Driving Factors of Green Climate Fund Leverage

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Abstract

The Green Climate Fund (GCF) is a fund that is targeted at countries that have suffered losses due to the impact of climate. The article looks at the GCF financing situation by evaluating the effect of GCF's joint financing and determining the influencing factors of the GCF leverage ratio. This article mainly analyzes the problem of charging station network construction. For the first question: evaluate the effectiveness of GCF's co-financing. The evaluation of financing effects should not be absolute, however, there should be some comparisons and references. First, we develop an evaluation index system for financing effects and standardize the collected data. Secondly, we process the eight indicators that affect the financing effect hierarchically and obtain the weight vectors of indicators at all levels through the analytic hierarchy process. Finally, use the fuzzy comprehensive evaluation model The financing effect scores of GCF, GEF, and UNDP are calculated (0.9160> 0.5743> 0.4092). For the second question: determining the influencing factors of the GCF leverage ratio. First, the median is used to fill in the data and standardized. Second, we establish a structural equation model to determine the weight of each indicator's impact on the project's leverage. The results show that the main factors affecting the project's leverage are the proportion of government debt to GDP and GDP per capita. Finally, a random forest model is established, with 75% of the sample as the training set and 25% as the test set. The accuracy of the trained random forest on the test set can reach 100%.

Keywords

GCF; Financing effect; Factors Affecting GCF Penetration; Structural equation model.

1. INTRODUCTION

1.1. Problem Background

In October 2018, the 48th plenary session of the IPCC released a special report that the impact of global temperature rises of 1.5°C. The IPCC puts forward that it is necessary to strengthen international cooperation and provide developing countries with funding, technology and capacity building support.

The Green Climate Fund (GCF) plays an important role in the global climate governance system by providing public funding support for developing countries. The Green Climate Fund was one of the core topics of the 17th Conference of the Parties to the United Nations Framework Convention on Climate Change, held in Durban, South Africa. The idea is that developed countries need to spend $ 100 billion a year to help developing countries cope with climate change by 2020. In the early morning of December 11, 2011, the Durban Climate

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Conference passed a resolution to implement the second commitment period of the Kyoto Protocol and launch the Green Climate Fund. In the complex international situation in which the current multilateral process of climate change is facing challenges, the sustainable, healthy and stable development of GCF is the key to rebuilding the confidence of all parties and promoting multilateral cooperation on climate change. We study the development history of GCF and the process of global climate governance and sustainable development, build a climate financing system for China, effectively use international public funds to promote green and low-carbon development, and participate in global climate governance.

1.2. Problem Restatement

According to the requirements of the problem, the final network we need to solve for evaluating the GCF joint financing effect. At the same time, we make use of model to determine the influencing factors of GCF leverage.

For the first question, we are asked to evaluate the GCF joint financing effect. It should not be absolute, isolated standard not applied to quantitative calculation, comparison and reference, and should have a certain or a simple numerical results it is difficult to evaluate the effect of financing offer direct help. Therefore, the article selects the Green Climate Fund, the Global Environment Facility, the United Nations Development Program to evaluate three groups. Financing effect is influenced by many factors, characteristics of international fund, the author of this paper formulated the financing effect of multilayer evaluation standard, at the same time through the fund's website to obtain relevant data and standardize, through the Analytic Hierarchy Process to determine index weight, financing effect score is obtained by Fuzzy Comprehensive Evaluation and comparison, the related conclusion are given.

For the second question, we are supposed to determine the influencing factors of GCF leverage. By consulting the literature, we have concluded that the factors affecting macro leverage are economic growth, industrial endowment, financial market structure, and financial institution structure. The question requires to determine what is the influencing factors of GCF.It is a micro-level analysis of the leverage ratio of a single fund. In addition to GCF's own capital injection, the projects implemented by GCF also absorb a large amount of social capital. The funds of each project of GCF are classified by equity, which can be roughly divided into loan funds, investment funds, donation funds, and guarantee funds, of which investment funds and donation funds belong to the project's equity funds, loan funds and guarantee funds.

Due to the different economic and financial development levels and industrial structures of each country, the response of social funds to GCF projects in each country will also be different.If a country's financial market is very developed, the implementation of GCF projects in this country will leverage more loan funds and guarantee funds, which will lead to a higher leverage ratio.From the perspective of the economic and financial development level and financial stability level of each country, we will determine the factors that affect the leverage ratio of a single GCF project.

