

Research on Optimization Model of Investment Projects Based on Information Entropy

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Abstract—There are many uncertainties in the optimal decision-making of project selection. This paper constructs a mathematical model of multi-index evaluation based on information entropy, and combines the objective information of investment plan with subjective experience to quantify the composite weight coefficient. By calculating the weighted sum of the difference between the closeness of the evaluation index and the expected proximity of the investment plan, the actual project case is optimized, and further through the 0-1 integer programming, the portfolio optimization of the investment plan is achieved under the resource constraints. The practical problem of scientific decision-making on investment projects is solved.

Keywords—Entropy; Composite Weight Coefficient; Economic evaluation; Scientific Decision

I. INTRODUCTION

Entropy theory originated from the second law of thermodynamics. Entropy, as a new potential function, can make mathematical analysis of the direction of energy movement and quantitatively determine the direction and measurement of the process. In 1865, Clausius defined this potential function as entropy for the first time in the book "The Theory of Heat" and expressed it with the symbol S, which also marked the official birth of the concept of entropy.

In statistical physics, entropy is a measure of the degree of uncertainty of random events; In information theory, entropy is a measure of the degree of uncertainty of the state, or a measure of the lack of information in the system[4].

C.E.shannon called the uncertainty of the random event result entropy. For the uncertain non-equal probability random experiment, C.E.shannon concluded that the formula for the entropy of probability inequality is (1-1)

$$H(p_i) = -C \sum_{i=1}^n p_i \log p_i \quad (1-1)$$

Entropy $H(p_i)$ is a measure of the amount of information contained in this random process and a representation of the uncertainty of the random process.

The properties of entropy mainly include: (1) symmetry, that is, the size of entropy has nothing to do with the order of p_i ; (2) additivity, that is, the total entropy of a random process is equal to the sum of the entropy of its constituent events; (3)

extremum, when P_i is equal probability value, the entropy of a random process is the largest.

In probability theory, the results of random experiments can be represented by random quantities, linking information entropy to probability problems. The formula for calculating the entropy of random variables is (1-2).

$$H(p_i) = -C \sum_{i=1}^n p(x_i) \log p(x_i) \quad (1-2)$$

II. THE "ENTROPY" MODEL OF ECONOMIC EVALUATION

A. Economic Significance of Entropy Model

When making decisions on project investment projects, it is necessary to take into full consideration the combined effects of technical, economic, policy and social factors. A single economic indicator for decision-making on a project programme is neither objective nor subjective[1]. On the one hand, the objectives of investment subjects are diverse, and some goals are conflicting and non-fair; On the other hand, Information asymmetry, the risk of investment decision is relatively large. Therefore, it is necessary to make comprehensive evaluation and optimization of multi-index for the investment projects of engineering construction based on the overall development of technology, economy, society and culture[6].

Based on the principle and nature of entropy, an application model for comprehensive evaluation of multi-index of investment projects is constructed. The model not only combines static index with dynamic index, but also combines qualitative index with quantitative index. At the same time, for the objective and fair of economic evaluation, not only the objective factors of the inherent information of the investment plan are considered, but also the subjective role of the decision maker's experience judgment ability is fully absorbed, so as to achieve subjective and objective unity[7]. Finally, a numerical set is formed to represent the comprehensive effect of multi-index evaluation. According to the numerical set, not only can the investment scheme be ranked, but also the investment project can be optimized.

B. Construction of "Entropy" Model

Using "n" evaluation index to make comprehensive evaluation decision on "m" project investment. Assume that X_{ik} is the projected estimate of investment programme item K

relative to evaluation indicator I, and X_i^* is the expected value of the evaluation indicator. For income indicators such as net present value (NPV), the greater X_i^* , the better; For loss indicators such as investment, the smaller the X_i^* , the better. According to the definition of entropy, The formula for the closeness of X_i^* to X_{ik} is shown as formula 2-1.

$$D_{ik} = \begin{cases} \frac{x_{ik}}{x_i^*}, x_i^* = \max(x_{ik}) \\ \frac{x_{ik}}{x_i^*}, x_i^* = \min(x_{ik}) \end{cases} \quad (2-1)$$

Assuming $M = \sum_{i=1}^n \sum_{k=1}^m D_{ik}$, normalized D_{ik} , $d_{ik} = \frac{D_{ik}}{M}$ ($0 \leq d_{ik} \leq 1$, $\sum_{i=1}^n \sum_{k=1}^m d_{ik} = 1$).

