OPTIMIZATION OF CONTAINER AVAILABILITY WITHIN DOMESTIC TRADE WITH SUPPORT DIGITAL ECONOMY DEVELOPMENT

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Abstract: In international trade, particularly in Indonesia, the availability of containers is crucial and affects how well supply chains operate around the world. It also has a direct impact on how well transportation costs are used. In order to assist the growth of the digital economy and reduce the prices of such boxes in domestic trade through the use of efficient routes and times, the study looks at the elements that affect the price of empty boxes. Mix integer programming was utilized in this study to optimize the data while accounting for stochastic elements. The study uses Mix Integer Programming, specifically the Travel Salesman Problem, to enhance communication and collaboration among stakeholders in the supply chain. It also emphasizes the significance of digital platforms in doing so.

Keywords: Empty Containers, Dynamic Stochastic, Cost Optimum

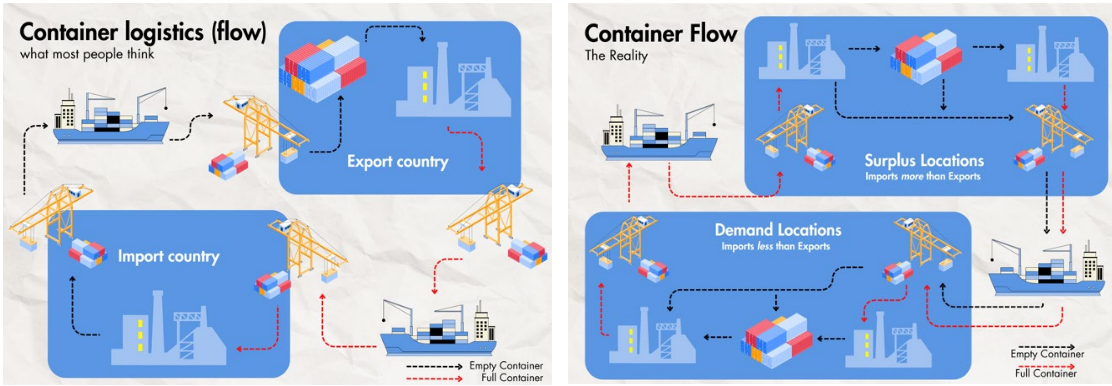
1. INTRODUCTION

Long-distance transportation can be divided into three segments: first-mile (pick-up process), long-haul (i.e., long-distance transportation), and last-mile (i.e. delivery process). Usually first-mile and last-mile transportation needs to be routed by road transportation because most of the companies do not have direct connections to the rail network and are not located in ports. On the other hand, in the longer term, additional modes of transport such as rail or water may be considered. The main advantages of combining multiple modes of transport are lower costs and lower environmental impact compared to traditional unimodal road transport (Wolfinger, Tricoir, & & Doerner, 2019). In this study, we will focus more on problems on the first-mile, namely regarding the movement of ports that connect several international ports. The three areas of significance global supply chain are delivery and customs clearance, distribution management, and import logistics and distribution (Branch, 2009). Furthermore, logistics is the process of maximizing management such as procurement, movement goods, and inventory through the organization and supply chain (Caplice & Sheffi, 1995). Throughout history, the world has experienced natural disasters that have affected business and society with varying degrees of disruption. COVID-19 represented a major systemic shock and was a stark reminder of the vulnerability and sensitivity of supply chain to economic pressures (Rejeb, Rejeb, & Keogh, 2020). Additionally, the COVID-19 pandemic has led to increased demand for essential goods, such as personal protective equipment, sanitizers, and medical supplies, causing price spikes and supply chain disruptions. In some cases, this has led to a shortage of essential goods, which has further impacted the long-haul supply chain. Likewise long haul routing decisions determine the selected departure and arrival terminals for containers and imply corresponding drayage task (Heggen, Molenbruch, Caris, & Braekers, 2019).

International transport comprehension is at the core of developing an efficient global logistics strategy (Branch, 2009). Nevertheless, In terms of goal supply chain, logistics efficiency is the determinant of international trade flow and logistics cost reduction, is which measured by logistics performance (Song & Lee, 2020). International trade is also one of the key determinants that influence international competitiveness (Selva, M.L, & Menendez, 2012). This is because international competitiveness depends on the ability to manage logistics in today's global business environment. Logistics has become a key element of international trade as the importance of international competitiveness increases due to globalization, and the efficient service of such logistics ensures trade flows within the global supply chain and the reduction of logistics costs between countries (Cheung, Bell, Pan, & Perera, 2020). Therefore, understanding international logistics performance should be priority in order to increase international trade. It is necessary to understand the logistic performance at the national level in order to establish a plan for future trend and transportation promotion policies (Song & Lee, 2020).

Seaports are a part of a complex system of supra system because they interact with internal and external subsystems to create an effective process within the supply chain. The most seaports across the globe are now faced with the stiff challenges of congestion, limited cargo space, increase in vessels turnaround time, and the dwell time of containers (Jeevan, Chen, & Lee, 2015). Usually, the demand and supply of containers are not rightly balanced in a port. As a result, the carriers incur a substantial cost in managing their containers. Therefore, carriers need highly effective and efficient container inventory management system to minimize these costs (Edirisinghe, Jinb, & Zhihong, 2016). Moreover, logistics and supply chain cost reduction has become the focus for companies and after containerization the container logistics plays a dramatic role in global supply chain. Not only does it have an economic effect, but it also has an environmental and sustainability impact, since the reduction of empty container movements will reduce fuel consumption and reduce congestion and emissions (Song D.-P. , 2009). This is also has been discussion at the G20’s event which was held in Bali in 2022. The issue of empty containers has been discussed in the context of global trade and supply chain management. The efficient management and movement of empty containers is an important aspect of ensuring the smooth functioning of international trade, as it allows for the efficient repositioning of containers for their next use. The volume of container traffic has increased many folds during the last two decades owing to increased globalization of trade. The imbalance of trade has also increased along with the increase in global trade (Tulpule, Diaz, Longo, & Cimino, 2010).

