ICIC Express Letters
Volume **14**, Number **6**, June **2020**

 ISSN 1881-803X
pp. **629–634**

DESIGN OF A SUSTAINABLE SHARED LOGISTICS SERVICE MODEL

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Received December 2019; accepted March 2020

Abstract. *With increasing interest in logistics, the logistics market is becoming increasingly saturated, unlike other industries. Although consumers can utilize more convenient SNS or web-based services, and the volume of money in circulation has increased, logistics companies and centers continue to report a slight increase in profits, but a substantial increase in volume. In this study, game theory was applied to the cooperation of logistics companies with the aim of strengthening the competitiveness of logistics companies by dispersing the risks of inventory and distribution, and sharing resources and profits. Specifically, a sustainable sharing model that allows different companies to share logistics service centers located in regions with low demand for storage and traffic was developed. The proposed sharing economy logistics model was purposed to achieve the equal and proportional distribution of gain, while taking account of the transaction and fixed costs of a logistics center to ensure equal distribution. Finally, the proposed shared logistics model was verified via a case study.*

Keywords: Shared logistics, Game theory, Sustainable service, System design

1. **Introduction.** Large logistics companies in South Korea currently handle logistics services for wide areas, whereas small- and medium-sized companies provide good-quality logistics services to residents. As logistics companies have continuously improved their services, an overnight delivery service has become available to every region. The development of the logistics industry significantly affects regional economic development, and is also recognized as an indicator for the economic vitality of a region. However, this industry development has created the following problems: 1) the monopoly of a few large companies, 2) the duplication of service areas, and 3) increased logistics center system disparity with increasing traffic. The overall sales revenue of the domestic logistics market shows a 10.21% increase relative to that of 2017 [1]. Since 2015, the market has been stable, with an increase rate of 8% or less. Nevertheless, the logistics center market for transport, delivery, and storage still faces excessive competition, which reduces the average unit price, and results in a decline, despite companies realizing profits from increasing volumes. Because a sharing economy that focuses on cooperation creates an economy of scale, the operating cost can be reduced, and efficient cooperation among logistics centers may increase the net profit of each logistics center in the target service region [2]. This study proposes a sustainable sharing model based on the concept of a sharing economy;

DOI: 10.24507/icicel.14.06.629

the proposed model equally distributes gain, and enhances the competitiveness of companies through the cooperation of the logistics centers that are suffering because decreased demand has reduced volume. In practice, the key problem of a sharing and cooperative process is the distribution of the profits of monopolistic logistics centers. For long-term sharing and cooperation, the staff of a shared logistics center needs to equitably distribute their wages, and there are three systematic methodologies for a profit-sharing process: 1) the equal distribution of gain, 2) the proportional distribution of gain, and 3) the shapely value method. This study applies the concept of equal and proportional distribution of gain as a systematic methodology, and examines the ability of each method to share economy logistics according to the marginal contributions of each company. Because the storage cost and fixed cost are considered in the determination of fair profits, the operating cost of a logistics center can be more accurately calculated. However, this model does not include a solution for the survival of a single logistics center. This paper proposes a network design model to organize the cooperation of companies through shared logistics centers. In this study, we investigated logistics companies that are located in the new port of Busan and surveyed a total of five logistics companies. Five logistics companies were divided into A, B, C, D, E and A, B companies operate two logistics centers (terminals), while the remaining C, D, E operate one logistics center. Each logistics center has two main tasks, pick up and transport, and the operating costs and workload of each company are different. The aforementioned profit equal distribution, profit proportional distribution and merger distribution were studied to derive the result value through the mathematical model and to derive a better result value.

