Research on the Factors Influencing Business Growth Based on ANN-MLP Algorithm Title Case Taking China Maotai Group as an example

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Abstract. The growth of enterprises is the key to the national economy and even the annual economic recovery. Therefore, it is of great theoretical significance and practical value to construct a scientific and effective enterprise growth evaluation model. Multi-layer perceptron (MLP), as a typical representative of artificial neural network (ANN), has the performance of rapid computation and high fault tolerance. In this paper, we take the enterprise data and social data of Maotai Group from 2001 to 2020 as samples, combine enterprise growth theory and, through the literature research method, initially select seven indicators to evaluate enterprise growth and twenty-seven indicators as factors affecting enterprise growth. Then, Kendall correlation coefficient was used to reduce the dimensions of indicators, and the index system of enterprise growth and influencing factors were obtained. Finally, the MLP algorithm was used and optimized to optimize the robustness of the model. The results show that the final model is highly accurate, with MSE of 0.033 and R^2 of 0.942, and return on assets and GDP have the greatest influence on firm growth. In other words, the profitability of an enterprise and the country's overall economic prosperity can largely influence the growth of an enterprise, and the stronger the profitability of an enterprise, the stronger its growth ability will be in the era of continuous national economic development. The model has a certain reference value for enterprises to formulate development strategies and the government to formulate macro policies to promote economic growth.

Keywords: ANN-MLP, firm growth; firm, factor analysis.

1. Introduction

The recently released UN report "World Economic Situation and Prospects 2022 [1] pointed out that the global economic recovery is facing significant headwinds due to a new round of new crown pneumonia outbreaks caused by mutated strains of Omicron, ongoing labor market challenges, unresolved supply chain issues, and increasing inflationary pressures. Against the backdrop of a deteriorating global economy and multiple unpredictable factors, enterprises play an important role in developing national economies, especially in making a decisive contribution to financial recovery and growth [2]. Therefore, the sustainable development of enterprises has become a popular research topic, not only for the benefit of managers and investors, but also for the economic development of the whole country and the world.

Zhao, LJ et al. [3] used data of Chinese A-share listed companies from 2009 to 2018 to explore the impact of venture capital on firms with different life cycles. Shen, N et al. [4] studied the non-linear dynamic effects of different environmental regulations on total factor productivity (ETPF) in the industrial sector by using MML approach and threshold model from a heterogeneity perspective. Aghion, P et al. [5] adopted the Lerner index to measure competition, and subsidy tax holidays, loans, and tariffs are listed as industrial policies. In other countries, Lee, C et al. [6] examined the effects of internal capabilities and external networks on firm performance using data from 137 Korean

technology startups. Based on firm resource base theory, Terziovski, M et al. [7] identified innovation drivers and their impact on the performance of SMEs. Anderson, BS et al. [8] proposed a three-way interaction model between EO, firm age, and intangible assets. Russo, MV et al. [9] have assumed that there is a positive relationship between environmental performance and economic performance, which is mitigated by industry growth, and the return on environmental performance of high growth industries is higher. This assumption is verified by using independent environmental rating. The above literature mainly focuses on the empirical analysis of factors related to business growth, and rarely examines the construction of evaluation models.

However, most business growth assessment studies only examine the impact of some of the influencing factors on the business. Most of the index systems built in the literature are less comprehensive and prone to endogeneity. Therefore, applying a comprehensive indicator system and a scientific assessment method are necessary. The research in this paper will comprehensively examine the endogenous factors and exogenous opportunities of enterprise development, comprehensively assess enterprise growth in terms of scale and trend, and combine the ANN-MLP algorithm for research and analysis. Compared with traditional statistical methods, machine learning has significantly improved the evaluation capability of the model and broken the limitation that traditional statistical models can only cope with linear problems. The empirical analysis was conducted using the data of Moutai Group, a typical Chinese company. The study results are helpful for enterprises to develop effective business models, corporate strategies and tactics, and improve their ability to manage and integrate resources. In addition, they can also optimize external value networks to cope with external uncertainties, gain competitive advantages in the market, and achieve the growth of enterprise growth scale and growth trend. At the same time, the research can be applied to the government's formulation of macro policies, thus promoting the joint development of enterprises and the national economy.

