Research on Cost-Benefit Evaluation Model of Social Security Project Based on Fuzzy Entropy

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Abstract. At present, there is no uniform standard for the cost estimation of social security projects for reference, and the cost composition and estimation contents of projects under the self-management mode of all regions are different. In order to do a good job in the basic data collection and information submission for cost estimation, it is necessary to deeply study the cost efficiency of social security projects and realize the high precision assessment thereof. Aiming at the short-comings of current cost-benefit evaluation model of social security project, such as large error, long time-consuming, low sensitivity to change of inspection value, etc., this paper studies the relevant reference, and puts forward a cost-benefit evaluation model of social security project based on fuzzy entropy. This paper uses analytic hierarchy process to construct the cost-benefit evaluation index system of social security project. By comparing the two indexes, the importance of each index is judged. The final evaluation index is determined according to the consistency test results of the judgment matrix. Combining with the calculation of fuzzy entropy, the indexes are empowered, and the social security project is established by synthesizing the weight of each index, the relevant data of investment budget and project demand. The cost-benefit evaluation model of the project is integrated to realize the benefit evaluation. The experimental results show that the evaluation efficiency of the proposed model is higher, the sensitivity of the model to the changes of the observed values is significantly higher than that of the experimental comparison model, and the evaluation results are closer to the reference values.

Keywords: Fuzzy entropy · Social security project · Cost- benefit · Evaluation

1 Introduction

With the treaty-based development of information technology and the wide application of computer systems in production, life and business activities, social security projects as an independent whole have gradually become independent and developed rapidly. Social security project is an interdisciplinary subject based on computer technology, system science, management science and communication technology. Social security project is a cross-disciplinary subject, which is oriented to technology and management, and

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pays attention to the combination of engineering methods and human subjective analysis methods [1]. In today's era of knowledge economy, social security projects will play a more important role. While seeing the rapid development of social security projects, we must clearly see the problems in the construction of social security project. Whether in developed countries or in developing countries, the success rate of social security project construction is far less than other construction projects. One of the important reasons for this situation is lack of timely and necessary evaluation. Compared with the rapid development of information industry, social security project evaluation is lagging behind seriously. Strengthening the research of social security project evaluation theory and method is one of the important contents in this field [2, 3]. The cost-benefit of social security project has a strong lag and recessiveness, which can be reflected only after a considerable period of time, and there are hidden costs, such as maintenance costs and a large proportion of investment, etc. There are many factors affecting the cost-benefit of social security project, which increase the difficulty of evaluation [4].

Now some scholars have put forward better cost-benefit evaluation models. For example, in reference [5], a project cost-benefit evaluation model based on multi-level extension evaluation method was proposed. According to the characteristics of social security project, an index system for evaluating the economic benefit of social security project was constructed from three aspects: operation economic benefit, enterprise financial benefit and social economic benefit. The cost theory in whole life cycle was introduced into the analysis and calculation of enterprise's financial benefit evaluation index. From the long-term economic benefit, the cost of different stages of the system project was considered comprehensively. The comprehensive weight of each index was determined by interval analytic hierarchy process. By introducing matter-element extension theory, an social security project benefit evaluation model based on multi-level extension evaluation method was established. The evaluation results of the model were accurate and sensitive to the changes of the observed values, but it took a long time. Reference [6] presented a cost-benefit evaluation model of social security project based on multi-objective optimization. According to the time dimension and influence, the multi-objective optimization mathematical model of project's cost-benefit evaluation was established. By queuing and filtering, a portfolio solution satisfying the objective and constraint conditions was generated, and the characteristic parameters of the solution were used as the constraint conditions for linear optimization. The local optimal solution of the portfolio was obtained, and the feasible solution was obtained by combining genetic algorithm. The evaluation efficiency of the model was high, but the sensitivity of the model was low. Reference [7] proposed a cost-benefit evaluation model of social security project based on regression analysis. The main influencing factors of project benefit were analyzed, and the benefit evaluation index system was constructed from two aspects of operation efficiency and investment benefit. Through the regression analysis model, the grading interval of indicators for different project characteristics was to determine, an improved matter-element extension model based on A.J. Klee method was proposed to realize the combination of subjective and objective evaluation, and the benefit evaluation model was constructed to calculate the comprehensive evaluation value of each project benefit. The computational complexity of the model was small, but the sensitivity of the model to the variation of the observed values was low. Reference [8] presented a cost-benefit evaluation model of social security project based on marginal benefit. The optimization framework of a project was constructed to describe the overall idea of optimal decision-making, and the marginal benefit of each index to project decision-making optimization was calculated based on the reliability calculation results of the impact index system. The weight distribution of the index was determined according to the marginal benefit of the index, and the comprehensive decision-making value of the project was calculated by combining the corresponding relationship analysis between the project and the index. Combining with the total investment quota, the optimal project was determined and the cost-benefit of social security project was evaluated. Reference [9] taking the power grid cost as an example, based on the importance evaluation, a hierarchical backbone grid construction method is proposed. Based on the life-cycle cost theory and considering the equipment grade, service life and depreciation value, a cost calculation model for differentiated construction investment is established. The typical users of various loads are taken as representatives to establish a load-side outage loss model, which constitutes the disaster-resistant benefit of the hierarchical backbone network with the benefits of the generation side and the power grid side. When the proportion of investment was high, the evaluation result of the model was more accurate, but the sensitivity of the model to the change of the observed value was lower.

