Evaluation and Improvement of Enterprise Budget Performance Based on Multiple Linear Regression Algorithm

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Enterprise performance evaluation is a comprehensive analysis of an organization's production and operation activities. It combines quantitative and qualitative methods and uses reasonable and scientific principles and assessment tools to evaluate and judge the overall work performance or overall management level of the evaluated object, and to evaluate and supervise it, which is an important means to improve the enterprise management level to a certain extent, to achieve rational allocation of resources and improve operational efficiency. This paper first introduces the multiple linear regression (MLR) analysis algorithm, the main role of the MLR analysis algorithm model in performance evaluation is to provide a scientific basis for budget performance evaluation, so that enterprise managers through the analysis of the indicators that affect the results of the implementation of the enterprise's strategic plan and the quality of work, and then can determine its performance in the management process. In turn, it is possible to determine what problems exist in their management process and to create an evaluation system and improve it through an MLR model. The model mainly uses the least squares method to estimate the parameters and transforms it into a linear regression model. Secondly, it introduces the traditional performance evaluation method of the cause-based budget and proposes an improved MLR model to evaluate the enterprise performance.

Povzetek: Ta študija opredeljuje uporabo algoritma mnogotere linearne regresije (MLR) za ocenjevanje uspešnosti podjetij, ki zagotavlja znanstveno podlago za finančne ocene.

1 Introduction

Assessment of enterprise effectiveness related to the application of statistical methods to analyze an organization's production and operation activities qualitatively and quantitatively, determine its objectives, index weights, and other factors based on the results, and then evaluate them comprehensively to finally determine the enterprise's objectives, indicators, and performance standards [1]. In the process of performance evaluation, incomplete or inaccurate information is caused by a variety of factors. It not only reflects the strategic management level and efficiency of the company but also provides managers with effective reference information to improve the accuracy of decision-making and provide effective information for the strategic management of the company [2]. At the same time, it can also help to improve employees' behaviors and shortcomings in the work process, to achieve the ultimate goal of maximizing corporate value and provide a new idea for corporate performance management [3].

From the current situation of domestic and foreign research, the enterprise performance evaluation system is formed and developed in a specific environment for certain economic interests. It includes not only quantitative analysis methods such as financial indicators, business performance, and non-financial factors but also a combination of qualitative and semi-quantitative methods. The quantitative analysis method relates to the application of information, arithmetic, and other academic tools to qualitatively assess and forecast the business activities of enterprises, and then make evaluations or propose improvement measures. Foreign scholars have conducted a lot of research work on budget management and found that there is a big difference between different industries and competition between sectors, which makes the problems involved in the enterprise performance evaluation system compared to developed countries. Therefore, these differences should be considered in effect at the practical application, so that the theory and method of performance evaluation system can be more scientific and reasonable, which can improve the competitiveness of enterprises in the fierce market competition [4].

The traditional method of enterprise budget performance evaluation is a static evaluation index system, which is mainly based on financial statements and uses qualitative analysis to assess the results of enterprise budget execution. However, in today's complex, ever-changing, and competitive market economy, Chinese enterprises are facing great challenges, and how to discover the problems in strategic management through performance evaluation and take corresponding measures to improve their competitiveness has become an important topic of research. Based on this, it is necessary to establish a dynamic index system based on an MLR algorithm, the core of this dynamic index system is to set multi-level

financial indicators, which can reflect the relationship between the evaluation objects more accurately [5]. The evaluation of a dynamic index system can reflect the effect of enterprise budget execution more accurately, thus making performance management more effective. The advantages of the MLR algorithm are simple, and practical, with strong theoretical significance and application value. It obtains the regression equation by introducing the sample data at different time points, processes the data through the prediction model, and can obtain the results of budget evaluation. Table 1 demonstrates the related work.

Table 1: Related work

Study	Objective	Findings
[6]	Investigated the financial functioning of municipal governments in Malaysia, focusing on the impact of adequate and participatory budgets and how effective budget performance fosters accountability.	Explored the financial functioning of municipal governments. Analyzed the impact of adequate and participatory budgets. Examined how effective budget performance fosters accountability.
[7]	Evaluated the water budget of a small watershed dominated by boreal peatlands, by comparing three evaporation models and their effect on hydrological modeling with in-location data.	Evaluated three evaporation models. Compared model results with in location data. Assessed effect on hydrological modeling.
[8]	Introduced responsibilities and obligations of budget management and examined issues in contemporary businesses' budget systems. Offered optimization recommendations to enhance budget management systems.	Introduced budget management responsibilities. Examined issues in contemporary business budget systems. Offered optimization recommendations.
[9]	Investigated creation and application of operating budgets in small and medium-sized businesses (SMEs) for encouragement, assessment, and control.	Explored the creation and application of operating budgets in SMEs. Identified operational budgets as crucial control mechanisms.
[10]	Examined the use of budget targets in performance evaluations of small and SMEs from a contingency viewpoint.	Examined the use of budget targets in SME performance evaluations. Recommended inclusion of budget targets in performance evaluations.
[11]	Suggested a data-mining based approach for evaluating financial budget success, comparing it to conventional methods.	Proposed data-mining based approach for evaluating financial budgets. Demonstrated the method's efficiency and accuracy. The recommended method for a thorough assessment of financial budget performance.

