A Method of Interorganizational Cooperative Profit and Cost Allocation Considering the Transaction Costs: From the Perspective of the Interorganizational Sharing Economy

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***Abstract*—**Recently, many enterprises have been facing difficulties in their technology, capital, and labor force, and thus, respective efforts have been carried out as solutions for these problems. With this, many enterprises are attempting to strengthen their competitiveness by spreading the investment costs and risks through cooperation and by sharing their resources and profits. The sharing economy that has recently emerged refers to a cooperative consumption in economic activities to increase the efficiency of idle goods or services by sharing with other enterprises. The fair allocation of the profit and cost that are incurred among enterprises with various interests is thus becoming the important success element of the interorganizational sharing economy. The fair allocation of the profit and cost is a complicated issue. Although preceding research suggested the method of profit and cost allocation based on the cooperative game theory, research that suggests the allocation method in consideration of the transaction cost, which is the essential element of the economic activities of enterprises, are seldom conducted. In this research, a method of allocating the profit and cost that are incurred in the process of forming a coalition for cooperation among enterprises was analyzed using the cooperative game theory and a method of profit and cost allocation that applied transaction cost was suggested. In addition, it was identified that the transaction cost is an important element in forming a coalition and that it is associated with the trust relationship among enterprises.

***Keywords*—**Interorganizational, Profit and Cost Allocation, Sharing Economy, Cooperative Game Theory, Transaction Cost

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2012S1A5A2A03034683).

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I. Introduction

Nowadays, many enterprises have problems in technology, capital, and labor force. To solve them, many methods, such as independent efforts of enterprises, governmental support, and cooperation among enterprises, are being attempted. The concept of the sharing economy that has recently emerged can be an alternative to solve such problems. The interorganizational sharing economy refers to a cooperative economic activity for the efficient management of shared resources of enterprises. Through cooperation, enterprises try to achieve the economy of scale by sharing the resources and costs of other enterprises and to create the opportunity of obtaining profit by reducing the risks. Interorganizational cooperation refers to the activity conducted by independent enterprises with the common goal for mutual benefits [1]. To secure and maintain the competitiveness in the market of limitless competition, enterprises are establishing a cooperative relationship among them to create the new market and demand through cooperation while maintaining the existing competition. However, their interorganizational cooperation is not well conducted because of the problems of limited communication, lack of mutual trust, obscure responsibility, profit allocation, etc. [2].

For smooth cooperation in the interorganizational sharing economy with various interests, a clear method of allocating the profits, such as cost reduction by the allocation of the invested costs and through cooperation, resource saving, and sales increase, is necessary [3]. What is the most important is the objective, fair, and easily understandable allocation of the profits and costs. There have been various researches on the profit and cost allocation. Most of those researches are based on the cooperative game theory. However, the researches on the method of allocation in consideration of transaction cost, an essential element in economic activities of enterprises, are rarely found.

In this research, a profit and cost allocation method will be suggested by applying transaction costs that are incurred in interorganizational sharing economy activities. This research will also explain that the transaction cost is an element that should be considered in forming a coalition for cooperation

among enterprises and will suggest a method of profit and cost allocation using equal distribution of gain, proportional cost allocation, Shapley value, among the various methods of profit and cost allocation based on cooperative game

II. Literature Review

A. Concept of the Sharing Economy

1) Interindividual Sharing Economy

A term first used by Professor Lawrence Lessig of the Harvard University of the United States, the shared economy is an economic concept that was created to prepare for the 20th-century capitalistic economy characterized by mass production and mass consumption. The core element of the sharing economy lies in its economic model that aims to increase the efficiency of produced goods by sharing them with many enterprises. This sharing economy is based on the economic pattern that prevents excessive consumption and in which resource is not owned but is rather shared, exchanged, and lent. This has changed the existing "saving" paradigm and transformed it to the new "sharing" paradigm. Today, the observance of the sharing economy continues to expand as it is now practiced in sectors most relevant to society, such as housing, office, automobile, clothing, and general merchandise. Therefore, the sharing economy is considered as the economic activity to increase the applicability of the resources or services to more than their overall value by eliminating unused values among the overall values of the resources or services. Based on previous literature and cases, the interindividual sharing economy can be defined as "a type of economic activity that lends the idle resources owned by individuals to other people or that uses the resources that are expected to be idle when they are owned by individuals, with other people through joint investment [4]-[6]."

