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An Empty Container Reposition Study with Foldable Containers

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Abstract

In order to solve the problem of empty container reposition considered foldable containers, the key factors affecting the use of foldable containers are found out. The mixed integer linear programming model is used to compare the total transportation cost whether install fold/unfold equipment or not. By the sensitivity analysis, factors include installation cost, transportation cost, lease cost, and storage cost, the fold/unfold cost could affect the economy of foldable containers by different degrees. It shows that transportation cost is a key factor affecting the use of foldable containers. When the transportation cost increased by 20%~40%, the total transportation cost of foldable containers in empty container transportation increased by 12.82%, 17.65% and 23.47%, respectively, while the total transportation cost of non-foldable containers increased by 15.86%, 24.34% and 29.06%, respectively. In conclusion, foldable containers is affected by many factors, and it is more economical to use foldable containers with the increase of transportation cost and reduce of the installation cost.

Keywords

Foldable container; Empty container reposition; Equipment installation; Mixed integer linear program.

1. Introduction

As an important cornerstone of import and export trade, shipping industry is a powerful driving force for the development of international economy and trade. Shipping is favored by large importers and exporters because of its large capacity and low cost. Since the advent of the container in the 1950s, the shipping industry has seen another disruptive development.With the characteristics of standardization and simple operation, container transportation promotes the rapid development of trans-regional trade, which in turn promotes the development of containerization. Container liner transportation has become an increasingly important part of maritime transport.

However, international trade is unbalanced. Taking the trans-pacific route as an example, the container cargo flow from Asia to North America in 2016 was about 26 million TEU, while the flow in the opposite westbound direction was only about 10 million TEU.This imbalance leads to an accumulation of empty containers in import-dominated regions (North America) and a shortage of empty containers in export-dominated regions (Asia).At the same time, because the current container management is not scientific and reasonable, some system factors and human factors have led to the flow of containers is not smooth, resulting in a large number of empty containers from the surplus of empty containers to the shortage of empty containers, that is, the problem of empty container reposition. According to the statistics of Drewry in 2017, the global full container transportation reached nearly 560 million TEU, while the empty container reposition also reached 180 million TEU, accounting for about 24% of the total container transportation.

At present, the effective management of empty containers has become one of the focuses of the shipping industry and one of the key factors for the sustainable and steady development of international trade. Empty container reposition not only wastes a lot of container resources, but also causes the increase of container transportation cost of liner shipping companies, which seriously

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affects the economic benefits of enterprises and becomes the bottleneck for shipping companies to accelerate the pace of market development.Especially now that the shipping market is seeking recovery, shipping companies are pursuing cost-effectiveness, the problem of empty container reposition is becoming more prominent. In the backdrop of the container transport routes of trade imbalance, empty container reposition is inevitable. Although reasonable dispatching empty container can not bring direct benefits for shipping companies, but effective scheduling is not only beneficial to the balance between supply and demand of empty container liner companies and leasing company, , but also decrease the empty container storage space and the flow of empty containers, this is also a powerful relieve the port city of traffic jams.Therefore, it is of great practical significance to study the optimization of empty container reposition.

As a traditional hot issue, empty container reposition has been attracting the research of domestic and foreign scholars. At the earliest, White[1] built a dynamic network model for empty container reposition in railway transportation process, which started the research on empty container reposition.

In the existing literature research, there are three aspects of certainty, randomness and fuzziness, aiming at the characteristics of container supply and demand. Meng[2] is according to the real shipping network ports , determining the demand and supply of empty containers with full outflow and inflow of difference. Considered MPC and H&S in the design of network, set up a mixed integer linear programming model, and compares the different network, found that network is better than that of a single form of network design combination. Han etc[3] thought empty containers demand in the process of empty containers reposition is uncertainty, built the empty containers model under the constraint of probability ,at the same time considering the credibility cost due to lack of container, found that comprehensively consider the joint optimization of reposition and credit costs relative to a single optimization has certain advantages and has more practical meaning.

Westarp etc[4] thought that due to seasonal and market factors, such as the freight rates, units available container quantity and available container number are a fuzzy variable , and exist in the actual operating limits on carbon emissions, considering the short-term and medium-term target respectively different fuzzy linear programming model is established, and found a certain condition, the load of empty container is more economical. Jiang et al.[5]considered the fuzziness of the gap between the demand and supply of empty containers at the port and the constraint of the transport capacity, and established a fuzzy planning model for the transport of empty containers at sea with the goal of minimizing the total cost of the transport of empty containers, which can effectively reduce the transport cost of liner companies.

