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Analytic Network Process (ANP)-Selection of the Best Alternative in the Promotion of Participation in Infrastructure Projects

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Abstract: This study uses the Analytic Network Process (ANP) to carefully study the feasibility that the private participation proposal can achieve the expected objective. The evaluation focuses on the selection of private enterprises to participate in infrastructure projects. It provides a reference for final selection of the best proposal based on a multiple-criteria decision making model to reduce the financial burden of the government and improve the public service quality. The government is hoping to guide the funds from the private sector to infrastructure projects, thus relieving the difficult financial status of the government. The experienced management strategies of the private sector are also hoped to improve the overall service quality, and drive the development of the regional economy.

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Introduction

The promotion of private participation in infrastructure projects (PPPIP) under current statutes has many procedural shortcomings that appear during the selection process. Shortcomings are denounced by the parties involved. Many items to be evaluated and affairs to be handled are not incorporated in the procedure. To effectively handle the issue of personal subjective consciousness, the Analytic Network Process (ANP) Two-level System is used to exclude and correct the deviation of the subjective consciousness, which appears during the selection process by exposing it to the consistency inspection index. The approach takes into account the interdependency and interplays among evaluation items and develops the sub-criteria evaluation index based on the four major evaluation criteria (Benefits, Opportunities, Costs, and Risks) of the two-level network system and the sub-network system. The sub-criteria evaluation index is based on the four major evaluation criteria (Benefits, Opportunities, Costs, and Risks) of the two-level network system and the sub-network system. The sub-criteria evaluation index is used for the preliminary selection of the best cooperative investment partner from the private sector. The ANP multiple criteria decision making (MCDM) method is then used for evaluation of the result to select the best investment proposal for PPPIP. The finally selected one can best improve the quality of the public service, development of the social economy, regional industry as well as increase the employment opportunities for the public. In this manner, it is possible to maximize the investment benefit of the private participation in infrastructure projects.

Brief Description of ANP

The ANP was developed by Saaty [1] as a generalization of the analytic hierarchy process (AHP) [2], one of the most widely used multiple criteria decision-making (MCDM) methods. The AHP decomposes a problem into several levels that make up a hierarchy in which each decision element is supposed to be independent. The ANP extends the AHP to problems with dependence and feedback. It allows for more complex interrelationships among decision elements by replacing a hierarchy in the AHP with a network [3].

The network relationship of ANP method not only presents the relationship between decision elements, but also calculates the relative weightings (eigenvectors) of each decision element. The result of these computations forms a super-matrix. Finally, after the computation of the relationship of the super-matrix and the comprehensive evaluations, it is possible to derive the interdependency of each valuation criteria and options and the weighting of priorities. The higher the priority weightings, the more priority will be placed. In this manner, it is possible to select the most appropriate decision alternative. In recent years, there have been many applications of the ANP in a variety of problems such as quality [4], logistics [5], purchasing [6], strategy [7], production [8], project management [9], product design [10], and supplier selection [11].

ANP Application Models

ANP models have three parts: the first is a strategic criteria in terms of which a decision is evaluated according to its merits of Benefits, Opportunities, Costs, and Risks. Each merit provides control criteria for the second part of the decision, and, with each control criterion, there is an associated network of influences that determine the priorities of the alternatives of the decision for that control criterion. The priorities of the merits and those of the control criteria are then used to synthesize the priorities of the alternatives to obtain the final best answer. The super-matrix and its powers are the fundamental tools needed to lay out the workings of the ANP [12].

ANP has the following four application models: basic feedback network model, two-level network model, multi-level network model, and amoeba model [12]. The first three models are most commonly seen. The ANP basic model is similar to the AHP

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hierarchy model, as both have a top-to-bottom hierarchical relationship. The amoeba model is rarely seen. It has no obvious hierarchical relationship but a network model most close to a neural network. However, use of the ANP application models changes depending on the guideline and scope of the research. Depending on the criteria and application scope of the study, what is applicable might be the simple feedback model, the amoeba-like complex model, or the AHP multi-level network model. These models can be used not only as a reference for the decision maker to make decisions, but also for the prediction of the demand and potential market share of a product in terms of its form and functionality.

