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A study of corporate profitability prediction combining logistic regression and financial ratios

Yunhong Cao[1,*], Yanrou Mi[1] and Tianyu Huang[1]
[1] College of Economics and Management, Tianjin University of Science and Technology, Tianjin, 300222, China
Corresponding authors: (e-mail: cyh123456123@126.com.

Abstract This paper focuses on the field of corporate profitability prediction, and innovatively constructs an analytical framework integrating financial ratios and logistic regression. Through factor analysis, 11 financial ratios are downgraded to construct a four-dimensional core index system of profitability factor, debt service factor, operation factor and growth factor. Combined with the logistic regression model to establish a dynamic prediction mechanism to realize the prediction of corporate profitability. Taking the quarterly data of 2023-2024 of 20 listed enterprises in City A as samples, the results of factor analysis show that the comprehensive score of A5's profitability ranks the first with 2.274 points, which is much higher than A6's score of 1.383 points, and it is the best performance among the 20 enterprises. Enterprises with positive composite scores include A5, A6, A10, A4, A13, A15, and A20.The model's predicted F-value for A5 enterprises from 2023 to 2024 has a small gap with the actual value, which is within 0.03, and the correlation is greater than 95%. Based on the prediction results, the profitability of A5 enterprises will be improved in 2025, and the four quarterly profitability composite scores are 2.233, 2.488, 2.321, and 2.289 scores, respectively.

Index Terms profitability prediction, financial ratios, factor analysis, logistic regression

I. Introduction

Profitability is an important indicator for measuring the business performance of an enterprise, which is the fundamental driving force for maintaining the survival of the enterprise and promoting the development of the enterprise, and is highly concerned by the managers, owners, creditors, government regulators and other stakeholders of the enterprise [1]. Enterprise profitability forecast is an important part of financial analysis and financial management. Enterprises use financial analysis tools to forecast the profitability of a future period of operation, by integrating the past financial and business information and data of the enterprise, and at the same time, using financial analysis models to conduct in-depth excavation and focus on the business performance and current business development trends [2]-[4]. The prediction results contain both the prediction of the enterprise's future profitability, the prediction of the operational development ability and the prediction of the operational investment efficiency, as well as the prediction and assessment of the enterprise's operational development within a certain period of time in the future [5], [6]. By predicting and evaluating the future profitability of the enterprise, it can help the enterprise to understand its own development strength and future ability to participate in the market competition, and early prevention of the risk of corporate losses, earlier to start the future development of the enterprise's planning, so as to scientifically guide the enterprise's future investment and operation decisions and financial management activities [7]-[10].

When the enterprise future profitability forecast results are better, the enterprise is more confident to carry out investment and business activities, on the contrary, the enterprise needs to do a good job in advance of the risk of loss planning, and explore other effective business development path [11], [12]. However, because the profitability of enterprises not only involves a series of quantitative indicators, but also includes a large number of qualitative indicators, which are inherently very complex, coupled with the ambiguity inherent in accounting information, it creates a great deal of difficulty in evaluating and predicting profitability [13]-[15]. Therefore, introducing the logistic regression method into the task of predicting the enterprise stress capacity can provide accurate and reasonable evaluation and prediction of the enterprise's financial status.

This paper firstly explains the non-linear mechanism of financial ratios and profitability, and constructs the profitability index model through factor analysis. The core factors with economic explanatory power are refined and a four-dimensional core factor system is developed. Aiming at the dichotomous characteristics of profitability prediction, a logistic regression prediction model is constructed. Select representative listed enterprises in City A for inter-annual validation, and use the logistic regression model to calculate the predicted values of the independent

variables. By running the logistic regression model, the prediction of corporate profitability is realized. Combined with quantitative means such as error analysis and significance test, the effectiveness of the model in profitability prediction is verified.

II. Evaluation of corporate profitability based on financial ratios

A company's production and operational status can often be seen in its profitability level, and an accurate grasp of profitability will play a crucial role in the company's operations. Against the backdrop of intensifying global economic uncertainty, corporate profitability forecasting has become a core issue of concern for stakeholders. Traditional analytical methods mostly rely on single financial indicators or linear regression models, which have defects such as redundant indicators and insufficient timeliness of forecasting. In this paper, from the perspective of financial ratios, factor analysis and logistic regression are combined and applied to profitability forecasting.

