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해상운송을 고려한 공 컨테이너 재배치에 관한 연구

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요 약 : 해상운송에 있어서 컨테이너 운송수요의 증가와 변화에 효율적으로 대응하기 위해서는 공 컨테이너(Empty Container)의 효율적인 관리 및 최적화 할 수 있는 기술이 요구되고 있다. 본 연구에서는 다품목을 고려한 다수의 포트간의 공 컨테이너 재배치문제를 다루고자 한다. 공 컨테이너의 효율적인 관리 및 운영을 위한 수리 모형을 통해 지역간의 공 컨테이너 재배치량과 지역내 데포간의 공 컨테이너 재배치량을 결정하고자 한다. 간단한 수치실험을 통해 해상 지역내와 해상 지역간을 통합한 다지역간의 재배치 방안의 효율성을 보이고자 한다.

핵심용어 : 공 컨테이너, 다 지역간 재배치, 해상 재배치

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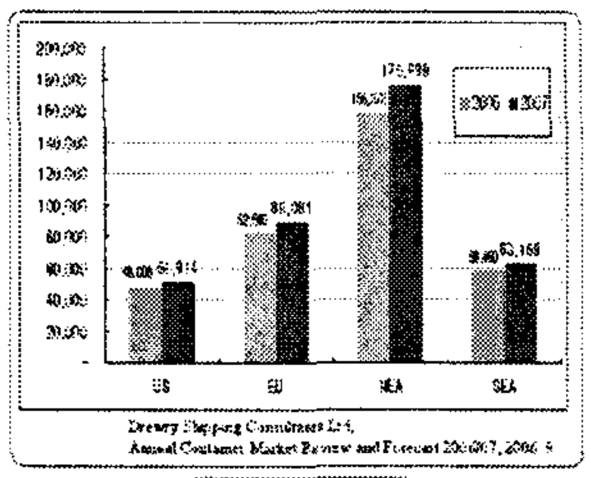
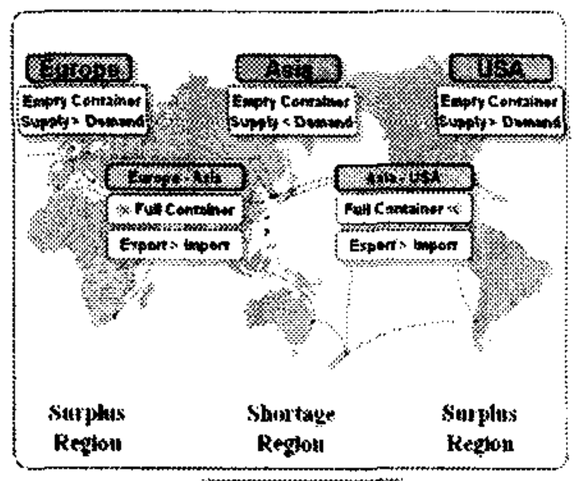
1. Introduction





- Global container population has increased.
- The difference between import and export containers has increased.
- There is a regional empty container imbalance.

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1. Introduction

◆ In the paper, there are two kinds of distribution network problems.

◆ Intra-regional positioning problem
- → Several non-identical depots
- → One level distribution network problem

◆ Multi-regional positioning problem
- → A regional depot and N non-identical depots
- → Inter-regional and intra-regional positioning problem
- → Two level distribution network problem

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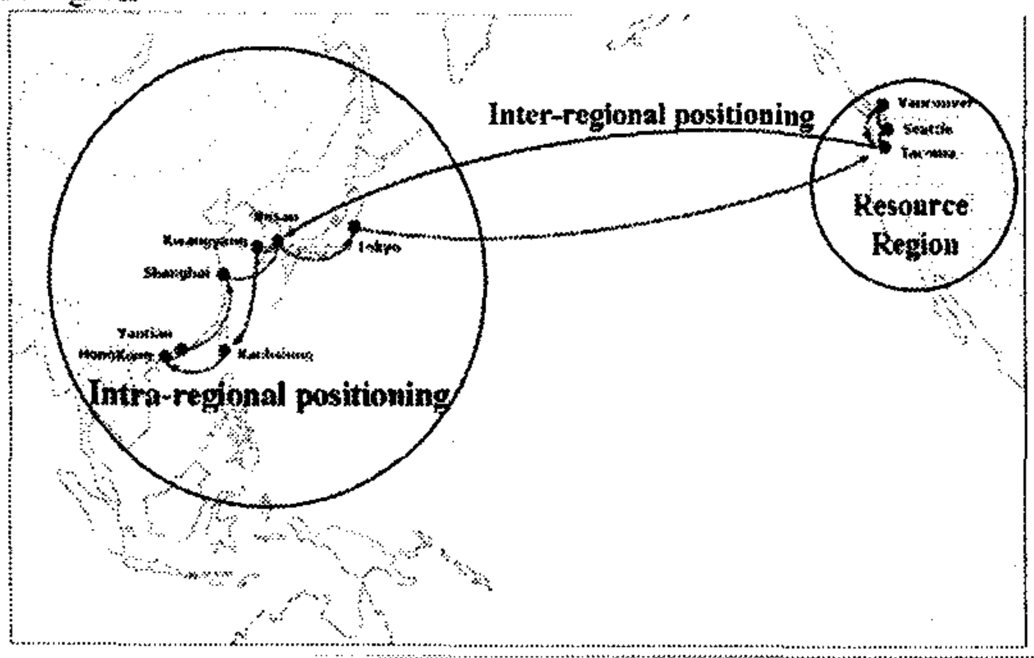
1. Introduction