2) Interorganizational Shairng Economy

Based on the aforementioned definition of the interindividual sharing economy, the interorganizaitonal sharing economy can be classified according to the type of the ownership of the shared resources and the pattern of the shared resources. Type 1 shows the idle resources owned by individual companies and Type 2 shows the sharing of the resources that are expected to be idle when owned by individual companies, through joint investment with other companies [4]-[6].

B. Interorganiztional Cooperation

Interorganizational cooperation can be conducted in various forms, such as partnership, strategic alliance, cooperation, joint development of new products, and cooperative marketing, etc.[7][8]. By having a special competitive advantage in value chain and through the cooperation using that competitive advantage, profit can be created [9][10]. Various types of cooperation, such as taking equity stake, license agreement, joint research contract, and joint venture, are actively being conducted [11].

The interorganizational cooperation means the joint establishment, management, implementation, and assessment of a plan and joint performance of the core activities in cooperative relationship [12].

C. Cooperative Game Theory

The method of profit and cost allocation is based on the cooperative game theory, which is composed of a set of game participants and a set of coalition efficiency, which is a subset of the game participants. This theory aims to examine, "What is the method of fair allocation when the practicable efficiency set of each coalition is given?"

1) Equal distribution of gain

$$v(i)=C(i)-\frac{1}{n}\left[\sum_{j\in N}C(j)-v(N)\right]$$

$v(i)$ = Cost burden of the participant i
$v(N)$ = The cost assigned to the overall coalition
n = A total number of participants
$C(i)$ = Costs of the individual participants
$\sum_{j\in N}C(j)$ = Sum of individual costs of all participants

Equal distribution of gain is a method of equally distributing the total costs of the individual participants saved in forming a coalition according to the number of participants [13].

2) Proportional cost allocation

$$v(i)=\frac{C(i)}{\sum_{j\in N}C(j)}v(N)$$

$v(i)$ = Cost burden of the participant i
$v(N)$ = The cost assigned to the overall coalition
n = A total number of participants
$C(i)$ = Costs of the individual participants
$\sum_{j\in N}C(j)$ = Sum of individual costs of all participants

Proportional cost allocation is a method of allocating the total costs saved in forming a coalition proportionally to each cost of the participants [13].

3) Shapley Value

$$v(i)=\sum_{C\subset N}\frac{(|C|-1)!(n-|C|)!}{n!}\left[v(C)-v(C-i)\right]$$

$v(i)$ = Cost burden of the participant i
$|C|$ = Number of participants belonging to the coalition C
n = A total number of participants
$[v(C) - v(C - i)]$ = A value that the participant i additionally contributes to the coalition C

Shapley value distributes the economic value, which increased through coalition, on the basis of the marginal contribution of each participant. This method can accurately reflect the level of contribution to the efficiency increase

through coalition. Through this marginal contribution, the individual enterprises can accurately understand and recognize the level of their contribution through participation. Thus, this method is useful in deriving the agreement on the standard of distribution among the participating enterprises [14].

D. Transaction Cost

To explain the appropriateness of the creation of competitive advantage, which is a reason behind the cooperation between enterprises, the transaction cost theory [15], knowledge-based theory [7], and resource-based theory [16] were suggested.

This research considers the transaction cost as the cost to operate the economy system. The structural forms were classified into ex ante transaction cost and ex post transaction cost. The ex ante transaction cost means the cost required for the preparation, negotiation, and guarantee of the implementation of the agreement on transaction conditions. The ex post transaction cost includes 1) nonconformance adjustment cost that is incurred when the transaction is not in compliance with the contract conditions for implementation of cooperation, 2) negotiation cost that is incurred when both parties make efforts to remedy the unequal relationship, 3) dispute-related costs, and 4) the costs to ensure the contract implementation [17].