2. GENERAL ASSUMPTION

As discussed above, we make several assumptions in our model. In latter part of the essay, we may relax some of these assumptions to deal with diffferent issues.

Assumption I: The indicators of the Green Climate Fund, the Global Environment Facility and the United Nations Development Programs will not change much in the short term.

Assumption II: The effect of co-financing is only limited to the four primary influence indicators described below, and there are altogether eight secondary cultural indicators.

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Assumption III: The leverage ratio of each project is affected by the level of macroeconomic and financial stability and the level of economic and financial stability. The samples selected are representative and there will be no special cases.

Assumption IV: The level of economic and financial development can be quantified by GDP per capita, GDP growth rate, and GDP of the service industry. The level of economic and financial stability can be quantified by the consumer price index CPI, inflation rate, unemployment rate, and government debt as a percentage of GDP.

3. SYMBOLS AND DEFINITIONS

3.1. Symbols

In the section, we use some symbols for constructing the model as follows:

Table 1. Variables

Symbols	Meanings
ξ	Exogenous latent variable matrix
ς	Structural residuals
x	Measurement index matrix of exogenous latent variables
$\wedge_x$	Matrix between exogenous latent variables and their measurements
δ	Measurement residuals of exogenous latent variables
y	Measurement matrix of endogenous latent variables
$\wedge_y$	Path relationship matrix between endogenous latent variable and its measurement matrix
ε	Measurement residuals of endogenous latent variables
s_{ij}	The data after standardization of item i in item j,
o_{ij}	The original data of item i in item j
ϕ	Covariance between exogenous latent variables
φ	Covariance between structural residuals
θ_δ	Covariance matrix between exogenous factor measurement residuals
θ_ε	Covariance matrix between endogenous factor measurement residuals

3.2. Definitions

Leverage: The ratio of total assets to equity capital in the balance sheet. Leverage is an indicator of a company's liability risk, which reflects the company's ability to repay from the side.

Latent variable: Indicators that cannot be directly and accurately observed or that can be observed but need to be synthesized by other methods

4. EFFECT MODEL OF GCF CO-FINANCING

4.1. Model Preparation

4.1.1 Construct the evaluation index system

During the selection of indicators, we follow the systematic principle, quantifiable principle and comprehensive principle to ensure the scientific selection of these indicators and the

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comprehensive evaluation of GCF financing effect. The final evaluation indicator system is shown in Table 2.

Table 2. Evaluation index system of joint financing effect

The target layer	Rule layer	The child rule layer
The co-financing effect of GCF	Number of investment projects	Public projects
		Private projects
	The financing amount	Fund—financing
		Co—financing
	Participating countries	Financing countries
		Benefited from the country
	Project beneficiaries	Project beneficiaries
	C02 emissions are expected to be avoided	C02 emissions are expected to be avoided

4.1.2 Raw data

Table 3. Raw data

Rule layer	The sub-standard layer	GCF	GEF	UNDP
Number of investment projects	Public projects	100	3000	3200
	Private projects	28	850	280
The financing amount ($100 million)	Fund—financing	66.3098	125	8.461
	Co—financing	195.8022	580	37.9
Participating countries	Financing countries	24	39	50
	Benefited from the country	147	165	175
Project beneficiaries (million)	Project beneficiaries	348	960	51
C02 emissions are expected to be avoided (one hundred million tons)	C02 emissions are expected to be avoided	16	42	2.56

4.1.3 Standard data

The original data units of the above eight evaluation indicators are different, and the numerical order of magnitude is very different, so it is difficult to conduct direct calculation. Therefore, we standardized them according to their respective ranges to obtain a unified measurement for the use of model evaluation. The standardized formula is as follows:

$$s_{ij} = \frac{o_{ij}}{Max(o_{ij})}$$

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Table 4. Standard data

Rule layer	The child rule layer	GCF	GEF	UNDP
Number of investment projects	Public projects	0.0313	0.9375	1.0000
	Private projects	0.0329	1.0000	0.3294
The financing amount ($100 million)	Fund—financing	0.5305	1.0000	0.0677
	Co—financing	0.3376	1.0000	0.0653
Participating countries	Financing countries	0.4800	0.7800	1.0000
	Benefited from the country	0.8400	0.9429	1.0000
Project beneficiaries (million)	Project beneficiaries	0.3625	1.0000	0.0531
C02 emissions are expected to be avoided (one hundred million tons)	C02 emissions are expected to be avoided	0.3909	1.0000	0.0609

4.2. Model Establishing and Solving

GCF financing effect, which involves many factors can increase the amount of the investment project, financing for project benefit, the number of participating countries, and C02 is expected to avoid emissions as the primary index, quantitatively and the five indexes are given to measure the actual standard of financing effect, and the relationship between them is blurred. There are 8 corresponding secondary indicators under the primary indicator, and their definition, evaluation ability and their relationship are also ambiguous. Therefore, it is appropriate to adopt the fuzzy comprehensive evaluation method to evaluate the co-financing effect of GCF.

