AN OPTIMAL SLOT ALLOCATION IN INTRA ASIA SERVICE FOR LINER SHIPPING

Cheng-Min FENG  
Professor  
Institute of Traffic and Transportation  
National Chiao Tung University  
4F, No.114, Sec.1 Chung Hsiao W. Road  
100, Taipei, Taiwan, R.O.C.  
Fax: +886-2-2349-4965  
E-mail: cmfeng@mail.nctu.edu.tw

I-Chang CHOW  
Associate Professor  
Department of Urban Planning  
Feng Chia University  
P.O. Box 25-76  
40724, Taichung, Taiwan, R.O.C.  
Fax: +886-4-2451-8101  
E-mail: chowic@fcu.edu.tw

Chia-Hui CHANG  
Candidate for doctor’s degree  
Institute of Traffic and Transportation  
National Chiao Tung University  
4F, No.114, Sec.1 Chung Hsiao W. Road  
100, Taipei, Taiwan, R.O.C.  
Fax: +886-2-2349-4965  
E-mail: emmatpe168@trat.com.tw

Abstract: In practice, liner shipping company pursues to fully load cargo on vessel. It has brought about argument for slot allocation between shipping agencies in booming market and ignored the revenue management to maximize profit for liner shipping company. Especially in Asia service, the service route is designed to call more ports, it is an important issue to make a slot allocation which determined the slot to different port-pairs to increase profit and provide shipping agencies a rule to follow. This paper presents an optimal slot allocation in intra Asia service for liner shipping. The slot allocation model is formulated through mathematical programming to maximize operational profit (freight revenue minus variable cost) with the consideration of revenue management. We illustrate this slot allocation model with a case study of Taiwan liner shipping company and the results show the applicability and better performances than the previous allocation used in practice.

Key Words: liner shipping, slot allocation, revenue management

1. INTRODUCTION

In intra Asia liner shipping, the service route is designed to call more ports. Given the service route, the vessel needs to load and discharge cargo and the sequence for the cargo operation is to discharge some of cargoes onboard before it again starts loading in every calling port. Fagerholt and Christiansen (2000) presented a bulk ship scheduling problem that is a combined multi-ship pickup and delivery problem with time windows (m-PDPTW) and multi-allocation problem. Revenue management (also known as yield management) is used to find optimal inventory allocation and scheduling strategies as well as price setting for perishable assets so as to maximize revenue with the planning horizon (Lai and Ng, 2005). It is a broad term that describes how a service provider can secure higher revenues from its relatively fixed capacity. Although it has been successfully applied in airlines, car rental firms, cruise lines, restaurants, and hotels (Berman, 2005), it is not popular in liner shipping. Ting and Tzeng (2004) presented revenue (yield) management systems to increase profits by using slot allocation in long haul service for liner shipping. It is different in service route between long haul service and intra Asia service. This paper proposes an optimal slot
allocation intra Asia service for liner shipping.

Slot allocation involved two stakeholders, one is liner shipping company, the other one is shipping agency. Liner shipping company obtains freight revenue by delivering cargo on container vessel. For the widespread business around the world, liner shipping company depends on shipping agency in port or country to solicit cargo that obtains commission from ocean freight. In practice, liner shipping company often pursues to fully load cargo on the vessel. It has brought about argument for slot allocation between shipping agencies in booming market and ignored the revenue management to maximize profit. Consequently, liner shipping company cannot gain reasonable profit and even get a deficit, if the freight revenue in next calling port is higher than that in first calling port. In standpoint of shipping agency, they just obtain commission from ocean freight and look forward to load more and more cargo. Therefore, the shipping agency in first calling port has opportunity to load more cargo on vessel in result that the other shipping agency in next calling port doesn’t have enough space to load cargo which has already been arranged. The shipping agency in next port loses commission and has to deal with the customer complaint. Another situation, the space or slot is the most perishable inventory, as long as the vessel departure port, the unsold space revenue right there will be none. Liner shipping company has to build up revenue management to maximize voyage profit by means of slot allocation that allocates slot for port-pairs of higher operational profit and provide shipping agency a rule to follow.