To solve these problems, a cost-benefit evaluation model of social security project based on fuzzy entropy is proposed. The main research work is as follows:

(1) Using analytic hierarchy process (AHP), the evaluation index system is constructed and compared. After obtaining the judgment matrix, according to the consistency test results, the matrix is revised to determine the final evaluation index system.
(2) Combining the theory of entropy and the calculation of fuzzy entropy, the comprehensive weight of each index is determined.
(3) The cost-benefit evaluation model of social security project is constructed based on the integration of investment budget and demand of social security project. The model is used to evaluate the cost-benefit.

2 Cost-Benefit Evaluation Model of Social Security Project Based on Fuzzy Entropy

2.1 Cost-Benefit Evaluation Index System of Social Security Project

Before the cost-benefit evaluation of social security project, it is necessary to construct the cost-benefit evaluation index system of social security project, and to complete the construction of evaluation index system by using analytic hierarchy process.

Analytic Hierarchy Process (AHP) was proposed by Saaty, an American operational researcher at the University of Pittsburgh, in the 1970s. The main idea is as follows: divide the evaluation object index into several layers according to the membership relationship, invite experts in relevant fields to compare the importance of each level and factor, establish two or two judgment matrices, and finally calculate the relative weight of the index based on matrix knowledge. The above ideas can be summarized into the following steps:

(1) Establishing an index system;
(2) Obtaining weight vectors of indexes at all levels;
(3) Determining the evaluation value of the relative evaluation index of each scheme;
(4) By synthesizing the evaluation values at all levels, the index weight and the comprehensive evaluation value relative to the total objective are obtained.

This method is a multi-criteria decision-making method combining qualitative method and quantitative method, which has the characteristics of conciseness, systematicness and practicability. Now it has been widely used in complex decision-making systems.

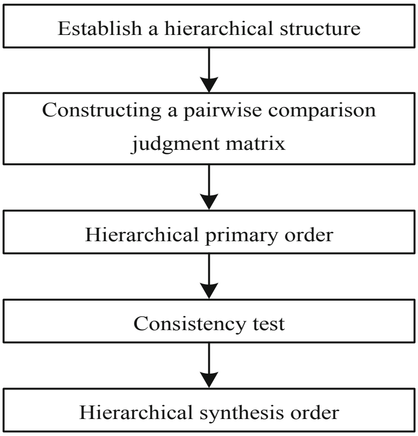

Fig. 1. Basic process of analytic hierarchy process

The analytic hierarchy process is shown in Fig. 1. As can be seen from Fig. 1, the following four aspects of work need to be solved in the analytic hierarchy process:

(1) Establishment of the index system: that is, dividing the constituent elements into different levels and constructing a multi-level hierarchical structure model;
(2) Construction of pairwise comparison judgment matrices: using the upper indexes as the basic criteria, invite experts in the field compare the importance of different indexes at the same level, and construct pairwise comparison judgment matrices according to the corresponding judgment scales;
(3) Hierarchical single ranking and consistency test: on the basis of the judgment matrix, the single ranking of the elements at each level, i.e. the weight vector, is determined. The consistency of the pairwise comparison judgment matrices is tested according to the relevant formulas.
(4) Hierarchical whole-ranking: the ultimate goal of evaluation is to obtain the ranking of the underlying indicators relative to the total objective. This step mainly uses the single-ranking results to obtain the whole-ranking of the evaluation objectives.