2. **Case Study of Shared Logistics.** The logistics commonalities referred to in this study are being studied from a consultative perspective of a shared economy. A shared economy is defined as one or more entities participating in the project to gain economic benefits by sharing one good. Based on this, logistics costs can be reduced by using a shared economy for logistics. A shared economy is an economic model that improves effectiveness by sharing a product with multiple participants. Logistics sharing and shared economy are closely related, parts of the economy exist in the logistics system, and shared economy theoretically helps to form a logistics economic model. Logistics sharing using shared economy can be applied widely to realize sharing, and through exchange and leasing of various types of goods that do not need to own, it can prevent logistic monopoly of volume and reduce amount and cost [4,5]. Therefore, a shared economy can be regarded as an economic activity that eliminates unused value from the value of resources or services and increases utility above the total value. A shared economy can be expressed as a kind of cooperation as it has been implemented by businesses. Such cooperation aims to prevent extreme competition and share profits so that two or more companies can coexist and continue to grow. The concept of a shared economy was embodied through transaction-cost theory, knowledge-based theory and resource-based theory. The general Korean logistics-sharing system forms a union that binds the common concept more strongly than the concept of sharing. In the case of such an alliance, it is very difficult for a less competitive company to enter the union, aggravating the competition even further. Table 1 presents several examples of various entities that implement a shared economy [3].

There are many cases of individuals implementing a sharing economy. In contrast, few companies have organized a sharing economy [6]. Because resources owned by the participating companies are shared, the trust among those companies that acquire information and possess or use resources is essential. However, each company is concerned about their intellectual property. Moreover, if there is existing distrust between competing companies and the joint project is not successful, the level of distrust will increase. As the company-based sharing economy is dependent on mutual trust, the existing trust relationship needs to be taken into account to determine a method for gain distribution.

Table 1. Cases of various companies implementing a sharing economy

Category	Contents
Busan Marine Equipment Association	– Operation of a common logistics center – Cost reduction by using common facilities (plant and parking lot)
Korea Electrical Manufacturers' Cooperative	– Sharing an R&D project – Establishment of a standard common operating organization
Busan Automobile Industry Association	– Construction of a common logistics center, resource sharing, and international buyer membership
Korea Foundry Cooperative Association	– Joint foundry facilities provide to member – Procuring the group resources
Korea Federation of Plastic Industry Cooperative	– Co-brand (adiaphora) development – Procuring the group resources
Korea Publishers Cooperative	– Joint logistics of publication
Korea Pump Industries Association	– Co-brand (pumpro) development

There are many kinds of sharing logistics studies. For example, the use of the game theory model of strategic interaction makes this effect worse as the competitive value of information about suppliers increases, and paradoxically, providers lose more and more value as providers create value in sharing information. Furthermore, it proves that buyers do not need to share information to extract the competitive value of information from suppliers. Although the purchaser may not be able to obtain value from the information, it is likely to share the information. We also analyze the impact of other factors such as technical cost and demand uncertainty on these information-sharing contracts. Finally, the critical predictors of the level of information sharing between entities show that the relative position of the supply chain is relative negotiating power and potential proxy costs. The other type focuses on the general logistics status among different regions, and the other type examines strategies to develop the logistics for companies within a single region. A study on an existing cooperative logistics system, which was designed for local offices for parcel delivery services and their terminals, attempted to unify the offices and terminals, which were each run by a different company, into a monopolistic system to form a sharing economy model. Another study on transaction cost and profit distribution in a company-based sharing economy utilized game theory to equally distribute profits. Logistics centers and terminals are generally located in a service area [6]. Each logistics center has to be located in a service area to ensure that delivery and storage requests can be respectively received from local parcel delivery offices and terminals and efficiently executed. This study has three objectives. The first objective was to construct a shared logistics model that can maximize the profits of each logistics center. The second objective was to develop a method to calculate the fixed and transaction costs for profits made as a result of applying the proposed model. The final objective was to determine a method to distribute profits among the logistics companies. If there is low demand in a region, participating companies can agree to cooperate through the monopoly of service centers. The following forms of cooperation are subject to strategic partnership.

1) In most parts of a candidate area, at least one or two service centers can be installed. However, to ensure the survival of the majority of service centers, only a few parts are available to the sharing economy. The sum of the volumes processed by all service centers is applied to the candidate area after the sharing economy is implemented.

2) Allocation of the pickup and delivery volumes of the logistics centers within a shared area does not change.

3) The processing capacity requirements for each company must be satisfied after sharing. However, a certain amount of loss, proportional to the profits of two or more shared logistics centers, is expected.

A systematic model of a sharing economy was constructed to achieve equal distribution among participating companies, and to organize a shared consortium according to contribution [7,8]. The shares of each company were obtained by measuring the for-profit contributions of the logistics centers according to the owning company in the service area. Note that the proposed model does not take account of the common additional cost of each company. Additionally, the results are only based on the pickup volume, traffic volume, and fixed cost of each logistic center.