Therefore, it is necessary to establish a set of influence evaluation levels $V = \{V_i\}$to evaluate the level of financing effect, construct the membership function F (x) of single index factors for each evaluation level, and establish the fuzzy relation matrix R. At the same time, it is necessary to weigh each index and calculate the comprehensive evaluation matrix by combining the membership matrix. In order to avoid too large subjective factors, the analytic hierarchy process is used to calculate the weight of each index.

4.2.1 Model Establishing

Construct judgment matrix

Let the judgment matrix be $A = (a_{ij})$, where a_{ij} is set according to the 9-scale method shown in the following table.

Table 5. 9-scale method

Scale	Meaning
1	Indicates that the two elements are of equal importance
3	Indicates that the former is slightly more important than the latter
5	Indicates that the former is obviously more important than the latter
7	Indicates that the former is more important than the latter
9	Indicates that the former is more important than the latter
2, 4, 6, 8	Represents the intermediate value of the above adjacent judgments
The bottom	If the ratio of importance of element i to element j is P_{ij}, then the ratio of importance of element j to element i is $P_{ji} = \frac{1}{P_{ij}}$

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Evaluate the eigenvalues and eigenvectors

(a) The product of the elements of each row of the judgment matrix, and $m_i = \Pi_{j=1}^{n} p_{ij}, i = 1,2\ldots,n$

(b) Calculate the NTH root of $m_i \overline{w_i}, \overline{w_i} = \sqrt[n]{m_i}$.

(c) The vector $w = (\overline{w_i}, \ldots, \overline{w_n})^T$ normalization, namely $w_i = \frac{\overline{w_i}}{\sum_{j=1}^{n} \overline{w_j}}$, $w = (\overline{w_i}, \ldots, \overline{w_n})^T$ for the desires of feature vector.

(d) Calculate of the judgment matrix with λ_{max}, $\lambda_{max} = \sum_{i=1}^{n} \frac{(pw)_i}{nw_i}$, type in the $(pw)_i$ said pw of the ith element.

Consistency test

CI is defined as the consistency index of the judgment matrix. In order to determine the allowable range of the inconsistency degree of the judgment matrix, it is necessary to find out the standard of the consistency index CI of the judgment matrix and introduce the random consistency index RI. For different order matrices, the values of random consistency index RI are obtained as shown in Table 6:

Table 6. Random consistency indicator RI numerical table

Tier N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Let CR=CI/RI, and call CR the consistency ratio. When CR<0.1, the judgment matrix has satisfactory consistency; otherwise, it is necessary to adjust the judgment matrix to make it have satisfactory consistency.

According to the above steps, the judgment matrix of criterion layer to target layer and sub-criterion layer to criterion layer is constructed.

The judgment matrix between criterion layer and target layer is:

$$A = \begin{bmatrix} 1 & \frac{1}{5} & \frac{1}{3} & 3 \\ 5 & 1 & \frac{1}{2} & 5 \\ 3 & 3 & 1 & 4 \\ \frac{1}{3} & \frac{1}{5} & \frac{1}{4} & 1 \end{bmatrix} \quad \lambda_{max} = 4.2657$$

$$w_0 = \begin{bmatrix} 0.1300 \\ 0.3704 \\ 0.4307 \\ 0.0689 \end{bmatrix} \quad \text{CR=0.0984<0.1}$$

It passes the consistency test.

The judgment matrix of sub-criterion layer to criterion layer is:

$B_1 = \begin{bmatrix} 1 & 5 \\ \frac{1}{5} & 1 \end{bmatrix}$ $\lambda_{max} = 2$ $w_1 = \begin{bmatrix} 0.8333 \\ 0.1667 \end{bmatrix}$ CR=0<0.1 passes the consistency test.