2. Constructing Explanatory and Dependent Variables

2.1 Business Growth

The essence of enterprise growth is a process, both quantitative and qualitative, depending on the ability and potential of the enterprise to achieve "quantitative" expansion and "qualitative" improvement in the future, which determines the possibility and degree of development of the enterprise. It determines the possibility and degree of development. Therefore, this study considers that enterprise growth is a dynamic process, a collection of growth capacity and growth potential. Quantitative change refers to a company's growth in terms of size and quantity, while qualitative change refers to the improvement of a company in terms of operational quality. Therefore, in terms of enterprise growth measurement, we mainly focus on expanding enterprise scale and enterprise growth trend from two aspects. According to the commonly used quantitative indicators, this paper classifies the expansion of enterprise scale into output value (y_1), net profit (y_2), main business income (y_3) and number of employees (y_4), and the trend of enterprise growth into total assets growth rate (y_5), main business income growth rate (y_6) and profit growth rate (y_7), by constructing the above indicators to quantify the enterprise growth.

2.2 Construction of the index system affecting the growth of enterprises

The essence of the enterprise is a form of economic organization resulting from the economic rent-seeking behavior of resources in an exchange economy where uncertainty prevails, manifested formally as a collection of heterogeneous resources within a regulatory framework. The premise of the emergence and development of the enterprise is the prevalence of uncertainty in the exchange economy. The reason for the existence of the enterprise lies in the fact that this form of enterprise economic organization can reduce the risk of uncertainty and provide higher economic rents for resources, thus aggregating them within a regulatory framework. The analysis of the sources of

influence on the firm must be carried out both internally and externally to the firm. The endogenous influences of the firm come from the demand for economic rents for resources, while the exogenous influences of the firm are rooted in the prevalence of uncertainty. Therefore, the following study examines the sources of influence factors of firms from both economic rent-seeking and uncertainty perspectives.

2.2.1 Intrinsic vibrancy

From the perspective of economic rent-seeking, the sustainable growth of enterprises needs to be realized through the agglomeration of resources. Therefore, the indicators affecting the growth of enterprises are firstly various tangible and intangible resources, such as land, mines, or highly qualified personnel, and then the ability to integrate and use the resources, such as operating ability, profitability, solvency, and marketing ability and technological innovation ability. Hence, combined with Wang's evaluation of the multi-criteria decision-making method [10] for the growth of enterprises, this paper selects capital intensity (x_1), cash ratio (x_2), inventory (x_3), and accounts receivable (x_4) as the evaluation indexes of enterprise resources, and choose inventory turnover (x_5), return on assets (x_6), earnings per share (x_7), gearing ratio (x_8), current ratio (x_9), quick ratio (x_{10}), and R&D investment (x_{11}) as the evaluation indexes of enterprise capability.

2.2.2 Exogenous opportunities

With the development and exploration of modern theories of business growth, researchers have focused more on the impact and influence of opportunities and risks brought by the external environment on business growth. Guo's [11] empirical study classifies the factors affecting firm growth into natural resources and infrastructure, human resource environment, technological environment, business and economic environment, policy environment and socio-cultural environment. Therefore, this paper selects the number of registered employment (x_{12}), labor productivity (x_{13}) to measure the human resource environment, technology market turnover (x_{14}), and the number of scientific and technological papers published (x_{15}) to measure the scientific and technological environment; In this paper, Gross Domestic Product (x_{16}), venture capital intensity (x_{17}), total bond transactions on Shenzhen Stock Exchange (x_{18}), and turnover on commodity trading market (x_{19}) are selected to measure the business economic environment; This paper chooses export tax rebate income (x_{20}), fiscal social security expenditure (x_{21}), fiscal public service expenditure (x_{22}), fiscal public security expenditure (x_{23}), labor dispute mediation rate (x_{24}) and patent administration case settlement rate (x_{25}), and the number of books, periodicals and newspapers published (x_{26}) and the total number of visitors to public libraries and museums (x_{27}) are selected to measure the socio-cultural environment.

3. Index Dimension Reduction Based on Kendall correlation coefficient

When using the ANN-MLP algorithm to train data, large data dimensions will not only reduce the running rate of machine learning model, but also may have the problem of 'dimension disaster' and multicollinearity of data. Therefore, it is necessary to improve the model's generalization ability and ensure the dimensionality reduction of independent data between feature attributes.

Statistician Maurice Kendall proposed the Kendall correlation coefficient (τ) in 1938, which can detect the nonlinear correlation between the two variables, and the correlation coefficient will not change with the change of the degree of nonlinear correlation. Therefore, this paper uses the Kendall rank correlation coefficient to test the correlation.

The calculation steps of the Kendall correlation coefficient are as follows:

STEP 1 When there is no $(X_j - X_i)(Y_j - Y_i) = 0$ in the set:

$$\tau = \frac{C - D}{\frac{1}{2}N(N-1)} \tag{1}$$

Where C denotes the number of identically ordered pairs of elements in XY; D Represents the number of inverse pairs of elements in XY.

