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Assessment of Port Development Priority with Conflicts among Decision Makers -From the Perspective of Environment-friendly Port Development-

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의사결정자의 대립하 항만개발 우선순위 평가 -환경친화적 항만개발의 관점에서-

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Abstract : *In this study, the priority was assessed and the compensation relationships were analyzed with regard to the issue of port development with conflicts among decision makers. First, the assessment factors were selected by the relevant literatures on port development, and fuzzy structure modeling was used to select assessment factors via structuralization analysis. Second, the local residents, port users, and local government were chosen as the main port-development related entities, and the analytic hierarchy process was used to calculate the total assessment value. Third, the justice based on majority power rule method was used as an assessment method that would minimize the amount of complaints according to the total assessment results and the alternative selection when a partnership was formed among the assessment entities. Moreover, the compensation issue according to the alternative selection was quantified, and the compensation relationships were analyzed. As a result, it was found that port development in Busan must be the top priority in terms of port development in South Korea, that awareness of environmental issues must be promoted among the port users, and that the local governments must promote environmental incentive policies for Environment-friendly port development.*

Key words : *Port development, FSM(Fuzzy Structure Modeling), AHP(Analytic Hierarchy Process), JMPR(Justice based on Majority Power Rule), Compensation relationship*

요 약 : 본 연구에서는 의사결정자의 대립관계가 있는 항만개발 문제에 대한 우선순위 평가와 보상관계를 분석하였다. 이를 위해 먼저 항만개발에 대한 관련문헌을 분석하여 평가요소를 추출하였고, FSM법을 이용하여 평가요소를 구조화하고, 구조화 분석을 통해 평가항목을 선정하였다. 두 번째, 항만개발 평가 주체를 지역주민, 이용자, 지자체로 선정하고 AHP법을 이용하여 종합 평가치를 산출하였다. 세 번째 JMPR법을 이용하여 평가주체간 제휴를 구성하였을때 종합 평가결과와 대체안 선정에 따른 불만량을 최소로 하여 평가하는 방법을 제시하였다. 또한 대체안 선정에 따른 보상문제를 정량화하고 보상관계를 분석하였다. 그 결과 대상 항만중 부산항 개발이 가장 우선되어야 하며, 항만이용자는 환경에 대한 인식의 개선과, 지자체에서는 환경 친화적인 항만개발을 위한 환경 인센티브 정책을 추진해야 할 것이다.

핵심용어 : 항만개발, 퍼지구조모델, 계층분석법, 공정 기반 다인수 파워원리, 보상관계

1. Introduction

Many countries and cities, such as Japan, Taiwan, and Hong Kong are expanding their port development efforts to develop a hub port. In South Korea, port development is expanding, centered on Busan, Incheon, Gwangyang, etc.. In particular, as the interest in climate change has risen internationally and as the standard of living has improved, the national interest in Environment-friendly Port development has been increasing of late.

In the assessment of port development in South Korea, researches focusing on the assessment of the competitiveness of the country's ports are under way, and most of these researches consider the perspective of the port users. The assessment of port development, however, should involve not only the port users but many other entities as well, such as the local residents and the local government. Moreover, entities sometimes form partnerships

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with other entities to push their stand, and may raise complaints about the selected port development related alternative. Thus, it is necessary to perform assessment considering the compensation relationships of the other port development related entities with regard to the selected alternative.

Therefore, in this study, the other entities involved in the development of the major ports in South Korea were considered in the analysis of the method of selecting the option that minimizes the complaints with regard to the selected alternative, and the compensation relationships of such entities according to the selected alternative were analyzed. For this, fuzzy structure modeling(FSM) was first used to perform structuralization analysis, to determine the assessment factors per assessment entity. FSM helps facilitate decision making by expressing the subjective awareness of the decision maker as a graph, and is widely adopted in the field of port development. The total assessment per assessment entity was evaluated using the analytic hierarchy process(AHP), and the justice based on majority power rule(JMPR) method was used to select the alternative that minimizes the complaints.