Nowadays, due to the enlargement of industrial activities, port terminal is facing changes in demand of container services. However, existing port infrastructure requires for expanding capacity to anticipate growing demand of container services. Container terminal with limited capacity required reliable operational strategy for providing efficient services. Factors contribute to inefficiencies are low performance equipment and limited of container yard area (Kurniawan, Musa, & Moin, 2021).



(a) (b)

Figure 1 Container Flow: a. Most people think; b The Reality
Source: Container Owner Association, 2023

As seen in Figure 1, the commonly known process of container shipping is: A container transports ship will dock at a container terminal with full containers and transports them to a warehouse by truck. At the warehouse, full containers are unloaded until empty and returned to the container terminal (import channel) for shipment to the destination port. At the destination port, empty container ships dock at a container terminal, then transfer to a container depot for unloading, and finally transfer to a warehouse. At the warehouse, these empty containers are repacked and shipped together with full containers (export flow). However, the actual process of transporting these containers is more complex and tends to result in empty surplus containers, leading to imbalances in the economics and orderliness of container supply.

Container flows are quite complicated and involve numerous variables. They cover the transportation of containers via various forms of transportation and border crossings, entailing a large number of participants and check stations. When attempting to establish direct control over container flows, shipping corporations are however constrained. Their authority is mainly restricted to repair depots, where they can exercise supervision and put required policies into place. Comprehensive inspections and cleaning can be done at these repair locations to guarantee container integrity (COA, 2023). Nevertheless, Some ports have enough or too many empty containers due to an imbalance in commerce, while other ports require more empty containers to move freight as described in the container shipping process above. As a result, shipping companies frequently move empty containers between ports and depots. The most challenging issue with repositioning is that it is difficult to predict the precise number of empty containers needed in the future. The economic effects of empty container management and the trade imbalance caused by container shipping have been extensively established in the literature. While Asian ports are experiencing severe shortages, European and American ports have been having a large surplus of empty containers along the Europe-Asia and Trans-Pacific trade routes (Song & Dong, 2015). This is also shown at the ports in Indonesia that have a surplus of empty containers with the shipping process which still tends not to be fully integrated. The delivery process lacks a streamlined system, making it challenging to access and verify delivery-related information. The importance of information flow argues that consistent information flow is essential to ensure organized progress. They further explained that highly volatile supply chains that respond quickly to customer needs require specific information flows for monitoring, planning, and regulating activities. (Kassou et al., 2021).

Vertical or horizontal integration of supply chains can only be achieved through the use of information technology. As the level of control over container flow increases, the need for Electronic Data Interchange (EDI) becomes even more important. Sharing timely and accurate information among supply chain members reduces the level of uncertainty and increases opportunities for container fleet management. In recent years, IT has also become important to security issues (E-manifesto), prompting industry progress towards compliance with advance notification systems for freight being transported(Song & Dong, 2015). This study focuses on operational container terminal performances due to lacking port capacity, especially on the container operational cost which causing imbalance container in each port. The capacity both of the vessel and each port will be considered. However, random fluctuation in empty container demand have increased in recent years, which could be attributed to the increased frequency of noncyclical adjustment of container shipping networks, the increasing prevalence of shippers returning empty containers interregional, and the rapid growth of intercontinental rail container transportation (Chen, et al., 2022). Hence, in situations of uncertainty, stochastic considerations are made to optimize the cost of empty containers through the implementation of Dynamic Stochastic Programming (DSP). Additionally, the optimization process includes the implementation of a centralized information and payment system. The aim of both cost optimization and system centralization is to address economic imbalances in the container supply chain by leveraging digitalization.

Figure 2 indicated the shipping system used in this study for empty containers and full containers in national trade. The limitation of this study is that it does not consider the multimodality that occurs after the container arrives at the storage warehouse. Handling costs and penalty costs will be considered due to the loading/unloading of goods at each port and shipments that do not comply with the specified time.