◆ One resource depot from US region and N non-identical depots in EA region



1. Introduction

◆ Multi-regional positioning problem

- Inter-regional positioning orders are placed with a resource depot.
- In each period, intra-regional positioning provides a means to reconcile demand-supply mismatches within N non-identical depots.

◆ The goal is to find the inter-regional positioning and intra-regional positioning quantities that minimize the expected long-run average cost over an infinite horizon.

- The cost is the sum of the inter-regional positioning, intra-regional positioning, and inventory holding costs.

2. Literature review

◆ Empty container allocation model for an inland transportation

- T.G. Crainic, M. Gendreau, and P. Dejax (*Operations Research*, 1993)

◆ Empty container allocation problem at a port

- J.A. Li, K. Liu, S.C. Leung, and K.K. Lai (*Mathematical and Computer Modelling*, 2004)

◆ Empty container allocation problem between multi-ports

- J.A. Li, S.C. Leung, Y. Wu, and K. Liu (*European Journal of Operational Research*, 2007)

3. Mathematical model

◆ ***Problem data***

◆ **p_{itk} : inter-regional positioning cost per unit for container type k at depot i in period t;**

◆ **h_{itk} : inventory holding cost for container type k at depot i in period t;**

◆ **c_{ijtk} : intra-regional positioning cost per unit for container type k from depot i to depot j in period t;**

◆ **d_{jtk} : demand of depot j for container type k in period t;**

◆ **r_{it} : positioning capacity (quota of transportation) at depot i in period t;**

◆ **K_{it} : storage space capacity (limitation) at depot i in period t.**

3. Mathematical model

◆ ***Decision variables***

◆ **q_{itk} : inter-regional positioning quantity of container type k at depot i in period t;**

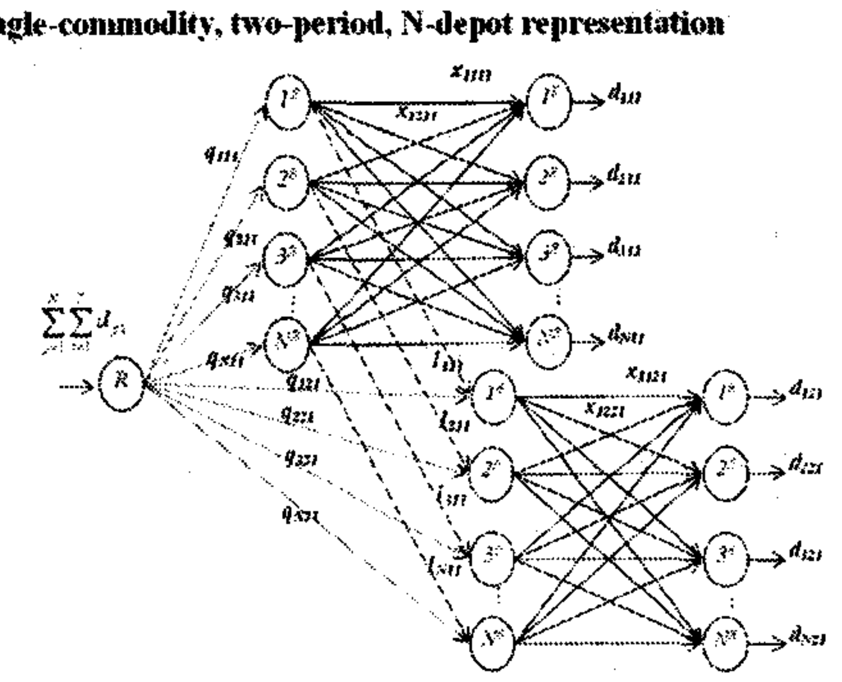
◆ **I_{itk} : amount of container type k in inventory at depot i at the end of period t;**