The ANP two-level network system is also known as the BOCR (Benefits, Opportunities, Costs, and Risks) Model. The BOCR concept is applied in various studies, including advances in decision analysis and systems engineering [13], R&D project [14], group decision-making [15]. Under the BOCR concept, pair-wise comparison questions ask which alternative is most beneficial under each sub-criterion in the benefits (B) sub-network, or has the best opportunity under each sub-criterion in the opportunities (O) sub-network [16]. In addition, the pair-wise comparison questions ask which alternative is riskiest under each sub-criterion in the risks (R) sub-network or most costly under each sub-criterion in the costs (C) sub-network. The weights of alternatives are first combined according to the weights of sub-criteria for each sub-network. The weights of alternatives under B, O, C, and R are further combined to get a single outcome for each alternative using the aforementioned four formulae.

The advantage of this model consists in its four-facet basis of Benefits, Opportunities, Costs and Risks, which are very helpful in the selection of the best alternative for the private participation in infrastructure projects. The model is comprised of the top objective, control criteria and the sub-network cluster under each criterion. A hierarchical relationship exists between each criterion and its slave network cluster, and these sub-networks supersede the ordinary nodes. However, the four BOCR criteria may not be present simultaneously, depending on the purpose of the evaluation and the actual demand. The major hierarchy and network model of the ANP two-level system are shown in Fig. 1

Proposed Approach

This study focuses on the creation of major evaluation levels and criteria in the current statutory system for the promotion of private participation in infrastructure projects. The operation and its major steps are described below.

Step 1. Creation of the ANP - BOCR Model

This article model will be used to show a two-level model with a top-level control network and four sub-networks. It is a model to pick the best alternative of the project: Alternative A, B, C. The top-level control network is actually a hierarchy with four control criteria--Benefits, Opportunities, Costs, and Risks--and four sub-networks associated with each. Every sub-network must contain a cluster with the alternatives in it, and these sub-networks do.

The ANP two-level network system can meet the requirements of the governmental authority in charge for an evaluation and decision model based on multiple criteria to select the best alternative in the promotion of private participation in infrastructure projects. The authority in charge must study the feasibility of the proposal based on the four control criteria—Benefits, Opportunities, Costs and Risks—and choose the alternative that has the best benefit and service out of different cooperative offers. With reference to the literature, we used questionnaires, interviewed experts, and referred to the cases of private participation in past infrastructure projects to acquire the criteria. A discussion team was organized whenever there were doubts about the structure of the criteria to clarify the necessity and importance of the criteria to be selected. In addition to the creation of the sub-network cluster evaluation criteria and two-level network hierarchy, the admissible number was set to seven for the evaluation criteria of the sub-network cluster, and the interdependency and interplay among different criteria within the sub-network cluster were considered The modeling framework that is applicable to the selection of the alternative in the private participation in national major infrastructure projects are put forward in Fig. 2 based on the above-mentioned BOCR control criteria and the evaluation criteria of its sub-criteria cluster.

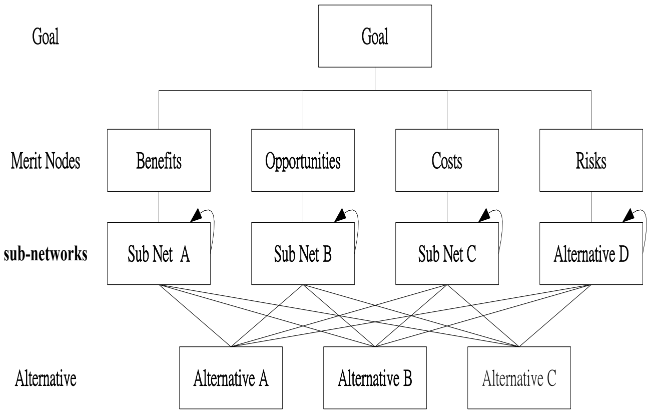

Fig. 1. The Two-level System Framework of ANP.

Step 2. The Pair-wise Comparison and Consistency among Sub-criteria in the Benefits Major Criterion

The difference between the ANP two-level network model and the simple feedback model is in that it does not subject to pair-wise comparison directly from the control criteria. Instead, a pair-wise comparison matrix is created for the sub-network cluster evaluation in each control criterion. The pair-comparison matrix for the net-network evaluation criteria is based on the measurement approach of Satty: A 9-point scale is used for the measurement where points 1, 3, 5 and 7 stand for equal importance, weak importance, essential importance, very strong importance, and absolute importance. Points 2, 4, 6 and 8 are intermediate. A reciprocal is used for no importance. The score “1” stands for two items that have equal importance, while the score “9” stands for the situation where the antecedent is absolutely important in comparison with the consequent. This scale is used to clarify the subject preference framework of the decision maker. If the pair-wise comparison matrix is a positive reciprocal matrix, it is difficult for the decision maker to keep consistent during the pair-wise comparison. However, if the inconsistency is too significant, there could be a big discrepancy between the result of the research and the actual situation that may lead to misjudgment by the decision maker. To avoid this, an effective indicator must be used to inspect the consistency.