The selection of renting strategy has also become the focus of scholars. Zheng et al. [6] established a two phase optimization model based on multiple liner companies, and through reverse optimization technology for empty container liner companies exchange costs, i.e. the perceptive price of empty container in different ports, comparing with the container leasing prices can choose the corresponding strategy. At the same time, using different number of liner companies, found that cooperation between liner companies have stability. Also, Zheng et al. [7] further considered the substitution of different container types in the transportation strategy, and the comparison of container leasing prices in the mixed integer nonlinear programming model is more realistic.

Based on the development of the transformation from stochastic chance constraint to deterministic constraint, Francesco et al. [8] studied the problem of empty container reposition in multiple ports by using stochastic constraint programming, and carried out robust analysis to reduce the risk caused by the uncertainty of empty container demand. Chen et al. [9] study on the basis of comprehensive consideration, established a liner shipping space leasing mode based on stochastic chance-constrained programming, through sensitivity analysis found that the unit freight rate, available shipping capacity and total number of refrigerated outlets were positively correlated with the total revenue of the alliance, shipping cost was negatively correlated with alliance total revenue, the alliance space leasing fees does not affect the total revenue.

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In order to reduce the cost more effectively, the use of foldable containers is also included in the model design of the researchers. Although foldable containers have the same storage capacity and size as standard containers, and foldable containers only account for a quarter of the storage space of standard containers in the folded state, the high purchase cost of foldable containers and the expenses incurred in folding and unfolding during transportation require consideration. Wang et al.[10] showed the economy and feasibility of foldable containers while making the ship type decision on the optimization of the empty heavy container transportation, and pointed out the profitable situation of the use of foldable containers. In addition, the spare time of customer unpacking is also considered.Under the condition that container demand and supply are determined, Myung et al. [11] established a multi-port multi-stage network flow model, taking into account foldable containers and standard containers , and found that the consideration of foldable containers and the proposed network flow model can effectively save cost for liner companies. Zhao et al. [12] combined the uncertain demand with the use of foldable containers, and found that the use of foldable containers has certain economic advantages in the case of peak season for empty containers or long-distance transportation between inland ports. However, the leasing cost has the greatest impact on the use of foldable containers, and when it is reduced by more than 20%, it is more reasonable to invest in foldable containers.

The above researches contribute to the study of empty container reposition, but they did not consider the equipment of folded/unfolded for foldable container. So in this paper, in order to achieve the goal of minimizing the total transportation cost of empty container, an optimal transportation model is established, and a mixed integer linear programming is adopted to accurately solve the model, so as to evaluate the feasibility of using foldable container and explore the key factors affecting the use of foldable container.

The outline of the paper is as follows. In Section 2, the optimal problem is more formally described and develops a mixed integer linear programming model for the proposed problem. Section 3 carries out example simulation based on reality problems, followed by concluding remarks in Section 4.

2. Model Formulation

2.1 Problem Description

In this paper, the optimization of empty container reposition is studied from the point of standard empty container and foldable container. The model considers that there are some demand ports and some supply ports in the shipping system, study the empty container reposition based on the transfer period. The supply port provides the demand port with standard empty containers, unfolded empty containers and folded empty containers within each period, but only the two ports that have the unfold/fold equipment installed at the same time can transport the foldable containers. At the same time, supply ports can not transfer empty containers to each other, demand ports can not transfer empty containers to each other. This paper aims to find out the key factors affecting the total cost by minimizing the total cost of empty container reposition, and to provide a theoretical basis for practical application.

2.2 Assumptions

(1) The supply and demand of the port are determined in each period.

(2) The folded volume of four foldable containers is equivalent to one standard container.

(3) All the containers are 20 TEU.

(4) The demand must be met. If it cannot be met through transportation, we can consider renting containers. The leasing containers are not considered to be returned within a single period, and there is no upper limit on the quantity of the leasing containers.