[12]	Presented a mining enterprise performance management system driven by consumer demand to enhance competitiveness.	Introduced mining enterprise performance management system. Enhanced divisions between performance management and operational administration. Improved company competitiveness.

2 Dataset

The collection utilized for calculating inter-sectional effectiveness variables was made up of 27 overseas-owned businesses functioning in India that were identified as such and for which firm-level information from the year 1991 was accessible, 63 comparable Indian private-sector businesses, and sixty-seven Indian government-owned businesses functioning in the industrial and commercial industries. In all, one hundred fifty-seven businesses make up the collection.

The amount of relative according to category variations must be evaluated by comparing effectiveness and relaxation assessments. The sample is chosen in an approach that allows the relative strength of the budget-constraint concept to be assessed in comparison to manufacturing organization predictions. This is considering the state-owned businesses under evaluation compete with businesses that are generally fully controlled by Indian investors or include international interests [20].

3 Multiple linear regression (MLR) analysis algorithm

Using MLR analysis to examine at the correlations between different elements influencing financial outcomes, we can evaluate the success of an enterprise budget. The method in this case enables analysts to determine and measure the effects of several independent variables on the dependent variable of budget performance, including marketing expenditures, manufacturing expenses, and external market circumstances. Businesses may determine which factors significantly affect budget performance and how they interact by constructing a regression model to historical budget data. Better decisions can be made with the use of this information, including resource allocation optimization, strategy adjustments in response to shifting market conditions, and projecting future budget performance based on various scenarios. Furthermore, regression analysis enables organizations to improve their budgeting procedures and enhance overall financial management by making it easier to identify outliers or variations that might require additional examination.

3.1 Regression analysis concept

In practical applications, corporate performance evaluation index systems include financial, market, and non-financial. These different types of evaluation objects have their unique nature, therefore, classification and statistical analysis are needed to determine their attribute characteristics or quantitative relationships, then the data samples are screened according to the principle of correlation, and regression equation models are established to predict the degree of correlation between variables, to obtain the factors affecting the level of enterprise budget performance and their change laws [13]. Finally, the mathematical expression of the regression function is described by fitting the influence factors and each sub-dependent variable and other parameters. In practical application, the linear regression model in the enterprise budget performance evaluation index system has some problems, such as: when solving the sample data, the original data need to be processed statistically; and in the actual work process, due to various objective factors and constraints make the model difficult to reach the optimal.

3.2 MLR model

MLR analysis is a multivariate statistical analysis method that estimates the parameters in the model based on the observed samples, performs statistical tests on the estimated parameters and the regression equation, and then uses the regression model to forecast and analyze the scale and determine the budget performance evaluation. The MLR model contains several explanatory variables, which can better reflect the interrelationship among the variables in the model, and it can, to a certain extent, eliminate the influence of non-systematic factors on the level of enterprise budget performance. It can be seen that the regression coefficients in the model are partial regression coefficients, and the magnitude of the regression coefficients reflects the degree of influence of the variation of each parameter in the model on the overall budget performance level. However, in practical application, the calculation method of regression coefficients does not fully reflect the linear relationship between the variables of the model, which leads to a large error in the budget performance evaluation system [14,15]. The MLR model is shown graphically in Figure 1, where a regression line illustrates the link between several independent factors and a dependent variable. Based on the influence of the provided independent factors, this model predicts the values of the dependent variable.

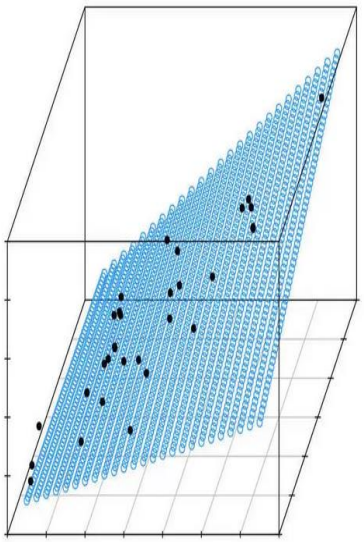

Figure 1: MLR model

(1) MLR models and their matrix representations. In the budget performance evaluation of enterprises, regression analysis is generally used, and the deviation is corrected by the error between the predicted index and the actual value. A linear relationship is established by the interdependent influence of multiple factors and is described mathematically. Assuming that y is a random variable whose value is observable, it is affected by the factors x1, x2,...,xp, and it is assumed that formula (1) holds:

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p + \varepsilon \qquad (1)$$

where $\beta_0, \beta_1, \cdots, \beta_p$ are p+1 parameters to be estimated, so the formula can be an MLR model, with y as the explanatory or dependent variable and x as the independent variable?