2. Theoretical background

2.1 Considerations for the port development priority assessment issues

Port development priority assessment may generate multiple opinions according to the assessment entities. For example, from the perspective of the local residents, port development may raise issues related to urban functions, so they are likely to have a negative stand on the matter. On the part of the port users, as port development can facilitate freight handling and can improve distribution costs and corporate competitiveness, they are likely to have a positive stand on it. The issue of port development can be viewed as a game where n entities participate in making a decision. On the other hand, when trying to adopt an alternative, if the assessment entities participate in the assessment as a group rather than as individuals, based on the majority decision rule, the direction preferred by the majority will be adopted. Thus, groups have an advantage in the assessment.

The aforementioned situation can be referred to one where partnerships are formed among the assessment entities, and this should be reflected on the assessment. Moreover, as choosing an alternative in an assessment issue may give rise to complaints on the part of some entities with regard to the selected alternative, it is necessary to find a way of minimizing such complaints. Thus, in this study, the JMPR method suggested by Nagao(1984), which enables a decision to be made with minimum complaints, and which considers the partnership relationships and the majority power rule based on which the alternative preferred by the majority is selected, was used to assess the port development priorities. But the alternative is still bound to be complaints by entities.

Therefore, in this study, the compensation relationships with regard to the complaints of the entity or entities that endorsed a rejected alternative were considered. For this, the ideal and actual division points were compared to come up with an accurate compensation value and to suggest an appropriate compensation method.

In this study, FSM was used to structuralize the assessment elements and decided assessment factors and AHP was used to calculate the weighted average value.

2.2 FSM and AHP method

Let the target system be $S=(s_1, s_2, ..., s_n)$, and define the matrix displaying the subordinate relationship between the extracted elements as fuzzy subordinate matrix $A=[a_{ij}]$(Eiichiro and Michio, 1979; Yang, 2003). Here, matrix A is an n×n matrix, and element a_{ij} is expressed as a binomial relationship for formula (1).

$$a_{ij} = f_r(s_i, s_j),\ 0 \le a_{ij} \le 1 \quad (1)$$

Here, a_{ij} is the level of subordination of element s_i to s_j, f_r is the membership function with regard to the fuzzy binomial relationship between the elements of set S, and f_r and $f_{\bar{r}}$ are defined as in formulae (2) and (3), respectively.

$$f_r : S \times S \to [0,1] \quad (2)$$
$$f_{\bar{r}} : S \times S \to [0,1]$$

In addition, the relationship between f_r and $f_{\bar{r}}$ is as in formula (3).

$$f_{\bar{r}} = \frac{(1-f_r)}{(1+\lambda f_r)},\ -1 < \lambda < \infty \quad (3)$$

The algorithm for structural analysis via FSM consists of five steps. :

[Step 1] When the fuzzy subordinate matrix $A=[a_{ij}]$ is given, build matrix A′ satisfying fuzzy antireflexibility, fuzzy asymmetry rat, and fuzzy antitransitive law from A.
[Step 2] From threshold value p, find the level set from A′.
[Step 3] Form modified matrix A′.

To perform structural analysis of the subordinate relationship between each element, the row of $L_t(s)$, the column of $L_b(s)$, and the row and column of $L_{is}(s)$ found in step 2 are removed, and the remaining rows and columns are used to reconstruct A′.

[Step 4] Form a monohierarchical matrix.
From A′ reconstructed in step 3, monohierarchical matrix $A^{(j)}$ is constructed according to block set Q_j.
[Step 5] Prepare a structuralization graph.
Set fuzzy structural parameter λ and construct the structural graph for monohierarchical matrix $A^{(j)}$.

AHP is widely used in various fields, such as for optimal location, marketing planning, and policy making(Kim et al., 2009). In this study, the logical consistency was confirmed via the paired comparison of two elements, and the weighted value was calculated. The calculation method for the weighted value of AHP is widely known, and there are software implementations of such. Thus, this study was omitted.