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2.3 Symbol Description

Sets

D The set of deficit ports in the system

S The set of surplus ports in the system

T The set of periods in the system

Parameters

C_{ij}^{TS} Unit transport cost of standard, unfolded empty container from port i to port j

C_{ij}^{TF} Unit transport cost of folded empty container from port i to port j

B_i Cost of installation of fold/unfold equipment at port i

C_i^{HS} Unit handling cost of standard empty container, unfolded empty container at the port i

C_i^{HF} Unit handling cost of folded empty containers at port i

H_i^S Unit storage cost of standard empty container, unfolded empty container at port i

H_i^F The unit storage cost of folded empty container at port i

R_j^S Unit standard empty container lease cost at port j

R_j^F Unit foldable empty container lease cost at port j

P_i^{fold} Unit folding cost at port i

P_i^{unfold} Unit unfolding cost at port i

S_{it}^s Supply of standard empty container at port i in period t

S_{it}^U Supply of unfolded empty container at port i in period t

S_{it}^F Supply of folded empty container at port i in period t

D_{jt} Demand of empty containers at port j in period t

U_{ijt} The maximum empty container transport quantity from port i to port j in period t

The decision variables

X_{ijt}^s The volume of standard empty container from port i to port j in period t

X_{ijt}^U The volume of unfolded empty container from port i to port j in period t

X_{ijt}^F The volume of folded empty container from port to port j in period t

L_{jt}^s The volume of the standard empty container leasing at port j in period t

L_{jt}^F The volume of the foldable empty container leasing at port j in period t

I_{it}^s Average storage capacity of standard empty container at port i in period t

I_{it}^U Average storage capacity of unfolded empty container at port i in period t

I_{it}^F Average storage capacity of folded empty containers at port i in period t

G_{it}^{fold} The volume of empty containers that port i needs to fold in period t

G_{it}^{unfold} The volume of empty containers that port i needs to unfold in period t

K_i Binary variable: 1 means installation of unfold/fold equipment in port i, 0 means installation of unfold/fold equipment in port i

2.4 Mathematical Model

The shipping network model based on empty container reposition and foldable container is as follows:

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$$
\begin{aligned}
&+\sum_{t=1}^{T}\sum_{j=1}^{D}\sum_{i=1}^{S}\left[C_{ij}^{TS}\left(X_{ijt}^{s}+X_{ijt}^{U}\right)+C_{ij}^{TF}X_{ijt}^{F}\right]\\
&\quad+\sum_{t=1}^{T}\sum_{j=1}^{D}\sum_{i=1}^{S}\left[\left(C_i^{HS}+C_j^{HS}\right)\left(X_{ijt}^{s}+X_{ijt}^{U}\right)+\left(C_i^{HF}+C_j^{HF}\right)X_{ijt}^{F}\right]\\
&\quad+\sum_{t=1}^{T}\sum_{i=1}^{S}\left[H_i^{S}\left(I_{it}^{S}+I_{it}^{U}\right)+H_i^{F}I_{it}^{F}\right]+\sum_{t=1}^{T}\sum_{j=1}^{D}\left[H_j^{S}\left(I_{jt}^{S}+I_{jt}^{U}\right)+H_j^{F}I_{jt}^{F}\right]\\
&\quad+\sum_{t=1}^{T}\sum_{j=1}^{D}\left[R_j^{S}L_{jt}^{s}+R_j^{F}L_{jt}^{F}\right]+\sum_{t=1}^{T}\sum_{i=1}^{S}\left[P_i^{fold}G_{it}^{fold}+P_i^{unfold}G_{it}^{unfold}\right]\\
&\quad+\sum_{t=1}^{T}\sum_{j=1}^{D}\left[P_j^{fold}G_{jt}^{fold}+P_j^{unfold}G_{jt}^{unfold}\right] \qquad (1)
\end{aligned}
$$

S.T.