Establish a multiple regression equation to deal with the actual problem, assuming that n independent observations are made, the corresponding n sets of sample data are obtained, and also to ensure that each set of sample data satisfies formula (1) so that formula (2) holds, and formula (2) can be expressed in matrix form as formula (3).

$$\begin{cases} y_1 = \beta_0 + \beta_1 x_{11} + \beta_2 x_{12} + \cdots + \beta_p x_{1p} + \varepsilon_1 \\ y_2 = \beta_0 + \beta_1 x_{21} + \beta_2 x_{22} + \cdots + \beta_p x_{2p} + \varepsilon_2 \\ \cdots \\ y_1 = \beta_0 + \beta_1 x_{11} + \beta_2 x_{12} + \cdots + \beta_p x_{2p} + \varepsilon_n \end{cases} \qquad (2)$$

$$Y = X\beta + \varepsilon \qquad (3)$$

The matrix X in the above equation can be expressed as shown in formula (4).

$$X = \begin{bmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1p} \\ 1 & x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix} \qquad (4)$$

(2) Least squares parameter estimation and representation. The least squares method is a linear regression analysis method, which is mainly used to determine the trend of the dependent variable under uncertainty conditions, and its principle is shown in Figure 2. According to the known data set in the equation, the optimal parameters of one are obtained by solving the model. The algorithm can well reflect the existence of interconnection and influence the relationship between each factor in the enterprise budget performance evaluation index system [16]. It can quantify these factors and find out the inner law and causal relationship among them, as well as the degree of interrelationship among the elements to judge the superiority and inferiority level of each variable in the overall role, and then use them as the key factors in the evaluation of enterprise budget performance, and get the optimal solution by solving, and to a certain extent, suggest improvements to enterprise budget management [17]. This paper focuses on the estimation and representation of the least squares method for the parameters, as shown below.

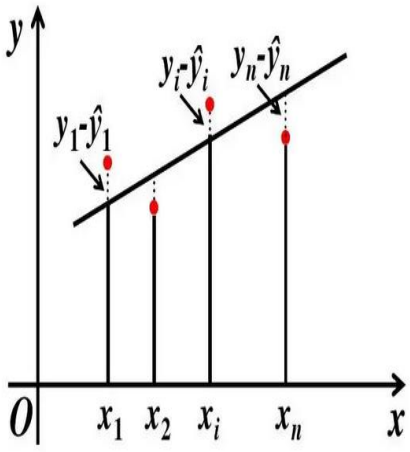

Figure 2: Least squares method

According to the theory of regression analysis, the optimal solution can be calculated by estimating the parameters in solving a linear programming problem to determine the optimal solution, and in the process of solving the model, the optimal solution can be calculated so that the enterprise can better control the cost. In the MLR equation, the unidentified variables are estimated using the smallest square approach i.e., it is chosen so that the following sum of squared errors is minimized. Specifically, as shown in formula (5).

$$Q(\beta) \triangleq \sum_{i=1}^{n} \varepsilon_i^2 = \vec{\varepsilon}^T \vec{\varepsilon} = (Y - X\beta)^T (Y - X\beta) = \sum_{i=1}^{n} (y_i - \beta_0 - \beta_1 x_{i1} - \beta_2 x_{i2} - \cdots - \beta_p x_{ip})^2 \qquad (5)$$

For formula (5), the partial derivative method of calculus can be used to obtain formula (6):

$$\begin{cases} \frac{\partial Q(\hat{\beta})}{\partial \beta_0} = -2\sum_{i=1}^{n}(y_i - \hat{\beta}_0 - \hat{\beta}_1 x_{i1} - \hat{\beta}_2 x_{i2} - \cdots - \hat{\beta}_p x_{ip}) = 0 \\ \frac{\partial Q(\hat{\beta})}{\partial \beta_1} = -2\sum_{i=1}^{n}(y_i - \hat{\beta}_0 - \hat{\beta}_1 x_{i1} - \hat{\beta}_2 x_{i2} - \cdots - \hat{\beta}_p x_{ip})\, x_{i1} = \\ \frac{\partial Q(\hat{\beta})}{\partial \beta_k} = -2\sum_{i=1}^{n}(y_i - \hat{\beta}_0 - \hat{\beta}_1 x_{i1} - \hat{\beta}_2 x_{i2} - \cdots - \hat{\beta}_p x_{ip}) x_{ik} = \\ \frac{\partial Q(\hat{\beta})}{\partial \beta_p} = -2\sum_{i=1}^{n}(y_i - \hat{\beta}_0 - \hat{\beta}_1 x_{i1} - \hat{\beta}_2 x_{i2} - \cdots - \hat{\beta}_p x_{ip}) x_{ip} = \end{cases} \quad (6)$$

where $\hat{\beta}_i = (i = 0,1,\cdots,p)$ is the least squares estimate of $\beta_i = (i = 0,1,\cdots,p)$. The above equation system is represented by a matrix as shown in formula (7), and this equation system is called a normal equation system.

$$X^T X\hat{\beta} = X^T Y \quad (7)$$

By solving the regular system of formula (7) the parameters are estimated as in formula (8).

$$\hat{\beta} = (X^T X)^{-1} X^T Y \quad (8)$$

The empirical regression equation is a statistical model used to predict the regression parameters of variables. In practical problems, the enterprise budget performance evaluation index system is important for budget decisions. The empirical regression equation can be expressed as shown in formula (9).

