

# Application of DS Evidence Theory in Performance Evaluation of Fiscal Key Expenditure

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**Abstract.** Some provinces and cities in China continue to promote the performance evaluation of fiscal key expenditure. Considering the inadequate and conflict information caused by expert scoring method, we use DS Evidence Theory as a method of evaluation and put 18 industrial projects of GF special funds as evaluation object to explore and prove the DS evidence theory's effectiveness and applicability which based on the characteristics of the project. The research shows that the multi-attribute decision-making of performance evaluation of fiscal key expenditure involves many qualitative and quantitative information. DS Evidence Theory realizes the calculation of attribute value by confirming the confidence level under the evaluation level so as to make the qualitative representation of the qualitative indicator more scientific; For the quantitative attribute, this method broadens the range of the basic attributes, and thus make its performance evaluation results more in line with the objective reality; Especially for the insufficient information and the missing information, this method can make fuzzy inferences based on the information which given by other experts to avoid the subjective scoring randomness. Therefore, DS Evidence Theory method can effectively improve the objectivity and scientificness of the performance evaluation result of fiscal key expenditure.

**Key words.** performance evaluation, fiscal key project expenditure, DS evidence theory, expert evaluation method.

## 1. Introduction

In recent years, the research on the performance evaluation index system of fiscal expenditures in China has been gradually increasing, but the study of performance

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appraisal methods still not be concerned. Especially the practice of financial expenditures performance evaluation mainly adopts the subjective evaluation methods such as expert scoring. The performance evaluation of fiscal key expenditure is a multi-attribute decision-making problem which contains both qualitative information consideration and quantitative information consideration. Most of the indicators are usually qualitative indicators, so it couldn't obtain enough data to do mathematics calculation. The subjective evaluation method based on expert scoring usually suffered by experts' insufficient and conflicting information. Besides simply use the performance evaluation method to deal with the qualitative or quantitative information, could seriously affects the accuracy and objectivity of performance evaluation results. However, with the DS evidence theory, the problem of information fusion and the shortage of qualitative and quantitative index evaluation in fiscal key expenditure performance could be solved. Based on the empirical analysis of performance evaluation of B City's 18 industrial projects of GF in 2016, this paper proposed a rationality and scientificity evaluation results through the DS evidence theory.

## **2. Theoretical Analysis of Performance Evaluation of Fiscal Key Expenditure Based on DS Evidence Theory**

DS evidence theory is mostly used to solve multi-attribute decision making problems with uncertain information. The main features of DS evidence theory are as follows: first, with the satisfaction of weaker conditions than Bayesian probability theory, the DS evidence theory don't need to know the prior probability; Second, the DS evidence theory has the direct expression of "uncertainty" and "unknown" ability; third, the DS evidence theory has the advantages of simple reasoning form. The fiscal key expenditures refer to the large amount of special financial expenditures which set up by the government's development plans or policies, and they aim to promote the development of industry or specific industries. The performance evaluation of fiscal key expenditures is a multi-attribute decision-making problem which contain both qualitative and quantitative factors. The outcome of the decision-making is influenced by multiple relevant factors. First of all, considerate the large scale of funds, wide range of benefits and long duration of project, the selection of evaluation indicators should not only consider the indicators of beneficiaries but also the changes of different years in the whole project cycle to reflect the dynamic performance. There are many qualitative and quantitative information involved in multi-attribute decision-making, some indicators tend to be contradictory. There is no unified dimension and it is difficult to evaluate with uniform standards. Many evaluation methods can only deal with either qualitative or quantitative information, but DS evidence theory can combine qualitative and quantitative information, so it could effectively improve the accuracy of fiscal key expenditures evaluation results; Secondly, due to the uncertainty of decision-making information and the limitation of decision maker's cognitive ability, most of the multi-attribute decision-making belong to the uncertain multi-attribute decision-making[1]. Fiscal key expenditure involved with multiple government departments and multiple industries, so it's performance evaluation become much more complex. The normally used fiscal key