In this paper, we select the 2024 data of relevant listed enterprises in A city, and by screening the database of GuotaiAn, we find out the enterprises with comprehensive data and strong linkage, and finally we get 20 of them, numbered A1~A20 respectively, as the research objects of this paper.

II. A.Relationship between corporate profitability and financial ratios

There is a close relationship between corporate profitability and financial ratios. Financial ratios are important tools for measuring and analyzing corporate profitability. Profitability is one of the key indicators of corporate profitability. Profitability can be calculated and assessed by indicators such as net profit growth rate in financial ratios. Solvency and operational capacity indicators in financial ratios are also closely related to corporate profitability. The strength of an enterprise's solvency and operating capacity directly affects the profit level and profitability of the enterprise. Growth indicators such as total asset growth rate can also reflect the profitability of the enterprise. By analyzing and comparing the financial ratios, we can comprehensively and systematically assess the profitability of the enterprise and provide important guidance and reference for the development and decision-making of the enterprise. Financial ratios are closely related to enterprise profitability, and the analysis and assessment of financial ratios is an important means of evaluating enterprise profitability, which is of great significance to the development and business decisions of enterprises. In this paper, the construction of enterprise profitability assessment model based on financial ratios and its application will be further introduced.

II. B.Factor analysis

Factor analysis as a statistical method can be used to assess the profitability of a business. It is used to determine and evaluate the profitability of a company by analyzing its financial data and discovering which factors have the greatest impact on profitability. In factor analysis, analysts usually choose some economic indicators, such as net profit, sales, asset margin, financial leverage, and stock market value, as assessment indicators and quantify these indicators. Then, they use statistical methods to convert these indicators into a number of uncorrelated factors to reveal potential profitability factors. The core of the factor analysis method is to establish a factor model, which can downscale the raw indicator data to describe the complex financial data with fewer variables, thus better reflecting the profitability of the enterprise. The principal component analysis method is usually used to build this factor model. Principal Component Analysis linearly combines the original indicators to produce a number of new factors, which are the result of dimensionality reduction of the original indicators. These new factors are much smaller in number than the original indicators, while still being able to adequately explain the variance of the original data. Through factor analysis, analysts can determine which factors have the greatest impact on corporate profitability and incorporate these factors into a comprehensive assessment model to better assess corporate profitability.

Overall, factor analysis is an effective method for evaluating enterprise profitability, which can help business managers better understand the profitability of enterprises, improve their operations and create more value.

Factor analysis method describes the structure of data by converting a set of highly correlated variables into a few irrelevant or weakly correlated factors. In the process of factor analysis, it is necessary to standardize the data first, and then apply mathematical methods such as principal component analysis to determine the minimum number of factors that can explain the variance of the data, and to correlate the original variables with the factors to determine the factor loading (i.e., the correlation coefficient between the factors and variables) corresponding to each variable. The factor analysis method can find the hidden representative factors among many variables and avoid the correlation between the sample data indicators from influencing the analysis results, and the basic model is as follows:

$$\begin{cases} X_1 = a_{11}F_1 + a_{12}F_2 + \cdots + a_{1p}F_p + \varepsilon_1 \\ X_2 = a_{21}F_1 + a_{22}F_2 + \cdots + a_{2p}F_p + \varepsilon_2 \\ \cdots \quad \cdots \\ X_n = a_{n1}F_1 + a_{n2}F_2 + \cdots + a_{np}F_p + \varepsilon_n \end{cases} \tag{1}$$

Let there be an indicator marker quantity $X=\left(X_1,X_2,X_3,\cdots,X_n\right)$, a transformed common factor variable $F=\left(F_1,F_2,F_3,\cdots,F_p\right)$ (where $p<n$), with the value mean $E(F)=0$, indicating no correlation between the components. E denotes the special factor of X, the common and special factors are independent of each other, and the covariance is expressed as $Cov\left(F,E\right)=0$. $A(a_{ij})$ is the final factor loading matrix.

II. C.Evaluation of enterprise profitability

II. C. 1) Modeling of profitability indicators

This paper selects 11 profitability-related indicators, and the detailed explanation of each variable is shown in Table 1. Numbered X1~X11, they represent return on net assets, earnings per share, net sales margin, net profit growth rate, return on total assets, quick ratio, current ratio, total asset growth rate, fixed asset turnover, operating income growth rate, and total asset turnover.