$$I_{it}^{S}=I_{it-1}^{S}+S_{it}^{s}-\sum_{j=1}^{D}X_{ijt}^{s}\text{，}\ \forall i\text{，}\ t \qquad (2)$$

$$I_{it}^{U}+I_{it}^{F}=I_{it-1}^{U}+I_{it-1}^{F}+S_{it}^{U}+S_{it}^{F}-\sum_{j=1}^{D}X_{ijt}^{U}-\sum_{j=1}^{D}X_{ijt}^{F}\text{，}\ \forall i\text{，}\ t \qquad (3)$$

$$I_{jt}^{S}+I_{jt}^{U}+I_{jt}^{F}=I_{jt-1}^{U}+\sum_{i=1}^{S}X_{ijt}^{s}+L_{jt}^{s}+I_{jt-1}^{U}+I_{jt-1}^{F}+\sum_{i=1}^{S}X_{ijt}^{U}+\sum_{i=1}^{S}X_{ijt}^{F}+L_{jt}^{F}-D_{jt}\text{，}\ \forall j\text{，}\ t \qquad (4)$$

$$S_{it}^{U}+S_{it}^{F}-\sum_{j=1}^{D}X_{ijt}^{U}-\sum_{j=1}^{D}X_{ijt}^{F}-G_{it}^{fold}\le M(1-K_i)\text{，}\ \forall i\text{，}\ t \qquad (5)$$

$$D_{jt}-S_{it}^{S}-S_{it}^{U}-S_{it}^{F}-G_{it}^{unfold}\le M(1-K_i)\text{，}\ \forall i\text{，}\ j\text{，}\ t \qquad (6)$$

$$G_{it}^{unfold}\le I_{it}^{F}\text{，}\ \forall i\text{，}\ t \qquad (7)$$

$$G_{jt}^{unfold}\le I_{jt}^{F}\text{，}\ \forall j\text{，}\ t \qquad (8)$$

$$D_{jt}-\sum_{i=1}^{S}X_{ijt}^{s}-\sum_{i=1}^{S}X_{ijt}^{U}-\sum_{i=1}^{S}X_{ijt}^{F}-G_{jt}^{unfold}\le M\left(1-K_j\right)\text{，}\ \forall j\text{，}\ t \qquad (9)$$

$$X_{ijt}^{s}+X_{ijt}^{U}+\frac{1}{4}X_{ijt}^{s}\le U_{ijt}\text{，}\ \forall i\text{，}\ j\text{，}\ t \qquad (10)$$

$$\sum_{i=1}^{S}X_{ijt}^{s}+\sum_{i=1}^{S}X_{ijt}^{U}+\sum_{i=1}^{S}X_{ijt}^{F}+L_{jt}^{s}+L_{jt}^{F}+I_{jt}^{S}+I_{jt}^{U}+I_{jt}^{F}\ge D_{jt}\text{，}\ \forall i\text{，}\ j\text{，}\ t \qquad (11)$$

$$X_{ijt}^{F}\le MK_iK_j\text{，}\ \forall i\text{，}\ j\text{，}\ t \qquad (12)$$

$$I_{it}^{U}\le M(1-K_i)\text{，}\ \forall i\text{，}\ t \qquad (13)$$

$$I_{it}^{F}\le MK_i\text{，}\ \forall i\text{，}\ t \qquad (14)$$

$$I_{jt}^{U}\le M\left(1-K_j\right)\text{，}\ \forall j\text{，}\ t \qquad (15)$$

$$I_{jt}^{F}\le MK_j\text{，}\ \forall j\text{，}\ t \qquad (16)$$

$$K_i=\{0,1\}\text{，}\ \forall i \qquad (17)$$

$$X_{ijt}^{s}\text{，}\ X_{ijt}^{U}\text{，}\ X_{ijt}^{F}\text{，}\ L_{jt}^{s}\text{，}\ L_{jt}^{F}\text{，}\ I_{it}^{s}\text{，}\ I_{it}^{U}\text{，}\ I_{it}^{F}\text{，}\ G_{it}^{fold}\text{，}\ G_{it}^{unfold}\in N\text{，}\ \forall i \qquad (18)$$