The establishment of index system is the first step of analytic hierarchy process (AHP). Its main function is to construct a hierarchical model of evaluation index according to a certain degree of orderliness. The quality of its construction directly affects the effectiveness of the evaluation results. Under this hierarchical model, the complex evaluation object can be decomposed into a hierarchical model composed of many index elements. According to the different attributes of elements, elements of different attribute categories can be divided into different levels. Usually, before implementing this step, we should have a comprehensive, systematic and scientific understanding of the evaluation objectives. It satisfies the principles of scientificity and advancement, comprehensiveness and systematicness, combination of qualitative and quantitative analysis, as well as feasibility and operability [10].

According to the typical hierarchy shown in Fig. 2, each layer element is not completely dominated by the upper element, it is dominated by at least one element of the upper layer. Among them, the hierarchical structure can be macroscopically divided into target layer, intermediate layer and scheme layer.

(1) Target layer: This layer is the highest level, which contains only one element and is the target or ideal state of the evaluation object.
(2) Intermediate layer: This layer, also known as criteria layer, contains relevant intermediate steps and criteria to achieve the intended targets of the object to be evaluated. It often includes a main criteria layer and a sub-criteria layer.
(3) Scheme layer: This layer is the lowest level, representing the decision-making scheme provided to achieve the predetermined evaluation objectives in the target layer.

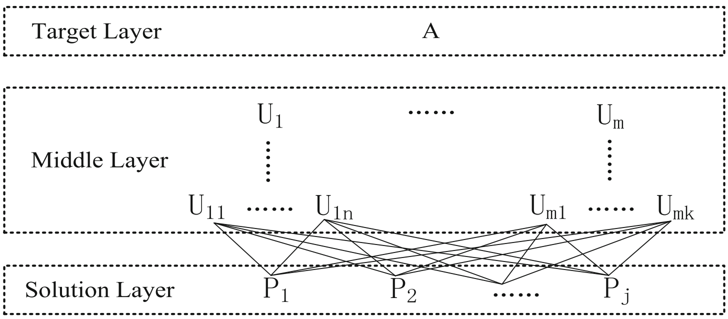

Fig. 2. Hierarchical diagram

In these three macro levels, the target level and the scheme level are fixed for different evaluation objects. In the target layer, no matter what the evaluation object is, the element is always fixed. In the scheme layer, the number of schemes can be taken from 1 to infinite in theory, and the specific number is related to the actual evaluation object. When there is only one scheme, the evaluation will evolve into a single scheme evaluation. For multi-scheme evaluation, it can be seen as a multiple realization of the single scheme evaluation. Among them, the order of the middle layer is at least one layer. The number of specific layers is related to the complexity of the evaluation object and the detailed degree of demand analysis. There is no limit to the number of layers in theory. However, the single-layer construction is better to satisfy the requirement of having less than nine elements, so as to reduce the difficulty of constructing a pairwise judgment matrix. According to the above analysis, a complete hierarchical structure contains at least three levels of order. With the increase of the complexity of the evaluation object, the order may also increase.

An important feature of analytic hierarchy process (AHP) is to express the importance degree of two indexes relative to the previous level in the form of the ratio of two importance degrees for each index [11, 12]. Next, we will explain how to build a pairwise comparison judgment matrix.

If in the cost-benefit evaluation index system of social security project, the index elements U_{k1}, U_{k2},$\cdots$, U_{kn} are the lower indicators with U_k as the basic criteria, now we can get the relative weights of U_{k1}, U_{k2},$\cdots$, U_{kn} based on U_k. When comparing the relative importance of U_{ki} and U_{kj}, a numerical value to represent them is selected. This value can be given directly by the decision maker or obtained through some kind of technical consultation. According to this method, the pairwise comparison judgment matrix $A = \left(A_{ij}\right)_{n\times n}$ can be obtained finally. Among them, A_{ij} represents the important value of factor i relative to factor j.

The matrix descriptions corresponding to the comparison results of the relative importance of pairwise elements are given by using formula (1):

$$A = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{21} \\ \vdots & \vdots & \cdots & \vdots \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{pmatrix} \tag{1}$$

The matrix shown in the above formula has the following properties:

(1) $A_{ij} \neq 0, (i, j = 1, 2, \cdots, n)$;
(2) $A_{ij} = \frac{1}{A_{ji}}, (i \neq j)$;
(3) $A_{ii} = 1, (i = 1, 2, \cdots, n)$.

