International Journal of Navigation and Port Research
Vol.30, No.4 pp. 317~323, 2007 (ISSN-1598-5725)

# Risk Allocation of Private Port Development with Hierarchical Fuzzy Process

† *Yu-Chang Seong* · Myung-Ou Youn***

** Student, Graduate school of Kobe University, Faculty of Maritime Science, Kobe 658-0022, Japan*
*** Professor, Division of Maritime Transportation System, Mokpo National Maritime University, Mokpo 530-729, Korea*

Abstract : *As economic trade between Korea and China has been encouraged with the rapid growth of Chinese economy and port competition in Northeast Asia, Korean government is trying to promote development and consolidation of ports to cope with the lack of facilities. Thus, many projects for port development have been propelled including the enactment the 'Private investment promotion law for social overhead capital 1994.' However, there are still some unsettled issues since considerable part of risk is still allocated to the Government when it has to support the private businesses in these port investments whenever unexpected problems arise. Allocation of risk among the participants - in this case especially - is a very subtle issue, however, it was revealed that not many precedent researches were done on the subject.*
*In my previous research, I classified and analyzed 4 principle risks i.e, construction, management, financial and social risk. This research investigates the reasonable allocation of the risks among the participants using the Hierarchial Fuzzy Process.*
*In the result of analysis, responsibility of private party is the most important and it must put the responsibility before Government' roll concerned. Also, this research displayed and proposed the direction of management method on port development in a view of minimizing risk and maximizing initiative of a private party.*

Key words : *Port development, Privateinvestet, Decision making, Allocation of risk, Hierarchical fuzzy process(HFP)*

## 1. Introduction

While ports process 90% of the entire world's trade, ports in Korea process 99% of the nation's freight distribution, making them all the more important to the national economy. Recently, Korean government has been promoting the development and consolidation of ports, as the economic trade between Korea and China has been constantly increasing with the rapid growth of Chinese economy and the port competitions in Northeast asian area. Since SOCs such as ports, roads and communication infrastructure are so important social facilities, it is generally thought that the Government should take charge of the provision. However in fact, the Government is trying to encourage private investments to participate in SOC constructions not only to avoid the burden of policy failure but also because it is more efficient. Thus, many projects for port development have been propelled by private investment since the enactment of the Private investment promotion law for SOC in 1994 & 1998.

In this cases Government and private investor make contract concerning construction, funds, responsibilities and combined as interested parties. However, whenever unexpected issues arise, the Government has to answer the calls for support. This structure aggravates and is aggravated by the awry management of the private part with certain moral looseness. Therefore, in development and expansion of ports, placing the responsibility of development and maintenance of the ports to the right bodies is crucial, as well as precise assessment of supply and demand for physical distribution. The appropriate re-allocation of risk on private investments can be an efficient way out of this vicious circle. Unfortunately, there are not so much research that examines different kinds of risks that occurs in the port development with private investments and how to distribute those risks.

In my previous research, I analyzed risk priority in private investment in port development. The research classified principal risks which could be generated in private port development. It also listed sub-elements that constitute a risk through literature research and questionnaires.

This research, based on assessments and evaluations by experts of the field, investigates the responsible subject of risks, which are classified by preceding review and previous research.

The opinions of experts from the Government, universities and industries are refined through discussions about responsible party on these risks. It also investigates the

† Corresponding Author : Yu-chang Seong smileseong@hanmail.net, 042)635-6940
** ymo@mmu.ac.kr, 061)240-7062

Table 1 Classification of Risks on Private Port Development

| Risk | Components | Risk | Components |
|---|---|---|---|
| Construction | • wrong estimation of cost<br>• mistake of schedule<br>• unexpected occurrence on construction<br>• wrong design at first stages<br>• environmental problem<br>• act beyond control | Management | • quantitative lack of cargo flows<br>• unexpected additional fee<br>• low quality of service<br>• problem of managing equipment<br>• unsuitable management<br>• change of managing method<br>• change of profit |
| Finance | • problem of credit<br>• fluidity problem<br>• inflation<br>• excessive debt<br>• chgange of exchange rate | Social environment | • trouble on custom and trade<br>• change of regulation<br>• work trouble<br>• petition<br>• unstable society |

reasonable distributions of each risks. The object port is limited in middle class port that requires redevelopment and maintenance as Mokpo port does. The HFP method is used to summarize the opinions of experts.