expenditures evaluation method is multi-attribute decision-making which contained many qualitative index and be influenced by uncertainty or unknown factors. The basic data of fiscal key expenditures performance evaluation come from the scoring of different experts. The performance evaluation experts are hired from different fields of industry, with different knowledge reserves and working experiences. So they could have different cognition about one project so it is almost impossible to coordinate their disagreements when they doing the subjective scoring, especially in the occasion of that some experts have cognitive blind spots on some indicators. So under this evaluation method, with much uncertain information, the evaluation results are not quite accurate. However, with the DS evidence theory, this problem could be solved. The DS evidence theory could directly express uncertain information and unknown information, and it could quantitatively deal with various fuzzy factors which affecting performance evaluation, so it could effectively solve the conflicts among evaluation experts and integrate the results of the assessment. Under the DS evidence theory, even if an evaluation expert could not score a certain qualitative index independently, he / she could also not be scored neither. This unique advantage of handling unknown information not only makes the analysis objectively but also reduces the workload of experts.

### 3. Performance Evaluation Methods of Fiscal Key Expenditure Based on DS Evidence Theory

#### 3.1. Determination of Decision Attributes

Based on the constructed performance evaluation index system, all the indicators, that is, the decision attributes are graded. According to the B city's fiscal key expenditure performance evaluation policy, the experts summarize the evaluation results of the basic attributes. The evaluation results are usually divided into four levels :excellent, good, medium and poor. This article will set the total attribute that the overall performance of the project B to H, the other attributes are the same, namely:  $H = \{H_n | n = 1, 2, 3, 4\} = \{Poor, Average, Good, Excellent\}$ .

Qualitative index in performance evaluation index system can be calculated by the expert group scoring situation, and the rating evaluation results can be used directly without conversion; According to the fuzzy evaluation, this paper use membership degree calculation method to convert quantitative indicators into qualitative evaluation level. Generally, the maximum value is determined as the highest level of the attribute, corresponding to the Excellent level in the total attribute, the minimum level as the lowest level of the attribute, and the same as the Poor level in the total attribute.

#### 3.2. Attribute Value Calculation

##### 3.2.1 Basic Attribute Value

The key to determine the evaluation of the basic attribute is to define the probability under the evaluation hierarchy, that is, the confidence in DS evidence

theory, This paper uses  $\beta_n(e_{ij})$  to denote the probability of attribute  $e_{ij}$  under the rating  $H_n$  Excellent Good Average Poor. The following conditions are required:  $\beta_n(e_{ij}) \geq 0 (e_{ij}) \leq 1, j = 1, 2, 3, 4 n = 1, 2, 3, 4.$

The following conditions are required:  $\beta_n(e_{ij}) \geq 0, (e_{ij}) \leq 1(i, j = 1, 2, 3, 4 n = 1, 2, 3, 4).$  Usually using  $S(e_{ij})$  to represent the value of the attribute evaluation, the basic value of item B can be expressed as:

$$S(e_{ij}(B)) = \{(P, a), (A, b), (G, c), (E, d)\}$$

$$= \{(H_1, \beta_1(e_{ij})), (H_2, \beta_2(e_{ij})), (H_3, \beta_3(e_{ij})), (H_4, \beta_4(e_{ij}))\}$$

The process of calculating the confidence of each basic attribute under each rating is as follows: According to the evaluation results of the experts, the number of basic attributes  $e_{ij}$  in each rating is calculated as  $N_n, n = 1 \dots 4$  The total number of statistical evaluation  $N = \sum_{i=1}^4 N_n$ ; Calculate the confidence level which under the evaluation level  $H_n$  of the basic attribute  $e_{ij}$  in item B,  $\beta_n(e_{ij}) = N_n/N, n = 1 \dots 4.$