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_1 + \hat{\beta}_2 x_2 + \cdots + \hat{\beta}_p x_p \quad (9)$$

Substituting the observed values of each group of independent variables into the regression equation, the estimates of the dependent variable can be calculated as shown in formula (10).

$$\hat{y} = (\hat{y}_1, \hat{y}_2, \cdots, \hat{y}_p) = X\hat{\beta} \quad (10)$$

The residual vector can be expressed as shown in formula (11), and through the residual vector, the residual sum of squares (SSE) can be obtained as shown in formula (12):

$$\vec{e} = Y - \hat{Y} = Y - X\hat{\beta} = [I_n - X(X^T X)^{-1} X^T Y] = (I_n - H)Y \quad (11)$$

$$\vec{e}^T \vec{e} = Y^T (I_n - H)Y = Y^T Y - \hat{\beta}^T X^T Y \quad (12)$$

Prediction of the dependent variable. With a well-established regression equation, the association among the independent and dependent variables can be firstly reflected (as shown in Figure 3), the prediction work of the dependent variable can also be carried out, and the regression equation can be used to evaluate the enterprise budget performance [18]. The association between the independent and dependent variables is depicted in Figure 3, which is important for understanding and assessing the process that is being researched. It shows the complex causal or correlative relationships that determine these relationships.

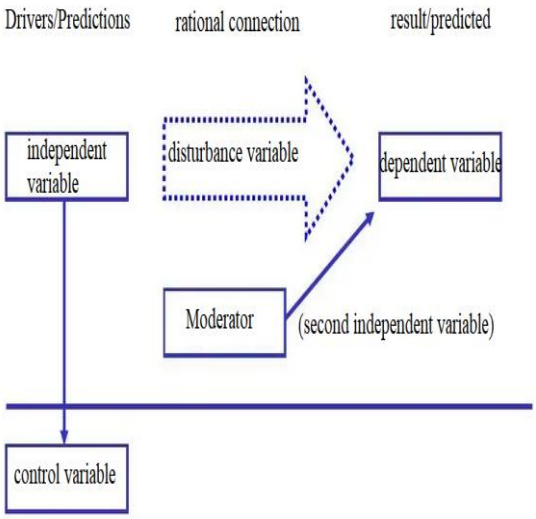

Figure 3: Association among independent and dependent variables

The particular forecasts are displayed below.
Given a linear regression model, as shown in formula (13).

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p + \varepsilon \quad (13)$$

The point prediction of the model is obtained by substituting the independent variable to be predicted into the regression equation. The interval estimate for the corresponding variable y0 is shown in formula (14).

$$\frac{\hat{y}_0 - y_0}{\hat{\sigma}\sqrt{1+\vec{x}_0'(X'X)^{-1}\vec{x}_0}} \sim t(n-p-1) \quad (14)$$

Thus for a given α, formula (15) is obtained.

$$p\{\frac{\hat{y}_0 - y_0}{\hat{\sigma}\sqrt{1+\vec{x}_0'(X'X)^{-1}\vec{x}_0}} < t_{\alpha/2}(n-p-1)\} = 1-\alpha \quad (15)$$

Therefore, it can be concluded that the prediction interval of y with a confidence level of 1-α is calculated as shown in formula (16).

$$\left(\hat{y}_0 - t_{\alpha/2}(n-p-1)\hat{\sigma}\sqrt{1+\vec{x}_0'(X'X)^{-1}\vec{x}_0},\ \vec{y}_0 + t_{\alpha/2}(n-p-1)\hat{\sigma}\sqrt{1+\vec{x}_0'(X'X)^{-1}\vec{x}_0}, \vec{y}_0\right) \quad (16)$$

4 Enterprise budget performance evaluation

4.1 Overview of enterprise budget performance evaluation

The purpose of enterprise performance evaluation is to identify the main factors affecting the effectiveness of performance management by analyzing the financial evaluation and economic efficiency indicators of the enterprise and to take measures to improve its operational efficiency and level based on these factors. Enterprise performance evaluation is a process of assessing the degree of achievement of an enterprise's business goals, and it provides managers with a basis for formulating the next work plan by analyzing the main factors that affect its development status and management level.

The assessment of an enterprise's effectiveness involves utilizing several techniques such as operations analysis and statistical methods by certain procedures, using a specific index system and standards to make a comprehensive analysis and comprehensive evaluation of the results achieved by the company in production and operation activities, to judge the merits of its business performance economic management activities. Enterprise performance evaluation is a complex and huge system project, which includes both financial and non-financial indicators. Therefore, it requires the use of multiple methods for comprehensive evaluation and assessment. Budget management, as a scientific management method, is widely used in state-owned enterprises in China, and it can bring great benefits to enterprises because of its flexibility and large operation space. However, there are some shortcomings in the performance evaluation system of enterprises. The basic problems to be solved in the performance evaluation system are: how to transform the strategic objectives of enterprises into the performance evaluation index system, how to combine the performance evaluation system with the strategic objectives of enterprises to make it work better, to provide strong support for improving the core competitiveness of enterprises. How to combine the evaluation results with incentive mechanism, and truly realize performance evaluation as an important incentive and control means to ensure the implementation of strategy.

An essential component of an organization's assessment system is the outcome assessment. Other components of the framework for performance assessment are the performance assessment topic, evaluating protest, goal, directory, accepted, and methodology. It not only reflects the interaction between various aspects of the budget management process but also can identify problems and propose improvement measures through a comprehensive analysis of the completion of budget targets. Figure 4 provides a visual representation of the organizational architecture and components of the performance evaluation system, facilitating better understanding and analysis.