This study takes the control criterion Benefits as an example. As shown in Fig. 3. There are seven sub-criteria and three alternatives in the Benefits sub-network cluster. The pair-wise comparison is made among the sub-criteria of the benefits sub-network. The operation of the pair-wise comparison is shown in Table 1, while the operation of the pair-wise comparison for the relative importance of each alternative in the sub-criteria is shown in Table 2. The eigenvector is used to determine the weight (percentage) of each criterion (i.e. $A=〔a_{ij}〕$, $a_{ij}=w_i/w_j$, $a_{ji}=1/a_{ij}$, $w=〔w_1, w_2 ... w_n〕$ (Row), $i,j=1,2,...,n$). As a result, the eigenvector is equal to n×w. The validity is enhanced by gaining the maximum eigenvalue λmax and conducting the consistency inspection (C.I.), wherein C.I.= $\leqq$ 0.1 , n=criterion number. The C.I. value that is less than 0.1 should be deemed as qualified, because it indicates the consistency of the matrix.

Step 3. Pair-wise Comparison Matrix of Interdependency and Interplay within the Public Interest and Other Sub-criteria in the Benefits Major Criterion

This step presents the interdependency and interplay within the Public Interest and other sub-criteria in the Benefits sub-network. A pair-wise comparison of the importance among them is also carried out in this step (Table 3). After the comparison of the interdependency and interplay within each cluster, a pair-wise comparison will be made between each sub-criterion and alternative. The eigenvector operation and C.I. will then be made as shown in Table 4.

Step 4. The Priority Weight of the Interdependency within the Sub-criteria in the Benefits Major Criterion