In general, the probability distribution of an attribute includes the assigned probability and the unassigned probability. The probability that the basic attribute has been assigned to the evaluation level  $H_i$  is expressed by the variable  $m_i, m_i = \text{the attribute weight} \times \text{confidence}$ ; the unallocated probability is represented by the variable  $m_H(\text{attribute})$  and  $m_H(\text{attribute}) = \bar{m}_H(\text{attribute}) + \tilde{m}_H(\text{attribute}).$   $\bar{m}_H$  indicates the importance of other attributes in the evaluation of the role,  $\tilde{m}_H$  represents the unallocated probability which caused by incomplete evaluation. Various probability distributions of basic attributes are calculated as follows:

$$m_n(e_{ij}) = w_{ij} \times \beta_n(e_{ij}); \bar{m}_H(e_{ij}) = w_{ij} \tilde{m}_H(e_{ij}) = w_{ij} (1 - \sum_{i=1}^4 \beta_i(e_{ij}))(e_{ij})$$

3.2.2 Total Attribute Rating

Definition  $I(i)$  for the result of collection of the first  $i$  evidences in layer  $i, I(i), m_n$  for the overall confidence of all the evidences to  $H_n$ , then the formula of evidence synthesis is:  $m_{n,I(i+1)} = K_{I(i+1)}(m_{n,I(i)}m_{n,i+1} + m_{H,I(i)}m_{n,i+1} + m_{n,I(i)}m_{H,i+1}),$

$$m_{H,I(i+1)} = \bar{m}_{H,I(i)} + \tilde{m}_{H,I(i)}:$$

$$\tilde{m}_{H,I(i+1)} = K_{I(i+1)}(\tilde{m}_{H,I(i)}\tilde{m}_{H,i+1} + \bar{m}_{H,I(i)}\tilde{m}_{H,i+1} + \tilde{m}_{H,I(i)}\bar{m}_{H,i+1}), \bar{m}_{H,I(i+1)} = K_{I(i+1)}[\bar{m}_{H,I(i)}\bar{m}_{H,i+1}],$$

$$K_{I(i+1)} = \left[ 1 - \sum_{n=1}^4 \sum_{t=1, t \neq n}^4 m_{n,I(i)}m_{t,i+1} \right]^{-1}$$

Synthetic total attribute rating. The probability distribution of the synthetic total attribute is expressed as:  $m_{i,I(3)}(Y) = m_i(Y), i = 1, 2, 3, 4, \bar{m}_{H,I(3)}(Y) = \bar{m}_H(Y), \tilde{m}_{H,I(3)}(Y) = \tilde{m}_H(Y), m_{H,I(3)}(Y) = m_H(Y).$  The total attribute  $Y$  's confidence which belongs to each evaluation level is  $\beta_n, n = 1, 2, 3, 4,$  and:  $\beta_n = \frac{m_n(Y)}{1 - \bar{m}_H(Y)}, \beta_H = \frac{\tilde{m}_H(Y)}{1 - \bar{m}_H(Y)},$  so  $S(Y) = \{(P, \beta_1) (A, \beta_2) (G, \beta_3) (E, \beta_4)\}.$

### 3.3. The Calculation of the Utility Value of Each Project

It is necessary to convert the total attribute into the utility value because the total evaluation value can't distinguish between good and bad. This paper put the evaluation of the item convert to an intuitive algebraic value, and sort the items.  $\mu(H_n)$  is usually used to represent the utility value of the rating  $H_n$ . The utility value of the total attribute  $Y$  of item  $B$  is expressed as  $\mu(Y(B))$ , and the formula for converting the total attribute evaluation value into the utility value is as follows:

If  $\beta_H = 0$  ( $\mu(Y(B)) = \sum_{n=1}^4 \beta_n \mu(H_n)$ ),

If  $\beta_H \neq 0$  (that means the evaluation information is incomplete),

$$\mu \max(Y(B)) = \sum_{n=1}^3 \beta_n \mu(H_n) \beta_4 + \beta_H \mu(H_4),$$

$$\mu \min(Y(B)) = \sum_{n=2}^4 \beta_n \mu(H_n) \beta_1 + \beta_H \mu(H_1),$$

$$\mu_{avg}(Y(B)) = \frac{\mu_{\max}(Y(B)) + \mu_{\min}(Y(B))}{2}.$$

In the above formula, it is assumed that  $\mu(H_4)$  is the maximum utility value of the highest evaluation level and  $\mu(H_1)$  is the minimum utility value of the worst evaluation level. This article sets the evaluation level of the utility value is as follows:  $\mu(H_1) = 0.25$ ,  $\mu(H_2) = 0.50$ ,  $\mu(H_3) = 0.75$ ,  $\mu(H_4) = 1$ .