Table 1: Profitability Indicators

Variable name	Variable symbol	Variable interpretation
Return on equity	X1	Average balance of net profit/Shareholders' equity
Earnings per share	X2	(Gross profit of the current period-preferred stock dividends)/Total share capital at the end of the period
Net profit margin on sales	X3	(Operating income-Operating Cost)/Operating income
Net profit growth rate	X4	(Current net profit-Previous net profit)/Previous net profit
Return on total assets	X5	Net profit/Average total assets
Quick ratio	X6	(Current Assets-Inventories)/Current liabilities
Current income ratio	X7	Current assets/Current liabilities
Growth rate of total assets	X8	Asset growth amount/Total assets of the previous period
Fixed asset turnover rate	X9	Operating income/Average net fixed assets
Growth rate of operating income	X10	Increase in operating income/Total operating income of the previous year
Total asset turnover rate	X11	Sales revenue/Total average assets

The total variance explained is used to judge whether the extracted male factors can explain the information of the original variables better, when the cumulative contribution reaches 80% and the eigenvalue is greater than 1, it indicates that the selected factors are representative and can be analyzed by factor analysis. The total variance explained results are shown in Table 2. It can be seen that the eigenvalues of the four male factors are greater than 1 and the cumulative contribution is 80.080%, which indicates that the four extracted male factors are the main factors affecting the 11 variables. Therefore, 1, 2, 3, and 4 were selected as the male factors, denoted by F1, F2, F3, and F4.

Table 2: Explanation of Total Variance

Component	Initial eigenvalue			Extract the sum of the load squares			The sum of squared rotating loads		
Variable	Total	Var%	Cum.Var%	Total	Var%	Cum.Var%	Total	Var%	Cum.Var%
1	4.273	38.849	38.849	4.273	38.849	38.849	3.046	27.693	27.693
2	1.775	16.138	54.987	1.775	16.138	54.987	2.108	19.165	46.858
3	1.562	14.201	69.188	1.562	14.201	69.188	1.927	17.520	64.378
4	1.198	10.892	80.080	1.198	10.892	80.080	1.727	15.702	80.080
5	0.763	6.937	87.017						
6	0.527	4.791	91.808						
7	0.386	3.509	95.317						
8	0.211	1.918	97.235						
9	0.185	1.682	98.917						
10	0.077	0.700	99.617						
11	0.042	0.383	100.000						

The rotated component matrix is shown in Table 3 and represents the magnitude of each variable's loading in the factor, i.e., which component has the greatest impact on that variable. Table 3 shows the representativeness of the 4 factors on the 11 variables. The variables with large loading coefficients corresponding to the 1st common factor are return on net assets, earnings per share, net sales margin, net profit growth rate, and total return on assets, which are 0.903, 0.885, 0.838, 0.832, and 0.779, respectively, which mainly reflect the impact of income situation on profitability, and therefore F1 is named as the profitability factor. The variables corresponding to the 2nd male factor with large loading coefficients are current ratio and quick ratio with loadings of 0.924 and 0.885 respectively, which mainly reflect the impact of financial situation and solvency on profitability, therefore, F2 is named as solvency factor. The loadings of the 3rd male factor corresponding to total asset turnover ratio and fixed asset turnover ratio are 0.896 and 0.827 respectively, which mainly show the impact of operation running on profitability, therefore, F3 is named as operation factor. The loadings of the 4th common factor corresponding to the growth rate of operating income and the growth rate of total assets are 0.839 and 0.817 respectively, which mainly reflect the impact of growth on profitability, therefore, F4 is named as the growth factor.

Table 3: Component Matrix after rotation

Variable	Component			
	1	2	3	4
X1	0.903	0.095	0.216	0.057
X2	0.885	0.172	0.335	0.094
X3	0.838	0.197	-0.242	0.083
X4	0.832	-0.122	0.057	0.299
X5	0.779	0.435	0.108	0.037
X6	0.137	0.924	0.073	0.022
X7	0.093	0.885	0.337	0.036
X8	0.128	0.128	0.896	0.074
X9	0.142	0.084	0.827	0.255
X10	0.105	0.025	-0.138	0.839
X11	0.196	0.093	0.209	0.817

II. C. 2) Results of profitability evaluation

Based on the variance contribution ratio of each factor, the comprehensive evaluation of profitability F-value is calculated. The results of the calculation and ranking of factor scores of the 20 listed enterprises are shown in Table 4.A5 ranked first with a score of 2.274, which is much higher than that of A6 with a score of 1.383, and is the best performer among the 20 enterprises. The enterprises with positive composite scores are A5, A6, A10, A4, A13, A15 and A20, while the remaining 13 enterprises have weak overall profitability and need to be improved.