2.3 Selection of an alternative, and arriving at an agreement based on compensation

Rawls(1957) suggested the principle of justice on the subject of distribution, and Schmeidler(1969) suggested a method of calculating the profit distribution in the game using the concept of nucleolus. Suzuki and Mikio(1976), based on the concepts suggested by Rawls(1957) and Schmeidler(1969), suggested a method of minimizing the complaints of the partnership with the greatest complaints within the partnership distribution method by nucleolus, based on the principle of justice(Suzuki and Mikio, 1976; Suzuki and Muto, 1981).

Nagao(1984) suggested JMPR, which combined a multifactor power game with MPR, and described the method of forming an agreement based on compensation. In this study, the JMPR method was used to assess the priorities and to analyze the compensation relationships in relation to port development.

On the issue of port development priority assessment, if there are no limitations on forming partnerships, the possible number of partnerships is $2^{[N]}$. In case alternative $a_j \in A$ is executed for arbitrary partnership $s \in S$, the profit of s is $\overline{U}^s(a_j)$, and partnership s can calculate the amount of complaints with $v(s)$ as the minimum guarantee level using formula (4).

$$D(S \mid a_j) = v(s) - U^S(a_j) \tag{4}$$

$U^S(a_j) > v(s)$ implies residue. The alternative that considers such complaints against all the partnerships and that minimizes the complaints the most is chosen as in formula (5).

$$\min_{a_j \in A} \cdot \max_{S \in S} [v(S) - U^S(a_j)] \tag{5}$$

Even if the alternative chosen using formula (5) is a^*, each assessment entity $\{1,2,\ldots,k,\ldots,n\}$ will still have complaints. Thus, the concept of nucleolus is used again to find the ideal distribution for each assessment entity, based on which the complaints can be resolved.

When the alternative is chosen based on formula (5), the total profit acquired by the participants in assessment $\{1,2,\ldots,n\}$ becomes $\sum_{k \subset N} U^k(a^*)$. At this time, the profit is for the entire society, acquired by the execution of a^*, and is expressed as $U^N(a^*)$. Thus, the final profit $x(k)\ (k=1,2,\ldots,n)$ to be distributed to the assessment participants $k \in N$ must fulfill formulae (6) and (7)(Nabatame, 2005).

$$\sum_{k \subset N} x(k) = U^N(a^*) \tag{6}$$

$$x(k) \geq U^k(a_k) \tag{7}$$

Formula (6) is the Pareto optimality condition, which expresses the rationality of the whole, and formula (7) shows the individual rationality conditions. Thus, the solution of the nucleolus can be calculated using formula (8).

$$\max_{x} \cdot \min_{k \in N} \{x(k) - U^k(a_k)\} \tag{8}$$

Formula (8) serves to maximize the distribution to the participants that does not achieve the minimum satisfaction. On the other hand, if the solution of formula (8) is made to be $x^*(k)\ (k=1,2,\ldots,n)$, then the difference between $x^*(k)$ and $U^k(a^*)$ will consider the

$$c(k) = x^*(k) - U^k(a^*) \tag{9}$$

compensation for fairness, $c(k) > 0$ will receive compensation, and $c(k) < 0$ will provide compensation, and the positives and negatives will obviously cancel out because the incorporation of formulae (8) and (9) will result in formula (10).

$$\sum_{k \subset N} c(k) = \sum_{k \subset N} x^*(k) - \sum_{k \subset N} U^k(a^*) - \epsilon^* = 0 \tag{10}$$

3. Assessment structure of the port development priority

3.1 Selection of assessment factors

For port development priority assessment, the assessment items were structured in this study via FSM.

1) Structural analysis of port users

For the extraction of assessment items as in Table 1 for the port users, the existing papers on port competitiveness assessment(Baek and Moon; Yang and Lee, 1999) were used.

