transhipment CY
T_1 = Stacking Period 1 (1-5 days)
T_2 = Stacking Period 2 (6-10 days)
M_1 = Percentage Period 1 (Lt> 10 days)
M_2 = Percentage Period 2 (6 <Lt ≤ 10 days)
M_3 = Percentage Period 3 (Lt <5 days)
Tm_1 = Rates at the loading terminal (Nilam, Mirah, Berlian)
Tm_2 = Rates at the loading terminal (Teluk Lamong)
Tm_3 = Rates at the loading terminal (TPS)

d. Cost calculation through depot

$$Bd = (((Prd\ .M_1) + (Prd\ .M_2))\ .\ (2\ .(Tb + Th + TL) + Tm + (T_1\ .(\ Lp_2) + Td)) \quad (6)$$

Prd = Number of container relocation through shipping depot (Box)
Tm = Loading rate
LP_2 = Stacking time in shipping depot
Td = Shipping depot rates

e. Time Services Calculation through Transhipment CY

$$PT = (Prt\ .\ M_1) + (Prt\ .\ M_2) + (Prt\ .\ M_3) \quad (7)$$

$$Wt_1 = PT\ .\ (Wbm + Wb + Wt + Wm + Hb + Hm + Tbt + Ttm) \quad (8)$$

$$Wbm = Prt\frac{M_1+M_2+M_2}{Pbm} \quad (9)$$

PT = Number of containers through transhipment CY
Wt_1 = Time of container transhipment through unloading container yard at Teluk Lamong Terminal and TPS
Wbm = Time of unloading activities
Wb = Activity time in unloading terminal
Wt = Activity time in Domestic transhipment CY
Wm = Activity time at the loading terminal
Hb = Haulage time of quay - unloading CY
Hm = Haulage time of load CY - quay
Tbt = Relocation time of unloading CY – domestic transhipment CY
Ttm = Relocation time of domestic transhipment CY – loading CY
Pbm = Productivity of loading and unloading

Times for containers through Transhipment CY unloaded at Terminal of Nilam, Terminal of Mirah, and Terminal of Berlian, are as follows:

$$Wt_2 = PT\ .\ (Wbm + Wt + Wm + Hm + Tdt + Ttm) \quad (10)$$

Wt_2 = Unloading container transhipment time at Terminal of Nilam, Terminal of Mirah, and Terminal of Berlian
Tdt = Dock trucking time - domestic transhipment CY

To find out the duration of haulage and relocation use the following equation:

$$W_0 = 2\frac{St}{vT} \quad (11)$$

$$f = \frac{W_0}{(\text{Daily operating time})} \quad (12)$$

$$Tc = f.nT \quad (13)$$

$$HT = 24.Prt\frac{M_1 + M_2 + M_3}{nT} \quad (14)$$

W_0 = Time of haulage/relocation (hours)
St = Distance (Km)
Vt = Speed (Km / hr)
f = Frequency
Tc = Truck visits (units / day)
nT = Number of trucks (units)
HT =Duration of haulage/relocation (hour)

f. Time Services Calculation through Depot

$$W_{d1} = PT\ .\ (Wbm + Wb + Wm + Hb + Hm + Tbd + Tdm) \quad (15)$$

Wd_1 = Container transhipment time through depot (unloading container at Terminal of Teluk Lamong)
Tbd = CY relocation time unloading - depo
Tdm = Shipping depot relocation time - CY Load

$$W_{d2} = PT\ .\ (Wbm + Wm + Hm + Tdd + Tdm) \quad (16)$$

Wd_2 = Container transhipment time through depot (unloading container at Terminal of Nilam, Terminal of Mirah, Terminal of Berlian, and TPS)

Tdd = Trucking time from quay to depot
Tdm = Relocation time from depot to loading CY

3.2 Analysis of Yard Occupancy Ratio (YOR) in Unloading Terminals

The number of containers transhipment will affect the value of YOR at each unloading terminal. This can be seen from the number of containers relocating between terminals and the time of transhipment containers which indicate that the containers must stack before the loading terminal issues the open stack status. Terminals involved in these services have the loading capacity varies, so there is a difference in the value of YOR (Velsink & Ligteringen, 2012).

After knowing the YOR at each unloading terminal, it can be seen that containers unloaded at terminals that have a YOR value exceed the port operational standards (Directorate General of Sea Transportation, 2018), require Transhipment CY / Depo to stack containers. The number of containers that are relocating to Transhipment CY / Depo is as many as containers that cannot be piled up in the terminal stacking yard. From the number of relocated containers, the duration of each transhipment container is seen, to find out the distribution of inter-terminal transhipment container services through CY Transhipment/Depo. The following are YOR unloading terminals in the Tanjung Perak Port area.