## 2. Literature Analysis

### 2.1 Precedings of Risk in Private Development

Preceding researches that have been reviewed for this paper concerning private investment can be classified in two categories; Allocation and Classification of Risks.

<Allocation of Risks>

Kay(1993) asserted that efficiency to construction and management of social overhead capital could increase under the condition that private parts submit to more danger by mutual competition.

Kim(1995) proposed that it is important for success on private investment enterprise that the matter on risk taking accomplishes the balance between subjects to be responsible. Nho and Jeong(1997) thought that it should not give risks of uncertainty which private parts cannot control by themselves. They suggested that Government have to typify various risks and prepare the risk-taking standard.

The institute on civil & transport (1998) classified the risk for parties to be assigned more clearly. According to UNCITRAL(2001), it remarks that it was not desirable to carry out risk allocation through the establishment of law, particularly in cases where it could not perform allocation of risks.

<Classification of Risks>

Bae(1995) classified various risks of infrastructure project. He classified risks based on time period; before a construction completion, risk processing to construction and risk on first stage. Walker and Smith (1995) classified three kinds of risk on private investment enterprise. Those were financial risk, political risk and technical problem.

In the report by institute of civil & transport (1998), Government took the risks of inevitable casualties and inflation. Risks that private part had were the cost of construction, operational expense and financial matter of profit change. Ha and Ahn(1998) proposed that the profitability of enterprise has to be applied according to risk level, because it might be changed with enterprise characteristics.

Yang(1998) made the design of classification about business risk construction, completion, product, control of maintenance and safety. Philippe Jorion (1998) classified the risks into commercial risk, fluid problem, management risk and legal parts at his work 'VAR' (Value at Risk).

UNCITRAL[1] suggested that there is a business failure related with project risk; natural disaster, political risk, construction and management risk, commercial risk and financial risk. In PFI (Private Finance Initiative, U.K), those risks were classified similarly to that of UNCITRAL.

### 2.2 Risk Priority on Private Port Development

To analyze priority level in port development, my previous research carried out two questionnaires. Through the first questionnaire, we classified principal risks and the sub-elements. Through the first questionnaire, the risks in private port development were classified into four categories: Construction, Management, Finance and Social risk, as shown in Table 1. The secondary questionnaire analyzed pair-wise comparison on each risks. (Seong, 2006)

1) UNCITRAL. The United Nations Commission on International Trade Law, an organization of UN.

Through the analysis results, the risky status of the management and the finance was shown in higher value (0.28) than the construction (0.24) and social (0.18).

In construction risks, the wrong estimation of cost was analyzed as more important (0.38) than the other risks. Then, the problem related on environment was analyzed for environment related problems (0.29).

In the risks of the management, the problem of management by the quantitative lack of cargo flows (0.8) was higher than any other risks. Then, other high risks that were given priority are, in order, unsuitable management, change of profits, and additional charges.

For financial risks, fluidity problems and excessive debts are rated as (0.51) and (0.36), respectively. The inflation is not seen as a high risk factor.

Analyzing detailed items under social risk, which was relatively classified as lower than other risks, related regulations changes and petitions are noticeable(0.38 and 0.35, respectively).

### 2.3 Evalution of Expert on Risk Allocation

With the risks, which are generated in port development and construction, we can classify the risks into four principal risks and detailed elements. Each relative importance was examined using the hierarchical decision making method. However, determining the responsible party of risk still remained ambiguous. The method of risk management was not able to obtain a conclusion by the broad sense questionnaire, which carried out for the personnel of the Government concerned and the private party. For such reasons, experts' evaluation is carried out by same number from the following categories: Government / University / Industry.