$B_2 = \begin{bmatrix} 1 & \frac{1}{7} \\ 7 & 1 \end{bmatrix}$ $\lambda_{max} = 2$ $w_2 = \begin{bmatrix} 0.1250 \\ 0.8750 \end{bmatrix}$ CR=0<0.1 passes the consistency test.

$B_3 = \begin{bmatrix} 1 & \frac{1}{3} \\ 3 & 1 \end{bmatrix}$ $\lambda_{max} = 2$ $w_3 = \begin{bmatrix} 0.7500 \\ 0.2500 \end{bmatrix}$ CR=0<0.1 passes the consistency test.

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$B_4 = \begin{bmatrix} 1 & 2 \\ \frac{1}{2} & 1 \end{bmatrix}$ $\lambda_{max} = 2$ $w_4 = \begin{bmatrix} 0.6667 \\ 0.3333 \end{bmatrix}$ CR=0<0.1 passes the consistency test .

Fuzzy Comprehensive Evaluation matrix

The standard matrix of sub-criterion layer to criterion layer is:

$$m_1 = [0.0313\ 0.9375\ 1.0000; 0.0329\ 1.0000\ 0.3294]$$
$$m_2 = [0.5305\ 1.0000\ 0.0677; 0.3376\ 1.0000\ 0.0653]$$
$$m_3 = [0.4800\ 0.7800\ 1.0000; 0.8400\ 0.9429\ 1.0000]$$
$$m_4 = [0.3625\ 1.0000\ 0.0531; 0.3909\ 1.0000\ 0.0609]$$

The judgment matrix of sub-criterion layer to criterion layer is:

$$s_i = m_i \times w_i \quad (i = 1,2,3,4)$$

The comprehensive score of the sub-criteria layer is:

S=[0.0316 0.9479 0.8882;
0.3617 1.0000 0.0656;
0.5700 0.8207 1.0000;
0.3720 1.0000 0.0557]

The judgment matrix between criterion layer and target layer is:

$$W = S \times w_0$$

4.2.2 Model Solving and Result Analysis

Results

$$\mathrm{W} = [0.4092\ 0.9160\ 0.5743]$$

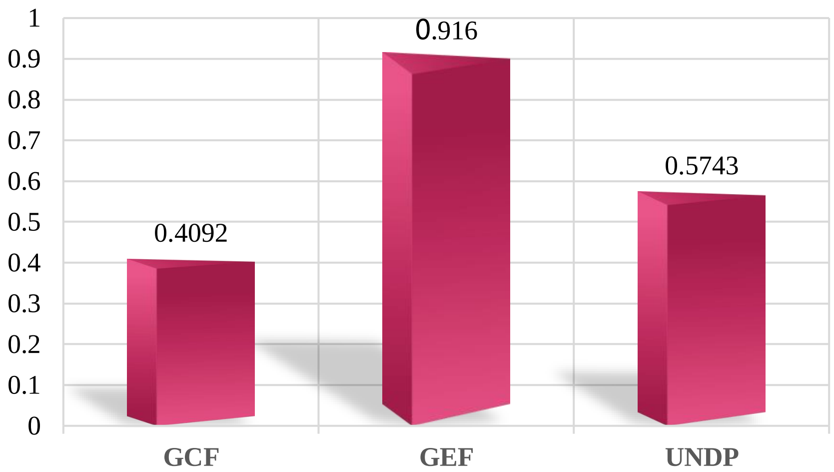

Fig 1. Schematic diagram of fuzzy comprehensive evaluation results

Result Analysis

According to the results of the model, 0.9160>0.5743>0.4092 can be obtained, that is, the co-financing effect of GEF is higher than that of UNDP, and the co-financing effect of the Green Climate Fund is the worst among the three. Since 1991, GEF has provided $12.5 billion in grants and leveraged $58 billion in co-financing for 3,690 projects in 165 developing countries. Developed and developing countries use these funds to support environmental protection activities related to biodiversity, climate change, international waters, land degradation, chemicals and waste in the implementation of related projects and programs; The United Nations Development Programs is the world's largest multilateral agency responsible for

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technical assistance. Green Climate Fund system is not perfect, investment projects at an early stage, the number needs to be increased, at the same time, green climate fund financing allocation mechanisms are still controversial, there is no clear, the financing amount is far less than, but for the improvement of the environment, CO2emission reduction effect is remarkable, Green Climate Fund needed to expand its influence, let more developed countries and developing countries to participate, to raise more money to improve the environment of the earth.

