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Estimation of Construction Cost of Smart Joint Refrigerated Logistics Center Applying Collaborative Game Theory –A Case Study of Republic of Korea–

Jae-Min Kim[1], Gyusung Cho[2,*] and Young-Tae Park[3]

[1]System Support Department, Korea Keyence Co., Ltd., Gyeonggi-do 13591, Korea
[2]Department of Port Logistics System, Tongmyong University, Busan 48520, Korea
[3]Division of International Trade & Distribution, Dongeui University, Busan47340, Korea
*Corresponding author: gscho@tu.ac.kr

Introduction

In S. Korea, the smart logistics center is jointly developed to meet the exact material delivery schedule for the smart manufacturing process.

However, because the cost of constructing a smart joint logistics center is very high, efforts to reduce the construction cost are required.

We developed a construction cost estimation model for logistics companies involved in constructing a smart joint logistics center, to which a collaborative game theory is applied.

Korea's smart joint logistics center was divided into four scales based on the construction cost calculation model, and the construction cost of the smart joint logistics center was determined for each scale capable of supporting smart manufacturing processes.

Repair Model for the Construction Cost

The costs are allocated to these companies. Each logistics company, of the four different types, has its own logistics center with the following sizes: 1,000-2,000 m^2, 2,000-5,000 m^2, 5,000-10,000 m^2, and 10,000 m^2.

When more than one public logistics center exists, the company using the 1,000-2,000 m^2 logistics center is considered the smallest logistics company.

Mathematical Formulas

Construction cost was derived by substituting the number of logistics centers in the status.

$$min\ c(S) = \sum_{i=1,\, s_i \in S} H_{s_i}(c_{s_i} - c_{s_{i-1}}) \quad (1)$$

such that,

$$c(S \cap N) \geq c(S) + c(N) \quad (2)$$

$$i < j, \qquad c_i < c_j \quad (3)$$

$$S = \{s_1 \dots, s_n\}, \qquad s_i < s_j, c_{s_j} < c_{s_j} \quad (4)$$

$$\sum_{i \in S} c_i \leq c(S), \qquad \sum_{i \in N} c_i \leq c(N) \quad (5)$$

$$c_i = \{c_1, c_2, \dots c_m\}, i \geq 0,\ c(\emptyset) = 0 \quad (6)$$

Conclusion

This study examined the problems related to the development of a port hinterland in South Korea.

This study presented a construction method for improving the logistics facilities in public logistics centers selected four types of participants to build one public logistics center.

The presented model can serve as a method for efficiently improving logistics facilities.

In the case of collaboration, construction costs for small- and medium-sized units increase, but construction costs for large and hub areas decrease. Large- and hub-sized companies are at a disadvantage in comparison with small- and medium-sized companies.

Tables

TABLE 1. CONSTRUCTION COSTS OF LOGISTICS CENTER BY SIZE.

Index	Area (m^2)	Volume of goods (kg)	Construction cost*($10)
1	1,000–2,000	< 15,000,000	64,206
2	2,000–5,000	< 30,000,000	179,626
3	5,000–10,000	< 60,000,000	552,818
4	More than 10,000	> 60,000,000	949,233
Total	-	-	1,745,883

*Source: National Logistics Information Center (http://www.nlic.go.kr).

TABLE 2. CONSTRUCTION COST OF THE PUBLIC LOGISTICS CENTER WITH RESPECT TO THE UNION OF LOGISTICS COMPANIES.

Union	Equation based on marginal cost	Method	Construction cost (10$)
c(1)	$4 \times c_1$	-	256,824
c(2)	$3 \times c_2$		538,878
c(3)	$2 \times c_3$		1,105,636
c(4)	c_4		949,233
c(1,2)	$3(c_2 - c_1) + 4 \times c_1$	$c_1 + 3 \times c_2$	603,084
c(1,3)	$2(c_3 - c_1) + 4 \times c_1$	$2(c_1 + c_3)$	1,234,048
c(1,4)	$(c_4 - c_1) + 4 \times c_1$	$3 \times c_1 + c_4$	1,141,851
c(2,3)	$2(c_3 - c_2) + 3 \times c_2$	$c_2 + 2 \times c_3$	1,255,262
c(2,4)	$(c_4 - c_2) + 3 \times c_2$	$2 \times c_2 + c_4$	1,308,485
c(3,4)	$(c_4 - c_3) + 2 \times c_3$	$c_3 + c_4$	1,502,051
c(1,2,3)	$2(c_3 - c_2) + 3(c_2 - c_1) + 4 \times c_1$	$c_2 + c_1 + 2 \times c_3$	1,349,468
c(1,2,4)	$(c_4 - c_2) + 3(c_2 - c_1) + 4 \times c_1$	$c_1 + 2 \times c_3 + c_4$	2,119,075
c(1,3,4)	$(c_4 - c_3) + 2(c_3 - c_1) + 4 \times c_1$	$2 \times c_1 + c_3 + c_4$	1,630,463
c(2,3,4)	$(c_4 - c_3) + 2(c_3 - c_2) + 3 \times c_2$	$c_2 + c_3 + c_4$	1,681,677
c(1,2,3,4)	$(c_4 - c_3) + 2(c_3 - c_2) + 3(c_2 - c_1) + 4 \times c_1$	$c_1 + c_2 + c_3 + c_4$	1,745,883

TABLE 3. COMPARISON OF ACTUAL CONSTRUCTION COSTS AND THOSE OBTAINED USING THE SHAPLEY VALUE.

Index	Actual construction costs	Construction costs obtained using Shapley value	Difference
1	54,308	186,062	+131,754
2	179,626	343,359	+163,733
3	552,818	506,829	- 45,989
4	949,233	699,735	-249,498
Total	1,735,985	1,735,985	0

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