Table 1. Assessment items of port users

S1	User(shipowner, shipper)	S20	Level of information services
S2	Container throughput	S21	Safety of port labor
S3	Port hinterland	S22	Freight safety
S4	Port services	S23	EDI
S5	Port facilities	S24	Waterway width
S6	Geographic conditions	S25	Depth
S7	Transportation connectivity	S26	No. of anchorages
S8	Import/export cargo volume	S27	No. of berths
S9	Transshipment cargo volume	S28	Quay length
S10	Size of the local market	S29	No. of cargo handling equipment
S11	No. of industries at the port	S30	Level of construction of port information facilities
S12	Existence of a compound distribution complex	S31	Distance from the trunk route
S13	FTZ	S32	Distance from the import/export locations
S14	Inland container station level	S33	Distance from the nearest airport
S15	Hinterland development conditions	S34	Railroad industrial line
S16	Free time period	S35	No. of highways
S17	Distribution costs	S36	No. of national roads
S18	Storage system level	S37	No. of local roads
S19	Port usage methods		

Fig. 1 shows the resulting structure for port users when FSM was used. As the P value decreases, the layers become too many. Further, as the λ value increases, the connection becomes more complicated. In this study, the λ=-0.3 value was used, which is known to be clear about the connection of the assessment items(Yang, 2003). The P value is on the third hierarchy level.

From the perspective of the port users, as the connecting point of sea and land transportation, a port provides terminal functionality for smooth freight transportation by offering an elementary transportation center facility for cargo handling, transfer, inspection, storage, and management.

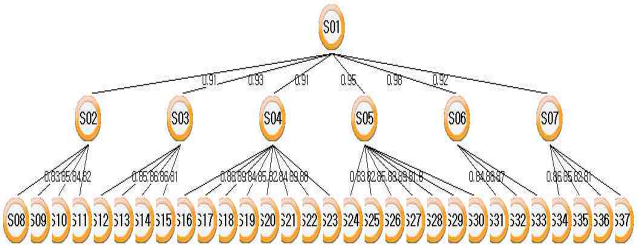

Fig. 1. Structure graph of port user(p=0.8, λ=-0.3).

2) Structural analysis of local residents

For the assessment items for the local residents, the elements listed in Table 2 were extracted with reference to assessment papers(Nakamura, 1997; Nagao, 1984) considering the environment.

Table 2. Assessment items of local residents

S1	Local residents	S11	Automotive sounds
S2	Scenery	S12	Dust
S3	Urban environment	S13	Noise
S4	Urban traffic	S14	Traffic accidents
S5	Container throughput	S15	Passage time increase
S6	Coastal scenery	S16	Passage obstruction
S7	Urban scenery	S17	Import/export cargo volume
S8	Urban nightscape	S18	Transshipment cargo volume
S9	Road scenery	S19	Size of the local market
S10	Air pollution	S20	No. of industries at the port

Fig. 2 shows the resulting structure for the local residents when FSM was used. For the local residents, a port plays the role of forming a port city by strengthening the urban base and accelerating the population concentration in the process of mutual development in proximity to the cities. With the increase in port transportation, however, the port area will expand and will eventually invade the residential area, causing traffic chaos or colliding with the urban functions.

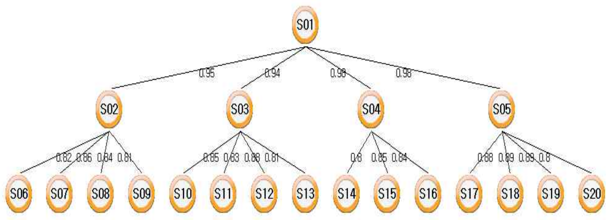

Fig. 2. Structure graph of local residents(p=0.8, λ=-0.3).

3) Structural analysis of the local government

Referring to assessment papers(Nakamura, 1997; Nagao, 1984; Baek and Moon, 2005) on local governments, the representative elements listed in Table 3 were extracted.