The first goal in the paper is to examine the responsibility of risk in private port development, especially in redevelopment or the maintenance of middle class port like Mokpo. The second goal is to collect and propose the concrete solutions on management against each risk.

## 3. Framework of Evalution

### 3.1 Decision Making Method

The AHP method has been frequently used to analyze and compare the importance between plural evaluation items. The AHP method estimates all elements by weight., which is calculated by pair-wise comparison between evaluation items. Weight uses ratio measurement (companion measurement) and weight is used only when additives are concluded. When integrating weights between evaluation items, we use the simple weight method - which is available only when additives can be formed.

To calculate more precise weights that reflect the attributes of each element, we use the fuzzy measurement; the HFI method, as devised by Tsukamoto, which is an improved version of AHP method. The method, however, used relative importance degree drawn by calculating the AHP process, which displayed some problems because it only used the approximate measurement for coefficients. The calculation is also very complex. The HFP method, which proposes to supplement the defects of the methods above, can seek the fuzzy measurement directly from coefficients with the importance degree. This can correspond with structures where the hierarchy is complex. (Tsukamoto, 1982)

### 3.2 Hierarchical Fuzzy Process

1) Concept of fuzzy

Decision making process of human beings is relative and abstract, because it is influenced by person's subjective appraisal. Fuzzy theory is the attempt to objectify this subjectiveness, recognizing the subjective recognition by person. Thus, fuzzy theory uses ambiguity itself instead of defining the ambiguity with manifest ideas and concepts.

Fuzzy measure theory, proposed by Prof. Sugeno (1980), is a non-aggregative function which can be understood as a form of extended conventional measure theory - except aggregation; just as fuzzy set theory is a extended form of conventional set theory. Fuzzy Integral calculation which uses fuzzy measure has shown excellent results in application of subjective evaluation and decision making.

2) Fuzzy measure and integral

Fuzzy measure does not add an attribute only with monotonousness, such as when measuring ambiguous object to be a subjective one. Therefore, it can not calculate the level of Fuzzy measure $g$ set even though we know each measure degree. In order to solve this problem, Sugeno proposed λ fuzzy measure. This measure adopts interaction parameters $\lambda$ of fuzzy measure on $g_\lambda$.

$$g_\lambda(A \cup B) = g_\lambda(A) + g_\lambda(B) + \lambda g_\lambda(A) g_\lambda(B) \quad (1)$$
$$Only, A, B \in X, \quad A \cap B = \varnothing, \quad -1 < \lambda < \infty$$

Concretely, Fuzzy measure $g$ is a set function defined on the power set $P(X)$ of $X$ satisfying the following properties;

$$g: P(X) \rightarrow [0,1] \quad (2)$$

(a) $g\phi = 0, g(X) = 1$
(b) If $A, B \in P(X)$ and $A \subset B$, then
(c) If $F_n \in P(X)$ for $1 \leqq n < \infty$ and a sequence $F_n$ is monotone, then $\lim_{n\to\infty} g(F_n) = g(\lim_{n\to\infty} F_n)$

$\lambda$-fuzzy measure $g_\lambda$ is a fuzzy measure with the following equation;

$$\forall A, B \in P(X), A \bigcap B = \phi, \quad (3)$$
$$g_\lambda(A \bigcup B) = g_\lambda(A) + g_\lambda(B) + \lambda g_\lambda(A) g_\lambda(B) \text{ for } \lambda > -1$$

In the case of $\lambda$-fuzzy measure for a finite set $X = x_1, \cdots, x_n$, fuzzy density $g_i = g_\lambda(x_i)$ leads to the following equation;

$$g(X_l) = g(x_1, \cdots, x_l) \quad (4)$$
$$= \sum_{i=1}^{l} g_i + \lambda \sum_{i_1=1}^{l-1} \sum_{i_2=i_1+1}^{l} g_{i_1 g_{12}} + \cdots + \lambda^{i-1} g_1 g_2 \ldots g_l$$
$$= \frac{1}{\lambda}[\Pi_{i=1\sim l}(1+\lambda g_i) - 1]$$

Fuzzy integral has a consideration of a fuzzy measure $g$ of $(X, P(X))$ and $X$ is finite set. Let $f: X \rightarrow [0,1]$ and assume without loss of generality that the function $f(x_j)$ is monotonically decreasing with respect to $j$. i.e. $f(x_1) \geqq f(x_2) \cdots \geqq f(x_n)$. We can renumber the elements int $X$ if necessary.