This paper proposes an optimal slot allocation with consideration of revenue management and vehicle routing problem with pick-up delivery in intra Asia for liner shipping. The slot allocation model is formulated through mathematical programming to maximize operational profit (freight revenue minus variable cost). We illustrate the model with a case study of Taiwan liner shipping company.

2. OPTIMAL SLOT ALLOCATION MODEL

The purpose of this paper is to build an optimal slot allocation model for fully utilizing slots and at the same time getting maximize operational profit for liner shipping. In this section, we first describe the problem, discuss the assumptions and then provide the model formulation.

2.1 Problem Description

Liner shipping company should secure higher freight revenue for port-pair from fixed vessel capacity by using slot allocation through revenue management. For example, there is one vessel sailing from port A, port B, port C to port D and it has capacity of 100 TEUs. The freight revenue for port-pairs is list on figure 1. In scenario 1, liner shipping company would load 100 TEUs from port A to port D directly and gain total freight revenue $215,000. The shipping agencies in port B and port C didn’t have any slot allocation to load cargo. It achieves to fully load for liner shipping company but it could damage the market activity and lost customer in port B and port C and didn’t obtain maximize freight revenue for this voyage. In scenario 2, it arranged to load 100 TEUs form port A to port B and 100 TEUs from port B to port C then 100 TEUs from port C to port D. Liner shipping company fully utilizes every port-pair to create higher total lifting and total freight revenue. But it had risk in cargo demand for every port-pair. If the cargo demands for port-pair were less than vessel capacity, the unsold space freight revenue was gone. In Scenario 3, it often happened in practice to
load and discharge cargo in every port. Liner shipping company should utilize revenue management system to increase freight revenue by using slot allocation. It does not only pursue to fully load but also to create maximize total lifting and freight revenue.

It is different in service route between long haul services and intra Asia service. Long haul service often deploys mega vessel and applies to hub and spoke network in service route. The mega vessel sails between both sides of hub and it just fully load cargo in one side port and discharge cargo in other side port. In Asia, it just allows berthing middle-size vessel for most ports. Therefore, middle-size vessel is deployed and the service route is designed to call more ports. Liner shipping company in intra Asia hopes to have more opportunity to load cargo through calling more ports and provide more convenient and directly service for customers. The vessel needs to load and discharge cargo in every calling port and more complex in making slot allocation for liner shipping company. It is an important issue to make an optimal slot allocation which is the process of determining the space to be allocated to different port-pair on a give voyage to increase profit and provide shipping agency a rule to follow for liner shipping company (see figure 2).

### 2.2 Assumption

The following assumption are imposed for the model:

1. The freight revenue of various origin-destination port pairs have been estimated basing on average market level. Liner shipping company charge ocean freight of origin-destination port pair and surcharge including currency adjustment factor (CAF), fuel adjustment factor (FAF), terminal handling charge in loading port (L/THC), terminal handling charge in...
discharging port (D/THC) and document fee from shipper. Occasionally, liner shipping company often offers all-in freight including ocean freight and surcharge. The ocean freight is offered depending on quantity of cargo, container specification, customer classification etc. In this paper, the freight revenue is estimated with average freight revenue and surcharge for dry container for each port-pair.

![Figure 2 Service route and slot allocation in intra Asia service](image)

(2) The variable cost of various origin-destination port pair has been estimated. The cost includes port charge, bunker fee, vessel cost, handling charge, container rental and repair, drayage, commission, transfer fee and administration fee etc for a round trip. The fixed cost includes port charge, bunker fee, vessel cost and administration fee would not be affected by vary in amount of shipment which were loaded and discharged in a round trip. In this paper, the variable cost is considered into model only.