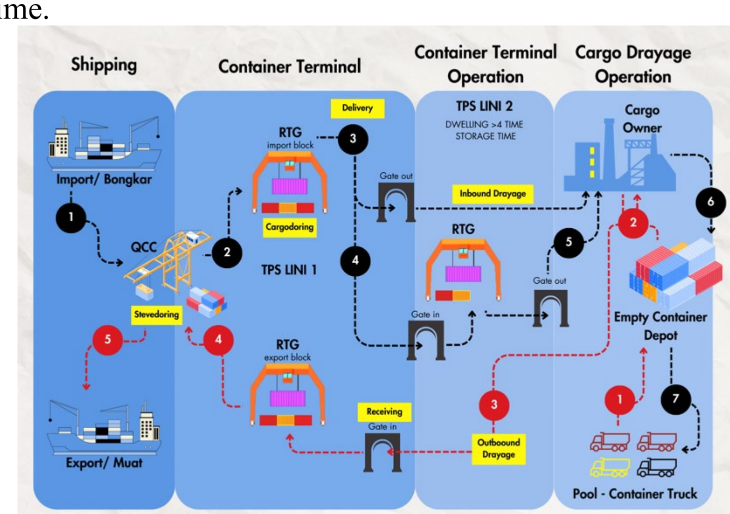


Figure 2 An Empty and Filled Container Shipping System in International Trade

2. LITERATURE REVIEW

According to the existing research, this section conducts a literature review from two aspects the empty allocation problem and cost operational optimum. Research related to the empty container allocation problem can be further divided into two major categories: deterministic and stochastic. In the context of deterministic studies, (Wang & Jing, 2020) is considered as a container. They envisioned that the empty containers could be delivered first to the hub and then to the inland freight stations, taking advantage of the economies of scale of centralized shipping to significantly reduce shipping costs. For example(Jeong et al., 2018)designed a shipping line network considering empty container management and an empty container management strategy for bilateral trade was proposed. (Du, Hu, Zhang, & Meng, 2021) discussed a composite problem combining the schedule of vessels, and cargo routing. The above problem aimed to minimize the total cost (including transportation cost, inventory holding cost, container leasing cost, and container repositioning cost) under the alliance cooperation situation. In contrast, as (Kamal, 2021) pointed out, the structural trade imbalance has an impact on the fluctuation of demand in empty containers. Thus, it is not surprising that a growing number of scholars have focused on the unpredictability of empty container demand and have attempted to address stochastic empty containers in recent decades. (Lu, Lee, & Lee, 2020) investigated simultaneous pricing and empty container decisions considering stochastic demand in two-depot shipping services. They solved the problem by developing a large-scale dynamic programming model.

Table 1 has classified several studies that optimize the placement and use of empty containers using different approaches and parameters. The first study by (Luo & Chang, 2019) applies Dynamic Programming and considers the cost of empty containers at seaports and dry ports, transportation costs, and penalty fees if requests are not fulfilled. The second study by (Eide et al., 2020) used Cplex and a heuristic algorithm by considering the costs at the port and shipping costs. Meanwhile, (Lee & Moon, 2020) utilizes robust optimization and multistage stochastic programming by considering various costs such as transportation costs per unit, empty container repositioning costs, storage costs, and penalty costs. Moreover, (Najafi & Zolfagharinia, 2021) apply robust optimization and consider the cost of moving filled containers, the cost of repositioning empty containers, and the price per unit of transport service. These studies aim to find optimal solutions in the use and management of empty containers in the supply chain. With different approaches and parameters, this research provides important insights for the industry in overcoming complex problems associated with empty container optimization.

Table 1 Classification Method and Parameters Optimization of Empty Container Papers

Author(s)	Method	Parameter
(Luo & Chang, 2019)	Dynamic Programming	- The cost per empty container at the seaport - The cost per empty container at the dry port - The cost of transporting per empty container - The goodwill penalty cost per unmet demand
(Eide et al., 2020)	Cplex & Heuristic algorithm	- Port cost at port - Sailing cost
(Lee & Moon, 2020)	Robust optimization & multistage stochastic programming	- unit transportation cost - unit repositioning cost - holding cost - penalty cost - unit folding cost - unit unfolding cost

Author(s)	Method	Parameter
(Najafi & Zolfagharinia, 2021)	Robust optimization	- The loaded movement cost - The empty Repositioning cost - The unit price of transportation service
This Paper	Dynamic Stochastic Optimum dan Mix Integer Programming toward Travel Salesman Problem	- Storage cost - transport cost - loading/unloading cost - demurrage cost - port cost - Handling cost

Based on a review of the above literature, several studies have examined various variables with stochastics, one of which is demand. However, most of the abovementioned deterministic studies assume that the transportation demand for empty containers is known and constant, making the approaches provided in our paper inapplicable to the empty container. For stochastic studies, the authors assumed that if self-owned containers are not accessible (Chen, et al., 2022). **Table 1** is a classification of methods and parameters used by several studies to optimize empty containers in the last 5 years. Amidst the various concentrations, Luo & Chang optimizes empty containers with dynamic programming on seaports and dry ports by considering the penalty cost for unmet demand. Along a different method, Eide et al use a simple method, namely CPLEX, and Heuristic to optimize shipping costs without considering empty containers. In 2020, in optimizing shipping costs, Lee & Moon chose to use Robust optimization and multistage stochastic in shipping and container repositioning. They consider uncertain things as real situations. Similarly, Najafi and Zolfagharinia use Robust Optimization on costs considering empty containers and repositioning, and then moving which is quite complex. Unfortunately, the event did not take into account the uncertain circumstances that often affect the repositioning of shipments. Considering this with a case study in Indonesia which has problems with container-based logistics costs which are quite high and there is a deficit of empty containers. This further motivated the authors to share the same assumption: the probability distribution function of empty container demand is certain and known. This study fills the above-mentioned research gap by Taking into account the things that have been discussed previously, this study aims to centralize the shipping and payment system for containers at ports in Indonesia by digitalization considering the efficiency shipping and minimalization the logistic cost. The several parameters considered are Storage cost, transport cost, loading/unloading cost, demurrage cost, port cost, and handling cost using Dynamic programming and Mix Integer Programming toward Travel Salesman Problem.

3. METHODOLOGY

3.1 Problem description

In this section, we present the necessary notation to explain mathematically the formulas for Dynamic Programming and Mixed Integer Programming by considering the effective Path using the Travel Salesman Problem. This study aims to minimize shipping costs by considering the balance of empty containers from the merchant side where an optimization approach is needed, and balancing demand based on the level of need with the routes that have been considered. However, it is important to note that mathematical models are only as accurate as the input data and may not always accurately reflect real-world market conditions. This study, it will use actual data from research locations that are expected to resolve national market conditions in Indonesia. In the following section, a consistent formulation of a mathematical problem will be presented. The detailed assumptions for this problem are described as follows:

1. This study proposes a novel methodology that adopts decision variables using Mix Integer Programming and dynamic programming which considers stochastic conditions. Further, the concept is to formulate Travel Salesman Problem (TSP) which analyse the vessel to deliver and pickup containers (empty dan full) considering random demands and effective route.
2. Only inland freight stations are used to load and unload containers. We assume that the demand for empty and full containers at each inland freight station corresponds and is un-normal distributed. It should be noted that activity beyond inland freight station is not allowed. The cost of inland activity are handling costs (containers that arrive to the port), demurrage cost (containers that arrive to port earlier or late), and penalty costs (containers that arrive to port that have quantity more than required and beyond timeline). Additionally, the cost to be charged for the containers are transport cost which considering distance and quantity.
3. Only the container yard has the capacity to keep empty containers. The container yard's operational cost is a strictly monotonic function of the total number of empty containers stored in the yard. In practice, inland freight stations usually have some capacity to store empty containers. However, this capacity is usually very limited. In addition, these empty containers are usually used immediately or transported to the designated yard for inspection, cleaning, or maintenance in practice. In view of this, we assume that only the container yard near the port can be used to store empty containers to simplify the problem (Chen, et al., 2022). Furthermore, we assume that the operational cost of the container yard is a strictly monotonic function of the total number of empty containers stored in the yard. This is because, in practice, the larger the empty container storage inventory in a region, the higher the associated expenses that a carrier must pay (such as operational expenses, empty container depreciation, and management costs).
4. The whole demand and supply for containers must be met. For each inland freight station, the trader must determine the proportion (called the 'utilization rate') of empty containers to the total supply of containers. The utilization rate is also the basis for determining the number of full containers. This assumption derives from the capacity of the vessel and container's yard. Both must have the same amount. If more then it will incur a penalty cost.
5. Traders are the focus of the object in this study. That activity will have the same transportation fee.
6. The capacity of containers is given.

3.2 Route structuring

On this section will be modeled related to the Travel Salesman Problem (TSP) by considering the Route and time for the service by minimizing delays. On this model will be proposed stochastic mixed integer Program for the problem at time t is defined as follows. According to the model used by (Archetti, Feillet, Mor, & Speranza, 2019), this research will be developed for empty and full container shipping routes from several ports in Indonesia by minimizing service time so that there is no delay. Service time that has a tendency is uncertain, so we use a stochastic model to solve it. In this model also enforce subtour by eliminating with it the variable flow u^r_{ij}. Defines that $G = (V, A)$ is a complete graph. Traveling Time and cost related to each $arc(i, j) \in A$. Both values are assumed and quoted as d_{ij}. A set of V vertices is a composition identified as a depot and a set of N of Port and R is a set of routes. At this stage, the objective is to minimize the route and travel time. The Objective function Eq. (1) minimizes the total completion time of travel time and the expected waiting time at the depot. The waiting time is the amount of time spent on the loading, the time spent loading the container, and the time to start the departure to the route $(r + 1)$. Constrain Eq. (2) enters that visits all scheduled ports. Constrain Eq. (3) - Eq. (5), requires that each route is a connected circuit.

$$\min_{d_{ij},Q} D(i,j) = \sum_{r \in R} d_{ij}.x^r_{ij} + E[Q(x,\widetilde{b^t})] \tag{1}$$

state to:

$$\sum_{r \in R} p^r_i = 1 \qquad i \in N_r \tag{2}$$

$$\sum_{j \in V} x^r_{ij} = \sum_{j \in V} x^r_{ji} = p^r_i \qquad i \in N_r \cup \{0\}, r \in R \tag{3}$$

$$\sum_{j \in V} u^r_{ji} - \sum_{j \in V} x^r_{ij} = p^r_i \qquad i \in N_r \cup \{0\}, r \in R \tag{4}$$

$$u^r_{ij} \leq (n-1)x^r_{ij} \qquad (i,j) \in A, r \in R \tag{5}$$

$$x^r_{ij} \leq 1 - x^r_{00} \qquad (i,j) \in A, r \in R\backslash\{|R|\} \tag{6}$$

$$x^r_{00} \geq x^{r+1}_{00} \qquad r \in R\backslash\{|R|\} \tag{7}$$

$$x^r_{ij} \in \{0,1\} \qquad (i,j) \in A, r \in R \tag{8}$$

$$p^r_i \in \{0,1\} \qquad i \in N_r \cup \{0\}, r \in R \tag{9}$$

$$u_{ij} \geq 0 \qquad (i,j) \in A, r \in R \tag{10}$$

A constrain Eq. (5) produces a decreased flow When a ship visits a port, this avoids a subtour. Constrain Eq. (6) is indicating that set $x^r_{00} = 1$ if the route r is empty or no delivery is available, 0 for the rest. Later, the Constrain Eq. (7) shows all routes are empty, but if there are, then the blank route should be done before the route is not emptying. Given a solution that $Q(x, \widetilde{b^t})$ is the waiting time in each port. Waiting time occurs if the start time for the next route is greater than the ending time of the previous one, or if in this case, it is the completion of the process in the Port. The end time of the route is calculated as its starting time plus its travel time. The starting time of a route must be greater than or equal to the release time or notification departure time to the next port in the route and the ending time of the foreseen route. It is known that τ_{start}^{r} and τ_{end}^{r} are the starting and ending times of route $r \in R$. It can be described as follows:

$$\tau_{end}^{r} = \tau_{start}^{r} + \sum_{(i,j)\in A} d_{ij}.x_{ij}^{r} \qquad r \in R \tag{11}$$

$$\tau_{end}^{r} \leq \tau_{start}^{r} \qquad r \in R\backslash\{|R|\} \tag{12}$$

$$\tau_{start}^{r} \geq \tilde{b}^{t}{}_{i} p_{i}^{r} \qquad i \in N, r \in R \tag{13}$$

$$E[Q(x,\widetilde{b^{t}})] = E\left[\sum_{r\in R\{|R|\}} (\tau_{start}^{r+1} - \tau_{end}^{r})\right] \tag{14}$$

From (11) to (12) it follows that the starting time of a route can be computed as:

$$\tau_{start}^{t} = \max\left\{\tau_{end}^{r-1}, \max_{i\in N_r} \widetilde{b_{i}}\right\} \tag{15}$$

Where $N_r \coloneqq \{i \in N_t | p_i^r = 1\}$ is the set of ports served in route r. The objective function Eq. (1) can be calculated as the expected ending time of the last route by considering the process:

$$\sum_{r\in R} \sum_{(i,j)\in A} d_{ij} x_{ij}^{r} + E\left[Q\left(x,\widetilde{b^{t}}\right)\right] = E\left[\tau_{end}^{|R|}\right] \tag{16}$$

3.3 Cost Function Estimation

Objective Eq. (1) and Constraints Eq. (2) - (16) are enough to represent all feasible solutions for the delivery pickup problems. Therefore, to complete the first mathematical model, we define the objective function Eq. (*8*) which minimize the expectation total cost considering the factor of risk of uncertainty toward digitalization.