3. Sustainable Shared Logistics Service Model.

3.1. **Control design.** The sustainable shared logistics service model in this paper outlines how to distribute the gains made through a shared economy. In the case of logistics hollowing out, the hollowing out can save 12 percent of logistics costs. However, in the case of logistic hollowing out, the joint logistics center needs to be established to be feasible, so we conducted a study on logistics warehouses. Through logistics sharing, it can generate economies of scale and street economy, and it is believed that logistics costs will be saved by 7 percent. For the model design, a mathematical model was developed to accurately estimate the profit of each participating company. The following nomenclature has been applied to establishing an optimization model for a logistics service area with low traffic. The objective function indicates the sum of the net profits of a single logistics company connected to the sharing model through an integrated service center. The upper formula of the objective function corresponds to the sum of the net profits of a company with at least two logistics centers, whereas the lower formula corresponds to a company with only one logistics center. According to constraint of the shared service model, at least one logistics center should be operated in a service area. Constrain and integrate pickup volumes and traffic volumes on the basis of the number of shared centers to ensure equal distribution. The profit is the net profit of the logistics companies after the sharing model is implemented. Relationships respectively correspond to a volume, which may exceed the residual processing capacity, and the sum of the pickup and traffic volumes of all logistics centers. Constraint requires that every logistics company is located in a service area, and that each logistics center is appropriately affiliated with a service area and company. We used the Maxmin and Maxsum formulas, which are part of the game theory, and two formulas are cost-sharing. Maxmin is an equitable distribution of the benefits to the participants [9]. In the case of Maxsum, the distribution is based on the contribution. In this paper, the contribution of Maxmin, Maxsum is divided according to the contribution of the monthly processing volume of the company, and the difference between the two methods can be explained simply by the mathematical model (system (1) and (2)) assuming that there are players A and B, C.

$$Maxsum(A,B,C) = \frac{1}{2}\left[\frac{1}{2}(A+B+|A-B|)+C+\left|\frac{1}{2}(A+B+|A-B|)\right|-C\right] \quad (1)$$

$$Maxmin(A,B,C) = \frac{1}{2}\left[\frac{1}{2}(A+B-|A-B|)+C-\left|\frac{1}{2}(A+B-|A-B|)\right|-C\right] \quad (2)$$

3.2. **Analysis of the service model.** The efficacy of the sharing model was analyzed in terms of the complementary advantages of equal and proportional distribution of gain. With the proposed model, it is possible to quantify 1) the marginal profit increases that each company realizes as a result of implementing the sharing model, and 2) the combined profit of the model. Furthermore, among five companies A, B, C, D, and E, both A and B operated two logistics centers, while C, D, and E each had one logistics center. 15

service centers were distributed as shared areas. The pickup and traffic volumes of the logistics centers owned by each company were identified, and the volumes of companies that own a small number of logistics centers were combined for comparative analysis. In this way, the most appropriate method of operation could be identified. The pickup and traffic volumes of each logistics center were set to be between 1 and 10 (Unit: 10000). The fixed cost of operation was set to be a random number between 100 and 200 (Unit: 10000). Table 2 provides the information on the logistics centers of each company, which were distributed over 15 service areas. Additionally, the logistics centers were randomly distributed. We present the pickup volume, traffic volume, and fixed cost of each company; the same methodology is applied. A game theory-based method for implementing the sharing model was determined by using the information for a single logistics center. Note that the locations of the logistics centers were randomly determined. The inventory processing capacity of each company was assumed to be opened. The residual inventory of each logistics center was randomly set to be between 50 and 200. The results related to the equal and proportional distribution of gain for each company. As mentioned in the introduction, we conducted the study based on five companies operating logistics businesses in the Busan New Port Logistics Complex, and divided the overlapping service areas into one to 15 areas, while A and B operate two logistics centers and the remaining three companies operate one logistics center. In this case, a logistics center in the service area was applied as 1 using binary system, and zero was indicated if it did not exist. This can be seen at Table 2.