Matrix satisfying the above conditions is called positive and negative matrix. For both positive and negative matrix A, matrix A is called a consistent matrix if both of them satisfy $\forall i, j, k (i, j, k = 1, 2, \cdots, n)$ and $A_{ik} \cdot A_{kj} = A_{ij}$ is tenable. According to the above properties, when applying analytic hierarchy process (AHP) to evaluate an object containing n elements, the decision maker needs to carry out pairwise comparisons for at least $n(n-1)/2$ times, and quantifies the relative important values of the elements according to a certain ratio scale to form a numerical judgment matrix. The commonly used comparison scales are shown in Table 1.

Table 1. Scaling table of judgment matrix

Element comparison results	Scale
Element i is as important as j	1
Element i is slightly more important than j	3
Element i is obviously more important than j	5
Element i is intensely important than j	7
Element i is extremely important than j	9
Element i is slightly less important than j	1/3
Element i is obviously less important than j	1/5
Element i is intensely less important than j	1/7
Element i is far less important than j	1/9
The comparison results of the importance of the two elements are between the above conditions	2, 4, 6, 8, 1/2, 1/4, 1/6, 1/8

Ideal judgment matrix is consistent, but due to the lack of awareness of the evaluation object and the complexity of the evaluation object itself, the established judgment matrix often fails to meet the consistency. In order to ensure the use of analytic hierarchy process to obtain reasonable and effective evaluation results, it is necessary to test the consistency of two judgment matrices. The method of consistency test is introduced below.

From the knowledge of matrix theory, we can draw the following conclusion: if $\lambda_1, \lambda_2, \cdots, \lambda_n$ is the characteristic root of matrix A, it satisfies:

$$Ax = \lambda x \tag{2}$$

And if A satisfies $a_{ii} = 1 (i = 1, 2, \cdots, n)$, then:

$$\sum_{i=1}^{n} \lambda_i = n \tag{3}$$

When matrix A satisfies complete consistency, there is $\lambda_1 = \lambda_{\max} = n$, then $\lambda_i = 0 (i = 2, 3, \cdots, n)$; when matrix A does not satisfy complete consistency, $\lambda_1 = \lambda_{\max} > n$, and the sum of the remaining eigenvalues satisfies:

$$\sum_{i=2}^{n} \lambda_i = n - \lambda_{\max} \tag{4}$$

The formula for calculating the consistency test index CI is as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{5}$$

The smaller the calculated value of CI is, the better the consistency is; when $CI = 0$, the judgment matrix has complete consistency.

After completing the consistency test of hierarchical single-ranking, the consistency test of hierarchical whole-ranking is carried out from top to bottom. Assuming that the consistency test index value $CI_j^{(k)}$ is based on the element j at the $k-1$th level, the comprehensive index $CI^{(k)}$ at the kth level is:

$$CI^{(k)} = \left(CI_1^{(k)}, CI_2^{(k)}, \cdots, CI_{n_{k-1}}^{(k)}\right)w^{(k-1)} \tag{6}$$

When $CI^{(k)}$ is less than the set threshold, it is considered that all judgement matrices above the kth level of the hierarchical structure have overall satisfactory consistency.

According to the consistency test results, the judgment matrix that does not meet the needs is revised to determine the final evaluation index system.

2.2 Weighting Computation

After determining the evaluation index system, it is necessary to empower the indicators, describe the proportion coefficient of the corresponding indicators in the cost-benefit evaluation of social security project, and improve the accuracy of the evaluation results. The specific process is as follows:

Let $(i' = 1, 2, \cdots, n', \ j' = 1, 2, \cdots, m')$ be the observation data of the j'th index of the i'th evaluated object, and n' be the number of evaluated objects. m' is the index number of the the i'th evaluated object. For any j', the greater the difference between the observed data $x_{i'j'}$ is, the greater the comparative effect of the index on the system is, and the more the information it contains and transmits are. Entropy is used to measure the uncertainty of information. If entropy increases, information decreases, and vice versa. This method of measuring information with entropy is the Entropy Value Method [13]. The steps to determine the weight of the index by the method of entropy are as follows:

(1) Under calculating the i'th object, the characteristic proportion $f_{i'j'}$ of the j'th index is calculated, and the formula is as follows:

$$f_{i'j'} = \frac{x_{i'j'}}{\sum_{i'=1}^{n'} x_{i'j'}} \tag{7}$$

The constraint condition is $x_{i'j'} \geq 0$, and $\sum_{i'=1}^{n'} x_{i'j'} > 0$.