We consider a vessel network $D(i,j)$, where i and j denote the sets of origin nodes and destination nodes, respectively. Moreover, d_{ij} denotes the path set of OD pair (i,j). We discretize the time period T of interest and the departure time period T_D into finite sets of time intervals $d = \{1,2,\ldots,D\}$ and $d_D = 1,2,\ldots,d_D$. In this section, a nonlinear stochastic programming empty container restoration model (ECRM) is constructed with the objective of minimizing the sum of the expected total cost of empty and full container. Also, the factor of risk uncertainty toward digitalization is considered. The following are notation which adopted for Dynamic Stochastic Programming (DSP) problem for minimum cost operational and minimum factor of risk:

Table 2 Notation of Parameters, Variables, and Decision Variable

Parameters	
P	Number of port

K	Number of Vessel
T	Length of observed period (number of weeks), $t \epsilon \{1,2,3,\dots,T\}$
i	No. port depart, $i = 1,2,3,\dots,P$
j	No. port Arrive, $i = 1,2,3,\dots,P$
C	Total Cost for Empty dan Full Container
TC	Total Cost Container that transported form port i to j
HC	Total Handling Cost that arrived to port j
PC	Total Demurrage Cost that transported from port i to j with time $t - o$
YC	Total Lease Yard Cost in port j with time t
c_{ij}^{t}	Unit cost transport cost from port i to j
c_{ij}^{h}	Unit cost handling cost from port i to j
c_{ij}^{y}	Unit cost container yard in port i
$pc_{i,j,t-o_{i,j,t}}^{EC,FC}$	Unit penalty cost empty and full container that transported from port i to j with time $t - o$
$o_{i,j,t}$	Time it take to go from port i to j arriving at time t
$EC_{i,j,t}^{k}$	The empty container going from port i to j at time t using vessel k
$EF_{i,j,t}^{k}$	The full container going from port i to j at time t using vessel k
$m_{i,t}$	Sum all the container provide by port i at time t
$n_{i,t}$	Sum all the container received by port i at time t
Q_{i}^{p}	Capacity of port i
$K_{cap_{ij}}$	The capacity of Vessel going from port i to j at time t
D_{ij}	Route optimum for delivery/pickup container
u_i	Continuous variable to determine delivery position
h_t	The number of days of provisions existing in port
h_T	Number of days provision
h_p	the amount of time too early and the delay
J_{in_j}	Sum all container that coming in port j
J_{out_j}	Sum all container that out from port j
Y_{cap}	Container yard Capacity
Decision variables	
δ_j	If port j is selected for delivery and pickup containers, $\delta_j = 1$;otherwise, $\delta_j = 0$.
α_j	If port j is selected for to visit, $\alpha_j = 1$; otherwise, $\alpha_j = 0$.
β_j	If container in port j have condition $h_t > h_T$, so $\beta_j = 1$; otherwise, $\beta_j = 0$
γ_j	If container need to load to container yard in port j, so $\gamma_j = 1$; otherwise, $\gamma_j = 0$.

Based on the above-mentioned descriptions and definitions, a DSP model is formulated with the objective of minimizing operational cost both of empty and full containers. The total operational cost are defined depend the containers is empty or full. For the full container have total costs are transportation cost, handling cost, penalty costs, and lease yard cost. In fact, either full or empty container have those complete total cost which to be paid. The total expected costs are computed with Eq. (17). Transportation cost (TC) is a function which have component of unit transportation cost, the container going (empty and full container) from port i to port j at time t with considering expectation of demand, and vessel Network Eq. (1), as computed with Eq.(18). Furthermore, total cost includes penalty cost (PC), which is a function of unit penalty cost and the quantity of container that the container associated with factors such as late or early deliveries and bid adjustment factors, as computed with Eq.(20). In opposite the empty container, the full container also have additional namely handling cost (HC) is a function of unit handling cost and the number of containers that need to be handled. The container has to pay HC at port i (origin charge) and j (destination charge) as computed with Eq.(19). Eventually, containers destined for the port yard must be paid for and await processing namely yard lease cost (YC).

$$\min_{EC,EF,\lambda} C = TC + HC + PC + YC] \tag{17}$$

$$TC = \sum_{ijk} \left(EC_{ijt}^{k} + FC_{ijt}^{k}\right). D_{ij}. c_{ij}^{t} \tag{18}$$

$$HC = \sum_{ijk} \left(EC_{ijt}^{k} + FC_{ijt}^{k}\right). c_{ij}^{h}. \alpha_j \tag{19}$$

$$PC = \sum_{ijk} \left(EC_{ijt}^{k} + FC_{ijt}^{k}\right). pc_{i,j,t-o_{i,j,t}}^{EC,FC}. \beta_j. h_d \tag{20}$$

$$YC = \sum_{ijk} \left(EC_{ijt}^{k} + FC_{ijt}^{k}\right). c_{ij}^{y}. \gamma_j \tag{21}$$

The first group of constraints is to allocate quantity. The Constraints Eq.(22) is definition of the $m_{i,t}$ variables which that sum all the containers provided by a specific port in time. Same as, Eq. (23) is the definition Sum of all the containers received by port i at time $t - o$ which have a potential late or early delivery. The second of constraints is to satisfy demand and feasibility. Constraint Eq. (24) and Eq. (25) are the definition of empty and full containers have to less than Vessel capacity and equal Port capacity, respectively.