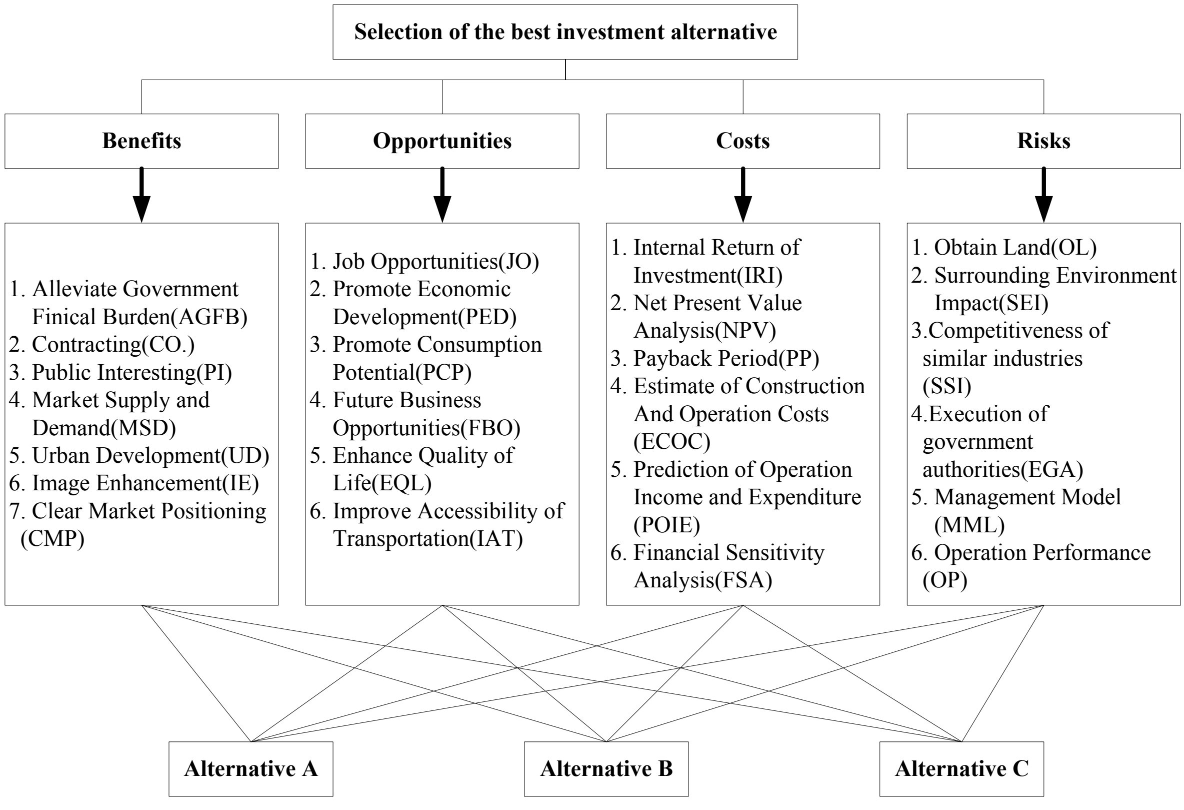

Fig. 2. ANP-BOCR Two-level Network Model for Selection of the Best Alternative in Private Participation in Infrastructure Projects.

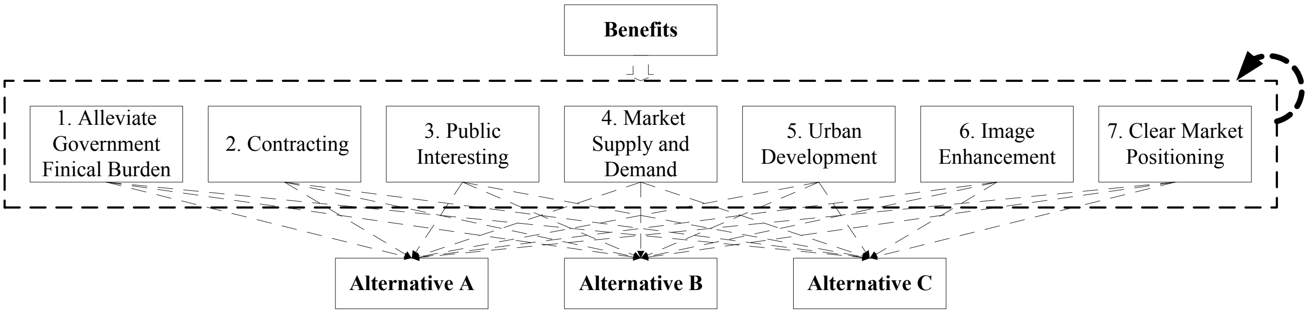

Fig. 3. The Pair-wise Comparison Framework of the Sub-criteria in the Benefits Sub-network.

Table 1. Pair-wise Comparison among Sub-criteria in the Benefits Sub-network.

Benefits	AGFB	CO.	PI	MSD	UD	IE	CMP	e-vectors
AGFB	1	1/2	1/9	1/3	1/3	1	1/3	0.041
CO.	2	1	1/5	1	1/2	3	3	0.115
PI	9	5	1	7	3	9	5	0.448
MSD	3	1	1/7	1	1/2	1	1	0.083
UD	3	2	1/3	2	1	7	1	0.163
IE	1	1/3	1/9	1	1/7	1	1/5	0.040
CMP	3	1/3	1/5	1	1	5	1	0.109
	22.000	10.167	2.098	13.333	6.476	27.000	11.533	1.000
						λmax=7.505	C.I=0.084＜0.1	

Table 2. Pair-wise Comparison among Sub-criteria in the Benefits Sub-network.

Benefits	AGFB	CO.	PI	MSD	UD	IE	CMP	e-vectors
Alternative A	7	7	7	5	9	7	9	0.357
Alternative B	7	9	5	7	7	9	7	0.360
Alternative C	5	7	9	3	5	7	5	0.282
	19	23	21	15	21	23	21	1.000

Table 3. Pair-wise Comparison among Sub-criteria in the Benefits Sub-networks.

Public Interesting	AGFB	CO.	PI	MSD	UD	IE	CMP	e-vectors
AGFB	1	1/3	1/9	1/5	1/3	1/2	1/5	0.033
CO.	3	1	1/3	1	1/3	3	2	0.110
PI	9	3	1	7	3	9	5	0.415
MSD	5	1	1/7	1	1/2	3	1	0.101
UD	3	3	1/3	2	1	7	3	0.201
IE	2	1/3	1/9	1/3	1/7	1	1/5	0.037
CMP	5	1/2	1/5	1	1/3	5	1	0.103
	28.00	9.17	2.23	12.53	5.64	28.50	12.40	1
							λmax=7.474	C.I=0.079< 0.1

This step presents the pair-comparison between each sub-criterion and alternative in the Benefits major criterion (Table 5) and conducts the operation of the interdependency weight matrix for each alternative under each sub-criterion in each sub-network (Table 6). The purpose of the operation is to clarify the interdependency and conduct the operation of the interdependency weight matrix for each alternative under each sub-criterion in each sub-network (Table 6). The purpose of the operation is to clarify the interdependency, interplay, and relative importance among the sub-criteria, and gain the priority weight value for each sub-criterion. The operation value is then put in the appropriate column on the table.