The transaction cost necessary in the interorganizational sharing economy can be divided in two kinds, such as contracting costs and implementation costs. The contracting costs are the costs required until the time of contract signing and they include costs of measuring and costs of contracting. The costs of measuring are used to define and measure the rights through the various properties of the goods or services and employment of the agents. The costs of contracting are required to conclude the contract with the other party. The costs of contracting include the bargaining and negotiation costs, legal fees paid to the lawyers, and the fees paid to the brokers. The implementation costs are used to implement the contract contents after concluding the contract. The costs of policing and the costs of enforcement are included in the implementation costs. The costs of policing are used to check whether the contract parties are duly implementing the terms and conditions of contract and to find the breach of the contract. The costs of enforcement are used to ensure that the contract parties observe the contract conditions, such as the costs required to request the punishment for breach of contract or to claim the compensation for damages. One example is the cost for the policing or enforcing activities that are not conducted directly by the contract parties but by the agents employed by the parties [18][19].

When organizing the coalition for cooperation in the interorganizational sharing economy, the transaction costs are incurred between the participants and the difference of the transaction costs takes place according to the trust relationship between the participants.

The trust significantly reduces the transaction costs required for negotiation, contracting, and policing between the partnership enterprises. When a partnership relation is established with an unreliable enterprise, a high level of negotiation costs is incurred because much time and effort are required to examine whether the other party hides or distorts the information during the negotiation. In addition, a high level of contracting costs is necessary because one party should make the contract to protect itself from the opportunistic behavior of the other party. Furthermore, the monitoring costs may be necessary after signing the contract to monitor whether the other party faithfully implements the contract terms or whether there is no moral hazard. On the contrary, in the interorganizational cooperation based on the trust, these kinds of transaction costs can be reduced [20]-[24].

III. An Introductory Example

To apply the transaction cost, the costs of the individual participants incurred in forming a coalition should be distributed.

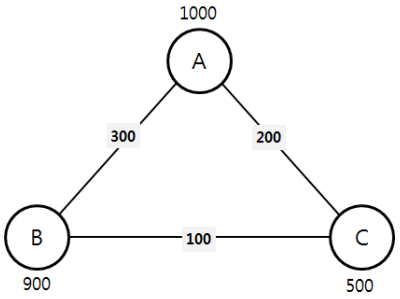

Fig. 1 Costs and Transaction Costs of Three Participants

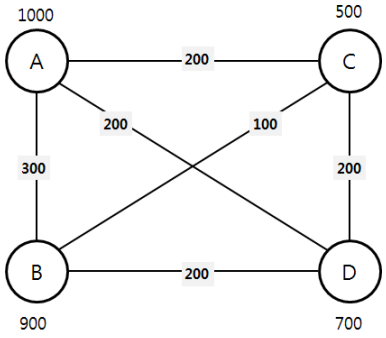

Fig. 2 Costs and Transaction Costs of Four Participants

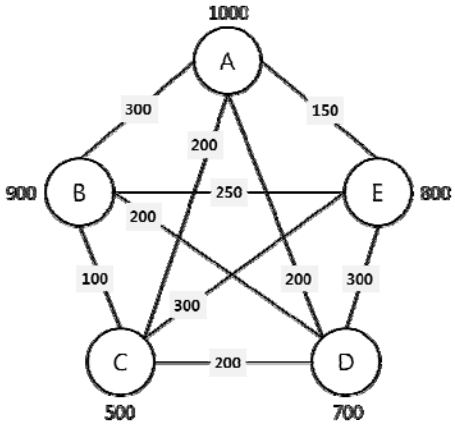

Fig. 3 Costs and Transaction Costs of Five Participants

The individual costs of 3 participants are 1,000, 9,000, and 500, respectively, and transaction costs of them (figure on the link) are 300, 200, and 100 as shown in Fig. 1, and the individual costs and the individual costs and transaction costs of 4 and 5 participants are shown on Figs. 2 and 3.

