ISSN 2616-5902 Vol. 3, Issue 10: 33-38, DOI: 10.25236/AJBM.2021.031006

Application and Research of Engineering Economic Evaluation Based on Multi-objective Intelligent Grey Target Decision System

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Abstract: *With the development of the times, enterprises and investors have more detailed requirements for engineering projects. Based on this, the application of engineering economic evaluation in engineering projects is becoming more and more important. This paper mainly aims at the engineering economic evaluation, uses AHP to screen the index weight that affects the project, and combines with the multi-objective grey target decision model to establish the relevant intelligent decision system. This paper mainly takes the long-distance natural gas pipeline laying project as an example and uses the multi-objective grey target decision model to evaluate its engineering economic evaluation. At the same time, the feasibility of the model and the accuracy and effectiveness of its evaluation of engineering economic indicators are explored.*

Keywords: *Multi-objective grey target decision model, Engineering economic evaluation, AHP, Gas Pipeline Laying Project*

1. Introduction

Engineering economic evaluation is mainly to evaluate the economic feasibility of related projects before their construction. Its purpose is to determine whether the related projects are worth implementing, avoid unnecessary investment and waste of resources, and provide a decision-making basis for enterprises and investors. Engineering economic evaluation is of great significance in the feasibility evaluation of engineering projects, so there are few studies in this regard.

Up to now, China's s economic evaluation of engineering projects is more conventional by comprehensive evaluation method, multidimensional economic evaluation method, uncertainty analysis, national economic evaluation, and national financial evaluation. The above results are the application and exploration of engineering economic evaluation knowledge by many scholars in various engineering projects. Among them, Wang Jing [0]used the comprehensive evaluation method to study the economic evaluation of water conservancy and hydropower projects; Wang Ling[1] did uncertainty analysis and related application and exploration on highway engineering economy; Yangliu[2] paid attention to the economic evaluation of long-distance gas pipelines; Yu Diyan[3] carried out economic evaluation and related analysis on Qiantang River control project from the perspective of project investment and economic benefits; Liu Xiaohui[4] used the method of net economic benefit evaluation to analyze the rural drinking water safety project. In addition, some scholars have made relevant explorations.

Based on meeting the interests of all companies and investors under the premise of engineering economic evaluation analysis should be through the analysis of as little information or angle as possible to get a more effective economic evaluation.At present, this problem has not been solved in many existing studies. Therefore, this article from the perspective of enterprises and investors, based on the above problems using multi-objective decision-making grey target model for engineering economic evaluation analysis and exploration.

2. Importance and research direction of engineering economic evaluation

2.1. Multi-objective intelligent grey target decision-making system

1) Case analysis

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The government of Region K needs to lay long-distance natural gas pipelines in the region. The construction period of planned long-distance natural gas pipelines is 10 months, and the delivery period is 1 month. Three existing natural gas pipeline companies (hereinafter referred to as "companies") are selected. According to the relevant requirements of the local government, three natural gas pipeline companies (Company A; Company B; Company C) provides self-assessment information and natural gas pipeline laying schemes respectively. Based on the data provided by the three companies, this paper uses the multi-objective weighted grey target decision-making model as the research method and then obtains the decision-making of which company the government should negotiate and cooperate with.

The investment payback period (X1) refers to the time required for the total amount of income obtained after the investment project to reach the total amount of investment invested in the investment project. That is, the shorter the payback period is, the faster the capital turnover is and the more profitable it is. The economic evaluation of the project can be used as an auxiliary evaluation index to make the evaluation more accurate; Net present value (X2) is the difference between the present value of future fund income and the present value of future fund expenditure, so it is generally used as the basic indicator of evaluation; Internal rate of return (X3) is the discount rate when the total present value of capital inflow is equal to the total present value of capital inflow and the net present value is zero, which is an indispensable indicator for project evaluation; Benefit-cost ratio (X4) is the ratio of the present value of each financial income and the present value of each expenditure cost obtained in the whole financial calculation period of the project, which is an important indicator of engineering economic evaluation; External rate of return (X5) refers to the rate of return when the future value of investment is equal to the cumulative value of net return of reinvestment, which can make the project evaluation more accurate. In summary, the target statistical table is given as shown in table 1.

Table 1: Statistical table of decision index of Natural Gas Company

Serial Number	Decision making indicators	Unit	Target type	Remark	Code
1	Payback period	Month	Cost index	Quantification	X1
2	Net present value	Million yuan	Benefit-oriented indicators	Quantification	X2
3	Internal rate of return	%	Benefit-oriented indicators	Quantification	X3
4	Benefit cost ratio	%	Benefit-oriented indicators	Quantification	X4
5	External rate of return	%	Moderate indicators	Quantification	X5

2.2. Determination of decision-making index weight

AHP (Analytic Hierarchy Process) is a combination of qualitative and quantitative, systematic and hierarchical analysis methods. Its characteristic is that in the case of complex decision-making problems and influencing factors and their internal relations, it can make use of less information to make the thinking process of decision-making mathematical, to provide a simple decision-making method for complex decision-making problems.