Table 3. Assessment items of local government

S1	Local government	S19	Road scenery
S2	Urban environment	S20	Import/export cargo volume
S3	Urban traffic	S21	Transshipment cargo volume
S4	Scenery	S22	Size of the local market
S5	Container throughput	S23	No. of industries at the port
S6	Port hinterland	S24	Existence of a compound distribution complex
S7	Water usage	S25	FTZ
S8	Regional influence	S26	Inland container station level
S9	Air pollution	S27	Hinterland development conditions
S10	Automotive sounds	S28	Industrial influence
S11	Dust	S29	Anchoring change
S12	Noise	S30	Waterway change
S13	Traffic accidents	S31	Port management
S14	Passage time increase	S32	Usage of the nearby port
S15	Passage obstruction	S33	Valid land use
S16	Coastal scenery	S34	Influence on port transportation
S17	Urban scenery	S35	Construction period
S18	Urban nightscape		

Fig. 3 shows the resulting structure for the local government when FSM was used. The local government, which tries to develop the port, can expect the economic and welfare benefits of increased productivity and expanded market by facilitating goods circulation through the terminal functions, revitalizing the local economy by encouraging consumption, and resolving the complaints of the local residents with regard to port development(e.g., traffic chaos) by improving the environment around the port.

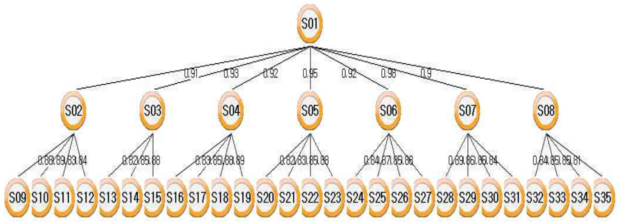

Fig. 3. Structure graph of local government(p=0.8, λ=-0.3).

3.2 Survey Characteristics Analysis

To maintain objectivity, the survey targets that were selected were general citizens for the local residents, shipowners and shippers for the port users, and hands on staff with port distribution tasks for the local government. A total of 121 people were randomly selected for the survey and the parallel interviews, but only 90 accomplished survey questionnaires were acquired(30 per assessment entity), which was the value that was used in the final assessment, for the analysis of the same number of survey respondents per assessment entity, and for the inspection of consistency via AHP. The details are shown in Table 4.

Table 4. Result of survey for port development

Investigation Targets		No. of distributions
Local residents	General citizens living near seaport (province distribution : Jeolla, 42 papers; Gyeongsang, 8 papers; Gyeonggi, 3 papers)	53
Users	Shipowners : container ship company business departments Shipper : import/export departments	36
Government, local government	Public officials in the field of port transportation, safety tasks	32

4. Port development priority analysis and compensation strategy

4.1 Analysis of port development priorities

Table 5 shows the importance of port development from the perspective of the local residents.

Table 5. Weight of port development by residents

R	Traffic safety	Environment	Scenery	Throughput	Weight
Traffic safety	1.00	2.38	4.37	6.24	0.522
Environment	0.42	1.00	2.60	4.31	0.261
Scenery	0.23	0.38	1.00	2.74	0.13
Throughput	0.16	0.23	0.36	1.00	0.087

λmax=4.01, C.I.=0.003

For the local residents, traffic safety is the most important consideration with regard to port development as port development will increase the number of trucks, which is expected to raise the risk of traffic chaos and accidents. Moreover, the local residents consider the elements related to the creation of a pleasant environment(e.g., environmental pollution, scenery) important, and do not consider economic growth elements such as port transportation important.

Table 6 shows the survey results pertaining to the importance of port development from the perspective of the port users(shipowners, shippers).

Table 6. Weight of port development by port user

U	Throu-ghput	Hinter-land	Port service	Port facility	Geogra-phical conditions	Transpor-tation connectivity	Weight
Throughput	1.00	3.38	5.24	6.30	7.24	8.73	0.490
Hinterland	0.30	1.00	3.57	5.13	6.54	7.38	0.267
Port service	0.19	0.28	1.00	3.79	4.32	7.17	0.131
Port facility	0.16	0.19	0.26	1.00	2.43	4.28	0.055
Geographical Conditions	0.14	0.15	0.23	0.41	1.00	3.21	0.034
Transportation connectivity	0.11	0.14	0.14	0.23	0.31	1.00	0.023

λmax=6.662, C.I.=0.098

From the perspective of the port users, port development is most important in terms of port transportation and hinterland. This appears to be supported by the fact that the existence of a place of origin and the demand for goods are important for port development. Other important elements include port services and facilities, which are believed to be considered important by the port users due to the speed and safety of freight handling at the ports.