The Container at time t Constraint

$$\sum_{i,j}^{P} \left(EC_{ijt} + FC_{ijt}\right) = m_{it} \qquad \forall i, j \in P, \forall t \in T, \tag{22}$$

$$\sum_{i,j}^{P} EC_{i,j,t-o_{i,j,t}}^{k} + \sum_{i,j}^{P} EF_{i,j,t-o_{i,j,t}}^{k} = n_{i,t} \qquad \forall i, j \in P, \forall t \in T, \forall k \in K \tag{23}$$

Constraints Eq. (26) is a feasibility constraint that the total number of containers received at a port plus the number of containers at the start of the day at that port minus the number of containers made available at that port cannot be negative. Constraints Eq. (27) ensure that the sum of all containers which will be sent toward vessel capacity has to less than equal availability of vessel and thus demand is also aggregated. The constraint represented by Eq.(28) states that the total number of containers sent must be less than the expected number of empty containers, to avoid a shortage of empty containers or an excess of empty containers, both of which are not allowed. Concerning to capacity of the yard, Eq. (29) makes clear that the combined movement of both empty and full containers, in terms of entering and exiting, must not exceed the warehouse's capacity.

Demand and Feasibility Constraint

$$\sum_{ijk}\left(EC_{ijt}^{k} + FC_{ijt}^{k}\right) \leq K_{cap}, \qquad \forall i,j \in P, \forall t \in T, \forall k \in K \qquad (24)$$

$$\sum_{ijk}\left(EC_{ijt}^{k} + FC_{ijt}^{k}\right) = Q_{i}^{p}, \qquad \forall i,j \in P, \forall t \in T, \forall k \in K \qquad (25)$$

$$\sum_{ij}\left(J_{ij} + J_{in} - J_{out}\right) \leq K_{Cap} \qquad \forall i,j \in P, \qquad (26)$$

$$\sum_{i}\frac{(EC_{ijt} + EF_{ijt})}{K_{cap}} = \sum_{i} K_i \qquad \forall i,j \in P, \qquad (27)$$

$$\sum_{ij} Q_{ij} \leq E[EC_{ij}] \qquad \forall i,j \in P, \qquad (28)$$

$$\sum (EF_{ijt} + EF_{ijt})_{in} - (EF_{ijt} + EF_{ijt})_{out} \leq Y_{cap} \qquad \forall i,j \in P, \forall t \in T, \qquad (29)$$

The third constraint is to define the time preference for the movement of containers and the condition of the shipping containers are important factors to consider. Constraint Eq. (30) is declared that to avoid a penalty, the absolute value of the time difference between the set time and the current time must be greater than zero. In addition, the current amount must be less than the specified day limit. Moreover, the constraint Eq. (31) explains that the penalty will be determined by the time difference between the existing time and the predetermined time. Finally, the constraint Eq. (32) must be declared as the time of process container moving. The time process at port i plus the time of transport to port j must be less than the equal process in port j. Also, the capacity of vessel that transported the container, must can load empty and full container as ordered.

Time Preference Constraint

$$\sum_{ij}|h_T - h_t|_{ij} \geq 0, \text{ jika } h_t > h_T \qquad \forall i,j \in P, \forall t \in T, \qquad (30)$$

$$h_p = |h_T - h_t| \qquad \forall t \in T, \qquad (31)$$

$$\sum_{i,j}^{P} t_i + t_{i,j} \leq t_j \qquad \forall i, j \in P, \forall t \in T, \qquad (32)$$

The third group of constraints is flow constraints. Eq. (33) and Eq. (34) restrict the number of containers empty and full to be more than zero. Certainly, the Eq. (35) must restrict rate of risk uncertainty regardless of time is to be more than zero and less than one.

$$EC_{i,j,t}^{k}, EF_{i,j,t}^{k} \geq 0 \qquad (33)$$

$$EC_{i,j,t}^{k}, EF_{i,j,t}^{K} \in \mathbb{Z} \qquad (34)$$

$$0 < \lambda_t < 1 \qquad (35)$$

4. ANALYSIS AND DISCUSSION

4.1. Route Optimization

This problem addresses how to efficiently move empty and full containers to reduce the number of vessels that are required to meet demand. As more and more containers pass through ports every year, it becomes increasingly important to efficiently move these containers (Dessouky, Carvajal, & Yao, 2020). By paying attention to the needs of containers today, it is necessary to systematically link the needs and the delivery process to the next day. In this study, we are still considering demand today. Based on this, we simulate minimizing the cost of shipping operations by paying attention to the demand from stochastic empty containers. Then, we also consider the process of shipping containers with vessels adjusted to the supply and demand according to the shipping and pick-up route.

Table 3 Route Optimum Delivery/Pick up The Container Using Vessel from port i to j

	Trip id	Property	Idx_val	x	y
1	Belawan	from	Tanjung Priok	107.122.500	-63.013.889
2	Tanjung Priok	from	Tanjung Perak	112.732.778	-71.966.667
3	Tanjung Perak	from	Banjarmasin	-2.958.333	-29.583.333
4	Banjarmasin	from	Makasar	119.414.444	-51.166.667
5	Makasar	from	Sorong	131.268.333	-0.8861111
6	Sorong	from	Belawan	98.702.500	37.800.000
7	Belawan	to	Belawan	98.702.500	37.800.000
8	Tanjung Priok	to	Tanjung Priok	107.122.500	-63.013.889
9	Tanjung Perak	to	Tanjung Perak	112.732.778	-71.966.667
10	Banjarmasin	to	Banjarmasin	-2.958.333	-29.583.333
11	Makasar	to	Makasar	119.414.444	-51.166.667
12	Sorong	to	Sorong	131.268.333	-0.8861111