N = {A, B, C, D}
C(i) = Subset of *N*
C(A) = 1,000 *C(B)* = 900
C(C) = 500 *C(D)* = 700
C(E) = 800
C(AB) = 1,500 *C(AC)* = 1,200
C(AD) = 1,300 *C(BC)* = 1,000
C(BD) = 1,300 *C(CD)* = 900
C(BE) = 1,400 *C(CE)* = 1,000
C(DE) = 1,100 *C(AE)* = 1,400
C(ABC) = *C(N)* = 1,500
C(ABD) = 2,100 *C(ACD)* = 1,800
C(BCD) = 1,500 *C(BCE)* = 1,700
C(BDE) = 1,600 *C(ABE)* = 2,300
C(ACE) = 1,900 *C(ADE)* = 2,000
C(ABCD) = *C(N)* = 2,500
C(ABCE) = 2,900 *C(ACDE)* = 2,700
C(ABDE) = 3,000 *C(BCDE)* = 2,400
C(ABCED) = *C(N)* = 3,200

The cost in coalition of 3 participants is 1,500, generating the gain of 900 from 2,400, the sum of individual costs and the cost in the coalition of 4 and 5 participants is 2,500 and 3,200, respectively, generating a gain of 600 and 700, respectively.

Based on the cases of Figs. 1, 2, and 3, the results of equal distribution of gain, proportional cost allocation, and Shapley value are shown in Tables 1, 2, and 3 below;

Table 1 Equal distribution of gain

Index	3participants	4participants	5participants
v(A)	700	850	860
v(B)	600	750	760
v(C)	200	350	360
v(D)	-	550	560
v(E)	-	-	660
Total	1,500	2,500	3,200

Table 2 Proportional cost allocation

Index	3participants	4participants	5participants
v(A)	625	806.45	820.51
v(B)	562.5	725.81	738.46
v(C)	312.5	403.22	410.25
v(D)	-	564.51	574.36
v(E)	-	-	656.41
Total	1,500	2,500	3,200

Table 3 Shapley Value

Index	3participants	4participants	5participants
v(A)	716.67	841.67	893.34
v(B)	566.67	675	701.67
v(C)	216.67	325	360
v(D)	-	658.33	526.67
v(E)	-	-	718.34
Total	1,500	2,500	3,200

IV. Calculation of Transaction Cost and its Application Method

In above three methods, the transaction cost is not considered but just the gains and costs are distributed. However, to apply the transaction cost, the process of calculating the transaction cost incurred by the enterprises is necessary.

The conditional equation to form a coalition by applying the transaction cost is as follows;

$$\sum_{i \in N} C(i) \geq v(N) + Transaction\ Cost$$

A coalition can be formed only when the cost incurred in forming a coalition by the participants plus the transaction cost is the same as or less than the sum of individual costs. If the above conditional equation is not satisfied, there is no need to form a coalition because the individual costs incurred without forming a coalition are less than the individual costs incurred in forming a coalition.

The three methods to apply the transaction cost are as follows;

A. MST (minimal spanning tree) method

$TC_{MST(N)}$ = Transaction cost according to N, the number of participants, using MST

In the minimal spanning tree (MST) method, the transaction costs between the participants select the route of minimal cost to form a coalition. When the participant *C* takes the lead in forming a coalition, the minimal transaction costs are $TC_{MST(3)} = 300$, $TC_{MST(4)} = 500$, $TC_{MST(5)} = 650$ as shown in Table 4 below.

Table 4 Transaction cost using the MST method

Index	3participants	4participants	5participants
$TC_{MST(N)}$	300	500	650

B. Average transaction cost incurred when each participant takes the lead in forming a coalition

$TC_{AVG(N)}$ = Average transaction cost according to *N*, the number of participants

The average transaction cost incurred when each participant—A, B, C, and D—takes the lead in forming a coalition is $TC_{AVG(3)} = 400$, $TC_{AVG(4)} = 600$, $TC_{AVG(5)} = 880$ as shown in Table 5.