STEP1: Establish a hierarchical structure model.

STEP2: Construct judgment matrix. Impact of m evaluation indicators $C_1, C_2, ..., C_m$ on guideline B, and a_{ij} is used to represent the ratio of the influence of C_i and C_j on criterion layer B, so the judgment matrix is as follows:

$$A = (a_{ij})_{mxm} = \begin{pmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mm} \end{pmatrix}, (a_{ij} > 0) \tag{1}$$

Quorum $a_{ii} = 1$, $a_{ij} = 1 / a_{ji} (i, j = 1, 2, ..., m)$, that is, A is a symmetric matrix of order m.

STEP3: Calculate the characteristic root.For the existing judgment matrix A, calculating the Eigenvalue and Eigenvector W of Judgment Matrix by $AW = \lambda_{\max} W$, then the normalized processing is carried out to obtain the importance ranking weights of the corresponding factors at the same level for a certain factor in the upper layer.

STEP4: Consistency test.When the judgment matrix cannot guarantee complete consistency, the characteristic roots of the corresponding judgment matrix will also change, so the consistency of the

ISSN 2616-5902 Vol. 3, Issue 10: 33-38, DOI: 10.25236/AJBM.2021.031006

judgment matrix can be checked by the change of the characteristic roots of the judgment matrix. Therefore, the negative average value of the remaining characteristic roots outside the maximum characteristic root of the judgment matrix is introduced in AHP as an indicator to measure the deviation consistency of the judgment matrix, that is, the consistency of the judgment matrix is tested by formula $CI = \frac{\lambda_{\max} - m}{m-1}$. When $CI = 0$ the judgment matrix has complete consistency; When CI is close to 0, the judgment matrix has satisfactory consistency. The greater CI, the more serious the inconsistency. Then the random consistency index IR of the judgment matrix is introduced to measure whether different interpretation matrices have satisfactory consistency. The calculation formula is as follows:

$$RI = \frac{CI_1 + CI_2 + ... + CI_m}{n} \tag{2}$$

CI and random consistency index RI was compared, get test coefficient CR. If $CR < 0.1$, that the judgment matrix passed the consistency test:

$$CR = \frac{CI}{RI} < 0.10 \tag{3}$$

2.3. Multi-objective Intelligent Grey Target Decision System

Based on the multi-objective weighted grey target decision model proposed by Liu Sifeng 错误!未找到引用源。, this paper lists the relevant explanations and definitions of the grey target model in reference [10-12] :

STEP1: All events within the research scope of a decision-making problem are called event sets, denoted as event set $A = \{a_1, a_2, ..., a_n\}$, and then a_i（i=1, 2, . . . , n） is the i event in the event set. As for all possible countermeasures, Is denoted as countermeasure set $B = \{b_1, b_2, ..., b_n\}$, that is, $b_j (j = 1, 2, ..., m)$ is the j decision of its countermeasure set. Let the Cartesian product $S = A \times B = \{(a_i, b_j) \mid a_i \in A, b_j \in B\}$ of event set A and countermeasure set B be the set of situations, and let $s_{ij} = (a_i, b_j)$ be the set of situations.

STEP2: Let k be the corresponding target, then the corresponding effect sample matrix is as follows:

$$U^k = (u_{ij}^k) = \begin{pmatrix} u_{11}^k & \cdots & u_{1m}^k \\ \vdots & \ddots & \vdots \\ u_{n1}^k & \cdots & u_{nm}^k \end{pmatrix} (k = 1, 2, ..., s) \tag{4}$$

STEP3: The critical value of the target effect is set. Under the condition of the corresponding target k, the consistent effect measurement matrix is as follows:

$$R^k = (u_{ij}^k) = \begin{pmatrix} r_{11}^k & \cdots & r_{1m}^k \\ \vdots & \ddots & \vdots \\ r_{n1}^k & \cdots & r_{nm}^k \end{pmatrix} (k = 1, 2, ..., s) \tag{5}$$

In the above formula, let u_{ij}^k be the effect sample value under the corresponding target k, which is discussed as follows:

a) Let k be the effect type target, that is, the smaller the sample value of the target effect is, the better. The decision grey target under the target is set as $u_{ij}^k \in [u_{iojo}^k, \underset{i}{Max}\underset{j}{Max}\{u_{ij}^k\}]$, that is, u_{iojo}^k is the critical value of the target effect of k, so is called the benefit-based target effect measure:

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$$r_{ij}^{k}=\frac{u_{ij}^{k}-u_{iojo}^{k}}{\underset{i}{Max}\,\underset{j}{Max}(u_{ij}^{k})-u_{iojo}^{k}} \tag{6}$$

b) Let k be a cost target, that is, the smaller the sample value of the target effect is, the better, and the decision grey target set under its target is $u_{ij}^{k}\in[u_{iojo}^{k},\underset{i}{Max}\,\underset{j}{Max}\{u_{ij}^{k}\}]$, that is, u_{iojo}^{k} is the critical value of the target effect of k, so :

$$r_{ij}^{k}=\frac{u_{iojo}^{k}-u_{ij}^{k}}{u_{iojo}^{k}-\underset{i}{Min}\,\underset{j}{Min}\{u_{ij}^{k}\}} \tag{7}$$

Is called cost - type target effect measure.After the calculation of the above two formulas, normalization has been completed and the differences between the indicators have been eliminated. So, for each effect measure, the bigger the better.