5. DETERMINE INFLUENCING FACTORS OF GCF LEVERAGE

5.1. Model Preparation

This question belongs to the problem of determining multiple influencing factors and their impact weights on the dependent variable. The most commonly used methods are principal component analysis, multiple regression analysis, decision trees and random forests, structural equations and so on.

Principal component analysis is applicable to the determination of the dimensionality reduction problem that converts multiple variables into a few comprehensive features.However, the regression equation is assumed to be strict.We need to know the cause of the dependent variable. Random Forest can directly obtain the weight of each influencing factor through objective training on data.The structural equation simultaneously processes multiple dependent variables and allows independent and dependent variables to be measured Error, the model can estimate both the factor structure and factor relationships.

In this article, we will establish a decision tree, a random forest model, and a structural equation model to determine the factors that affect the leverage of a single GCF project.

5.2. Index Selection and Data Collection

From the perspective of national economic and financial development level, we determine the influencing factors of the leverage ratio of a single GCF project. First we quantify the level of economic development and financial stability. For the latent variable economic and financial development level, we use three indicators of annual GDP growth rate, GDP per capita, and service industry GDP to quantify. For the latent variable financial stability level, we use inflation rate, government debt to GDP ratio, the unemployment rate and the consumer price index CPI are quantified.

We collect data on GCF project funds from dozens of developing countries from the GCF official website, aggregate equity capital and debt capital and calculate the project leverage ratio.

5.3. Structural Equation Model

5.3.1 Model preparation

The structural equation is divided into a structural part and a measurement part. The structural part describes the correlation and path relationship between latent variables, and the measurement part describes the path relationship between the latent variable and the measurement index.

The structural part can be expressed as an equation

$$\eta = B\eta + \Gamma\xi + \zeta$$

Model assumptions

Structural part:

$$\eta = B\eta + r\xi + \zeta$$
$$Cov(\xi, \xi) = \phi$$

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$$Cov(\zeta,\zeta)=\varphi$$

Measurement section

$$X = \Lambda_x \xi + \delta; Cov(\delta,\delta) = \Theta_\delta$$
$$Y = \Lambda_y \eta + \varepsilon; Cov(\varepsilon,\varepsilon) = \Theta_\varepsilon$$
$$E(\eta) = 0, E(\xi) = 0$$
$$E(\varepsilon) = 0, E(\delta) = 0$$
$$Cov(\varepsilon,\eta) = 0, Cov(\delta,\xi) = 0$$
$$Cov(\delta,\eta) = 0, Cov(\varepsilon,\xi) = 0$$

Hypothetical test

The variance covariance matrix of the sample is S. The variance covariance matrix of the population to be estimated is λ. The smaller the gap between S and λ is the better the model fits the data. In the structural equation, it will try to find the smallest gap with S. But if it is found there is a large difference with S,which means that the model does not match the data S.

5.3.2 Model construction

In view of this problem, we choose economic and financial development level and economic and financial stability as latent variables, and use AMOS software to solve the relationship between economic development level and single project leverage. Before the model is built, we first use the median padding method to fill in some missing values of the original sample data, and then standardize the data to make the data follow the normal distribution. The figure below shows the relationship between the latent variables and indicators drawn in the AMOS software.