Table 4. Pair-wise Comparison between Each Sub-criterion and Alternative.

Urban Development	Alternative A	Alternative B	Alternative C	e-vectors
Alternative A	1	3	5	
Alternative B	1/3	1	2	
Alternative C	1/5	1/2	1	
Alternative A	0.652	0.667	0.625	0.648
Alternative B	0.217	0.222	0.250	0.230
Alternative C	0.130	0.111	0.125	0.122
				λmax=3.004 C.I=0.002<0.1

Table 6. The Interdependency Weight Matrix of the Alternatives under the Urban Development Sub-criterion in the Benefits Major Criterion.

Urban Development

$$\begin{bmatrix} 0.652 & 0.667 & 0.625 \\ 0.217 & 0.222 & 0.250 \\ 0.130 & 0.111 & 0.125 \end{bmatrix} \times \begin{bmatrix} 0.429 \\ 0.333 \\ 0.238 \end{bmatrix} = \begin{bmatrix} 0.651 \\ 0.227 \\ 0.123 \end{bmatrix} \begin{array}{l} \text{Alternative A} \\ \text{Alternative B} \\ \text{Alternative C} \end{array}$$

Step 5. Creation of a Super-matrix

To cover the interplay among all elements in the system, the weight vector of the priority must be added to the appropriate column to form a super-matrix [17]. There are three forms of ANP super-matrices, unweighted matrix, weighted matrix and limit matrix. The unweighted index means the weight gained in the original pair-wise comparison. The weighted index is the product of the weight of the same element in the unweighted matrix multiplied by the weight of the related cluster. If the sum of the numbers in the vertical columns of an unweighted matrix is one, the weighted matrix is considered as the unweighted matrix. If the sum of the numbers in all columns of a supermatrix is greater one, it does not

Table 5. Pair-wise Comparison between Sub-criterion and Alternative in the Benefits Major Criterion.

$$\begin{array}{l} \\ \text{AGFB} \\ \text{CO.} \\ \text{PI} \\ \text{MSD} \\ \text{UD} \\ \text{IE} \\ \text{CMP} \end{array} \begin{array}{ccccccc} \text{AGFB} & \text{CO.} & \text{PI} & \text{MSD} & \text{UD} & \text{IE} & \text{CMP} \\ 0.046 & 0.073 & 0.033 & 0.025 & 0.104 & 0 & 0 \\ 0.244 & 0.193 & 0.110 & 0.085 & 0.069 & 0.041 & 0 \\ 0.455 & 0.484 & 0.415 & 0.352 & 0.274 & 0.411 & 0.550 \\ 0.162 & 0.062 & 0.101 & 0.184 & 0.213 & 0.229 & 0.118 \\ 0.093 & 0.156 & 0.21 & 0.182 & 0.205 & 0.155 & 0.249 \\ 0 & 0.033 & 0.037 & 0.044 & 0.026 & 0.164 & 0 \\ 0 & 0 & 0.103 & 0.127 & 0.11 & 0 & 0.083 \end{array} \times \begin{array}{c} \text{W} \\ 0.041 \\ 0.115 \\ 0.448 \\ 0.083 \\ 0.163 \\ 0.040 \\ 0.109 \end{array} = \begin{array}{c} \text{W} \\ 0.044 \\ 0.102 \\ 0.411 \\ 0.131 \\ 0.194 \\ 0.035 \\ 0.083 \end{array}$$

Table 7. Operation of the Priority Weight for Each Alternative in the Benefits Major Criterion.