Table 7 shows the survey results pertaining to the importance of port development from the perspective of the local government.

Table 7. Weight of port development by local government

G	Throu-ghput	Safety	Scenery	Environ-ment	Hinterland	Water usage	Regional influence	Weight
Throughput	1	3.74	5.36	5.28	2.34	4.96	6.34	0.331
Safety	0.27	1	3.38	0.23	0.42	2.42	2.83	0.098
Scenery	0.19	0.3	1	0.15	0.22	0.36	5.14	0.043
Environment	0.19	4.36	6.72	1	2.76	4.38	0.22	0.214
hinterland	0.43	2.39	4.57	0.36	1	2.92	4.38	0.164
Water usage	0.2	0.41	2.74	0.23	0.34	1	3.72	0.068
Regional influence	0.16	0.35	0.19	4.46	0.23	0.27	1.00	0.083

λmax=7.590, C.I.=0.083

For the local governments, it was found that transportation quantity and environmental factors are considered most important, which implies that the local government considers important not only the growth of the local economy due to the demand for and generation of freight but also the living environment of the local residents. The item of regional influence was found to be considered relatively low in importance by local governments, which appears to reflect the results of the consideration of the areas where port awareness is negative(e.g., Busan/Incheon) and of the areas where port development is yet inadequate(e.g., Mokpo/Pyeongtaek).

Thus, the importance and assessment values of the assessment factors were considered for a total assessment, and the results are shown in Table 8.

Table 8. Total weight of port development

k	Busan (a_1)	Pyeongtaek (a_2)	Masan (a_3)	Gwangyang (a_4)	Pohang (a_5)	Incheon (a_6)	Mokpo (a_7)
R	0.043	0.098	0.209	0.164	0.068	0.079	0.339
U	0.303	0.118	0.042	0.221	0.168	0.068	0.079
G	0.255	0.091	0.031	0.201	0.142	0.211	0.069
$\sum U^K$	0.601	0.307	0.282	0.586	0.378	0.358	0.487

The local residents believe that Mokpo, where port development is yet inadequate, should be given top priority in terms of port development, and that Busan should be given the least priority. In contrast, however, from the perspective of the port users, Busan should be given the top priority, and Mokpo the least. For the local governments, Busan should be given the top priority, along with Incheon.

Thus, the order of port development priority according to the majority was found to be Busan, Gwangyang, Mokpo, Pohang, Incheon, Pyeongtaek, and Masan. Mokpo is especially higher compared to the others because its assessment result value from the local residents was considerably higher than those of the two other entities. The sample size in the survey that was conducted in this study was inadequate, however, and the samples were restricted to certain areas. Therefore, generalizations cannot be drawn from the results of this study.

On the other hand, in this research, the assessment value from the decision makers after forming partnerships with one another was considered, along with the compensation.

4.2 Analysis of Port Development Priority considering the Partnerships Formed among the Decision-Makers

As the set of port development priority assessment entities is $N=\{U, R, G\}$, the possible partnerships are

$S=\{R, U, G, RU, RG, UG, RUG, \phi\}$, including ϕ, with no partnerships. By applying the previously defined majority rule to these partnerships, the partnership values are expressed as in the following Table 9.