Table 4: Comprehensive Score Results

Enterprise	Factor score	Ranking	Enterprise	Factor score	Ranking
A5	2.274	1	A9	-0.196	11
A6	1.383	2	A12	-0.232	12
A10	0.835	3	A14	-0.269	13
A4	0.726	4	A19	-0.301	14
A13	0.321	5	A2	-0.388	15
A15	0.303	6	A7	-0.524	16
A20	0.089	7	A8	-0.577	17
A1	-0.092	8	A18	-0.693	18
A17	-0.097	9	A3	-1.002	19
A16	-0.182	10	A11	-1.137	20

III. Forecasting corporate profitability based on logistic regression

III. A. Logistic regression model

Logistic regression is the most commonly used method in corporate profitability prediction methods, and is one of the most popular algorithms specifically used to solve discrete problems of binary classification. The purpose of this

research paper is to predict the profitability of listed companies, which just meets the usage scenario as well as the characteristics of the logistic regression model. It can fit a logistic function based on the existing data, and then apply the function to the real data of the enterprise that needs to be predicted, make predictions for each profitability indicator and return 0 or 1. Logistic regression is often used as the basis of other models because of its stability and strong interpretability.

Logistic regression is evolved from the linear regression model Logit, the expression of Logit is:

$$g(z)=\frac{1}{1+e^{-z}} \tag{2}$$

Assume that the dependent variable is F, F is a composite profitability indicator, and the independent variable $X=(X1,X2,X3,\cdots,Xn)$ order:

$$F=X0+\beta 1X1+\beta 2X2+\beta 3X3+\cdots+\beta nXn \tag{3}$$

X is the variable, that is, the selected indicators related to the profitability of the business, β is the coefficient, that is, the coefficient of each variable solved by the logistic regression model, the larger the absolute value of the coefficient, it means that the indicator has a greater impact on whether the customer is overdue. F is the dependent variable i.e. 0 and 1, the probability of F being 1 is P and the probability of F being 0 is $1-P$. The natural logarithm is taken for it:

$$Logit(P)=LN\left(\frac{P}{1-P}\right) \tag{4}$$

From this the logistic regression model can be converted:

$$LN\left(\frac{P}{1-P}\right)=X0+\beta 1X1+\beta 2X2+\beta 3X3+\cdots+\beta nXn \tag{5}$$

Let $F=X0+\beta 1X1+\beta 2X2+\beta 3X3+\cdots+\beta nXn$, get:

$$P=(y=1\mid x)=\frac{1}{1+e^{-z}} \tag{6}$$

$$1-P=P(y=0\mid x)=1-\frac{1}{1+e^{-z}}=\frac{1}{1+e^{z}} \tag{7}$$

The advantage of the logistic regression model is its strong interpretability, which is mainly reflected in the interpretation of its parameters. From the above formula, when β_n is greater than 0, the ratio of the occurrence of events will be increased accordingly; when β_n is less than 0, the ratio of the occurrence of events will be decreased, and when β_n is equal to 0, it indicates that the corresponding indicator has no relationship with whether the enterprise is profitable or not.

Table 5: Calculation Results of Comprehensive Profitability Indicators

	202303	202306	202309	202312	202403	202406	202409	202412
X1	1.387	2.408	1.397	1.635	1.973	2.864	2.082	2.117
X2	1.286	1.497	2.085	2.174	1.648	2.573	1.297	2.266
X3	-0.387	-1.322	-0.973	0.992	1.038	1.278	1.339	1.427
X4	-0.462	-1.486	-1.869	-1.022	1.397	2.274	2.683	2.975
X5	1.035	1.117	1.236	1.282	1.306	1.325	1.339	1.367
X6	1.028	1.386	1.375	1.388	1.409	1.426	1.414	1.425
X7	-2.382	-1.825	-0.862	1.287	2.863	2.973	2.973	2.836
X8	2.332	2.386	2.317	2.388	2.356	2.405	2.411	2.524
X9	0.386	1.285	1.275	2.083	2.177	2.208	2.274	2.396
X10	-2.486	-2.017	1.917	2.074	2.375	2.426	2.367	2.186
X11	-2.038	-2.173	1.836	2.087	2.186	2.375	2.188	2.363
F	-0.056	1.084	1.846	2.297	1.947	2.484	2.273	2.209