$$\text{WANP} = \left[\begin{array}{ccccccc} \text{AGFB} & \text{CO.} & \text{PI} & \text{MSD} & \text{UD} & \text{IE} & \text{CMP} \\ 0.392 & 0.123 & 0.288 & 0.231 & 0.651 & 0.342 & 0.269 \\ 0.112 & 0.648 & 0.081 & 0.077 & 0.227 & 0.142 & 0.660 \\ 0.497 & 0.229 & 0.631 & 0.692 & 0.123 & 0.516 & 0.071 \end{array}\right] \times \begin{bmatrix} 0.047 \\ 0.099 \\ 0.403 \\ 0.136 \\ 0.195 \\ 0.035 \\ 0.086 \end{bmatrix} = \begin{bmatrix} 0.339 \\ 0.218 \\ 0.218 \end{bmatrix} \begin{array}{l} \text{Alternative A} \\ \text{Alternative B} \\ \text{Alternative C} \end{array}$$

Table 8. Operation Result for Individual Alternatives of Each Major Control Criterion.

Goal	Alternative A	Alternative B	Alternative C
Benefits	0.339	0.218	0.443
Opportunities	0.204	0.608	0.188
Costs	0.303	0.489	0.208
Risks	0.465	0.350	0.185

have the random effect and, thus, is the unweighted matrix. The researcher can use the data of an unweighted super-matrix to evaluate the priority of the elements after being subject to the pair-wise comparison. A weighted matrix is a super-matrix in which the sum of the numbers in all columns is one and the random effect exists. According to Satty, each row of elements in a matrix can be proportionately converted into numeric values of standardization features based on the influence to which they are subject and the controlled importance of the elements in each column, if the relative importance of the elements in each column of a super-matrix has been given. The limit matrix intends to present a convergent, steady and consistent element relationship for a weighted matrix during a long-term equalization. Thus, Satty proposes to take 2k+1 power (k is a subjectively determined numeric value) of a weighted matrix to make it become a limit matrix [18]. The limit matrix derives from, and has the same form as, the weighted matrix. However, the limit matrix has the same weight value in each column to which an element corresponds. If the element weight values of each column block are standardized separately to make the sum of the values greater than 1, all element weights and alternative evaluation value will have a convergence effect. The weighted super-matrix is shown in Table 9.

Step 6. The Actual Priority Weight of Each Alternative in the Benefits Sub-network

Based on the values gained from the matrix operation of the previous step, this step presents the operation of the actual priority weight for each alternative in the Benefits major criterion. The operation result of the pair-wise comparison regarding the interdependency among the alternatives in the Benefits major criterion is multiplied by the result of the pair-wise comparison among the alternatives under the sub-criteria in the Benefits major criterion. The result is shown in Table 8. The maximum value of the multiplication is the final selection result of the alternatives for the Benefits major criterion. The results of other major control criteria are put in Table 7 for the final selection of the alternatives to be carried out in the next step.

Step 7. Combined Operation of the Major Control Criteria and Final Selection of Alternatives

In this step, the priority weight gained from Step 6 for each alternative and the results of other sub-networks are put in Table 7 under the four major criteria—Benefits, Opportunities, Costs and Risks. A final operation is conducted according to the BOCR model of Saaty [12] and Table 8. If the final positive number (absolute value) is Y and the major criteria after the normalization are Benefits (B), Opportunities(O), Costs(C) and Risks(R), then Y=〔(B×O)÷(C×R)〕>1. Equations are used in this study for operation of each alternative and the results are described below. The priority weight of each alternative gained in the B, O, C and R control criteria, respectively, is placed in Y=(B×O)÷(C×R) > 1 to gain:

Alternative A:〔(0.339×0.212) ÷ (0.306×0.477)〕= 0.492 < 1
Alternative B:〔(0.218×0.600) ÷ (0.485×0.371)〕= 0.726 < 1
Alternative C:〔(0.443×0.188) ÷ (0.208×0.156)〕= 2.567 > 1

According to the result of the combined operation, both Alternatives A and B have an evaluation value less than one, while Alternative C has an evaluation value greater than one. Therefore, the authority in charge should select Alternative C as the best investment plan for the infrastructure project concerned.

Validation of the Instance

Benefits: The private company leases the land from the transportation authority of the government in Taiwan. In addition to the land royalty, it must proportionately pay the operating royalty to the authority in charge. In this case, the government can save money for the management of the land and construction and operation of the facilities on land, while the private company can build an operation headquarters on the land and use it as its administration, crew dispatch center, and training center. It can also build world-class hotels and provide diverse services for domestic, international and transit passengers, meeting market demand and improving the image of the brand globally. The substantial benefits will surpass what the government requests at the beginning of the project.

