Empty container management for shipping industry

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Agenda

• Introduction
• Literature review
• Modeling
  – Two ports
  – Multi-ports
• Questions & Discussion
Why do we care empty containers?

Figure 2: Container Usage
Who do we care?

Ocean carriers’ bill:

Total operating cost: $100 billion
Empty container repositioning: $16 billion
SMR–Semarang Feeder Service

THE APL Advantage
- Two sailings a week between Semarang and Singapore.
- Reliable, dedicated feeder service capable of handling a wide variety of equipment.
- Connections to full-service IntraAsia sailings in Singapore.

Transit Times

<table>
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<tr>
<th>Destination</th>
<th>Jkt/Sby</th>
<th>Surabaya</th>
<th>Solo</th>
<th>Surakarta</th>
<th>Semarang</th>
<th>Tpe/Zha</th>
<th>Hknc</th>
<th>Sing</th>
<th>Thailand</th>
<th>Coun</th>
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Port Rotation

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<th>WEEK 2</th>
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<td>Tu</td>
</tr>
<tr>
<td>Semarang</td>
<td>3</td>
<td>We</td>
<td>Tu</td>
</tr>
<tr>
<td>Tpe/Zha</td>
<td>0</td>
<td>We</td>
<td>We</td>
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Empty container allocation between ports

Hong Kong

Singapore
A scenario

What we manage is not simply “inventory” but reusable resource

Port Hong Kong

Cargoes

Empty containers

Port Singapore
Problem

• Cost structure
  – Holding cost
  – Leasing cost
  – Transportation cost

• Decisions
  – Hold empty container
  – Reposition empty container
Literatures

• Cheung, R.K., A two-stage stochastic network model and solution methods for the dynamic empty container allocation problem
• Loo Hay Lee, Loon Ching Tang, Shao Wei Lam, Dynamic programming approaches for the empty container allocation problem. Working paper.
Two ports model
Notations

$c_i$  The cost shipping one container to port $i$
$h_i$  The cost holding one empty container at port $i$
$p_i$  The penalty cost for shortage at port $i$

$V$  The total number of empty containers owned by carrier

shortage & holding function

$L_1(x) = p_1 E(D_1 - x)^+ + h_1 E(x - D_1)^+$
$L_2(x) = p_2 E(D_2 - x)^+ + h_2 E(x - D_2)^+$
Optimality equation

Port 1:

\[ G_n(x_1) = \min_{x_1 \leq y \leq V} \left[ c_1(y - x_1) + L_1(y) + E(J_n(V - y + \min(y, D_1))) \right] \]

- Transportation cost
- The amount of empty containers to be available at port 2

Port 2:

\[ J_n(x_2) = \min_{x_2 \leq y \leq V} \left[ c_2(y - x_2) + L_2(y) + E(G_{n+1}(V - y + \min(y, D_2))) \right] \]
Optimal policy

Theorem: Both $G_n(x), J_n(x)$ are convex if

Assumption 1: The transportation cost of shipping one empty container is smaller than the shortage cost, that is, $p_2 > c_2$ and $p_1 > c_1$

Assumption 2: The holding costs and shortage costs of two ports satisfy: $p_2 + h_2 \geq \beta(p_1 + h_1)F_1(V)$ and $p_1 + h_1 \geq \beta(p_2 + h_2)F_2(V)$

Optimal policy: For both ports, optimal crucial points exist.
Multi-port case
Overview of Asia-Europe Services

THE APL ADVANTAGE

- Offers comprehensive coverage of the Far East, Europe and the Mediterranean regions
- Offers competitive transit times from the Far East regions to Europe, especially the Mediterranean region
- Offers express service between China and Europe via six services, providing more flexibility and convenience to our customers
Multi-ports

The fixed route

The problem faced by port 2
Network model

The arc cost is convex!

\[ L_{ij}(x_{ij}) = c_{ij}(x_{ij} - D_{ij})^+ + r_{ij}(D_{ij} - x_{ij})^+ \]
Summary

• Both models assume loss-sale
  – Two ports: MDP model
    • Optimal policy is obtained
  – Multi-ports: Convex network model
    • Numerically efficient
    • Hopeful to get analytical results
Future research

• Backlog is allowed for short voyage.
• Information updating is allowed for long voyage.