Table 9. Cooperation and value of dissatisfaction

s	v(s)	$D(S \mid a_j)$						
		a_1	a_2	a_3	a_4	a_5	a_6	a_7
R	0.043	0	-0.055	-0.166	-0.121	-0.025	-0.036	-0.296
U	0.079	-0.224	-0.039	0.037	-0.142	-0.089	0.011	0
G	0.211	-0.044	0.12	0.18	0.01	0.069	0	0.142
RU	0.147	-0.199	-0.069	-0.104	-0.238	-0.089	0	-0.271
RG	0.21	-0.088	0.021	-0.03	-0.155	0	-0.08	-0.198
UG	0.148	-0.41	-0.061	0.075	-0.274	-0.162	-0.131	0
RUG	0.282	-0.319	-0.025	0	-0.304	-0.096	-0.076	-0.205
MaxD(S)	0.282	0	0.12	0.18	0.01	0.069	0.011	0.142

First, as can be seen in Table 8, port development in Busan was chosen as the top priority by majority rule, and the local residents(R) are expected to raise complaints about such choice. The expected numbers of complaints $D(S \mid a_j)$ are shown in Table 9. Here, *v(s)* refers to the total assessment value on which the claim is based. The local residents, however, are expected to demand that port development in Mokpo be made the top priority, so the numbers of complaints from the port users and local government regarding port development in Mokpo can be shown as U and G, respectively. On the other hand, if the local residents form the RU and RG partnerships to push for making port development in Mokpo the top priority, the expected numbers of complaints from other ports regarding the choice of Mokpo as the priority site for port development through the RU and RG partnerships are shown in Table 9. In this way, the claims of all the decision making entities, and the corresponding numbers of complaints, can be calculated.

Therefore, considering the partnerships and numbers of complaints in the total assessment of the port development priorities, port development in Busan generated the lowest number of complaints (0).

4.3 Selection of compensation agents according to the selected alternative

Even though port development in Busan generated the lowest number of complaints from each entity, there were still complaints with regard to it. Thus, formula (8) was used to find the ideal distribution to consider the compensation level, and the results are listed in Table 10.

Table 10. Ideal division and indemnity

k	x^k	$U^k(a_1)$	$C(k)$
R	0.051	0.043	+0.008
U	0.289	0.303	-0.014
G	0.261	0.255	+0.006

As can be seen in Table 8, the distribution point moves from the ideal distribution point x^k to $U^k(a_1)$ according to the selection of Busan, so R becomes $\Delta R=0.008$, U becomes $\Delta U=-0.014$ and G becomes $\Delta G=0.006$. Thus, the compensation for R and G should be as much as the profit acquired by U.

In the actual issue, the provision of compensation for R may be the strategy for improving the living environment, and for G, it can be environment friendly port development policies. As for U, the living environment can be improved by increasing the port users' awareness of environmental issues. In South Korea, especially in Busan, there are many policies that are currently being enforced with respect to port construction for low carbon port operation. To increase the people's awareness of environmental issues, it is necessary to consider the cost burden of the port users. As this may of course harm the price competitiveness of the port, the decision must be made after a thorough deliberation. LA/LB is promoting policies that provide incentives even while imposing some environmental costs on the port users. Such policies can be referenced.

5. Conclusion

The decision making with regard to port development should be accompanied by assessment participated in by the port users, local government, and local residents. In this study, fuzzy structure modeling was used to structuralize the port development assessment elements, and the analytic hierarchy process was used for the total assessment. Moreover, the decision making with regard to port development priorities was viewed as a game with multiple players, and the assessment results after the formation of partnerships as well as the complaint relationships of the other entities according to the selection of alternatives were considered to determine the port development priorities with minimal complaints. On the other hand, the compensation relationships according to the selected alternatives were considered. As a result, it was found that port development in Busan should take precedence. Moreover, port development in Busan will generate profit for the port users and will bring about loss for the local residents and local government, so efforts must be made to increase the port users' environmental awareness, and the local government should promote environmental policies such as providing environmental incentives while imposing some of the costs on the port users for the efficient promotion of environmental issues.

This study is meaningful in that it selected an alternative for port development that considered the local residents, local government, and port users, and that minimizes the complaints, and the compensation relationship of the entities according to the alternative selection was quantitatively analyzed. The sample size for the survey that was conducted in this study was inadequate, however, and the samples were restricted to certain areas. Therefore, it is far too risky to make generalizations from the results of this study. The future research should consider all the factors for structuring port development efforts because the selection of the alternative supported by the port users will entail the consideration of many other factors, such as the port development cost.

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