According to the definition of entropy, the entropy value H of M items is calculated by N evaluation indexes. The calculation formula is shown in formula 2-2.

$$H = -\sum_{i=1}^n \sum_{k=1}^m d_{ik} \ln d_{ik} \quad (2-2)$$

If the relative importance of the evaluation indicator is not related to the investment plan, the formula for entropy H is 2-3.

$$H = -\sum_{i=1}^n d_i \ln d_i \quad (2-3)$$

Therefore, the relative importance of evaluation indicators for evaluation of investment programmes is uncertain, and the entropy is shown in formula 2-4.

$$H(i) = -\sum_{k=1}^m \frac{d_{ik}}{d_i} \ln \frac{d_{ik}}{d_i} \quad (2-4)$$

Normalization of formula(2-4), the entropy $e(d_i)$, which characterizes the evaluation index I, is shown in Formula 2-5.

$$e(d_i) = \frac{\sum_{k=1}^m \frac{d_{ik}}{d_i} \ln \frac{d_{ik}}{d_i}}{\ln(m)} \quad (2-5)$$

According to the nature of entropy, it can be judged that the smaller the $e(d_i)$ evaluation indicator, the greater the degree of evaluation importance. In order to conduct a comprehensive evaluation of the investment programme, the evaluation weights of the evaluation indicators θ_i were determined on the basis of $e(d_i)$, and shown in Formula 2-6.

$$\theta_i = \frac{[1 - e(d_i)]}{n - E} \quad (2-6)$$

θ_i Indicates the importance of evaluation indicators for investment programmes, as determined by the degree of importance among indicators and evaluation mechanisms[2]. The evaluation weight θ_i depends on the economic elements of the investment project.

In addition, in order to consider the decision-maker's evaluation experience, another weighted W_i is introduced to represent the decision-maker's evaluation practice experience. W_i is determined by the relative importance of the indicators. Brainstorming and Delphi methods can be used to determine W_i . The weight θ_i and the weight W_i are integrated into a practical evaluation weight λ_i , which is shown in formula 2-7.

$$\lambda_i = \frac{\theta_i \omega_i}{\sum_{i=1}^n \theta_i \omega_i} \quad (2-7)$$

For the project investment scheme, the weighted sum of the difference between the closeness of all evaluation indexes and the expected closeness of the investment scheme and S_k , according to the definition of S_k , it is obvious that the investment scheme with small S_k value is superior. This would make it possible to prioritize investment programmes. The formula for s_k is 2-8.

$$s_k = \frac{1}{M} - \sum_{i=1}^n \lambda_i d_{ik} \quad (2-8)$$

Further using the 0-1 integer programming model, using(1- S_k) as the coefficient of the objective function of the integer programming model, the investment plan is optimized under given constraints. The integer programming model is shown in formula 2-9. b_k is the resource demand of investment scheme K, R_q is the total resource demand, c_k is the contribution of investment scheme K, and T_q is the total contribution value.

$$\begin{cases} \max Z = \sum_{i=1}^m (1 - s_k) x_k \\ s \cdot t \sum_{k=1}^m b_k \cdot s_k \leq R_q \\ \sum_{k=1}^m c_k \cdot s_k \geq T_q \end{cases} \quad (2-9)$$

III. CASE ANALYSIS OF ENTROPY MODEL

According to the investment intention, a group company in Shandong submitted 6 investment plans for the project. According to the information entropy model, the investment plan is comprehensively optimized and investment decision is made.

Through the study, it is decided to adopt three evaluation indexes, namely, investment amount, net present value and social impact qualitative index, to comprehensively evaluate the six investment projects. Table I shows the estimates of evaluation indicators for each investment project and their proximity.

TABLE I. ESTIMATED VALUE OF THE EVALUATION INDICATOR X_{ik} AND ITS PROXIMITY D_{ik} DATA TABLE

Investment programme	Evaluation indicators					
	Investment		NPV		Social indicators	
	x_{ik}	d_{ik}	x_{ik}	d_{ik}	x_{ik}	d_{ik}
1	12	1	17	0.6296	20	0.4
2	40	0.3	19	0.7037	30	0.6
3	32	0.375	16	0.5925	50	1
4	18	0.6667	12	0.4444	32	0.64
5	38	0.3158	27	1	40	0.8
6	25	0.48	20	0.7407	18	0.36
d_i	3.1375		4.1109		3.8	

The net present value (NPV) is now used as an indicator, and calculate $e(d_i)$, θ_i , λ_i respectively.