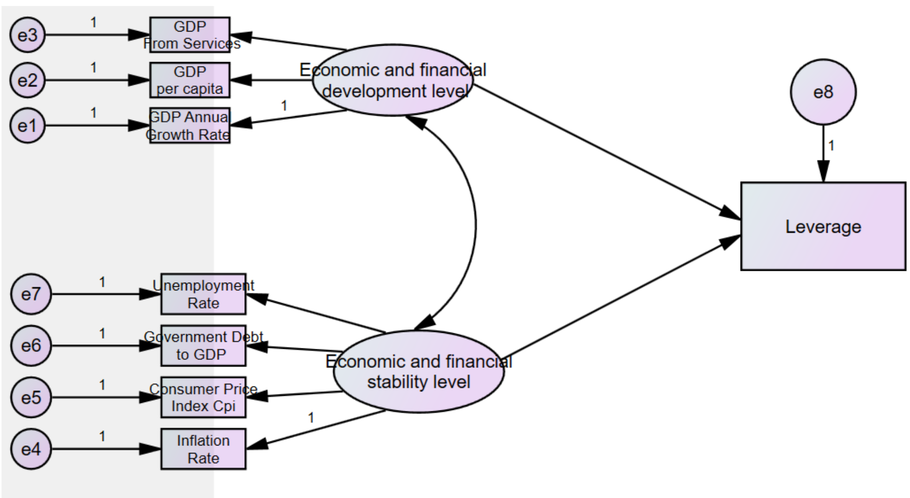

Fig 2. Relationship Road Map

5.3.3 Result analysis

With AMOS software, the results of solving the structural equation model are as follows. The following figure shows the relationship path between latent variables and indicators and their corresponding weights. By observing the weight of each indicator's effect on the leverage of the project, it concludes that the main factors affecting the leverage of the project are the proportion of government debt to GDP, per capita GDP, and inflation rate. Minimal impact on project leverage.The significance level of the calculated chi-square value of the model is 0.138. When the significance level is 0.05, the null hypothesis cannot be rejected, that is, the variance covariance matrix of the sample is not the same as the variance covariance matrix of the estimated population. The difference is 0, indicating that the model fits the data well.

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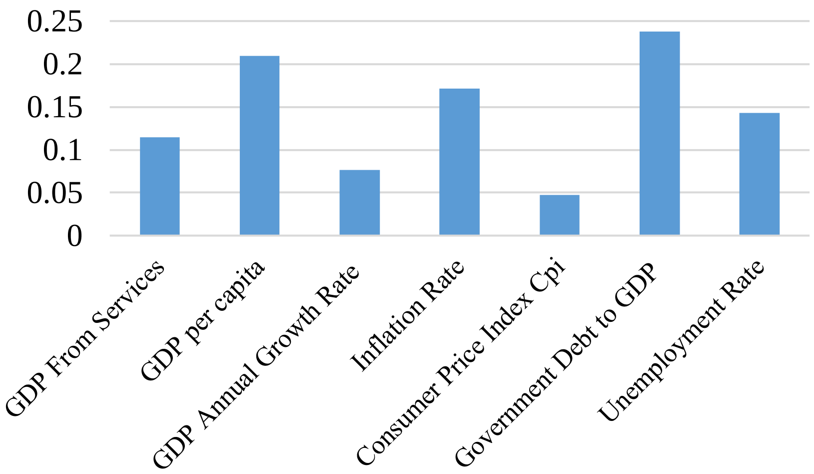

Fig 3. Indicator path weight

5.4. Decision Tree and Random Forest Algorithm

5.4.1 Model preparation

Decision tree algorithm is an algorithm used for inductive classification. It uses the training set and mines useful rules to predict the new set. The principle of decision tree construction is to continuously divide the various attributes so that the samples contained in the branch nodes of the decision tree that. The purity of the nodes is getting higher and higher, and the key of the decision tree construction is the measurement of purity. "Information entropy" is an effective method to characterize the purity of information sources. Assuming that the sample in the current sample set D accounts for all samples, the formula for calculating the information entropy of D is as follows:

$$Ent(D) = -\sum_{k=1}^{|y|} p_k \log_2 p_k$$

The higher the value of Ent (D), the lower the purity of D; otherwise, the higher the purity of D. For a binary classification problem, | y | is a value of 2. The model building strategy is to maximize the information gain by dividing the attributes, even if the purity of the sample is getting higher and higher.

Random forest is an integrated classification algorithm. Random forest is to solve the classification problem by integrating many decision trees. The randomness of the random forest is reflected in two aspects. On the one hand, the samples select when training a single decision tree are randomly selected. On the other hand, the attributes used when training a single decision tree are random, compared to The classification accuracy of a single decision tree is generally higher.

The pruning of the decision tree is divided into pre-pruning and post-pruning. Pre-pruning refers to the pruning operation of the model when the model is built, and then the pruning is performed on the decision tree constructed after the model is completed pruning operation. The purpose of the pruning operation is to increase the generalization ability of the model and avoid the phenomenon of overfitting the model. If the constructed model is not pruned, the depth of the decision tree will be deep, the classification of the original data will be very high, and the data other than the original data will be misclassified. The pruning judgment rate mainly includes: limiting the maximum depth of decision tree construction, limiting the minimum number of samples of leaf nodes, and including the number of leaf nodes in the evaluation function.

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5.4.2 Model construction

The data we collected will have missing values for some indicators of a few samples. We first fill in the missing samples using the median padding method. After that, we use the shuffle function to scatter the order of the filled data, and then extract the first 25% of the samples as the test set, and the last 75% of the samples as the training random forest model.