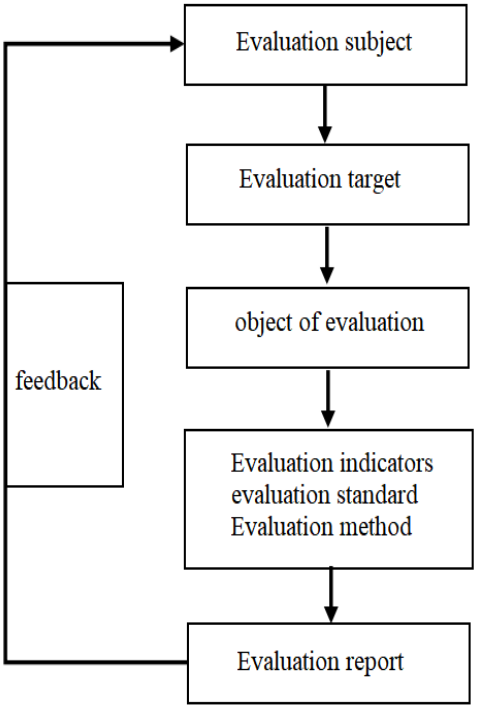

Figure 4: Performance evaluation system structure

4.2 Performance evaluation method of enterprise comprehensive budget management

4.2.1 Indicator selection.

In the evaluation of enterprise budget performance, the selection of indicators is an important issue, which directly affects the accuracy, validity, and operability of the indicator system. The selection of enterprise budget performance evaluation indicators is directly related to the construction of the indicator system and the calculation of weights. The organization's developmental orientation is influenced by several key aspects in the budget performance assessment system, including the enterprise's strategic goals and budgeted outcomes, while the financial data can also be used as key variables affecting the overall operation of the company and the forecast of future development trends.

4.2.2 Hierarchical analysis method

Hierarchical analysis is a combined qualitative and quantitative evaluation method, which decomposes the complex multi-objective decision-making process in a problem into multiple indicators, and then conducts comprehensive comparison and ranking to finally form a decision, and the hierarchical analysis can be shown in Figure 5. The application of hierarchical analysis in enterprise budget performance evaluation can effectively solve the problem of weight assignment that cannot be overcome by traditional methods, thus enabling managers to manage the company more scientifically and comprehensively, which can provide an effective decision-making basis for enterprise strategic management.

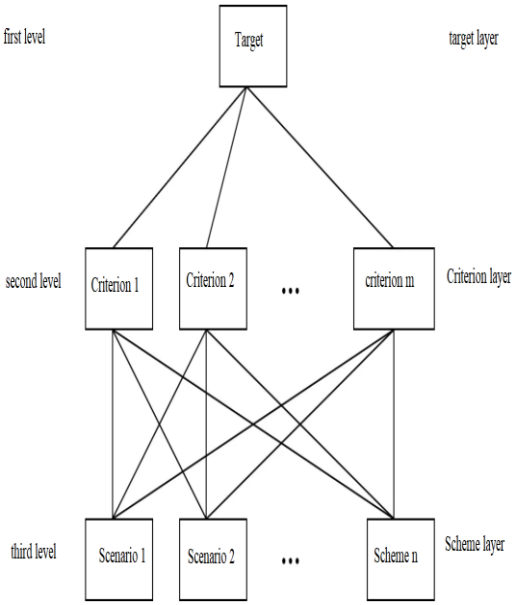

Figure 5: Hierarchical analysis method

4.2.3The main steps of the hierarchical analysis algorithm are as follows

firstly, determine the weight set, construct the judgment matrix, normalize the weights of each measure, and then choose the assessment level based on how consistently the weight set with the criterion and the size of the variation. Secondly, a hierarchical structure model is established, each indicator's values are normalized, and each indicator's coefficients of weight are calculated evaluation levels are determined according to the hierarchical structure, and the hierarchical ranking results are obtained. By comparing the relative importance of each hierarchical ranking and testing the weights for consistency, the improved algorithm is judged to have better indicator weights than the adjusted enterprise performance evaluation. If the consistency test criteria are satisfied, the indicator weights in the improved algorithm are better than the adjusted enterprise performance evaluation, and vice versa for downgrading or decreasing. The sequential steps of the hierarchical analysis algorithm and their connections for effective data processing and decision-making are shown in Figure 6 along with the algorithm's step-by-step evolution.