The entropy of net present value (NPV) index is $e(d_i)$.

$$e(d_1) = -\frac{1}{\ln 6} \left(\frac{0.6296}{4.1109} \ln \frac{0.6296}{4.1109} + \dots + \frac{0.7407}{4.1109} \ln \frac{0.7407}{4.1109} \right) = 0.95$$

The entropy of investment quota is

$$e(d_1) = -\frac{1}{\ln 6} \left(\frac{1}{3.1375} \ln \frac{1}{3.1375} + \dots + \frac{0.48}{3.1375} \ln \frac{0.48}{3.1375} \right) = 0.94$$

The entropy of social impact indicators is

$$e(d_1) = -\frac{1}{\ln 6} \left(\frac{0.4}{3.8} \ln \frac{0.4}{3.8} + \dots + \frac{0.36}{3.8} \ln \frac{0.36}{3.8} \dots \right) = 0.97$$

By calculation, $E = \sum_{i=1}^3 e(d_i) = 2.86$,

According to formula (2-6), θ_2 the evaluation weight of net present value (NPV) is calculated.

$$\theta_i = \frac{|1 - e(d_i)|}{n - E} = 0.429$$

Similarly, calculate the corresponding data of investment and social impact assessment indicators. As shown in table II.

TABLE II. SUMMARY TABLE OF EVALUATION INDEX PARAMETERS

parameters	Investment	NPV	Social indicators	Total
$e(d_i)$	0.95	0.94	0.97	2.86
θ_i	0.357	0.429	0.214	1
ω_i	0.35	0.45	0.2	1
λ_i	0.346	0.535	0.119	1

According to the data in the table, the weighted sum s_k of the difference between the closeness of the evaluation index and the expected closeness of the investment scheme is calculated by using the formula (2-8). And make a scientific decision based on S_k 's ranking of the investment programme. That is shown in table III,

TABLE III. S_k OF ALL INVESTMENT PLANS AND ECONOMIC EVALUATION RESULT

Investment programme	S_k	Rank	Investment	Income	Cost
1	0.526	5	12	15	10
2	0.623	6	40	50	20
3	0.342	1	32	42	14
4	0.416	3	18	24	12
5	0.384	2	38	60	15
6	0.493	4	25	38	16

The investment, operating income, and operating costs of each investment project are shown in Table III. According to the constraints: the total amount of funds is 1,000,000yuan, the total operating income is greater than 500,000 yuan, and the operating cost is less than 400,000 yuan. Construct a 0-1 integer planning model.

$$\begin{cases} \max Z = 0.474x_1 + 0.377x_2 + \dots + 0.507x_6 \\ 12x_1 + 40x_2 + \dots + 25x_6 \leq 100 \\ 15x_1 + 50x_2 + \dots + 38x_6 \geq 50 \\ 10x_1 + 20x_2 + \dots + 16x_6 \leq 40 \\ x_k = 0 \text{ or } 1 \quad (k = 1, 2, \dots, 6) \end{cases}$$

By calculation, $x_1 = x_3 = x_5 = 1$, the others are all zero. It is indicated that the optimal portfolio of investment program projects is investment program No. 1, No. 3 and No. 5.

This model realizes the ranking of investment programmes. It not only distinguishes investment programmes with the same value as individual evaluation indicators, but also makes the evaluation results more realistic because of the comprehensive evaluation effect of multiple indicators. In addition, by constructing an integer programming model with $(1-s_k)$ as the objective function, the portfolio of investment schemes can be optimized under resource constraints.

IV. CONCLUSION/SUMMARY

At present, time-based, value-based and ratio-based indicators are often used in the economic evaluation of investment programs. How to coordinate these distinctive evaluation indicators and synthesize other relevant evaluation indicators for multi-index comprehensive evaluation has become an interesting and practical research topic in the subject of technical economics[5].

The core of entropy in management decision-making is to work hard to create a low entropy system[3]. According to the nature of entropy, this paper establishes a model of entropy weight coefficient method to sort investment projects, and provides ways and methods to optimize projects under the condition of capital and other limitations. Through the application of practical case analysis, the following three features with practical significance are summarized in this decision model.

(1) In determining the weight of evaluation index, the subjective and objective factors are considered comprehensively, and the inherent confidence of the project investment scheme is put forward. Information is combined with subjective information quantification of decision makers' experience judgment, so as to make it more scientific.

(2) Using diversified indicators, there are both positive and negative indicators of quantitative analysis, and social impact indicators of qualitative analysis, reflecting the objective requirements of multi-criteria decision-making.

(3) Starting from the reality of management decision-making, combining with practical cases, this paper systematically analyzes and discusses the feasibility of the application of entropy theory and the ways and methods of its application, and provides reference for the comprehensive evaluation of multi-indexes in other disciplines.

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