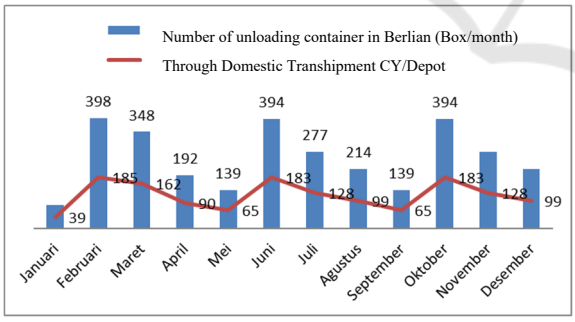


Figure 9. Containers unloading in Terminal of Berlian through domestic transhipment CY/depot.

YOR calculation results show that Terminal of Nilam and Terminal of Berlian have YOR values that exceed port operating performance standards. So, containers cannot be stacked in the Terminal of Nilam and Terminal of Berlian. The container must go through Domestic Transhipment CY at Terminal of Mirah/Depot according to the time of transhipment. The following is a graph of the number of containers going through Transhipment CY / Depot within 1 year for transhipment containers unloading at Terminal of Nilam. The number of domestic transhipment containers through Domestic Transhipment CY and Depot is 32% of the total containers unloaded.

3.3 Analysis of Cost Services

The results of the simulation of service fees for existing services Domestic Transhipment CY can be divided into 2 (two), namely service costs when transhipment containers are realized and when containers are canceled transhipment. The container is said to be the realization of the transhipment if the time of the transhipment container does not exceed 14 days and there is a 35% service fee discount. The container is said to be canceled if the time of the transhipment container exceeds 14 days and the service fee is 100% of the applicable tariff. Table 1 shows increase and decrease in the cost of domestic transhipment container services between terminals in 2019.

Table 1: Cost of unloading container services in Terminal of Nilam.

Loading Terminal	Increase/Decrease Costs
Mirah	-35%
Berlian	-35%
Teluk Lamong	-29%
TPS	-34%

For cost analysis the author does not only analyses containers that are unloaded at one terminal, but also analyses containers that are unloaded at all terminals involved. Next is the difference in the cost of domestic transhipment container services between terminals, where containers are unloaded at Berlian Terminal.

Table 2. Cost of unloading container services in Terminal of Berlian.

Loading Terminal	Increase and Decrease Costs
Nilam	-36%
Mirah	-34%
Teluk Lamong	24%
TPS	-33%

There was a 24% increase in fees on containers loaded at the Terminal of Teluk Lamong. This is influenced by the location of the Terminal of Teluk Lamong which is far from the Terminal of Berlian and the number of containers relocating to the Teluk Lamong Terminal is more than the containers relocating to other terminals. From the total cost of container services through transhipment CY and Depot, it can be seen that containers through Depo are

more expensive than containers through transhipment CY with an average cost reduction of 33%. In total, the cost of services with existing transhipment CY is cheaper than that of no transhipment CY services with an average reduction in costs of 30% in one year. Figure 10 shows the difference in service fees based on the number of containers unloaded every month.

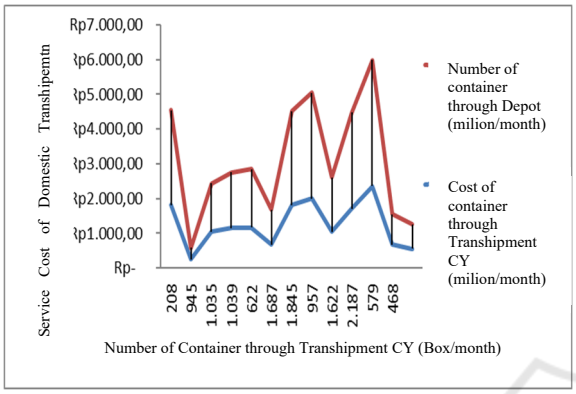


Figure 10. Difference in domestic transhipment service costs.

3.4 Analysis of Transhipment CY Location Accuracy based on Service Time

To find out the exact location of Transhipment CY in Mirah Terminal, the writer analyzed Transhipment CY location in Terminal of Nilam, Terminal of Berlian, Terminal of Teluk Lamong, and Surabaya Container Terminal by calculating the fastest service time of the five terminals. Equations for calculating the accuracy of Transhipment CY locations based on time considerations are as follows:

$$\sum_{1}^{5}(TL_1) : \sum_{1}^{5}(TL_2) : \sum_{1}^{5}(TL_3) : \sum_{1}^{5}(TL_4) : \sum_{1}^{5}(TL_5) \quad (17)$$