Opportunities: After the headquarters of the company has operated in the Airport City Zone, the airport, which seems somewhat desolate, will become more prosperous. The 12,000 employees of the company will directly impact the region around the Airport City Zone. The measures of the government to develop the transportation network around the area also drive economic development and employment in Taoyuan, thus increasing the substantial benefits of the project to a great extent.

Financial efficiency: As for the preliminary financial prediction,

Table 9. Super-matrix Based on All Sub-criteria in the Sub-networks.

Before convergence		Benefits							Opportunities						Costs						Risks						Alternative		
		AGFB	CO.	PI	MSD	UD	IE	CMP	JO	PED	PCP	FBO	EQL	IAT	IRI	NPV	PP	ECOC	POIE	FSA	OL	SEI	SSI	EGA	MML	OP	Alternative A	Alternative B	Alternative C
Benefits	AGFB	0.046	0.073	0.033	0.025	0.104	0.000	0.000																			0.380	0.118	0.501
	CO.	0.244	0.193	0.110	0.085	0.069	0.041	0.000																			0.122	0.648	0.230
	PI	0.455	0.484	0.415	0.352	0.274	0.411	0.550																			0.280	0.082	0.638
	MSD	0.162	0.062	0.101	0.184	0.213	0.229	0.118																			0.231	0.077	0.692
	UD	0.093	0.156	0.201	0.182	0.205	0.155	0.249																			0.648	0.230	0.122
	IE	0.000	0.033	0.037	0.044	0.026	0.164	0.000																			0.334	0.142	0.525
	CMP	0.000	0.000	0.103	0.127	0.110	0.000	0.083																			0.283	0.643	0.074
Opportunities	JO								0.172	0.145	0.038	0.155	0.347	0.039													0.589	0.159	0.252
	PED								0.243	0.197	0.114	0.081	0.153	0.198													0.197	0.702	0.101
	PCP								0.109	0.098	0.462	0.139	0.093	0.108													0.123	0.320	0.557
	FBO								0.032	0.033	0.117	0.061	0.028	0.124													0.102	0.686	0.211
	EQL								0.066	0.058	0.216	0.081	0.044	0.033													0.197	0.702	0.101
	IAT								0.378	0.470	0.053	0.484	0.335	0.497													0.139	0.794	0.067
Costs	IRI														0.244	0.276	0.315	0.163	0.408	0.041							0.648	0.122	0.230
	NPV														0.265	0.188	0.160	0.159	0.147	0.056							0.292	0.615	0.093
	PP														0.143	0.155	0.264	0.285	0.092	0.108							0.091	0.455	0.455
	ECOC														0.079	0.086	0.061	0.056	0.031	0.130							0.103	0.681	0.216
	POIE														0.204	0.223	0.148	0.078	0.050	0.156							0.200	0.600	0.200
	FSA														0.065	0.072	0.053	0.259	0.272	0.509							0.267	0.669	0.064
Risks	OL																				0.082	0.000	0.000	0.215	0.000	0.000	0.480	0.115	0.405
	SEI																				0.158	0.042	0.042	0.136	0.244	0.051	0.633	0.260	0.106
	SSI																				0.000	0.073	0.076	0.000	0.156	0.083	0.110	0.309	0.581
	EGA																				0.761	0.040	0.057	0.649	0.046	0.131	0.600	0.200	0.200
	MML																				0.000	0.365	0.413	0.000	0.082	0.164	0.158	0.655	0.187
	OP																				0.000	0.480	0.412	0.000	0.472	0.571	0.487	0.435	0.078