(1)

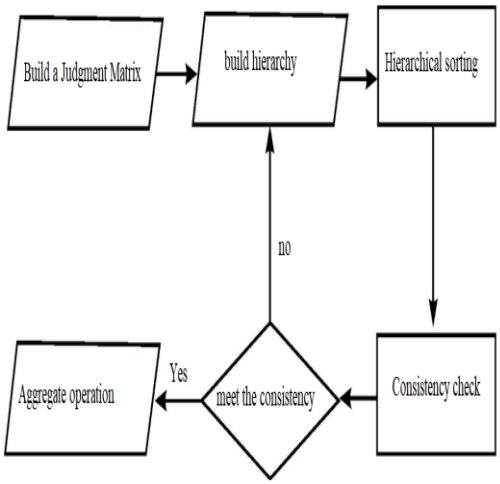

Figure 6: Hierarchical analysis algorithm flow

The basic idea of hierarchical analysis is to abstract the characteristics of the decision object into several hierarchical structures according to the nature of the analyzed object and the general mark of the decision or evaluation and to make the elements of each level have different weights by constructing a judgment matrix, and then to rank them according to their importance. Firstly, it divides each factor into several levels according to the interrelated influence and affiliation between factors and determines the weight of each judgment matrix through calculation, that is, assigns value to each level element. Secondly, according to the subjective judgment of the objective phenomenon, the weight is assigned to each index, and the weight of each layer element is calculated, that is, each factor in each layer is assigned a value, then according to the analytic hierarchy process, it is determined what kind of results each decision-maker has achieved by taking corresponding measures in the evaluation process. Ultimately, a mathematical strategy determines the dollar amount of each factor's weighting and the corresponding ranked order of all components at every level, that is, the evaluation result is determined. By comparing the relative importance of indicators at different levels, we can judge what effect the decision-makers have achieved by taking corresponding measures at a certain level.

4.3.4The method of a fuzzy thorough assessment

The connection function serves as the foundation for the imprecise thorough approach, which transforms qualitative description into quantitative calculation, uses figures to express the interactions and effects of various things, and determines the accurate judgment of things through the results of comprehensive evaluation. This method can reflect the status of enterprise budget performance and its important role in the overall economic activities, but its evaluation results cannot directly reflect the status of budget performance, and it cannot make a comprehensive assessment of the overall business activities of the enterprise. In practical application, the problem can be handled and analyzed and decisions can be made with the help of fuzzy mathematics, gray system theory, and other related principles, while for the financial indicators themselves, their evaluation is characterized by strong subjectivity and fuzziness, and in the evaluation of enterprise budget performance, the weight of indicators, determination methods and other factors can also affect the final results.

A type of multi-factor analytic theory founded on flexible arithmetic fuzzy thorough assessment theory primarily makes utilization of the relationship existing between multiple indicators in comprehensive evaluation to reflect the interconnection between things and closely combines it with the decision problem. Figure 7 illustrates the application of fuzzy comprehensive evaluation theory, a mathematical approach to decision-making that accounts for uncertainty and imprecision through fuzzy logic principles.

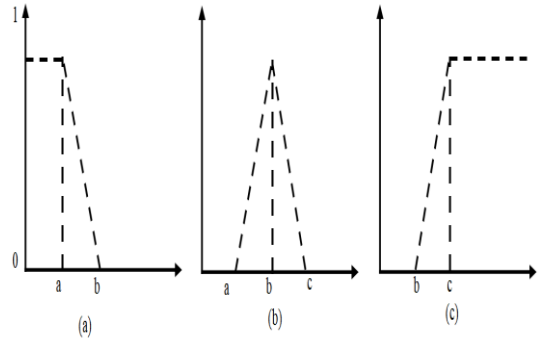

Figure 7: Fuzzy comprehensive evaluation theory

According to the above figure where the equations corresponding to figures (a), (b), and (c) are shown in (17), (18) and (19).

$$A(x)=\begin{cases}1, x \le a \\ \frac{b-x}{b-a}, a \le x \le b \\ 0, other\end{cases} \quad (17)$$

$$A(x)=\begin{cases}\frac{x-a}{b-a}, a \le x \le a \\ \frac{c-x}{c-b}, b \le x \le c \\ 0, other\end{cases} \quad (18)$$

$$A(x)=\begin{cases}0, x < b \\ \frac{x-b}{c-b}, b \le x \le c \\ 0, x \ge c\end{cases} \quad (19)$$

5 Evaluation and improvement of enterprise budget performance based on multiple linear regression

5.1 The traditional enterprise budget performance evaluation model

Budget performance evaluation refers to a comprehensive and objective analysis and assessment of the financial-related activities of an enterprise in the production and operation process by using mathematical and statistical methods. The EVA performance assessment model, which is directed towards the business plan and links the execution of budget results with the business's performance, is the conventional business budget achievement evaluation model. It establishes the appropriate weighting based on the index of assessment value. This evaluation model can effectively reflect the implementation of corporate strategy while decomposing budget targets and combining budget indicators with actual work. However, it has shortcomings in many aspects and does not truly and completely reflect the value of the enterprise.

5.2 Improvement of the evaluation model of enterprise budget performance

Based on the above description, it is learned that there are many shortcomings in the evaluation method of the traditional EVA performance evaluation index, so this paper adopts some measures to improve the evaluation model of enterprise budget performance, to achieve the improvement of enterprise budget performance evaluation and promote the economic development and social stability in China. The details are as follows.

5.3 Setting multi-level financial indicators

In the enterprise budget performance evaluation system, financial indicators are the key part, which not only determine the level of strategic management and operational efficiency but also have important significance to the sustainable development of the enterprise. The financial indicators mainly include net profit, sales revenue cost ratio, etc. Non-profit budget performance evaluation, on the other hand, refers to a performance management method based on cash flow, which takes profit as the core to evaluate the results of enterprise budget execution and proposes improvement suggestions based on the assessment conclusion. To improve the company's strategic management capability, reduce operational risks, and provide a strong guarantee for achieving the goal of maximizing economic benefits, this paper proposes to set multi-level financial indicators to reduce the weight coefficients of each level to improve the EVA model and optimize the analysis of budget performance by the improved evaluation system.