TL_1 = Transhipment CY service time at Terminal of Nilam
TL_2 = Transhipment CY service time at Terminal of Mirah
TL_3 = Transhipment CY Service Time at Terminal of Berlian
TL_4 = Transhipment CY Service Time at Terminal of Teluk Lamong
TL_5 = Transhipment CY Service Time at TPS
1 = Unloading terminal in Nilam
2 = Unloading terminal in Mirah
3 = Unloading terminal in Diamond
4 = Unloading terminal in Teluk Lamong
5 = Unloading terminal in TPS

3.5 Analysis of Benefit Cost Ratio (BCR) Calculation

BCR calculation is done to find out that the stacking field is needed from the side of the service provider and from the service user (Sulianti & Tilik, 2013). BCR value is obtained from the division between total benefit and total cost.

a. Procurement Costs
In this study, there are procurement costs for the transhipment build up the field at Terminal of Mirah and procurements costs for the Depot. In calculating the cost of procurement consider inflation in 2019 which is equal to 2.88% and the taxation of 10% of the cost of land investment.

b. Operating costs
Included in the operational costs of the transhipment container services are equipment fuel costs at the container terminal, maintenance costs, and labour costs.

1) Operational Cost of Transhipment CY
a) Fuel and Electricity Costs
To calculate the cost of fuel obtained by the equation:

$$\text{Fuel costs} = \frac{Pb}{B.K.H} \quad (18)$$

b) Equipment Maintenance Costs
Equipment maintenance costs are used for engine lubrication of loading and unloading machinery, assuming that in one-month oil needs as much as 8 litters /month.

c) Labour Costs
In this calculation, the salary value for operator workforce (GajiUmr.com, 2019), which is Rp 3,872,000/month. Costs for labour salaries in 1 month can be calculated by the equation:

$$\text{Labour costs} = TBM.G \quad (19)$$

TMB = Number of workers
G = Salary (Rp / month)

2) Operational Cost of Depot
a) Integrated Billing System (IBS) Operating Costs

Operational costs when there are Transhipment CY from the shipping side are the administrative costs for issuing job orders according to the number of containers transhipment, labour costs for payment system operations, and monitoring of containers that are transhipment domestically. The operational costs are borne by the shipping company are the administrative costs of issuing job orders and the operational costs of the Integrated Billing System (IBS) plus the cost of reserves.

c. Opportunity Cost
Opportunity costs or costs incurred when sacrificing opportunities to use services for other purposes. To find out the number of costs lost due to transhipment CY, the authors' analyses from two sides, namely from the side of the service provider and service user.

1) Opportunity Cost of Port
Port Opportunity Cost can be calculated with the following equation:

$$\text{Opportunity costs} = TBM.G \quad (20)$$

BS = Fee for rental of stacking field in Terminal of Mirah (Rp / m^2)
LS = Area of leased land (m^2)
K = Increase in cost by 2% / month

2) Opportunity Cost of Shipping Company
Shipping company opportunity cost can be calculated by the equation:

$$\text{Opportunity costs} = (Wt_1 - Wt_2).K \quad (21)$$

$Wt_1 - Wt_2$ = Time difference via transhipment CY and via depo
K = Loss (Rp / hour)

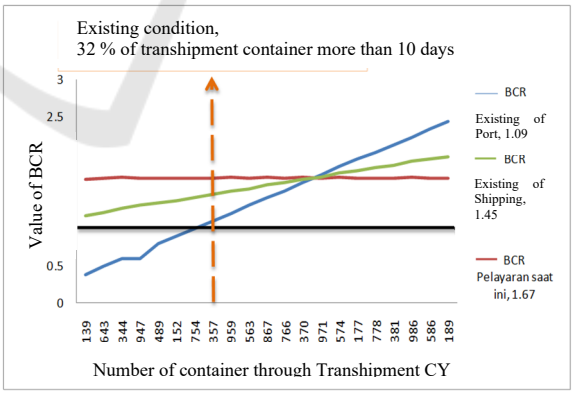
The calculation results show the value of BCR from the port side that is the total benefits obtained by the port minus the opportunity cost of the port divided by the total cost. From the calculation of Port BCR of 1.09> 1 so from the CY side transhipment side is needed. BCR calculation from the shipping company side is that the total benefits obtained by the shipping company are reduced by the shipping company opportunity cost. The calculation of Shipping BCR of 1.67> 1 so from the service user side (shipping company) transhipment CY is needed. From the results of the overall BCR calculation shows that the value of 1.45> 1 so that it can be said that the service with the existing transhipment CY is needed from the port side as well as from the service user (shipping company).

3.6 Analysis of Container Quantity Sensitivity to BCR Value

The sensitivity analysis of the BCR value is calculated based on the change in the percentage of the number of domestic transhipment containers between terminals through Transhipment CY for each unloading terminal. Changes in the percentage of the number of containers relocating through transhipment CY will affect the number of containers that have the terminal loading status directly. The following is the result of the sensitivity analysis of the change in the number of containers through transhipment CY to the value of BCR.