In practice, $f$ can be considered to be the performance on a particular attribute for the alternatives, while $g$ represents the grade of subjective importance of each attribute. A fuzzy integral of $f$ with respect to $g$ gives the overall evaluation of the alternative. Furthermore, we can use the same fuzzy measure but Choquet's integral instead of the fuzzy integral;

$$\int f \, dg = f(x_n) g(H_n) + [f(x_{n-1}) - f(x_n)] \quad (5)$$
$$g(H_{n-1}) + \cdots + [f(x_1) = f(x_2)] g(H_1)$$

$$where, H_1 = x_1, H_2 = x_1, x_2, \cdots,$$
$$H_n = x_1, x_2, \cdots, x_n = X$$

## 4. Emprical Calculation

### 4.1 Application

In this research, four representative risks were acquired through the preceding research (construction, management, financial and social risk) and have been designated for allocation of risk in port development as standard measures by using fuzzy hierarchy. The decision making group is composed of 9 people, 3 people in each group who were made up of university researchers including the leader of the port institute and experts from the Government and private part concerned. They discussed the risks' allocation from March to September, 2006. The reason that the discussion group is composed of 9 people is that it is easier to adjust and to control the differences in hierarchical, fuzzy analysis on multi-choice problems.

1) Weighting

Regarding the importance of classified and calculated coefficients interaction, we use the Analytic hierarchy Process. Namely, pair-wise comparison is done for calculating relative importance weight.

Next, let n be the relative number of elements. At that time, the decision making person does the pair-wise comparison of n(n-1)/2. The pair-wise comparison value uses 9 point scales. As a result, the ranking of the principal risk in port development is exposed as shown in Table 5 in terms of management, finance, construction and social risk in order.

The comprehensive opinion of experts is collected to the management part in a port development as being the most important success element. The CR degree as a ratio of coherence in the questionnaire comes out less than 0.1, more precisely, 0.06. It means that it has efficiency as a good result.

**Table 2** Pairwise Comparison by AHP

| | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $w$ |
|---|---|---|---|---|---|
| $x_1$ | 1 | 2 | 3 | 3 | 0.174 |
| $x_2$ | 1/2 | 1 | 2 | 6 | 0.446 |
| $x_3$ | 1/3 | 1/2 | 1 | 3 | 0.306 |
| $x_4$ | 1/3 | 1/6 | 1/3 | 1 | 0.074 |

$x_1$ is construction risk
$x_2$ is management risk
$x_3$ is finance risk
$x_4$ is social risk

Relating with the calculation of interaction coefficients, the overlap of some elements has appeared. Thus, we adopt $\lambda$ parameter to find out this phoneme.

For the calculation of $\lambda$, we have a close grasp to

examine this kind of phenomena through the questionnaire, which asks repetition attributes. This is done simultaneously by questionnaire of importance weight. In Table 6, we can understand repetition attributes of evaluation items and the interaction. All items are marks of minus.

Table 3 Interaction Value of Factors λ

| | $x_1$ | $x_2$ | $x_3$ | $x_4$ | Interaction |
|---|---|---|---|---|---|
| $x_1$ | 0 | -0.14 | -0.31 | -0.35 | 0.198 |
| $x_2$ | | 0 | -0.41 | -0.26 | 0.487 |
| $x_3$ | | | 0 | -0.19 | 0.342 |
| $x_4$ | | | | 0 | 0.086 |

λ= - 0.28

2) Fuzzy measure $g(\cdot)$ and intergration

Fuzzy measure $g(\cdot)$ is calculated through weight classified by evaluation degree and the operation of interaction coefficient $w(\cdot)$. It is shown like Table 7. $g(\cdot)$ calculated by the fuzzy evaluation and $h(\cdot)$ of integral are integrating fuzzily as the importance index at time of private port development. This index can judge the weight of risk allocation.