5.4 Setting non-financial indicators

The value of the enterprise is not only affected by financial factors, but also by non-financial factors, and the evaluation of enterprise budget performance is an important link, while there is still a big gap between the level of China's enterprise financial management and foreign countries. Therefore, in practice, corresponding adjustment measures should be taken according to different influencing factors. The EVA performance evaluation only pays attention to financial indicators, which cannot dynamically evaluate the future development of enterprises, this paper adds the factors of non-financial indicators and uses a linear regression algorithm for enterprise budget performance evaluation. By establishing an MLR model, screening the indicators, using the least squares estimation method to determine the coefficients and weights of each factor, and finally obtaining the composite index with the highest composite score as total profit, sales revenue, and total assets as a percentage and fixed expense ratio under the indicators to reach the optimal combination value. Through the calculation of this model, it can be seen that in the budget performance evaluation, financial metrics and business plans are the primary determinants of the business's future growth.

5.5 Determining the weights of evaluation indicators using the first value method

To determine the weights of evaluation indicators, it is necessary to standardize the evaluation indicators first and then use regression algorithms to determine the budget performance level of each enterprise. At present, the methods of determining the weights include an expert scoring method, factor analysis method, and Delphi method, which can better reflect the enterprise budget performance, but these methods have certain shortcomings, the evaluation indexes included in these methods are single, which can not fully reflect the budget performance, and these methods also have certain limitations. The programs can enhance prediction accuracy, automate decision-making and processes, and optimize reaction time for more valuable medical diagnoses. relationship between the influencing factors in the evaluation of enterprise budget performance, and can also more accurately reflect the connection between the index and the operation management level and strategic objectives of the evaluated unit [19].

5.6 Determining the coefficients of evaluation indicators using MLR models

In factor analysis, the correlation coefficient between indicators is very important, which reflects the interrelationship between evaluation objects and the size of the impact of each indicator on the comprehensive performance. In this paper, an MLR model is used to determine the coefficients of evaluation indicators, which can well reflect the impact of various aspects of enterprise performance and can accurately evaluate the difference between budget indicators and the actual situation, and it can accurately reflect the degree of impact of enterprise budget performance. Algorithm 1 illustrates the MLR algorithm.

Algorithm 1: MLR algorithm

```
function multiple_linear_regression(X, y)
coefficients = dot_product(inverse_X_transpose_X, X_transpose_y)
return coefficients
function add_intercept_column(X)
n_samples = number_of_rows(X)
ones_column = create_column_vector_of_ones(n_samples)
X_with_intercept = concatenate(ones_column, X, axis = 1)
return X_with_intercept
function transpose(matrix)
transposed_matrix = create_empty_matrix(number_of_columns(matrix), number_of_rows(matrix))
for i = 1 to number_of_rows(matrix)
for j = 1 to number_of_columns(matrix)
transposed_matrix[j][i] = matrix[i][j]
return transposed_matrix
function dot_product(matrix1, matrix2)
    result = create_empty_matrix(number_of_rows(matrix1), number_of_columns(matrix2))
for i = 1 to number_of_rows(matrix1)
for j = 1 to number_of_columns(matrix2)
sum = 0
for k = 1 to number_of_columns(matrix1)
sum += matrix1[i][k] * matrix2[k][j]
result[i][j] = sum
return result
function inverse(matrix)
```

```
function create_column_vector_of_ones(n)
ones_column = create_empty_matrix(n, 1)
for i = 1 to n
ones_column[i][1] = 1
return ones_column
function number_of_rows(matrix)
function number_of_columns(matrix)
function create_empty_matrix(rows, columns)
```

6 Results

6.1 Experimental setup

Collect historical budget data and relevant variables, such as expenses, revenue, and economic indicators, before utilizing Multiple Linear Regression (MLR) in Python for corporate budget management. For best results, run Python 3.8 or later on a computer with at least 8GB of RAM.

The ratio of accurately anticipated outcomes to all forecasts made is known as accuracy, and it can be computed as follows:

$$Accuracy = \frac{TP+TN}{TP+FN+FP+TN} \quad (20)$$

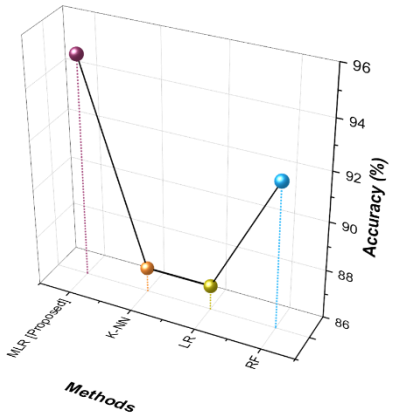

Figure 8: Accuracy

Equation (20) assesses a method's accuracy in determining its present position given the available data. Figure 8 shows the analysis of the recommended and current methods. If our suggested approach for the Improvement of Enterprise Budget Performance attains an MLR score of 95%, it will show its superiority over the current RF (92%), LR (87%), and KNN (87%) approaches.