Table 5 Transaction cost using the AVG method

Index	3participants	4participants	5participants
T(A)	500	700	850
T(B)	400	600	850
T(C)	300	500	800
T(D)	-	600	900

T(E)	-	-	1,000
$TC_{AVG(N)}$	400	600	880

C. Application of Shapley value to the transaction cost between the participants

$TC_{ShT(N)}$ = Sum of transaction costs paid by the participant *i* according to *N*, the number of participants

The Shapley value method allocates the gain and cost in the process of increasing value of efficiency based on the marginal contribution of the participants. With this, to apply Shapley value, the transaction cost should be calculated through a method that produces the minimum transaction cost of the participants when forming the coalition.

Using Shapley value, the transaction costs paid by each participant can be calculated as in Table 6 below and the sum of the transaction costs paid by each participant is $TC_{ShT(3)} = 300$, $TC_{ShT(4)} = 500$ and $TC_{ShT(5)} = 650$.

Table 6 Transaction cost using Shapley Value

Index	3participants	4participants	5participants
$TC_{ShT(A)}$	150	158.33	121.67
$TC_{ShT(B)}$	100	108.33	92.5
$TC_{ShT(C)}$	50	91.67	109.17
$TC_{ShT(D)}$	-	141.67	159.17
$TC_{ShT(E)}$	-	-	167.5
Total ($TC_{ShT(N)}$)	300	500	650

V. Profit and Cost Allocation that Applied Transaction Cost

Transaction costs, TC_{MST}, TC_{AVG}, and TC_{ShT}, in forming a coalition, were calculated using MST, average transaction cost, and Shapley value methods. The costs and transaction costs should be allocated by applying the transaction costs calculated by these three methods to equal distribution of gain, proportional cost allocation, and Shapley value allocation methods.

Cost allocation is possible for *C(N)*, the costs paid by the participants, plus the transaction costs in forming a coalition. The allocation methods that applied the transaction cost to the three cost allocation methods explained above are as follows;

$v_{MST(i)}$ = Cost burden of the participant *i* when allocate the transaction cost using MST method

$v_{AVG(i)}$ = Cost burden of the participant *i* when allocate the transaction cost using average transaction cost method

$v_{ShT(i)}$ = Cost burden of the participant *i* when allocate the transaction cost using Shapley value method

A. Equal distribution of gain

$$v(i) = C(i) - \frac{1}{n}\left[\sum_{j \in N} C(j) - \left(C(N) + TC_{MST,AVG,ShT}\right)\right]$$

Table 7 Equal distribution of gain, including transaction cost

Index	3participants	4participants	5participants
$v_{MST}(A)$	800	975	990
$v_{MST}(B)$	700	875	890
$v_{MST}(C)$	300	475	490
$v_{MST}(D)$	-	675	690
$v_{MST}(E)$	-	-	790
$v_{AVG}(A)$	833.33	1,000	964
$v_{AVG}(B)$	733.33	900	864
$v_{AVG}(C)$	333.33	500	464
$v_{AVG}(D)$	-	700	664
$v_{AVG}(E)$	-	-	764
$v_{ShT}(A)$	800	975	990
$v_{ShT}(B)$	700	875	890
$v_{ShT}(C)$	300	475	490
$v_{ShT}(D)$	-	675	690
$v_{ShT}(E)$	-	-	790

B. Proportional cost allocation

$$v(i) = \frac{C(i)}{\sum_{j \in N} C(j)}\left[C(N) + TC_{MST,AVG,ShT}\right]$$

Table 8 Proportional cost allocation, including transaction cost

Index	3participants	4participants	5participants
$v_{MST}(A)$	750	967.74	987.18
$v_{MST}(B)$	675	870.96	888.47
$v_{MST}(C)$	375	483.871	493.59
$v_{MST}(D)$	-	677.419	691.02
$v_{MST}(E)$	-	-	789.74
$v_{AVG}(A)$	791.67	1,000	1046.15
$v_{AVG}(B)$	712.5	900	941.53
$v_{AVG}(C)$	395.833	500	523.07
$v_{AVG}(D)$	-	700	732.31
$v_{AVG}(E)$	-	-	836.92
$v_{ShT}(A)$	750	967.74	987.18
$v_{ShT}(B)$	675	870.96	888.46
$v_{ShT}(C)$	375	483.871	493.59
$v_{ShT}(D)$	-	677.419	691.02
$v_{ShT}(E)$	-	-	789.74