III. B. Profitability projections

In this paper, we take enterprise A5 as an example to specify the forecasting methodology used. By collecting the quarterly indicators of enterprise A5 for 8 quarters from 2023 to 2024, the 2-year consolidated profitability index F is calculated through factor analysis. It is worth noting that F is calculated by using the matrix of factor scores

obtained from the factor analysis of the whole industry in each quarter and the contribution rate of the public factors to the consolidated profitability index, so a large amount of sample data is needed to ensure the accuracy of F. The results of the calculation of quarterly indicators and consolidated profitability index of enterprise A5 from 2023 to 2024 are shown in Table 5. The calculation results of quarterly indicators and comprehensive profitability indicators of A5 enterprises in 2023-2024 are shown in Table 5.

Firstly, on the basis of Table 5, a prediction is made for each independent variable X. This paper derives the short-term prediction relational equation for each independent variable X based on the logistic regression model, calculates the relationship that exists between the independent variable in the current period and the independent variable in the previous period, Xt, and then predicts the independent variable X in the future by iterative way.Taking the independent variable X1 as an example, the regression statistical results are shown in Table 6. As can be seen from the results after regression, the R2 is about 89.27%, which indicates that the numerical correlation is high, and the P-value is less than 0.05, which indicates that the obtained prediction data are more accurate.

Table 6: Regression Statistics R2

Regression Statistics	
Multiple R	0.93642
R Square	0.89273
Adjusted R Square	0.87251
SE	2.47533
Observed value	8
P	0.001

The data was substituted into matlab to run the logistic regression model to get the predicted F-value and the predicted results are shown in Table 7. Where FA denotes the actual F-value and FF denotes the predicted F-value. From the prediction of Table 7 for 2023~2024, it can be seen that the gap between the predicted F-value and the actual value is small, all within 0.03, and the correlation is greater than 95%, and the reliability of its prediction is guaranteed. Firm A5 will have improved profitability in 2025, with four quarterly profitability composite scores of 2.233, 2.488, 2.321, and 2.289 points, respectively.

Table 7: Prediction Results

Time	FA	FF	Gap
202303	-0.056	-0.038	-0.018
202306	1.084	1.072	0.012
202309	1.846	1.823	0.023
202312	2.297	2.285	0.012
202403	1.947	1.931	0.016
202406	2.484	2.462	0.022
202409	2.273	2.259	0.014
202412	2.209	2.192	0.017
202503		2.233	
202506		2.488	
202509		2.321	
202512		2.289	

IV. Conclusion

This paper proposes a corporate profitability prediction method combining logistic regression and financial ratios, and obtains the following conclusions through theoretical derivation and empirical testing.

The eigenvalues of the four male factors of the profitability index system are all greater than 1, with a cumulative contribution rate of 80.080%, and the four male factors are named profitability factor, debt service factor, operation factor, and growth factor respectively. Among the 20 listed enterprises, A5 ranked the first in the comprehensive score of profitability with a score of 2.274, which is much higher than the score of A6 of 1.383, and has the best performance among the 20 enterprises. The enterprises with positive composite scores are A5, A6, A10, A4, A13, A15 and A20, while the remaining 13 enterprises have weak overall profitability and are in need of improvement.

Taking the independent variable X1 as an example, the R2 is about 89.27%, and the P-value is less than 0.05, which indicates that the numerical correlation is high, and the predicted data obtained is more accurate. The model's predicted F-value for A5 enterprises from 2023 to 2024 has a small gap with the actual value, all within 0.03, and the correlation is more than 95%. The prediction results show that in 2025, the profitability of A5 enterprises will be improved, and the four-quarter profitability composite scores are 2.233, 2.488, 2.321, and 2.289 scores, respectively.

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