(3) The maximum and minimum cargo demand of various origin-destination port-pair has been estimated. It is in uncertainty for cargo demands basing on market situation; competitors and the ability of solicit cargo for shipping agency. In this paper, it is estimated from the past data for every voyage.

(4) There are three major types of containers, i.e. 20’*8’*8’6” dry container (20’DC is calculated as1 TEU), 40’*8’*8’6” dry container (40’DC is calculated as 2 TEU) and 40’*8’*9’6” high cube (40’HQ is calculated as 2.25 TEU) which are considered in this paper.

2.3 Model Formulation

The indices, decision variables, parameters, objective function, and constraints in the model are described as follows.

2.3.1 Indices

Let $P$ be the set of calling port in a service route, $P = \{1, 2, 3, \ldots, n\}$
Let $K$ be the set of container type, $K = \{1 \text{ for } 20' DC, 2 \text{ for } 40' DC, 3 \text{ for } 40' DC\}$

$i =$ index of loading port, $i \in P$

$j =$ index of discharging port, $j \in P$

$k =$ index of container type, $k \in K$

### 2.3.2 Decision Variable

$X_{ij}^k$: The number of slot allocation for $k$-type containers delivered from loading port $i$ to discharging port $j$

### 2.3.3 Parameters

$FR_{ij}^k$: Freight revenue including ocean freight and surcharge of $k$-type container delivered from loading port $i$ to discharging port $j$

$VC_{ij}^k$: Variable cost of $k$-type container delivered from loading port $i$ to discharging port $j$, including handling charge in both sides of port, commission, container rental (depreciation) and repair, truck fee and depot stowage cost etc.

$OP_{ij}^k$: Operational Profit of $k$-type container delivered from loading port $i$ to discharging port $j$

$$OP_{ij}^k = FR_{ij}^k - VC_{ij}^k$$ (1)

$Q_i$: The operational capacity of vessel or entitlement when vessel departures from port $i$. Strategic alliances between liner shipping have grown in recent decade years for increasing market coverage, decreasing overheads, sharing the cost of capital equipment and multiply market control (Ryoo et al., 1999). Therefore, the vessel capacity should share with co-partners and the liner shipping company gets entitlement through joint service, slot exchange and slot charter. (unit: TEU, twenty-foot equivalent units)

$DW_i$: The deadweight tonnage of vessel or entitlement when vessel departures from port $i$ (unit: ton)

$ROB_{ij}^k$: Total slot of remain on board before vessel arrive in port $i$ (unit: TEU). The cargo which was loaded on previous calling port is delivered to next port. For example, it calls five ports in service, the cargo still remain on board before vessel arrives in port 2 is $ROB_{ij}^k = X_{13}^k + X_{14}^k + X_{15}^k + X_{16}^k + X_{17}^k + X_{18}^k + X_{19}^k$ then loaded cargo in port 2 is $X_{23}^k + X_{24}^k + X_{25}^k + X_{26}^k$ and discharged cargo in port 2 is $X_{32}^k + X_{33}^k + X_{34}^k + X_{35}^k$.

Before vessel arrives in port 3, the cargo of remain on board is $ROB_{ij}^k = X_{14}^k + X_{15}^k + X_{16}^k + X_{17}^k + X_{18}^k + X_{19}^k$ then loaded cargo in port 3 is $X_{34}^k + X_{35}^k + X_{36}^k + X_{37}^k$ and discharged cargo in port 3 is $X_{43}^k + X_{44}^k + X_{45}^k + X_{46}^k$ (see figure 3).