According to the setted utility value of evaluation grade, the utility value of the total property of the project is calculated, then sort the overall performance of the project according to its advantages and disadvantages. However, the following evaluation rules should be followed in the sorting: For the financial key special expenditure  $B_p$  and  $B_q$ ,  $B_p$  is better than  $B_q$  if and only if  $\mu \min(Y(B_p)) \succ \mu \max(Y(B_q))$ ; and if  $\mu \min(Y(B_p)) = \mu \min(Y(B_q))$  and  $\mu \max(Y(B_p)) = \mu \max(Y(B_q))$  then  $B_p$  and  $B_q$  have the same priority; In other cases, the average utility formula  $\mu_{avg}(YB)$  is used to rank the decisions.

## 4. Empirical Analysis on Performance Evaluation of GF Major Special Expenditure in B City

### 4.1. Index System Construction and Empowerment

This paper selects the GF key special fund of B City as the research sample in 2016. This fund focus on supporting 18 specific industry projects, involving automobile industry, biomedical industry, basic and new materials industry, urban industry, electronic information industry, equipment industry, and aerospace industry, the amount of this fund is up to 400 million yuan. Based on the main body of performance appraisal and the performance-forming mechanism of key special expenditures, this paper construct the "decision-management-performance" model

and index system of GF special fund management department of B City which is the object of performance evaluation according to the whole project management theory and the "input-process-output-effect" logic model. This article refers to the B City Finance Bureau on "Interim Measures for the Administration of Financial Expenditure Performance Evaluation" and "Financial Expenditure Project Performance Evaluation Index System (template)". This paper invited 10 experts in the field of performance appraisal to score by using the AHP method to obtain the weighting result of the performance index, as shown in Table 1.

Table 1. GF special fund performance evaluation index system and weight

First level of indicators	Secondary indicators	Third indicators
Project decision (0.20)	Specific goals(0.20)	The rationality of overall goal(0.25)
		The rationality of Subproject goal(0.25)
		Performance indicators clarity(0.50)
	Decision management(0.40)	Decision-making body(0.25)
		Decision-making criteria(0.40)
		Decision-making process(0.35)
	Allocation of funds(0.40)	Allocation method(0.38)
		The result of the allocation(0.62)
Project management (0.35)	Funds in place(0.26)	Funding rate(0.33)
		Timely efficiency in place(0.33)
		The efficiency of funds(0.34)
	Money management(0.26)	Budget management(0.28)
		Use of funds(0.39)
		Financial management(0.33)
	Organization and implementation(0.23)	Organization(0.25)

#### 4.2. Performance Evaluation Based on DS Evidence Theory

First of all, according to the performance evaluation index system of GF special expenditures, all the decision-making attributes are divided into four levels. The first level attribute is the overall performance of the project. The second, third and fourth level attributes correspond to the first, second and third level indicators of the project in turn. Secondly, this paper use IDS software and DS evidence theory to form the comprehensive performance of 18 projects' the second-level attribute synthesis results through the weight of each basic attribute. And the results to be evaluated in decision-making, project management and project performance. Then compound the secondary attributes and formate a comprehensive attribute of the results. Thirdly, the evaluation information of basic attributes is complete and there is no missing value??so  $\mu \min(Y(B)) = \mu_{avg}(Y(B)) = \mu \max(Y(B))$ . Using the formula of utility value by IDS software, the utility value of each project could be obtained . Finally, the total performance of GF special fund is obtained by combining the result of utility value. GF special funds overall performance is expressed as:  $S(Y) = \{(P, 0.1284)(A, 0.1806)(G, 0.3824)(E, 0.3493)\}$ . The utility value mapping formula is used to convert the evaluation value of the total attribute into the utility value, and the final result is 0.7585.