STEP4: Determine the weight of each target decision. From $r_{ij}=\sum_{k=1}^{s}\eta_k r_{ij}^{k}$, the comprehensive effect measurement matrix can be obtained.

$$R=(u_{ij})=\begin{pmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nm} \end{pmatrix} \tag{8}$$

Judgment of hit gray target according to comprehensive effect measure value: When $r_{ij}^{k}\in[0,1]$, indicating hit the gray target; When $r_{ij}^{k}\in[-1,0]$, indicating off-target.

3. Application and research of engineering economic evaluation based on multi-objective intelligent grey target decision system

3.1. Data collection

The five decision-making indexes of the long-distance natural gas pipeline laying project are introduced above. Now, the expert scoring method is adopted, and the mean value is obtained through the scoring of 10 experts, and then the decision-making index judgment matrix is obtained by combining Equation (1), as shown in Table 2. Through the above judgment matrix, based on formula (2) and formula (3), the judgment matrix passed the consistency test, and finally got five correspondin decision index weight coefficients, such as Table 2.

Table 2: Decision Index Judgment Matrix and Statistical table of decision index weight

	Payback period	Net present value	Internal rate of return	Benefit cost ratio	External rate of return	Serial number	Weight coefficient
Payback period	1	3/2	1/2	2	5/2	1	0.2189
Net present value	2/3	1	1/3	4/3	5/3	2	0.1460
Internal rate of return	2	3	1	4	5	3	0.4380
Benefit cost ratio	1/2	3/4	1/4	1	5/4	4	0.1095
External rate of return	2/5	3/5	1/5	4/5	1	5	0.0876

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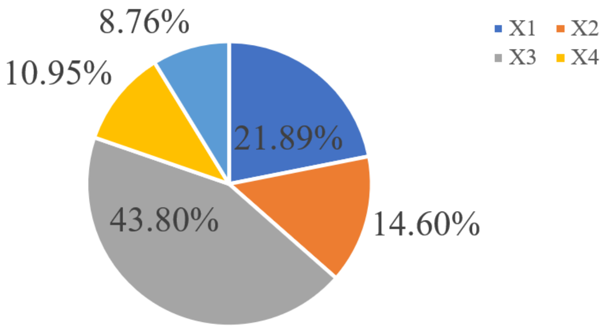

Figure 1: Decision index weight pie chart

It can be seen from Table 3 and Figure 1 that the weight coefficients of investment payback period, net present value, internal rate of return, benefit-cost ratio, and external rate of return are 0.2189, 0.1460, 0.4380, 0.1095 and 0.0876, respectively. Among them, the weight coefficient of internal rate of return is the largest, and the external rate of return is the smallest. This is because the internal rate of return is an expected return on investment, the greater the better, so it is the most important in the decision-making indicators, and the corresponding weight coefficient is larger than the other four indicators.In order to apply this model to this decision-making, this paper takes five projects of regional K government that need to be evaluated at present. Combined with this method, through the questionnaire of six experts the expert scoring method, the following scoring matrix is obtained as shown in Table 3.

Table 3: Score matrix table

Decision making indicators	Company A	Company B	Company C
Payback period	6.4	7.8	5.6
Net present value	7.9	5.1	4.3
Internal rate of return	7.5	7.8	7.1
Benefit cost ratio	6.2	5.3	7.5
External rate of return	3.2	4.5	2.7

3.2. Decision-making and result analysis

According to Formulas (4) – (8), the index weight and the consistent effect measurement matrix are calculated to calculate the comprehensive effect measurement matrix, and the comprehensive effect measurement values of Company A, Company B and Company C are 0.66, 0.31 and 0.29, respectively. This shows that the three companies are in line with the K government ' s bidding standards for long-distance natural gas pipeline laying projects, and the company A ' s comprehensive effect measurement value is the largest, that is, company A is most in line with the tender requirements of the K government in the region.

4. Conclusion

In this paper, the multi-objective weighted grey target decision model is used to evaluate the economic evaluation of natural gas long-distance gas pipeline laying project, which can effectively solve the inaccurate evaluation of engineering economic evaluation caused by excessive decision indicators, simplify the evaluation scheme, and can use less information and less data to complete the engineering economic evaluation accurately and scientifically. And through this study, it is feasible to apply the multi-objective weighted grey target decision model to engineering economic evaluation, and the model has strong adaptability, which can carry out engineering economic evaluation scientifically and effectively.

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