$ROB_{ij}$: Total deadweight tonnage of remain on board before vessel arrive in port $i$ (unit: ton)

$DU_{ij}^k$: The maximum number of cargo demand for $k$-type slot from port $i$ to port $j$

$DL_{ij}^k$: The minimum number of cargo demand for $k$-type slot from port $i$ to port $j$
\( W^k_{ij} \): The average weight (ton) of k-type from port i to port j

\( DW^k_i \): The maximum of deadweight tonnage for all loaded container in port i

\( \alpha^k \): Transferring coefficient of TEU (k=1 20’DC is calculated as 1 TEU; k=2 40’ DC is calculated as 2 TEU; k=3 40’HQ is calculated as 2.25 TEU)

![Figure 3 The concept map of remain on board cargo, loaded cargo and discharged cargo](image)

**2.3.4 Objective Function**

The objective function (2) seeks to maximize operational profit (freight revenue minus variable cost).

\[
\text{Max } Z = \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{k=1}^{3} OP^k_{ij} \times X^k_{ij}
\]  

(2)

**2.2.5 Constraints**

**1) Vessel Capacity Constraints**

The equation (3) of vessel capacity constraints represented that all the allocated slot which remain on board cargo minus discharged cargo then add loaded cargo cannot exceed the vessel operational capacity or entitlement for liner shipping company.

\[
ROB^i - \sum_{k=1}^{3} \sum_{j=1}^{n} \alpha^k X^k_{ji} + \sum_{k=1}^{3} \sum_{j=1}^{n} \alpha^k X^k_{ij} \leq Q_i \quad \forall \ i \in P, j \in P, k \in K
\]  

(3)

**2) Vessel Deadweight Constraints**

The equation (4) represented that all the allocated slot deadweight tonnage which remain on board cargo minus discharged cargo then adds loaded cargo deadweight tonnage cannot exceed the vessel deadweight or entitlement for liner shipping company.

\[
ROB^w - \sum_{k=1}^{3} \sum_{j=1}^{n} W^k_{ij} X^k_{ji} + \sum_{k=1}^{3} \sum_{j=1}^{n} W^k_{ij} X^k_{ij} \leq DW_i \quad \forall \ i \in P, j \in P, k \in K
\]  

(4)

**3) Cargo Demand Constraints**
There are two restrictions on the cargo demand constraint; equation (5) represented the slots allocated to various original-destinations port pair must be set between the interval of lower bound and upper bound of cargo demand. Equation (6) represented the total deadweight tonnage of loaded slot which cannot exceed the upper bound deadweight tonnage in loading port.

\[
DL_{ij}^k \leq X_{ij}^k \leq DU_{ij}^k \quad \forall \ i \in P, j \in P, k \in K
\]

\[
\sum_{k=1}^{n_1} \sum_{j=1}^{n_2} W_{ij}^k X_{ij}^k \leq D_i^w \quad \forall \ i \in P, j \in P, k \in K
\]

(4) Variable Integer Constraints

The final constraint is integrality restrictions on the decision variables, as presented in equation (7).

\[
X_{ij}^k \quad \forall \ i, j, k \in \text{integer}
\]

3. CASE STUDY AND DISCUSSIONS

An intra Asia service route (CHJ service, see figure 4) of liner shipping company in Taiwan (T Line) is used as a case study. The service route is Qingdao(TAO)-Shanghai(SHA)-Hong Kong(HKG)-Manila(MNL)-Jakarta(JKT)-Surabaya(SUB)-Manila(MNL)-Hong Kong(HKG)-Qingdao(TAO). Four full-container vessels were deployed on this service route to provide weekly service for every calling port. The specification of the vessel is 1,100 TEU operational capacity and 15,400 tons deadweight. For decreasing overheads and sharing the cost of capital equipment, T Line co-operates with other liner shipping companies to launch CHJ service through joint service, slot exchange and slot charter. T line gets entitlement of 350 TEUs and 4,900 tons in vessel respectively.