Objective equation (1) refers to the total cost in the process of empty container reposition, including installation cost, transportation cost, loading and unloading cost, storage cost, leasing cost and folding and unfolding cost.Equations (2) and (3) are that the empty container storage capacity for the port shall be equal to the storage capacity of the previous period plus the remaining empty containers after the supply. Equation (4) shows the empty container storage capacity of the demand port shall be equal to the storage capacity of the previous period plus the empty container shipped from the supply port in this period and the leasing container in this period minus the demand for the empty container in this period. Equation (5) indicates that the empty containers that need to be folded up for storage at the port in this period should be less than or equal to the remaining empty foldable containers in this period. Equation (6) indicates that the empty containers needed to be unfolded from the inventory to the port in this period shall be less than or equal to the quantity of insufficient supply in this period. Equation (7) and (8) represents the unfold/fold constraint. Equation (9) indicates that the empty folding containers needed to be folded from the supply port inventory in this period shall be less than or equal to the quantity in short supply in this period. Equation (10) indicates that the capacity constraint should be greater than or equal to the sum of standard empty container transport quantity, the unfolded empty container transport quantity and 1/4 folded empty container transport quantity. Equation (11) represents the demand of the port to meet the demand of each period. Equation (12-16) indicates that only when there is equipment in the port can the foldable empty containers be transported and stored in the state of folded; otherwise, the storage and transportation can only conduct in the state of unfold. Equation (17) is binary variable, indicating whether the equipment is installed or not.

3. Example Analysis

3.1 Example Solution

In order to verify our transport model, a numerical example is used to solve the problem. To simplify the model, there are 2 supply ports in the assumed transport system, which can provide standard empty containers and foldable empty containers every period. Also there are 3 demand ports with corresponding empty container demand in each period. The planning period of this model is appropriately set as 3T to simplify the model and meet the needs of the model simulation environment. Container transportation generally opens weekly routes, so it is 3 weeks. Various ports of transportation between ports are completed within a planned time period. The initial cost of equipment installation was $30,000 / year, which was based on the research of Ilkyeong Moon[13] and others. In this paper, the cycle is considered to be 3 weeks, so the installation cost of each equipment is 3000 USD according to the time allocation.

The supply and demand of empty containers at each port within the planned cycle are shown in Table 1, and the transportation cost per unit empty container per cycle is shown in Table 2, which S means standard container, U means unfolded container, F means folded container . Among them, the transfer cost of foldable empty containers in folded state is 1/4 of that of standard empty containers, which is in line with the actual situation. Related costs are shown in Table 3. The leasing cost of folding empty containers is 1.6 times that of standard empty containers. Standard empty containers cost $48 to store, four times the cost of folding empty containers. The average handling and fold/unfold costs are $2, 5, respectively, with adjustments allowed. The capacity limit is shown in Table 4, which is in line with the actual situation.

Table 1. Demand and Supply of empty containers for each port (TEU)

Port	T = 1	T = 2	T = 3
D_1	42	40	54
D_2	40	50	45
D_3	50	45	49
S_1(S)	30	25	30
S_1(U)	20	10	15
S_1(F)	35	25	20

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S_2(S)	40	30	35
S_2(U)	10	15	15
S_2(F)	23	30	25

Table 2. Unit empty container reposition cost (USD)

	D_1	D_2	D_3
S_1(S)	140	180	160
S_1(U)	35	45	40
S_2(S)	180	140	200
S_2(F)	45	35	50

Table 3. Cost structure for each empty container (USD)

	S_1	S_2	D_1	D_2	D_3
Hire (S)			180	200	200
Hire (F)			288	320	320
Hold (S)	48	48	48	48	48
Hold (F)	12	12	12	12	12
Load/Unload	1	4	3	3	2
Fold/Unfold	4	6	6	5	7

Table 4. Unit empty container reposition cost (USD)

	D_1	D_2	D_3
S_1	35	40	40
S_2	40	30	45

Here we used the MATLAB to establish the model, and the model was optimized and solved on a computer configured with CORE i5 8250U, main frequency 1.60GHZ and 8GB of memory. The total cost of empty container transportation is shown in Table 5.

It can be seen from Table 5 that the total transportation cost is $43,345 when the equipment is installed, and $69,055 when the equipment is not installed. The cost of 37.23% when the equipment is installed is saved compared with that when the equipment is not installed. This is because without the equipment, supply ports can only transport empty containers to demand ports with standard empty containers and unfolded empty containers, but if the equipment is installed between the supply ports and demand ports, the foldable containers can be transport in the state of folded, so the total cost gap is mainly due to the use of foldable empty containers in the process of reposition.

It shows that the container leasing cost in the reposition without the use of foldable containers would be higher than under the condition of using foldable containers, especially the difference of transport cost is significant, the reason is that the volume of folded containers in the transportation just

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equivalent to 1/4 of standard containers, so to reduce more empty container reposition costs under capacity constraints, and meet the demand better. The cost of leasing empty containers is much higher than the cost of transportation. The supply port can meet the demand of the port to the maximum extent under the restriction of transportation capacity, so as to reduce the cost of leasing empty containers at the demand port, reduce the storage cost, speed up the circulation of empty containers, and minimize the total cost of transporting empty containers, especially in the first period.