(2) According to the calculation formula of the entropy value, the entropy value $e_{j'}$ of the j'th evaluation index is:

$$e_{j'} = -\frac{1}{\ln n'} \sum_{i'=1}^{n'} f_{i'j'} \ln(f_{i'j'}) \tag{8}$$

In the formula above, $n' > 0$, $e_{j'} > 0$.

(3) Determining weights.

When given j', the difference of $x_{i'j'}$ becomes smaller, $e_{j'}$ will increase. For a given j', when $x_{i'j'}$ is all equal, $f_{i'j'} = 1/n'$, $e_{j'} = e_{\max} = 1$, then $x_{j'}$ will not play any role in comparing the indicators between systems; conversely, when the given difference of $x_{i'j'}$ increases, $e_{j'}$ will decrease, and then the comparative effect of index $x_{j'}$ on the system will increase. Based on the above analysis, $1 - e_{j'}$ is as the difference coefficient of index $x_{i'j'}$, the greater the value of it is, the more the attention should be paid to the comparative role of index is. Let the index entropy weight set $w' = [w'_1, w'_2, \cdots, w'_{m'}]^T$, and the entropy weight of the j'th evaluation index is as follows:

$$w'_{j'} = \frac{1 - e_{j'}}{m - \sum_{j'=1}^{m} e_{j'}} \tag{9}$$

Assuming the fuzzy number $r_{i'} = [a_{i'j'}, b_{i'j'}, c_{i'j'}]$, the corresponding membership function is:

$$f_{r_{i'}}(x) = \begin{cases} 0, & x \le a_{i'j'} \\ \frac{x - a_{i'j'}}{b_{i'j'} - a_{i'j'}}, & a_{i'j'} < x \le b_{i'j'} \\ \frac{x - c_{i'j'}}{b_{i'j'} - c_{i'j'}}, & b_{i'j'} < x \le c_{i'j'} \\ 0, & x > c_{i'j'} \end{cases} \tag{10}$$

Where, $x \in R$, $a_{i'j'} < b_{i'j'}$ and $c_{i'j'}$ are upper and lower bounds respectively, indicating the degree of ambiguity. The larger the values of $a_{i'j'}$ and $c_{i'j'}$ are, the higher the degree of ambiguity is. Among them, $a_{i'j'}$, $b_{i'j'}$ and $c_{i'j'}$ represent the most conservative, most likely and optimistic evaluation values given by the i'th expert on the importance of index j', respectively.

The expert evaluation weight set $E = [e_1, e_2, \cdots, e_k]$ is obtained, in which e_k is the proportion of the evaluation value of the kth expert to the evaluation object in the comprehensive evaluation.

The triangular fuzzy number complementary judgment matrix [14] is established by several experts according to the purpose of evaluation and the relevant information of evaluation index. Then the weight set of expert evaluation is used to calculate the triangular fuzzy comprehensive judgment matrix T of evaluation index.

$$T = [\alpha_{i'j'} e_{i'}, b_{i'j'} e_{i'}, r_{i'j'} e_{n'}] \tag{11}$$

Where, $\alpha_{i'j'} e_{i'}$, $b_{i'j'} e_{i'}$ and $r_{i'j'} e_{n'}$ represent the most conservative, most likely and optimistic estimates of index j', respectively.

If the weight vector of the fuzzy number to be determined is v, the formula for calculating the fuzzy score of the j'th index is as follows:

$$v_{j'} = (a_{j'} + 5b_{j'} + c_{j'})/7 \tag{12}$$

Let the index fuzzy set be $w'' = [w_1'', w_2'', \cdots, w_{m'}'']^T$, the j'-th index fuzzy weight is obtained by normalization.

$$w_{j'}'' = \frac{v_{j'}}{\sum_{j'=1}^{m'} w_{j'}''} \tag{13}$$

In the index combination weight set $W = [w_1, w_2, \cdots, w_{m'}]^T$, $w_{j'}$ is the j'th index weight after the above weighted combination. The $w_{j'}'$ and $w_{j'}''$ are replaced by $w_{j'}$ by linear combination.

$$w_{j'} = \theta w_{j'}' + (1 - \theta) w_{j'}'' \tag{14}$$

Where, θ is the proportion of objective preference coefficient weight to combination weight; $1-\theta$ is the proportion of subjective preference coefficient weight to combination weight.