The computational result of optimal slot allocation is shown as table 1 that makes a rule for agency to solicit cargo for every voyage in CHJ service. For shipping agency in TAO, it could solicit cargo of 21 boxes of 20’, 7 boxes of 40’ and 12 boxes of 40’HQ from TAO to HKG, 30 boxes of 20’ to MNN, 18 boxes to MNS, 42 boxes of 20’, 1 boxes of 40’ and 2 boxes of 40’HQ to JKT and 14 boxes of 20’, 1 boxes of 40’ to SUB. It spent much time on second calling MNS.
and HKG, that the cargo could not be arranged to load (it means $D_{ij}^k = 0$). The total outbound cargo from TAO are 125 boxes of 20', 9 boxes of 40' and 14 boxes of 40'HQ (174.5 TEU) and inbound cargo to TAO are 60 boxes of 20', 24 boxes of 40' and 25 boxes of 40'HQ (164.25 TEU). Total lifting of slot are 1,046.75 TEU and turnover rate is 2.99 (1,046.75 TEU/350 TEU) for round trip and grain the total operation profit is US$264,466.

Table 1 An optimal slot allocation for CHJ service

<table>
<thead>
<tr>
<th>POL</th>
<th>POD</th>
<th>TAO</th>
<th>SHA</th>
<th>HKG</th>
<th>MNN</th>
<th>MNS</th>
<th>JKT</th>
<th>SUB</th>
<th>MNS</th>
<th>HKG</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20'</td>
</tr>
<tr>
<td>TAO</td>
<td>20'</td>
<td>21</td>
<td>30</td>
<td>18</td>
<td>42</td>
<td>14</td>
<td>125</td>
<td>174.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>174.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HKG</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>14</td>
<td>174.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHA</td>
<td>20'</td>
<td>12</td>
<td>9</td>
<td>20</td>
<td>32</td>
<td>8</td>
<td>79</td>
<td>175.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>22</td>
<td>0</td>
<td>26</td>
<td>175.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HKG</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>0</td>
<td>16</td>
<td>175.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNN</td>
<td>20'</td>
<td>0</td>
<td>12</td>
<td>36</td>
<td>0</td>
<td>46</td>
<td>74.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>74.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HKG</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>74.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNS</td>
<td>20'</td>
<td>22</td>
<td>8</td>
<td>20</td>
<td>32</td>
<td>6</td>
<td>28</td>
<td>108.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>28</td>
<td>2</td>
<td>7</td>
<td>108.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JKT</td>
<td>20'</td>
<td>22</td>
<td>14</td>
<td>17</td>
<td>66</td>
<td>66</td>
<td>127.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>20</td>
<td>16</td>
<td>18</td>
<td>26</td>
<td>18</td>
<td>127.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNS</td>
<td>20'</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>47.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>47.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HKG</td>
<td>20'</td>
<td>56</td>
<td>15</td>
<td>20</td>
<td>71</td>
<td>71</td>
<td>181.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>24</td>
<td>1</td>
<td>22</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>181.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUB</td>
<td>20'</td>
<td>60</td>
<td>89</td>
<td>33</td>
<td>90</td>
<td>90</td>
<td>263.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40'</td>
<td>24</td>
<td>2</td>
<td>7</td>
<td>27</td>
<td>1</td>
<td>8</td>
<td>263.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HKG</td>
<td>25</td>
<td>7</td>
<td>12</td>
<td>7</td>
<td>31</td>
<td>31</td>
<td>132.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1046.75</td>
<td>74.00</td>
<td>263.75</td>
<td>32.25</td>
<td>132.50</td>
<td>144.00</td>
<td>538</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5, figure 6 and figure 7 show the relationship between outbound cargo and inbound cargo for 20' container, 40' container and 40'HQ container in every calling port. Figure 8 shows the relationship between total outbound cargo and total inbound cargo in every calling port. For example, in TAO, HKG, and SUB ports, the amount of outbound cargo is greater than the amount of inbound cargo for 20' container that resulted in repositioning into empty container (see figure 5). In SHA, MNN, MNS and JKT ports, the amount of outbound cargo is less than the amount of inbound cargo for 20' container that resulted in reposition out empty container. It is costly to reposition empty container for cargo imbalance that liner shipping company has difficultly generating reasonable profit and even run deficits.