#### 4.3. Evidence Theory and Analytic Hierarchy Process

Theoretically, Analytic Hierarchy Process (AHP), which is more mature, has been widely used in the performance appraisal of fiscal expenditure. In order to verify the suitability and validity of DS evidence theory, this paper evaluates the performance of this project according to the expert scoring method and finally obtains the comprehensive score of GF special fund of 85.79 points. In this score, the project decision-making is 17.00 points, the project management is 29.37 points, and the project performance is 39.42 points. For the convenience of comparison, the results of the two evaluation methods are unified as shown in Table 2.

Table 2. Comparison of DS Evidence Theory and AHP Performance Evaluation Results

Evaluation method	Project decision	Project management	Project performance	Comprehensive results
DS	82.18	80.28	70.44	75.85
AHP	85.00	83.91	87.60	85.79
Difference	-2.82	-3.63	-17.16	-9.94

According to the implementation plan for special funds of B City, the performance appraisal of 90 points or above (inclusive) is excellent, 90 ~ 80 points (inclusive) is good, 80 ~ 60 points (inclusive) is qualified, 60 points below is unqualified. Table 4-2 shows that the comprehensive score of DS evidence theory of GF special funds is 75.85 points, that is, the performance evaluation conclusion is "qualified"; the AHP comprehensive score is 85.79 points, that is, the performance evaluation conclusion

is "good." This shows that the performance evaluation results of DS evidence theory are more objective and rigorous, especially in terms of project performance. The reasons for the difference between the two are as follows:

First, AHP evaluation methods need to build a pairwise comparison judgment matrix according to the degree of importance of the indicators when dealing with qualitative indicators. The judgment of the relative importance of each pair of two is too much subjective, resulting in that the quantitative expression of qualitative indicators is not scientific enough. However the attribute value calculation of DS evidence theory algorithm needs to determine the confidence level under the evaluation level, so that the evaluation results are objectivity. In particular, the performance of the key financial expenditures which have many qualitative evaluation indicators and qualitative indicators of quantitative representation are more scientific. These are all highlighting the outstanding advantages of DS evidence theory.

Second, DS evidence theory directly deals with the minimum and maximum values of the basic attributes as the variation range, which leads to the more obvious differentiation of evaluation results. In particular, the "project performance"'s attribute has a large weight and often lack of performance information. The DS evidence theory broadens the range of the basic attributes to obtain objective and realistic results.

Third, when use DS evidence theory to evaluate the performance of key special expenditures, experts only need to classify the qualitative indicators of basic attributes according to their own knowledge and experience. They do not need to score or solicit other experts' opinions for the attributes which can not be scored for unknown information. This evaluation results can be inferred from the information given by other experts. This shows that DS evidence theory can reduce randomness and subjectivity in the scoring process. Simultaneously it can reduce the workload of experts, and make the evaluation results more rigorous and objective.

## 5. Conclusion

The performance appraisal of fiscal key expenditure is an important part of the modern budget management system. The special fund for fiscal key expenditures in the financial sector has a large amount of funds, a wide coverage, many departments involved and a long implementation period, which resulting in the complexity of performance appraisal and the difficulty of evaluation. According to the characteristics of the key special expenditures in the financial sector, this paper selects DS evidence theory as the performance appraisal method of the fiscal key expenditure, aiming at the problems solving of the traditional performance appraisal methods such as the insufficient information of experts and the information conflicts among experts. Based on the empirical analysis of performance evaluation of B City's 18 industrial projects of GF in 2016, the research shows that the multi-attribute decision-making of fiscal key expenditure performance involves many qualitative and quantitative information. The evidence theory realizes that the calculation of the attribute value by confirming the confidence level under the evaluation level in order to make the quantitative representation of the qualitative index more scientific. The processing



of the quantitative attributes broadens the range of the basic attributes and further makes the performance evaluation result more consistent to objective reality. In particular, the information given by other experts can be fuzzily inferred by the inadequate information or the missing information, which avoids the randomness of subjective scores and improves the objectivity and scientificity of performance evaluation results.

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