According to the linear weighted comprehensive evaluation method, a comprehensive score of $D_{j'}$ is obtained:

$$D_{j'} = \sum_{j'=1}^{m'} d_{i'j'} w_{j'} \tag{15}$$

Where, $d_{i'j'}$ is the evaluation index score, $w_{j'}$ is the combination weight of the j'th index.

2.3 Establishment of Cost-Benefit Evaluation Model

In order to meet the market demand, social security project expansion needs to adapt to the market development through certain adjustments. In the process of project expansion decision-making, decision makers must consider the cost of project expansion and subsequent operational benefits. With this as the objective function, an evaluation model is constructed, and the project expansion is carried out according to the results of calculation and analysis to maximize the benefits [15]. The concrete process of constructing cost-benefit evaluation model of social security project is as follows:

Assuming that in the stage t, for the economic benefits produced by the part x_{ij} of the social security project, α_{ij}' represents the cost consumed, β_{ij}' represents the depreciation cost of the project investment in that stage, y_{ij} represents the Boolean variable, b_t represents the investment budget in the stage t, B represents the total investment amount, d_j represents the project demand amount in this stage, M_{ij} represents the expansion restriction of the project in this stage, and then the demand is determined and the social security project is constructed. The mathematical model of project's cost-benefit evaluation is as follows:

$$BM = \max \sum_{i=t_1}^{t_s} \sum_{j=1}^{n} (\gamma_{ij}' x_{ij} - \alpha_{ij}' x_{ij} - \beta_{ij}' x_{ij}) \tag{16}$$

The constraints are:

$$\begin{cases} s.t.\ 0 \leq x_{ij} \leq M_{ij}y_{ij} \\ \sum_{i=t_1}^{t_s}\sum_{j=1}^{n}(\alpha'_{ij}x_{ij} + \beta'_{ij}x_{ij}) \leq B \\ \sum_{i=1}^{n} x_{ij} \geq d_j \\ y_{ij} \in \{0, 1\} \end{cases} \tag{17}$$

For the above model, the project demand is known, and the objective function of benefit evaluation requires the maximum of the net benefit obtained by the project. The constraints are the restriction of the increment of the project in each stage, the restriction of the investment cost budget, and the restriction of the demand of the project quantity.

In order to simplify the calculation and reduce the complexity, the model expression is transformed into the following form:

$$BM' = \min \sum_{i=t_1}^{t_s}\sum_{j}^{n} -(\gamma'_{ij}x_{ij} - \alpha'_{ij}x_{ij} - \beta'_{ij}x_{ij}) \tag{18}$$

For uncertain demand, in order to describe uncertain demand, the probability p'_i of different changes in demand is introduced. In order to avoid increasing the complexity of model constraints, the model is decomposed by scenario tree method, and the cost-benefit equilibrium analysis of uncertain demand is established on the description of new model. After splitting and reconstructing, the mathematical expression of the model is as follows:

$$BM^* = \min \sum_{j=1}^{n} P'_j \left(\sum_{i=t_1}^{t_s} \left(-\gamma'_{ij}x_{ij} + \alpha'_{ij}x_{ij} + \beta'_{ij}x_{ij} \right) \right) \tag{19}$$

The constraints of the model are the same as above. For the project's cost-benefit evaluation model with certain demand and uncertain demand, after model transformation, it is solved by lot-sizing heuristic algorithm.

3 Experimental Simulation

In order to prove the comprehensive effectiveness of the proposed cost-benefit evaluation model for social security project based on fuzzy entropy, a simulation experiment is needed. The experimental environment is as follows:

Windows 7, 32-bit operating system platform, Intel Core i7 8700K processor, 3.7 GHz main frequency, 4.7 GHz turbo boost, six cores.

Experiments are carried out with the proposed model, the cost-benefit evaluation model based on multi-level extension evaluation method, the cost-benefit evaluation model based on multi-objective optimization, the cost-benefit evaluation model based on regression analysis, and the cost-benefit evaluation model based on marginal benefit for social security project. The models are compared when the proportion of investment is different. The results of the overall benefit evaluation are shown in Table 2. In Table 2, MOA, MOB, MOC, MOD and MOE represent the proposed model, the cost-benefit evaluation model based on multi-level extension evaluation method, the cost-benefit evaluation model based on multi-objective optimization, the cost-benefit evaluation model based on regression analysis, and the cost-benefit evaluation model based on marginal benefit for social security project.