In general, the HFP method is desirable to use the objective evaluation data, which can determine fuzzy superiority or inferiority. But, here, it uses the indirect method of calculating the questionnaire data of the expert group for basis data shown in table 8.

Table 4 Fuzzy Measure $g(\cdot)$ by Evaluation Item

| $g(\cdot)$ | Measure value |
|---|---|
| $g(x_1)$ | 0.178 |
| $g(x_2)$ | 0.438 |
| $g(x_3)$ | 0.307 |
| $g(x_4)$ | 0.077 |

Table 5 Overall Evaluation Value $h(\cdot)$

| Subjects | $h(x_1)$ | $h(x_2)$ | $h(x_3)$ | $h(x_4)$ |
|---|---|---|---|---|
| Government | 1.000 | 0.681 | 0.648 | 1.000 |
| Local govern. | 0.372 | 0.542 | 0.194 | 0.813 |
| Private Part | 0.605 | 1.000 | 1.000 | 0.446 |
| Coresponsible | 0.427 | 0.272 | 0.166 | 0.264 |

## 4.2 Result of Analysis

Regarding the allocation of risk responsibility, this can be calculated by integrating $g(\cdot)$ value and $h(\cdot)$ value. We can see the calculation process in Table 9, the results show requested value of integrated judgment. Applying fuzzy integral calculus procedure, it shows the final result of applying the HFP algorithm with regards to the responsible party for risks as shown in Table 10.

On responsibility subject issue, the main opinion of experts points out that the private part owes the risks. This means that the private part has the burden of bearing the risks of the port development business.

Table 6 Evaluation by Hierarchical Fuzzy Process

| party on Responsible | Value | Procedure in Hierarchical Process | | | |
|---|---|---|---|---|---|
| Private Part | In Order | 2 | 3 | 1 | 4 |
| | Evaluation value | 1.000 | 1.000 | 0.605 | 0.446 |
| | Measure value | 0.438 | 0.745 | 0.923 | 1.000 |
| Government | In Order | 1 | 4 | 2 | 3 |
| | Evaluation value | 1.000 | 1.000 | 0.681 | 0.648 |
| | Measure value | 0.178 | 0.255 | 0.693 | 1.000 |
| Local government | In Order | 4 | 2 | 1 | 3 |
| | Evaluation value | 0.813 | 0.542 | 0.372 | 0.194 |
| | Measure value | 0.077 | 0.515 | 0.693 | 1.000 |
| Co-Responsible | In Order | 1 | 2 | 4 | 3 |
| | Evaluation value | 0.427 | 0.272 | 0.264 | 0.166 |
| | Measure value | 0.178 | 0.616 | 0.693 | 1.000 |

Secondly, for risk responsibility in port development, the opinion by experts is that the Government undertakes it.. This is because the port facilities are as public property as SOC, such that 99% of the nation's trade uses its ports for transportation.

Thirdly, local government owes responsibility. America and Japan have been going to their local government to execute port development before Korea even enacted it. Then, the local body takes charge of the schedule and the process of development to activate the local economy. On the other hand, however, there has been some deterioration of local finance owing to wrong policy and selfish

plannings lacking efficiency.

The form of co-responsibility is preferred to be the last type. This case is appraised the lowest because there is a probability connected with other problems due to the indefinite attributes of responsibility, when actual problems occur.

In addition, we requested the discussion regarding the management method and counteracting against each risk.

The guaranty on carrying out and the insurance system are presented mainly as the management method for construction risk. Others are citizen participation and environmental evaluation within construction plan and process, which were proposed in order to prevent the occurrence of environmental problems.