Table 5. Reposition result and cost structure

	Without Equipment			With Equipment		
	T = 1	T = 2	T = 3	T = 1	T = 2	T = 3
Allocation(TEU)	$42(S_1, D_1)$	$30(S_1, D_1)$	$32(S_1, D_1)$	$10(S_1, D_1)$	$42(S_1, D_1)$	$45(S_1, D_1)$
	$15(S_1, D_2)$	$6(S_1, D_2)$	$2(S_1, D_2)$	$15(S_1, D_2)$	$8(S_1, D_2)$	$0(S_1, D_2)$
	$23(S_1, D_3)$	$30(S_1, D_3)$	$28(S_1, D_3)$	$30(S_1, D_3)$	$20(S_1, D_3)$	$23(S_1, D_3)$
	$25(S_2, D_1)$	$10(S_2, D_1)$	$17(S_2, D_1)$	$28(S_2, D_1)$	$0(S_2, D_1)$	$5(S_2, D_1)$
	$5(S_2, D_2)$	$5(S_2, D_2)$	$16(S_2, D_2)$	$22(S_2, D_2)$	$25(S_2, D_2)$	$20(S_2, D_2)$
	$0(S_2, D_3)$	$16(S_2, D_3)$	$22(S_2, D_3)$	$8(S_2, D_3)$	$35(S_2, D_3)$	$25(S_2, D_3)$
Lease	$0(D_1)$	$0(D_1)$	$0(D_1)$	$0(D_1)$	$0(D_1)$	$0(D_1)$
	$12(D_2)$	$0(D_2)$	$20(D_2)$	$12(D_2)$	$0(D_2)$	$0(D_2)$
	$0(D_3)$	$0(D_3)$	$12(D_3)$	$0(D_3)$	$0(D_3)$	$0(D_3)$
Hold	$4(S_1)$	$30(S_1)$	$2(S_1)$	$4(S_1)$	$42(S_1)$	$10(S_1)$
	$4(S_2)$	$10(S_2)$	$2(S_2)$	$4(S_2)$	$34(S_2)$	$4(S_2)$
	$6(D_1)$	$2(D_1)$	$6(D_1)$	$6(D_1)$	$8(D_1)$	$4(D_1)$
	$5(D_2)$	$3(D_2)$	$4(D_2)$	$5(D_2)$	$12(D_2)$	$2(D_2)$
	$6(D_3)$	$2(D_3)$	$5(D_3)$	$6(D_3)$	$8(D_3)$	$2(D_3)$
Transportation cost(USD)		56480			30120	
Leasing cost		7960			7420	
Hold cost		2980			3960	
Handling cost		1635			1749	
Fold/unfold cost		0			96	
Total cost		69055			43345	
Transportation/Total		81.75%			69.495	

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The results of the model show that whether empty foldable containers are transported or not has a certain influence on the total cost of transportation. In order to further explore the economy of installation equipment and folding container, the following factors are analyzed.

3.2 Sensitivity Analysis

(1) Variation analysis of container leasing cost

When the empty container reposition cannot meet the demand of the port, it needs to choose to lease containers. See Figure 1 for the impact of the variation of container leasing cost on the total cost. When the container leasing cost increases by 10% ~ 50% without changing the empty container transportation, the total cost of standard containers is 65006, 65472, 65912, 64547, 66781 USD, and the total cost of foldable containers is 50442, 50766, 51090, 51414, 51738 USD, respectively. The total cost of foldable containers is less than the total cost of standard containers, and the growth rate is less than standard containers, which is more obvious in 40% ~ 50%, indicating that foldable container has advantages in the process of empty container transportation.

(2) Variation analysis of equipment installation cost

Without changing the condition of empty container reposition, equipment installation cost will be reduced with the progress of science and technology. When the equipment installation cost is reduced by 10% ~ 30%, the total cost is 46695, 45745, 44795 USD, and the total cost reduction ratio is 2.30%, 4.30% and 6.30% respectively, contributing to the total cost reduction.