We choose 20 single decision trees to build a random forest. In order to increase the generalization ability of the model and avoid overfitting, we limit the maximum depth of each decision tree to 3. Finally, we calculate the weight of each indicator when constructing a random forest, and then judge the impact of each indicator on the leverage of the project.

5.4.3 Result analysis

After obtaining a random forest model by training on 75% of the samples, the remaining 25% of the data is used to test the model with an accuracy of 100%. Although the size of the collected samples is not large, the correct classification of the samples in all test sets by the model. It indicates that the random forest model constructed is effective.

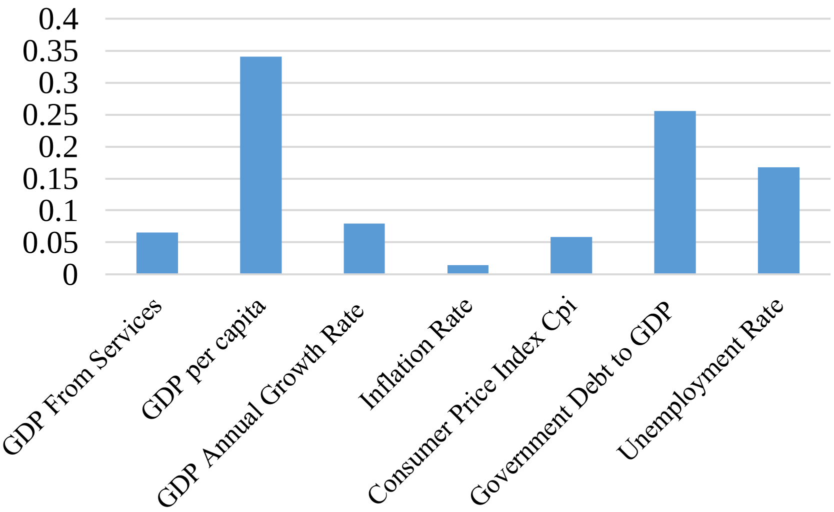

Fig 4. Indicator weight score

By calculating the weight score of each indicator when building a decision tree model, it is concluded that the factor that has the greatest impact on a single project is GDP per capita, and the factor that has the least impact is the inflation rate. The indicators that have a significant effect on the leverage of a single project are per capita GDP, government debt to GDP ratio, and unemployment rate.

6. ERROR ANALYSIS

For Model I: When determining the eigenvalues and eigenvectors of the judgment matrix, it is easier to deal with the second and third orders. But as the index increases, the order also increases. It becomes more and more difficult to calculate. There are three approximate calculation methods: sum method, power method, and root method. The root method is used in this article, but the exact method is more complicated.

For Model II: The object of our study is the impact of national economic and financial development level and economic and financial stability level on a single GCF project. The collected projects are a single project in a country. Although the country's macro factors will

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largely affect a company's project, there are often special cases for a single project. For example, in countries with low levels of economic and financial development and stability, a project with a high level of risk and high project leverage may also be introduced.

The number of samples collect by the model and the structural equations have high requirements on the number of samples. When setting up a random forest model, although 75% of the samples are classified as the training set and 25% as the test set, the model is eventually The accuracy rate can reach 100%, but due to the small sample size, it will also cause errors in model construction.

7. STRENGTHS AND WEAKNESS

7.1. Strengths

Systematic: taking objects as systems and making decisions in the way of decomposition, comparison, judgment and synthesis -- systematic analysis.

Practicality: combining qualitative and quantitative, it can deal with problems that cannot be solved by traditional optimization methods.

Simplicity: the calculation is simple and the result is clear, which is convenient for the decision-maker to understand and grasp directly.

The structural equation model can intuitively characterize the weight of the impact of each indicator on the leverage of the project, and the structural equation model can also characterize the internal relationship between each indicator and the internal relationship between the indicator and the latent variable.

The random forest model can be used to classify the samples objectively by training the training samples. At the same time, the forest model does not need to consider the multicollinearity between the indicators, and it does not need to select all factors that affect the leverage ratio.

7.2. Weakness

There is lack of relevant expert guidance and authoritative sample survey can not provide new solutions for decision-making.

There is less quantitative data, more qualitative components, but not convincing.

The exact method of eigenvalues and eigenvectors is complicated.

Both models have high sample size requirements, and sometimes sample data is often difficult to obtain.

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