As with the management method, the guaranty on carrying out and long contracts are mainly presented. Enforcement of the service contract prepared against the decreasing service level is proposed along with the management assistance of fund managing. The others request a supplement for cargo volumes since insufficiency was a frame of management.

For financial method, hedging and project circulation of fluids are presented. Others are proposed as financial resources supply plans and practical uses of connection financial instruments to minimize financial affairs in connection with private part.

Table 7 Responsible party on Port Development

| Rank | Reponsibililty | Evaluation Degree |
|---|---|---|
| 1 | Private Party | 0.887 |
| 2 | Government | 0.752 |
| 3 | Local government | 0.426 |
| 4 | Co-Responsibility | 0.266 |

For the social risk management method through the coordination of Government and the concerned, we have the reply that it must prevent administration, restrictions and regulations that make business itself difficult.

## 5. Conclusion

Many ports in relation with SOC projects being selected at private investment business are propelled by the Korean Government. In this case, the private party intends to get the support of the Government whenever the problems occur and the Government bears the burden of providing the support. Therefore, it needs reasonable allocation of risks and responsibilities for successful accomplishment of private investments . But, these kinds of research on risk allocation of port development have yet been done much.

Through preceding review of port development and consolidation, we were able to classify the risks into the following four principal risks: construction, management, financial and social risk for middle class ports. Then, we inspected the responsible party of these risks using the method of fuzzy hierarchy. Moreover, we also examined counteracting method against the risks.

In the problem of risk allocation in port development, the experts had the opinion that responsibility of the private party is the most important and that it must put the responsibility before Government's role concerned.

Since port facilities serve in the behalf of the public, experts agree that the Government's responsibility should second in rank, and same reason is exposed as the form of common responsibility on the end.

Also, this research displayed and proposed the direction of management method on port development in a view of minimizing risk and maximizing initiative of a private party. It was not meant to propose a specific plan such as a detailed financing connection system. More research should be achieved on management method to advise the private investment businesses to move forward.

Further researches such as level analysis of port investment risk and case studies of port private investment need be carried out thus accumulating more results and data regarding middle class ports.

## Reference

[1] Ha, H. G. and Ahn, J. H (1998), "Evaluation and reformation of private investment", Korea transport institute.

[2] Jorion, P. (1997), *"Value at Risk, The New Benchmark for Controlling Market Risk"*, New York: McGraw Hill.

[3] Kim, S. G.(1995), "Issue on Social Overhead Capital Construction of Inchoen air port", Korea transport institute.

[4] Kim, G. S. and Lee, G. C. (2003), "Fuzzy AHP and FCM driven Hybrid Group Decision Support Mechanism", Journal of information application & management, pp.239-250.

[5] Nho, S. K. and Jeong, W. H. (1997), "Improvement for infrastructure in private investment", Korea development institute.

[6] Park, J. J. (2002), "How to encourage Private Investment", Graduate shcool of civil science - Seoul metropolitan

university.

[7] Private, F. P. (1996), *"Risk and Reward in PFI Contracts"*, U.K.

[8] Satty, T. (1998), *"The Analytic Hierarchy Process"*, Mcgraw-Hill.

[9] Seong, Y. C. (2006), "Risk Priori쇼 and Allocation of Private Investment in Port Development", Internation journal of navigation and port research, 30(7). pp.599-605.

[10] Sugeno, M. (1980), Fuzzy System, seabooks, Tokyo

[11] Tsukamoto, Y. (1982), "Transformation from Probability Measure to Fuzzy", Journal of japan automatioc measurement and control. 19(3), pp269-270.

[12] UNCITRAL (1998), Legislative Guide on Privately Finance Infrastructure Projects.

[13] Walker, C. & Smith, A. J. (1995), "Privatized Infrastructure: the BOT Approach", London: Thomas Telford Publication.

[14] Yang, J. C. (1998), "Improvement of infrastructure and participating", Korea research institute for human settlements.

[15] Youn, M. O. and Keum, J. S. (2003), "Port management" Haein Publication.

Received 5 June 2007
Accepted 30 June 2007