(3) Variation analysis of transportation cost

Transportation costs for oil prices will rise, when the transport costs increase 10% ~ 50%, the cost of standard containers the foldable containers is shown in Figure 2, the total cost is on the rise and the growth rate of standard containers move faster than the rate of foldable containers, foldable containers with the increase of transport cost shows more obvious advantages, so using the foldable containers in the empty container reposition is economic.

(4) Variation analysis of storage cost

The storage space of port is limited, and the unit storage cost is also increasing gradually. When the storage cost increases by 10% ~ 50%, the total cost of foldable containers increases faster than that of standard containers, and the storage cost only accounts for a small part of the total cost, so it has little impact on the economy of foldable containers.

(5) Variation analysis of fold/unfold cost

With the development of technology and the improvement of supporting facilities, fold/unfold cost will reduce, which will make foldable containers more economical. When the fold/unfold cost is reduced by 10% ~ 50%, the total foldable container cost does not decrease significantly, and the fold/unfold cost accounts for a small proportion in the total cost, so it is not a key factor affecting the foldable containers.

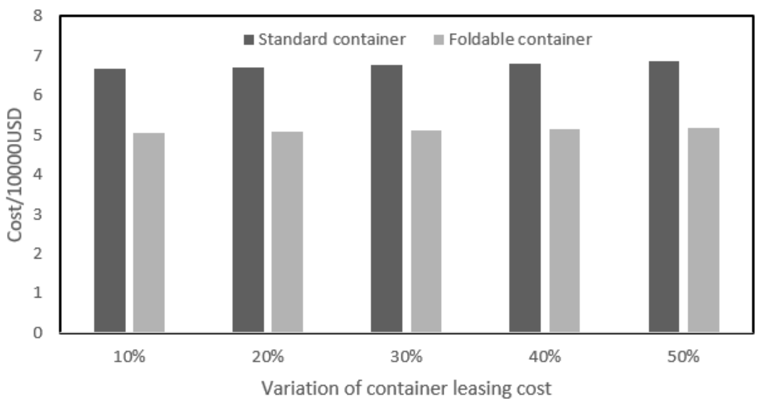

Figure 1. Influence of variation of container leasing cost

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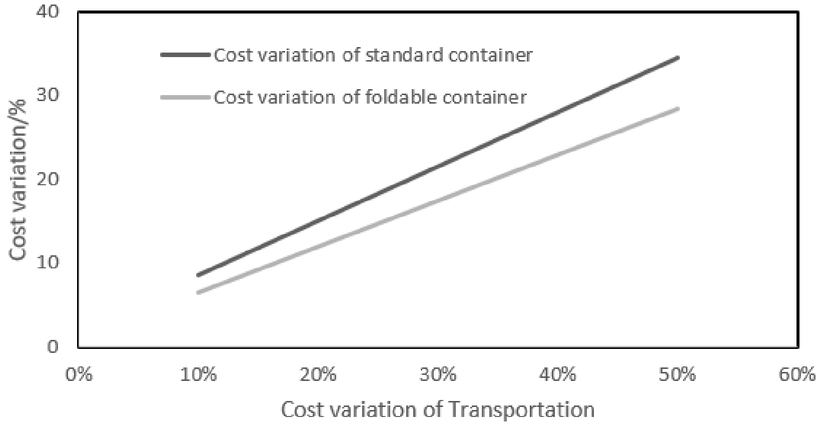

Figure 2. Influence of variation of transportation cost

4. Conclusion

This paper evaluates the feasibility of foldable containers in empty container reposition, compares the total cost of whether to use foldable containers, and analyzes the factors affecting the use of foldable containers. When the transportation cost increases by 10% ~ 20%, the foldable containers has a slight advantage over the standard containers, but when the transportation cost gradually increases to 20% ~ 40%, the foldable containers has a more obvious advantage over the standard containers. At the same time, equipment installation cost has a greater impact on the use of foldable containers than other residual factors, which cannot be ignored. The model in this paper can be used as a reference for shipping companies to make empty container reposition decisions. In addition, standard containers and foldable containers in the model are involved in transportation to better simulate the real situation. In this paper, the model is established under the condition of long-term container leasing, and the container returning problem in the model period is not considered. Meanwhile, the paper do not consider the full containers, which is more realistic In the future, the dynamic of container leasing will be studied and the full containers will be considered in the study.

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