C. Shapley Value

$$v(i) = \sum_{C \subset N} \frac{(|C|-1)!(n-|C|)!}{n!}\left[v(C) - v(C-i)\right] + ShT(i)$$

Table 9 Shapley Value, including transaction cost

Index	3participants	4participants	5participants
$v_{ShT'}(A)$	866.67	1000	1015.01
$v_{ShT'}(B)$	666.67	783.33	794.17
$v_{ShT'}(C)$	266.67	416.67	469.17
$v_{ShT'}(D)$	-	800	685.84
$v_{ShT'}(E)$	-	-	885.84

In the case of Shapley value, *ShT(i)*, which allocated the transaction cost using Shapley value, not $TC_{MST(N)}$, $TC_{AVG(N)}$, and $TC_{ShT(N)}$, should be added to allocation formula. In the case of Shapley value, *ShT(i)*, the transaction cost of each participant, is applied because the allocation is conducted considering all the number of cases for order of the coalition participation by each participant.

VI. Conclusion

This study focused on the interorganizational sharing economy and the gain and cost allocation method for cooperation between the enterprises. In many of the preceding researches, the method of profit and cost allocation was studied based on cooperative game theory, but the research performed in consideration of the transaction costs have rarely been conducted. The interorganizational cooperation is conducted as a method to strengthen the competitiveness but it is not well conducted because of problems, such as the trust relationship and profit distribution among enterprises. As an alternative to solve these problems, this study suggested a method to reflect the transaction cost that is incurred by the trust relationship among enterprises to the allocation of profits and costs. As the methods to apply the transaction costs, MST (minimal spanning tree), AVG (average of transaction costs incurred by the participants), and ShT (allocation of the transaction costs incurred by the participants using the Shapley value) methods were used and they were applied to profit and cost allocation methods. By applying the transaction costs calculated by the three methods, such as MST, AVG, and ShT, to equal distribution of gain, proportional cost allocation, and Shapley value, which are the three profit and cost allocation methods, the profit and cost allocation formula was derived.

The result of studying the three aforementioned gain and cost allocation methods showed that the Equal Distribution of Gain method allocates the transaction costs, which were derived through MST, AVG, and Shapley value, equally to the participants. The Proportional Cost Allocation method allocates the transaction cost proportionally to the participants in the order of higher individual cost among the participants. The Shapley value method allocates the cost derived through Shapley value to each participant.

Different from the AVG method, the transaction costs derived by the MST and Shapley value methods showed the same values because the transaction cost should be calculated through the method that produces the minimum transaction cost of the participants when forming the coalition during the process of applying Shapely Value.

For research, the correlation between the trust relationship among enterprises and transaction costs was identified and a formula was produced by giving the values to transaction costs according to the arbitrary costs of 3, 4, and 5 participants and trust relationship between them. This study can find its significance in that it suggested an allocation formula by quantifying the transaction costs incurred among enterprises. In particular, this study can find its significance in that it carried out advance research to efficiently allocate the transaction costs that can vary according to the trust relationship. The limits of this study are that it only carried out the analysis of the allocation results of 3, 4, and 5 participants but could not verify the result value when the number of participants increases. In case the number of participants increases, verification is necessary to generalize the profit and cost allocation formula that applied the transaction cost, which was previously derived.

In addition, as there are differences in the values of each gain and cost allocation method that applied transaction cost, it should be verified which of the aforementioned three methods is suitable for the interorganizational sharing economy. As various types of business and diverse types of participants are involved in the interorganizational sharing economy, the most proper method of allocation suitable for each situation is necessary.

For future research, the profit and cost allocation formula, which can be generalized according to the increase of the number of participants, needs to be derived.

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