Table 2. Logistics centers of the companies located in each service area

Service area	A		B		C	D	E
Logistics center	A-1	A-2	B-1	B-2	C-1	D-1	E-1
1	0	1	0	1	0	1	0
2	0	0	1	0	0	0	0
3	0	1	0	0	0	1	0
4	1	0	0	1	0	0	0
5	0	1	1	0	0	0	1
6	0	1	0	0	1	0	0
7	1	0	0	0	0	0	0
8	0	0	1	0	1	0	1
9	1	0	0	0	0	0	0
10	0	0	0	1	1	1	0
11	1	0	0	0	0	1	0
12	0	1	0	0	0	0	1
13	0	0	0	1	0	1	0
14	1	0	1	0	1	1	0
15	1	0	1	0	0	0	1

In this paper, a total of three methodologies were presented. A method of sharing profits through equal distribution of profits, proportionate distribution of profits and mergers was proposed. In the distribution through merger, A and B, the monopolistic enterprises, without making any changes, were merged and shared among the three companies C, D and E. The result values can be seen in Table 3.

4. **Conclusions.** As South Korea's logistics market becomes increasingly saturated, most logistics centers and companies face growing competition. The biggest obstacle to optimizing the enterprise-based shared economy is the participation of the monopolist and

TABLE 3. Results for the equal and proportional distribution of gain for A, B, C, D, and E

Equal distribution of gain	A	B	C	D	E	Integrated	A	B	C, D, E
Result	6145	4147	11226	2489	6738		568	379	189
Proportional distribution of gain	A	B	C	D	E		A	B	C, D, E
Result	4919	5081	1294	613	842		2748	9996	7248

the determination of how to equitably distribute the costs and benefits to the participating entities. In this study, a sustainable shared logistics system model was developed considering strategic alliances. This model is based on systematic methodologies, and is prepared to realize fair distribution according to the contribution between enterprises. The results of the existing methodology were created under the assumption that each company has only one logistics center. However, this assumption does not reflect reality. The actual distribution of businesses and logistics centers was reviewed accordingly. In addition, the distribution of resources is subject to intense competition with saturated markets. This paper presents the direction of logistics common transformation and upgrading to realize the integration and sharing of resources. Therefore, the service level and logistics efficiency of the logistics industry can be improved. Through this paper, it can be helpful to study each company's reports, projects in public facilities, business selection projects and logistics systems using a shared economy.

Acknowledgment. This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2019S1A5A2A03052217, NRF-2018R1D1A1B07044856).

REFERENCES

[1] W. S. Hong, Game theoretical competition model of mixed online and offline supply chains, *Korean Society of Logistics*, vol.27, no.2, pp.49-57, 2017.

[2] K. H. Chung, S. Y. Ko, C. U. Lee and C. S. Ko, Sustainable collaboration model with monopoly of service centers in express delivery services based on Shapley value allocation, *International Journal of Industrial Engineering*, vol.23, no.3, 2016.

[3] D. H. Kim and G. B. Lee, A method of profit allocation for sharing economy among companies considering the transaction costs, *Journal of the Korean Industrial Information Society*, vol.20, no.4, pp.111-126, 2015.

[4] F. N. Ferdinand, K. H. Chung, E. G. Lee and C. S. Ko, Collaborative system design in express delivery services: Formulation and solution heuristic, *ICIC Express Letters, Part B: Applications*, vol.5, no.1, pp.1-8, 2014.

[5] F. N. Ferdinand, I. Moon, K. H. Chung and C. S. Ko, A decision making model for strategic alliance-based network design in express delivery services, *ICIC Express Letters*, vol.7, no.6, pp.1813-1818, 2013.

[6] K. H. Chung, S. Y. Ko and J. J. Roh, A strategic alliance model with a regional monopoly of service centres in express courier services, *International Journal of Services and Operations Management*, vol.5, no.6, 2009.

[7] Y.-T. Park, H.-S. Kim and G. Cho, Study on the system development for port logistics system diagnostics, *ICIC Express Letters, Part B: Applications*, vol.10, no.7, pp.605-612, 2019.

[8] H.-S. Kim and G. Cho, Case study on the operation of smart refrigerated warehouse in Busan, *ICIC Express Letters, Part B: Applications*, vol.9, no.4, pp.369-374, 2018.

[9] D. Kalman, *The Maximum and Minimum of Two Numbers Using the Quadratic Formula*, Ph.D. Thesis, Augustana College, 1984.