Figure 10. Sensitivity analysis of containers number to the BCR value.

Benefit Cost Ratio for domestic transhipment services are needed from the Portside with a BCR value of 1.09, from the shipping company side with a BCR value of 1.67, and a total BCR value of 1.45 with the percentage of relocation containers between terminals via Transhipment CY 35 % of total transhipment containers unloaded at each terminal.



3.7 Analysis of Transhipment CY Capacity

In this study, the authors also analysed YOR or Domestic Transhipment CY's ability to accommodate transhipment containers in the Port of Tanjung Perak. Before calculating YOR, one must know the discharged capacity and used capacity of the

transhipment container stacking yard located in Mirah Terminal. In calculating the used capacity of the stacking yard, it must know the total containers piled up on Domestic Transhipment CY by the number of containers going through Domestic Transhipment CY and the number of containers to be loaded at Mirah Terminal. In this study, the authors analysed the change in the number of containers through Domestic Transhipment CY by changing the percentage of Period 1 (Lt> 10 days). The change in the percentage of Period 1 will affect the percentage of Period 2 and Period 3. The percentage change is intended to determine the ability of Domestic Transhipment CY to accommodate containers if the number of containers through Domestic Transhipment CY changes. The results of the calculation can be seen in the number of containers piled up on Domestic Transhipment CY from the total transhipment containers unloaded at each terminal, as follows.

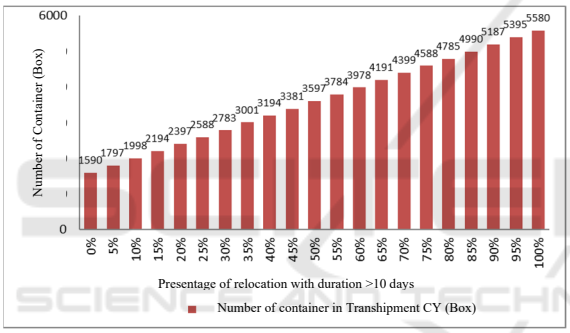


Figure 11. Analysis container number stacked at domestic transhipment CY.

After knowing the number of containers piled up in Transhipment CY, we can be calculated the ability of Transhipment CY to accommodate containers. The following are the results of the calculation of the number of container analysis of Transhipment CY capacity at Mirah Terminal. YOR (Yard Occupancy Ratio) in the Terminal of Nilam 61.9% and YOR in Terminal of Berlian 63.3% have exceeded the port operational performance standards. So, the service with Transhipment CY is only needed for transhipment containers which are unloaded at Terminal of Nilam and Terminal of Berlian. The following is the result of the sensitivity analysis of container number on BCR value.

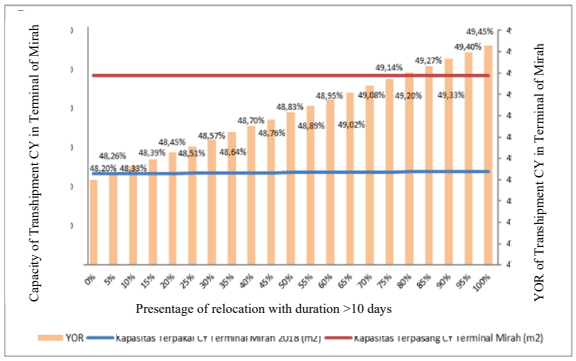


Figure 12: Sensitivity analysis of container number on BCR value.

4 CONCLUSIONS

From the results of research and calculations that have been carried out, then some conclusions are obtained, among others as follows:

1. The scenario of placing transhipment CY locations in all terminals involved shows that transhipment CY is right at Mirah Terminal with an average service time of 4.6 hours/box.
2. Transhipment CY Services can reduce service costs but not significantly, depending on the unloading terminal and the selected type of service distribution. Average transhipment container service costs are:
   a. Unloading transhipment containers at Terminal of Nilam decreased by 31%.
   b. Unloading transhipment containers at Terminal of Mirah decreased by 50%.
   c. Unloading transhipment containers at the Terminal of Berlian increased by 6%.
   d. Unloading transhipment containers at the Terminal of Teluk Lamong decreased by 38%.
   e. Unloading transhipment containers at the Container Terminal decreased by 42%.

Despite an increase in the cost of container unloading services at the Terminal of Berlian, the existence of Transhipment CY can reduce service costs by 33% when seen from all containers that transhipment in the Port of Tanjung Perak. Further analysis is needed with the presence of CY transhipment as a domestic container hub for Eastern Indonesia and is able to reduce logistics costs.

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