Figure 9 shows the relationship between total slot of remain on board and port. Before vessel arrived in SHA, it had unsold slot on vessel ($ROB_{SHA} = 281.50\text{TEUs} \leq 350\text{TEUs}$). The shipping agency in TAO had slot to load cargo, but they should reserve the slot for shipping agency in SHA for getting higher total amount lifting and higher operational profit for liner shipping company. Before vessel arrived in HKG, it was fully loaded on vessel and totally utilized T Line’s entitlement in SHA and TAO. After discharging cargo and loading cargo, the vessel still was fully loaded in HKG. For the follow-up calling ports, the vessel was not fully loaded and got unsold slot revenue. After checking the parameter data for CHJ service, it got limitation in the maximum number of cargo demand ($D^k_{ij}$). T Line should request shipping agency in MNL, JKT, SUB and HKG to increase marketing activity to solicit more cargo for
fully utilizing entitlement on vessel. Additionally, T line may consider cutting down entitlement for reducing overhead and risk through slot-exchange or slot-charter with other liner shipping companies. Freight revenue would be reduced from shipping agencies in TAO and SHA due to cut down entitlement on CHJ service. But it could increase the turnover rate (total lifting/entitlement) and utility rate for getting higher performance in CHJ service. For example, if the entitlement reduces to 300 TEUs then the vessel is fully loaded before arriving in first calling HKG, MNN, MNS and second calling MNS. If the entitlement reduces to 250 TEUs then the vessel will fully load for round voyage.

Figure 5 Relationship between outbound cargo and inbound cargo for 20'container

Figure 6 Relationship between outbound cargo and inbound cargo for 40'container

Figure 7 Relationship between outbound cargo and inbound cargo for 40'HQ container

Figure 8 Relationship between total outbound cargo and total inbound cargo

Figure 9 Relationship between total slot of remain on board and port

Entitlement: 350 TEUs
Entitlement: 300 TEUs
Entitlement: 250 TEUs
4. CONCLUSIONS AND FUTURE STUDY

This paper develops an optimal slot allocation in intra Asia service for liner shipping. The slot allocation model is formulated through mathematical programming to maximize operational profit (freight revenue minus variable cost) with the consideration of revenue management. Slot allocation involved two stakeholders, one is liner shipping company, the other one is shipping agency. In practice, liner shipping company often pursues to fully load cargo on the vessel and shipping agency hopes to load more and more cargo for obtaining more commission from ocean freight. It has brought about argument for slot allocation between shipping agencies and cannot gain reasonable profit due to ignore revenue management for liner shipping company. A conceptual model of optimal slot allocation is proposed to provide liner shipping to build revenue management and the computational result can be a guideline for shipping agencies in every calling port to achieve maximizes operation profit.

In this paper, we illustrate this slot allocation model with a case study of Taiwan Liner Shipping Company and the results show the applicability and better performances that the previous allocation used in practice. We also discuss the strategy for liner shipping company to adjust their own entitlement on vessel for getting better performance and turnover rate through slot exchange, slot charter and joint service with other liner shipping company. In reality, there have many factors to affect loaded cargo in each port including sales activity, competitor action, sailing vessel schedule etc. Therefore, the liner shipping company also pays more attention to monitor the actually loaded cargo in each calling port and adjust slot allocation to avoid unused slot to make more profit for every voyage.

The objective of the proposed slot allocation model is to maximize operational profit and it produces empty container reposition for cargo imbalance in every calling port. Song et al. (2005) pointed out that the cost of reposition empty container is 27% of the total world fleet running cost. It is costly to reposition empty container that liner shipping company has difficulty generating reasonable profit and even run deficits in the end. Another possible future extension of this work could be to consider the effect of empty container reposition cost into objective function. We expect the improvement could reduce the cost of empty container reposition and get better performance for liner shipping company.

REFERENCES