Precision assesses how well the model avoids false positives by calculating the ratio of true positive predictions to all positive predictions made:

$$Precision = \frac{TP}{TP+FP} \quad (21)$$

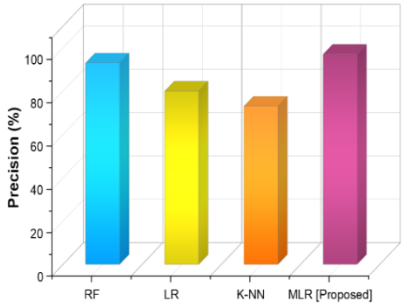

Figure 9: Precision

The computation is carried out using the suggested equation (21). The precision of the suggested method and the existing methodology are contrasted in Figure 9. Compared to widely used techniques such as LR (80%), KNN (73%), and RF (93%), the suggested MLR approach achieves a precision score of 97%. Consequently, the suggested method significantly outperforms the other for Improving Enterprise Budget Performance.

The percentage of true positive predictions that are captured from all real positive cases is measured by recall, which is also referred to as sensitivity:

$$Recall = \frac{TP}{TP+FN} \quad (22)$$

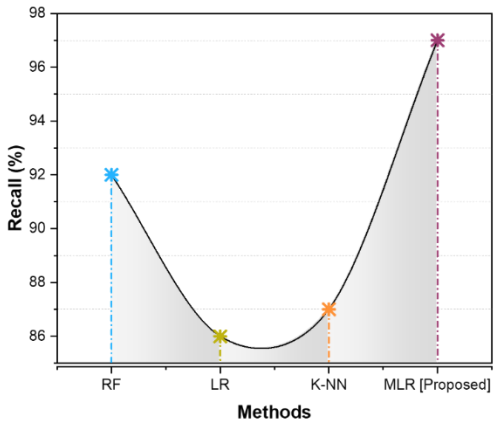

Figure 10: Recall

The computation is carried out using the proposed equation (22). A recall comparison between the suggested method and the current methodology is presented in Figure 10. Compared to widely used techniques such as LR (86%), KNN (87%), and RF (92%), the suggested MLR approach achieves a precision score of 97%. Consequently, the suggested method significantly outperforms the other for

Improving Enterprise Budget Performance.

The F1-score offers a fair evaluation of a model's performance since it is the average of precision and recall:

$$F1 - score = \frac{2*P*R}{P+R} \quad (23)$$

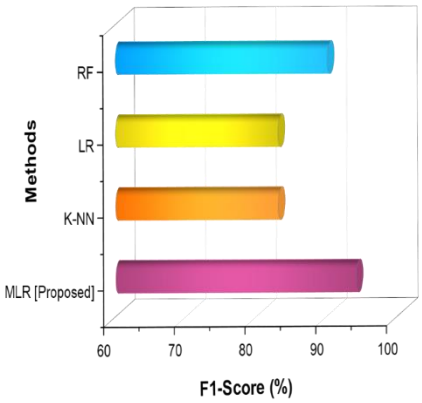

Figure 11: F1- score

The computation is carried out using the proposed equation (23). The F1-score of the suggested strategy and the existing methodology are compared in Figure 11. Compared to widely used techniques such as LR (83%), KNN (83%), and RF (90%), the suggested MLR approach achieves a precision score of 94%. Consequently, the suggested method significantly outperforms the other for Improving Enterprise Budget Performance. Table 2 displays the proposed methods' values.

Table 2: Values of accuracy, precision, recall, and F1-score

Methods	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
RF	92	93	92	90
LR	87	80	86	83
K-NN	87	73	87	83
MLR [Proposed]	95	97	97	94

6.2 Discussions

The interpretability of Random Forest (RF) is hindered by the intricacy of its ensemble method, which incorporates numerous decision trees. The assumption of a linear relationship between features and outcomes in logistic regression (LR) restricts its applicability to nonlinear patterns in data. Due to its sensitivity to extraneous features and difficulty with high dimensionality, K-Nearest Neighbours (KNN) may perform less well. To overcome these drawbacks, Multiple Linear Regression (MLR) shows promise as a substitute. Compared to RF, MLR is easier to read because each feature has distinct coefficients.

7 Conclusion

In summary, the enterprise performance evaluation index system is an important factor to measure the effect of budget management. In budget management, the performance evaluation index system is an important basis for enterprise budget execution, which not only reflects the effect of budget management but also provides feedback to enterprise managers to revise and improve the performance index system through the evaluation results. This paper introduces the hierarchical analysis method and fuzzy comprehensive evaluation method from the linear regression method to analyze and evaluate the enterprise budget performance comprehensively and objectively, which provides new ideas for enterprise budget management and has certain practical significance for its application in small and medium-sized private enterprises in China. Dependence on previous information could limit the ability to adjust to abrupt changes in the market or unanticipated economic circumstances, requiring ongoing model improvement and adaptive updating. Advanced machine learning approaches including ensemble methods or neural networks could improve prediction accuracy and offer a more in-depth understanding of how well an enterprise budget is performing.

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Suzhou Vocational University Talent Initiation Funding Project, “Research on the Correlation between R&D Investment and Business Performance” (Project No.: 201905000026).

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