Table 2. Comparison of the total benefit evaluation values of the funds of each model

Evaluation model	Proportion of expenditure %			Relevance
	60%	30%	3%	
MOA	0.9995	0.5213	0.0433	Strong
MOB	0.9986	0.7547	0.5436	Stronger
MOC	0.9987	0.9277	0.8251	Weak
MOD	0.9979	0.9168	0.8709	Weak
MOE	0.9962	0.9205	0.8324	Weak

Analyzing the data in Table 2 and comparing the changes of the evaluation value of each model with the proportion of investment, when the proportion of investment is 60%, the evaluation value of each model is close, but when the proportion of investment is reduced to 3%, the change of the evaluation value by using the cost-benefit evaluation model of social security project based on multi-objective optimization, the cost-benefit evaluation model of social security project based on regression analysis and the cost-benefit evaluation model of social security project based on marginal benefit are small, which shows that the sensitivity of the three evaluation models to the change of the evaluation value is small. The evaluation value of the cost-benefit evaluation model based on multi-level extension evaluation method decreases to 0.5436. It shows that the sensitivity of the model to the change of the evaluation value is high, and the evaluation value of the proposed model decreases to 0.0433, indicating that the sensitivity of response to change of value is very high.

The proposed model and the project's cost-benefit evaluation model based on multi-level extension evaluation method are used to carry out the experiment. The short-term net income evaluation results of the two models are compared and the experimental results are shown in Fig. 3. In Fig. 3, RA, RB and RC represent the evaluation results of the proposed model, the evaluation results of the project's cost-benefit evaluation model based on multi-level extension evaluation method and the reference evaluation values, respectively.

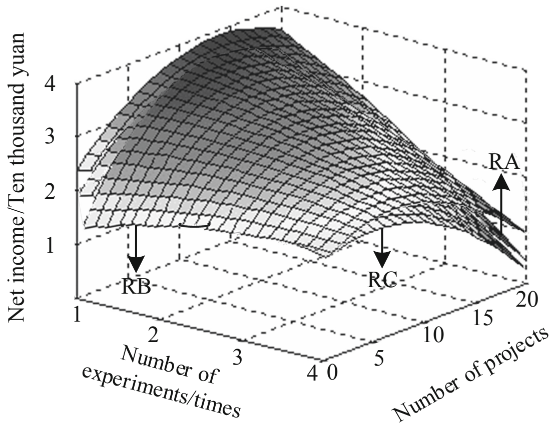

Fig. 3. Comparison of short-term net income evaluation results

According to Fig. 3, when the number of projects increases from 0 to 15, the net income of social security project increases gradually. When the number of projects increases from 15 to 20, the net income of social security project decreases gradually. Compared with the cost-benefit evaluation model based on multi-level extension evaluation method, the short-term net income evaluation results of the proposed model are closer to the reference value, indicating that the result of benefit evaluation of the proposed model is more accurate.

The cost-benefit evaluation model based on the proposed model, the cost-benefit evaluation model based on multi-level extension evaluation method, the cost-benefit evaluation model based on multi-objective optimization, the cost-benefit evaluation model based on regression analysis and the cost-benefit evaluation model based on marginal benefit for social security project are used to carry out experiments, and the models are compared with each other in the case of the number of projects changing. The time required for cost-benefit evaluation is shown in Table 3. In Table 3, MOA, MOB, MOC, MOD and MOE have the same meanings as Table 2.

Table 3. Time-consuming comparison of various models

Evaluation model	Number of projects		
	5	10	20
MOA	5.45 s	10.21 s	20.05 s
MOB	6.27 s	13.56 s	27.33 s
MOC	5.82 s	12.63 s	25.71 s
MOD	6.71 s	14.25 s	28.34 s
MOE	6.03 s	13.67 s	27.16 s

By analyzing the data in Table 3, the time needed for the benefit evaluation of each evaluation model increases with the increase of the number of projects. By calculating, it can be seen that when the amount of project increases, the evaluation time of the proposed model increases the least. By comparing the evaluation time of the same number of projects, it can be seen that the cost-benefit evaluation time of the proposed model is the shortest.