Figure 3 shows the result of an analysis using Rstudio 2022 assuming the vessel movements are found at six-port. The route on the table is the optimum using TSP with Mixed Integer Programming which has routes Belawan, Sorong, Makassar, Banjarmasin, Tanjung Perak, Tanjung Priok, and back to base port as describes on **Table 4**

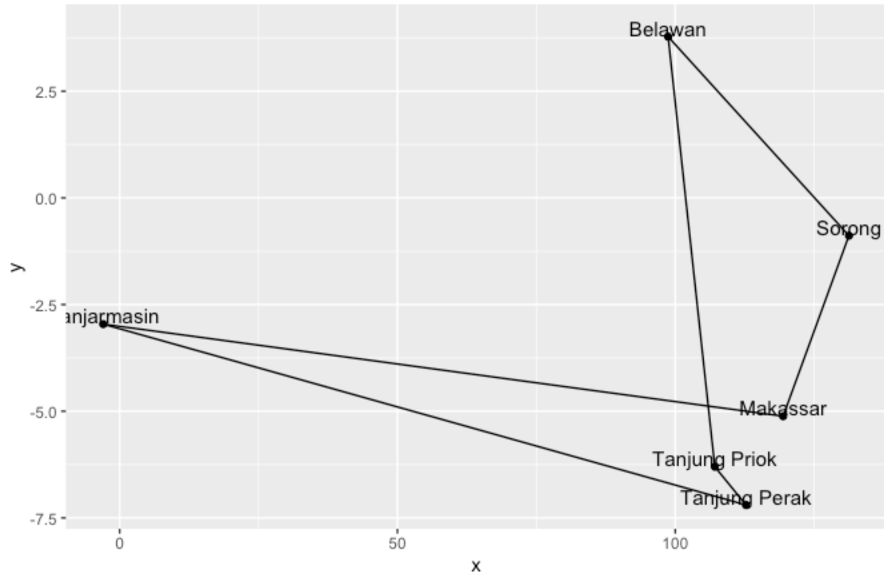


Figure 3 The Result of Mapping Delivery/Pick up The Container Using Vessel from port i to j

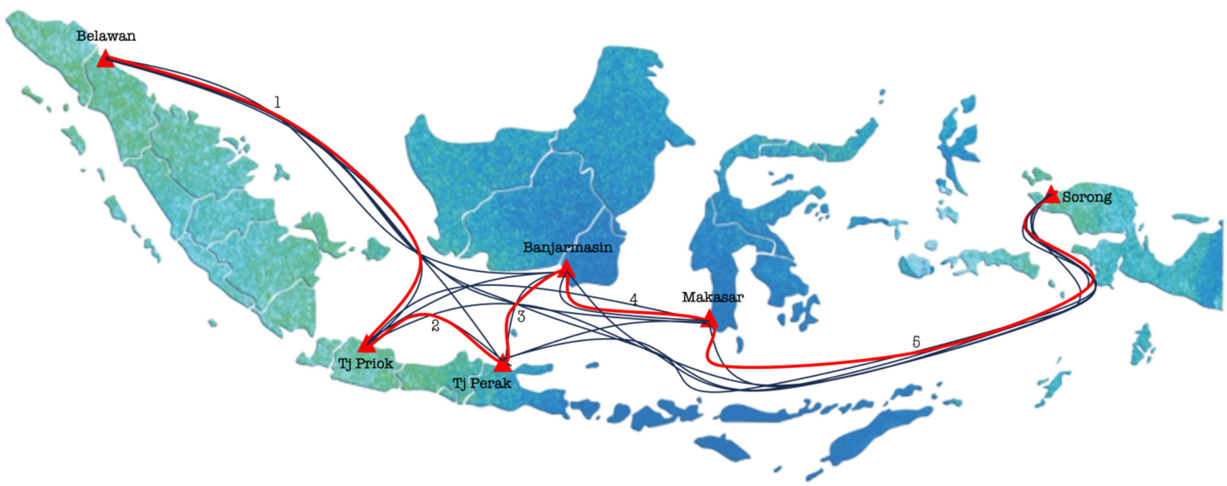


Figure 4 Maps of Route Delivery/Pick Up Based on Existing

With the reduction of unused empty containers, it can improve the economy of a country. This also needs to be supported by the digitization of the system that needs to be developed from each port. The system can track the shortage or excess needs of the container quickly. So that the container deficit and the economy of a port area will be resolved quickly. This also needs support from the local government by adjusting the applicable regulations. Because basically regulations sometimes prevent the problem-solving of empty containers. The digital economy is an economic concept related to the use of digital technology to optimize business processes and create added value in the economy. The digital economy can help overcome the problem of an imbalance between the supply and demand of goods through digital platforms such as marketplaces or e-commerce. In conjunction with empty containers, the digital economy can help optimize the use of ships carrying goods by facilitating international trade through digital platforms. By utilizing these platforms, producers or exporters can market their products to the global market more effectively, while importers can find and order products from various countries more easily. This can help reduce the number of empty containers and increase the overall efficiency of international trade.

In Indonesia already have an application/platform that can solve the problem of integrated container shipping. However, because several parties are part of the delivery service provider, they have not centralized the application. Thus, users will tend to use a different set of websites and platforms for container shipping. Therefore, this results in high costs for shipping containers, both empty and full. The tracking system is also hampered due to differences in these websites, so that not a few users experience penalty fees due to taking too long and arriving goods too early. Also, it hinders the movement of containers and reduces shipping revenue.

4.2. Cost Optimization

Based on Capacity, the vessel used is the Panamax_2400 type with a capacity of 2,400 Teus for container 20' feet. Thus, in order to meet demand, it is necessary to provide several ships that can load the pickup and delivery containers empty and contain. The provisions of each port are assumed that the ship must not exceed 12 days to lean. The average time to rely on for disassembly and sequence is 1 hour/30 containers.