◆ **x_{ijtk} : intra-regional positioning quantity of container type k from depot i to depot j in period t.**

3. Mathematical model

◆ **Network representation of the multi-regional positioning problem**

◆ **Single-commodity, two-period, N-depot representation**



3. Mathematical model

◆ **Mathematical Model**

$$\min \sum_{i=1}^{N}\sum_{t=1}^{T}\sum_{k=1}^{K}\left(p_{itk}\cdot q_{itk} + h_{itk}\cdot I_{itk} + \sum_{j=1}^{N} c_{ijtk}\cdot x_{ijtk} \right)$$

subject to

$$I_{i,t-1,k} + q_{itk} = \sum_{j=1}^{N} x_{ijtk} + I_{itk}, \quad i = 1 \ldots N,\ t = 1 \ldots T,\ k = 1 \ldots K, \qquad (1)$$

$$\sum_{i=1}^{N} x_{ijtk} = d_{jtk}, \quad j = 1 \ldots N,\ t = 1 \ldots T,\ k = 1 \ldots K, \qquad (2)$$

$$\sum_{k=1}^{K} q_{itk} \le v_{it}, \quad i = 1 \ldots N,\ t = 1 \ldots T, \qquad (3)$$

$$\sum_{k=1}^{K} I_{itk} \le K_{it}, \quad i = 1 \ldots N,\ t = 1 \ldots T. \qquad (4)$$

4. Numerical example

◆ **We tested four problems on 30 randomly generated problems.**

Table 1. Distribution for randomly generated problems

Parameters		Interval
inter-regional positioning costs	p_{itk}	[15,30]
inventory holding costs	h_{itk}	[10,20]
intra-regional positioning costs	c_{ijtk}	[5,10]
demand	d_{jtk}	[0,100]
inter-regional positioning capacity	v_{it}	[200,400]
storage space capacity	k_{it}	[100,300]

4. Numerical example

◆ **Four test problems** are considered by the intra-regional positioning cost factors.

◆ **Intra-regional positioning** cost among central depot and remote depots

Table 2. Four test problems by intra-regional positioning cost factors

Problem	c_{0jtk}	c_{i0tk}	c_{ijtk}
1	∞	∞	∞
2	c_{0jtk}	∞	∞
3	c_{0jtk}	c_{i0tk}	∞
4	c_{0jtk}	c_{i0tk}	c_{ijtk}

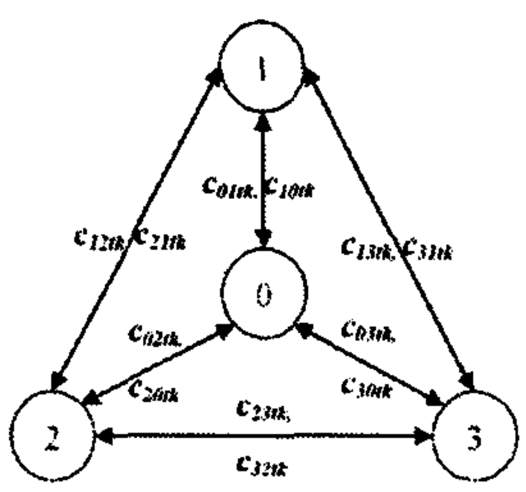


Figure 5. Configuration of intra-regional positioning with four depots

4. Numerical example

◆ Average inter-regional positioning quantity (q_{itk})

◆ Average intra-regional positioning quantity (x_{ijtk})

◆ Average total relevant cost of 30 randomly generated problems

Table 3. Computational results for test problems

Problem	Avg. q_{itk}	Avg. x_{ijtk}	Avg. Total Cost
1	3,954	0	101,133
2	3,878	326	96,497
3	4,039	816	89,695
4	4,012	1,157	86,179

5. Conclusions

◆ **We consider the multi-regional ocean positioning problem.**
  → **Multi-level, multi-period, multi-commodity problem**

◆ **We show the cost effectiveness of multi-regional positioning case by numerical example.**

◆ **We will develop a heuristic algorithm to solve a large size problem.**

◆ **We will perform more meaningful computational experiments**
  → **by comparing with other solution methods.**
  → **by testing a large size problem.**