After convergence		Benefits							Opportunities						Costs						Risks						Alternative		
		AGFB	CO.	PI	MSD	UD	IE	CMP	JO	PED	PCP	FBO	EQL	IAT	IRI	NPV	PP	ECOC	POIE	FSA	OL	SEI	SSI	EGA	MML	OP	Alternative A	Alternative B	Alternative C
Benefits	AGFB	0.047	0.047	0.047	0.047	0.047	0.047	0.047																			0.392	0.112	0.497
	CO.	0.099	0.099	0.099	0.099	0.099	0.099	0.099																			0.123	0.648	0.229
	PI	0.403	0.403	0.403	0.403	0.403	0.403	0.403																			0.288	0.081	0.631
	MSD	0.136	0.136	0.136	0.136	0.136	0.136	0.136																			0.231	0.077	0.692
	UD	0.195	0.195	0.195	0.195	0.195	0.195	0.195																			0.651	0.227	0.123
	IE	0.035	0.035	0.035	0.035	0.035	0.035	0.035																			0.342	0.142	0.516
	CMP	0.086	0.086	0.086	0.086	0.086	0.086	0.086																			0.269	0.660	0.071
Opportunities	JO								0.090	0.090	0.090	0.090	0.090	0.090													0.591	0.168	0.241
	PED								0.174	0.174	0.174	0.174	0.174	0.174													0.188	0.705	0.106
	PCP								0.147	0.147	0.147	0.147	0.147	0.147													0.126	0.323	0.551
	FBO								0.091	0.091	0.091	0.091	0.091	0.091													0.114	0.676	0.209
	EQL								0.065	0.065	0.065	0.065	0.065	0.065													0.223	0.667	0.110
	IAT								0.432	0.432	0.432	0.432	0.432	0.432													0.156	0.775	0.069
Costs	IRI														0.276	0.276	0.276	0.276	0.276	0.276							0.647	0.120	0.233
	NPV														0.184	0.184	0.184	0.184	0.184	0.184							0.297	0.612	0.092
	PP														0.162	0.162	0.162	0.162	0.162	0.162							0.091	0.455	0.455
	ECOC														0.070	0.070	0.070	0.070	0.070	0.070							0.102	0.687	0.211
	POIE														0.156	0.156	0.156	0.156	0.156	0.156							0.200	0.600	0.200
	FSA														0.152	0.152	0.152	0.152	0.152	0.152							0.284	0.651	0.066
Risks	OL																				0.157	0.157	0.157	0.157	0.157	0.157	0.633	0.260	0.106
	SEI																				0.128	0.128	0.128	0.128	0.128	0.128	0.648	0.253	0.099
	SSI																				0.010	0.010	0.010	0.010	0.010	0.010	0.091	0.455	0.455
	EGA																				0.590	0.590	0.590	0.590	0.590	0.590	0.600	0.200	0.200
	MML																				0.050	0.050	0.050	0.050	0.050	0.050	0.156	0.662	0.182
	OP																				0.065	0.065	0.065	0.065	0.065	0.065	0.491	0.432	0.076

the company invested nearly NT$ 6.2 billion in construction, which lasted for three years. It moved from leasing to constructing hotels by itself for the dispatching and accommodation of crews, and, as a result, saves about NT$56 million every year. With the support of income from various air transportation services and hotel operating revenue, the company changed the amortization period of the loan from 30 years to 20 years, and paid the government more operating royalty than what was expected at the beginning of the operation. This indicates that the operating and non-operating benefits of the company are greater than the originally estimated results.

Risks: The land developed belonged to the transportation administration of Taiwan. It was easier to gain the land and the cost needed was limited to demolition of the facilities on land. The performance is reflected in the planning and construction of the transportation network around the area. It does not differ much from the original expectation. Hence, the risk that the company will face in the future comes only from its business model and competition from industries of the same nature. The performance of all items that have been subject to the evaluation criteria is greater than the expectation.

Conclusion

No matter what the final objective is, the PPPIP, which many countries in the world have been implementing, aims at the improvement of overall public interest. This is helpful for the government to relieve its tight financial status. With the support of the innovative operating technique of the private sector, the participation promoting policy can provide the opportunity for the overall development of the region, helping to alleviate the impact of the global economic recession, and shortening the time needed for the government to return to prosperity.

The Participation Promotion Act is to govern six private participation models for infrastructure projects. Which model is used depends on the requirement of the authority in charge. No matter what model is used, all the evaluations and scopes of the multi-criteria evaluation are incorporated in the study and emphasized by both the public and private sectors. In addition to studying relevant laws and regulations, a project team was formed at the initial phase of the study with 13 members from the authority in charge, academic unit, industry, and management team of the company to determine the research approach and criteria for the promotion of private participation in infrastructure projects. This combination of members makes the criteria more comprehensive and feasible and provides the government with a basis for actual application.

The preliminary feasibility study for the selection of the best proposals is conducted by the Selection Committee. The MCDM model of the ANP two-level network system has not been applied to the PPPIP because the nature of the requirements, features, environment, and public service is different for each case. The MCDM model of the study can meet the requirements of the applicable participation promoting regulations in Taiwan. The MCDM model of the ANP two-level network system provides a basis for the authority in charge to make decisions regarding the selection of the best alternative in the PPPIP.

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