Table 5 Distribution Of Containers Based On Routes And Ship Capacity

Port(s)	Get on*	Get off*	Vessel	Number of Vessel	Capacity	Lean in port**	Over Capacity	Demand
Belawan	8.195	-	8.195	3	8.195	3	True	Match
Tanjung Priok	5.850	2.940	11.104	5	11.104	3	True	Match
Tanjung Perak	5.662	2.317	14.449	6	14.449	2	True	Match
Banjarmasin	1.291	4.411	11.329	5	11.329	2	True	Match
Makasar	0	4.891	6.438	3	6.438	3	True	Match
Sorong	5.456	6.438	5.456	2	5.456	7	True	Match
Makasar	4.849	0	10.306	4	10.306	2	True	Match
Banjarmasin	4.137	260	14.183	6	14.183	1	True	Match
Tanjung Perak	2.511	5.127	11.568	5	11.568	2	True	Match
Tanjung Priok	2.956	6.207	8.316	3	8.316	4	True	Match
Belawan	0	8.316	0	0	0	3	True	Match

**Sum of Empty and Full Container.*
***days/vessel*

Table 5 shows that the container delivery matches the request with the return route. With a total of 6 ships and routes that have been specifically designed to meet the needs, the demand required by numerous ports has been balanced and met. The X image demonstrates this. 61 days is the ideal amount of time to fulfill this need.

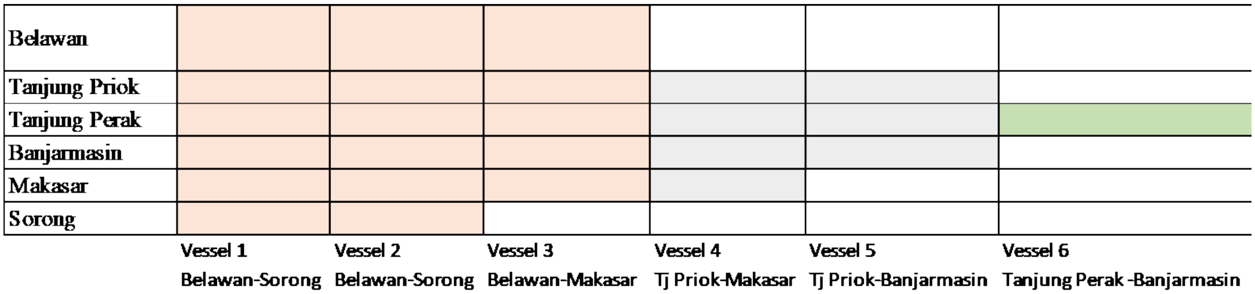


Figure 5 Distribution Of Ships Based On Their Capabilities And Requirements

Table 6 Cost Optimum Delivery/Pick Up The Container

Port(s)	Get On		Get off		TC	HC	PC	YC	Total
	Empty	Full	Empty	Full					
Belawan	2.680	0	5.515	0	1630,46	0,97	-	0,05	1.631,48
Tanjung Priok	3.237	2.231	2.613	709	902,86	1,32	-	0,04	904,22
Tanjung Perak	3.991	1.084	1.671	1.233	597,31	0,97	-	0,04	598,32
Banjarmasin	4	2.899	1.287	1.512	597,53	1,10	-	0,04	598,68
Makasar	0	2.720	0	2.171	2212,65	1,05	-	0,04	2.213,74
Sorong	1.049	979	4.408	5.459	4315,29	2,03	-	0,13	4.317,46
Makasar	2.591	0	2.258	0	320,11	0,57	-	0,02	320,70
Banjarmasin	2.576	24	1.561	235	281,78	0,54	-	0,02	282,34
Tanjung Perak	1.288	3.434	1.224	1.693	944,47	1,40	-	0,04	945,91
Tanjung Priok	2.247	3.595	709	2.613	2761,08	1,69	-	0,05	2.762,82
Belawan	0	2.697	0	5.620	0,00	1,79	-	0,10	1,89

Based on Table 6 empty containers and content, the table above shows the overall cost for each route. If there is no demurrage, as shown in Table 5, then penalty fees are not paid and the transaction reaches its optimal level free of penalty expenses. However, it is vital to take another look at the cost of the penalty because there may be other factors at play in this case.

5. CONCLUSION AND FUTURE WORK

The Dynamic Stochastic Programming (DSP) framework is a mathematical framework used to solve optimization problems over time under uncertainty. It involves modeling a system as a set of equations that describe how the system evolves over time and then using optimization techniques to find the policies or decisions that maximize some objective function over time. In this study, we conduct the cost function in the DSP framework for optimizing the empty container demand and finding the best set of decisions to minimize the total cost of a system. On the Other hand, the global shipping industry is facing a significant challenge with the issue of empty container repositioning, which is related to the regulation of international trade and the growth of the digital economy. The regulation of international trade plays a crucial role in ensuring that the shipping industry operates smoothly and efficiently. The implementation of regulatory measures can help to reduce the costs associated with empty container repositioning and promote sustainability.

Moreover, the digital economy has the potential to enhance supply chain management by providing greater transparency and efficiency and reducing costs. The use of digital technologies can help optimize container flows and reduce the need for empty container repositioning. However, the adoption of digital technologies also requires regulatory frameworks that address issues such as data privacy, security, and interoperability.

The delivery of empty containers and content will be at its best, according to numerical simulations, if routing is done at the right time. As a result of the delay or early delivery, the penalty fee does not display. With the right number of ships, container imbalances were also not discovered. The digitalization of interconnected systems can enable this by enhancing time, routes, and financial expenditures. Costs associated with container logistics will be decreased in this way. Further research may be concerned because, according to this model, it is still unable to identify external events that might affect the penalty fee. Hence, this study is still in the development process.

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