Based on the above experimental results, in order to further verify the effectiveness of the proposed model, an ablation experiment is designed below. The cost-benefit evaluation model based on multi-level extension evaluation method, the cost-benefit evaluation model based on multi-objective optimization, the cost-benefit evaluation model based on regression analysis, and the cost-benefit evaluation model based on marginal benefit for social security project are selected as the control group. The experimental results are compared with those of the designed model. The short-term net income and time consumption of the above different models are set to be the same. The short-term net income is 30,000 yuan, the time consumption is 20 s, and the number of experiments of different models is 70 times. The evaluation accuracy of different models is compared. The comparison results are as follows:

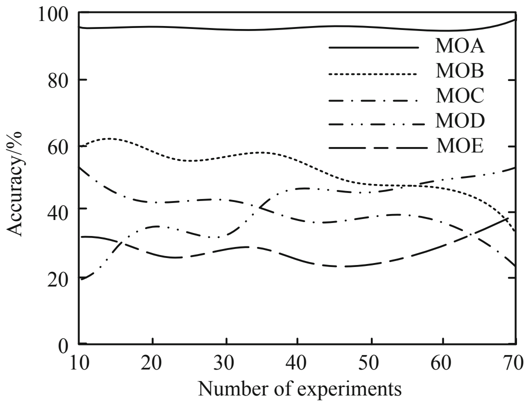

Fig. 4. Comparison results of accuracy of different models

According to Fig. 4. The experimental results, compared with the cost-benefit evaluation model based on multi-level extension evaluation method, the cost-benefit evaluation model based on multi-objective optimization, the cost-benefit evaluation model based on regression analysis, and the cost-benefit evaluation model based on marginal benefit for social security project, the proposed model has higher accuracy.

4 Conclusions

In order to improve the accuracy and decision-making efficiency of cost-benefit evaluation of social security project, a cost-benefit evaluation model of social security project based on fuzzy entropy is proposed in view of the problems existing in the current cost-benefit evaluation model of social security project. The cost-benefit evaluation index system of social security project is established by analytic hierarchy process to provide basis for cost-benefit evaluation. The evaluation matrix is obtained by comparing the importance of the index. According to the consistency test results of the judgement matrix, the judgement matrix that does not meet the consistency needs is revised to determine the final evaluation index system, reduce the number of indicators and improve the operation efficiency. Through the corresponding calculation results of fuzzy entropy, the comprehensive weight of each index is determined to improve the accuracy of cost-benefit evaluation results of social security project. Based on the above evaluation index system and weight calculation, the cost-benefit evaluation model of social security project is constructed by synthesizing the related data of social security project demand and investment budget. The simulation results show that the proposed model has good robustness, less error and higher evaluation efficiency.

The simulation results validate the cost-benefit evaluation performance of the proposed model, but some problems have been found in the whole research process, which still need to be further studied. The prospects for future research are as follows:

Cost-benefit model in social project expansion has always been a research hotspot. Especially in recent years, the benefit of social security project has attracted more attention and more extensive research. In the future research, there are still several problems to be further studied:

(1) Cost-benefit optimal equilibrium model of project expansion constrained by stochastic factors.

In recent years, stochastic programming and algorithms have been applied to the study of network flow planning theory, these models mostly involve stochastic demand, and there are many ways to represent stochastic demand. The optimal cost equilibrium model of stochastic social project construction is the maximum capacity model of social security project under stochastic constraints, the maximum net profit model of social security project, the minimum cost model of project construction and the profit generated by the maximum unit cost. This kind of model has a wide application background in real life, and the description of this kind of model is very close to many uncertain situations in real life.

(2) Cost-benefit optimal equilibrium model for multi-stage project expansion.

Multi-stage project expansion model has always been a very important model in the theory of social security project construction. The study of cost-benefit optimal equilibrium model for multi-stage project expansion is also complicated. Because it is built in stages, the decision-making of project expansion in the latter stage must be based on the former stage. The expression of operational benefit function of social security project will be more complex, and the expression of cost function will vary greatly in each stage, not only piecewise linear function. When we study the optimal adjustment capacity and maximum net profit model of multi-stage social security project expansion, there will be more changes, and the algorithm will be completely different from the single-stage project construction model. The cost-benefit equilibrium model of multi-stage project expansion can also be considered together with the stochastic project expansion model.

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