STEP 2 When there exists $(X_j - X_i)(Y_j - Y_i) = 0$ in the set:

$$\tau = \frac{C - D}{\sqrt{(T_0 - T_1)(T_0 - T_2)}} \tag{2}$$

Where: $T_0 = \frac{1}{2}N(N-1), T_1 = \sum \frac{t_i(t_i-1)}{2}, T_2 = \sum \frac{u_i(u_i-1)}{2}$ The same elements in X,Y are composed of subsets, and $t_i(or\ u_i)$represents the number of elements contained in the i^{th} small set in $X(or\ Y)$.

The range of τ : $-1 \leqslant \tau \leqslant 1$. $\tau = 1$ indicates that the two random variables have consistent hierarchical correlation; $\tau = -1$indicates that two random variables have opposite rank correlation; $\tau = 0$ indicates that two random variables are independent of each other.

4. Establishment of ANN-MLP

ANN was proposed by W. S. McCulloch and W. Pitts in 1943. They proposed the formal mathematical description and network structure method of neurons through the MP model. On this basis, Geoffrey Hinton invented the BP algorithm suitable for MLP in 1986, and used Sigmoid for nonlinear mapping. MLP is an ANN artificial neural network with a forward structure, which effectively solves the problem of nonlinear classification and learning. The main advantages of ANN-MLP are as follows: 1) high parallel processing; 2) High nonlinear global effect; 3) Good fault tolerance; 4) Very strong adaptive, self-learning function.

4.1 Model Instruction

ANN-MLP is a forward artificial neural network composed of a series of multi-layer nodes and maps one set of input vectors to another set of output vectors. The bottom layer of the multi-layer perceptron is the input layer, the middle layer is the hidden layer, and the last layer is the output layer. Weights can only connect the nodes between adjacent layers. The input layer is introduced by the sample feature vector of the training set, and the next layer is introduced by the weight of the connecting nodes. The output of the upper layer is the input of the next layer, and the weighted sum of the upper layer is converted into the input of the next layer according to the nonlinear equation.

All neurons in the MLP are similar, adding the values retrieved from the previous item to the corresponding weights, adding deviation items to each neuron, and using the sigmoid activation function to transform the sum:

$$f(x) = \frac{1}{1 + e^{-x}} \tag{3}$$

As shown in Figure 2, given layer n, the output of layer n + 1 is:

$$u_i = \sum {}_j (w_{i,j}^{n+1} \times x_j) + w_{i,bias}^{n+1}, y_i = f(u_i) \tag{4}$$

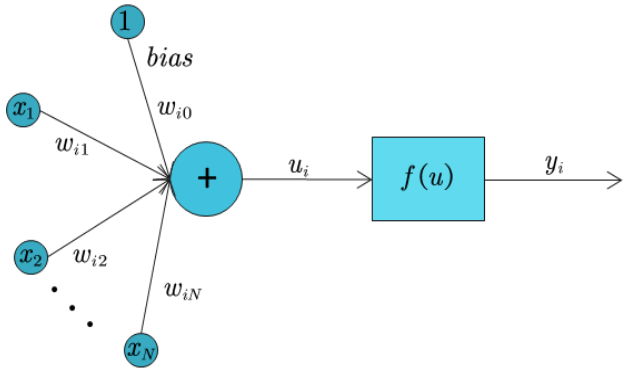

Figure 2. Neuron working mechanism

4.2 Precision measurement index

In this paper, MSE and R^2 are selected as the accuracy measurement indexes of machine learning algorithms.

MSE: Mean square error refers to the expected value of the square of the difference between the estimated value of the parameter and the real value of the parameter. It can evaluate the degree of change of the data, and the smaller the value, indicating that the prediction model has better accuracy in describing the experimental data.

$$MSE = \frac{1}{N}\sum_{i=1}^{N}\left(y_{test}^{(i)} - \hat{y}_{test}^{(i)}\right)^2 \tag{5}$$

R^2: The determination coefficient, also known as the determination coefficient, refers to the ratio of the sum of variance squares to the sum of total variance squares.

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\left(y_{test}^{(i)} - \hat{y}_{test}^{(i)}\right)^2}{\sum_{i=1}^{N}\left(y_{test}^{(i)} - \bar{y}_{test}^{(i)}\right)^2} \tag{6}$$

The molecule represents the prediction error, and denominators represent the prediction error using the average $y = \bar{y}$. The larger R^2, the better the prediction effect of our model, and the maximum R^2 is 1.

5. Empirical analysis

5.1 Research subject identification and data collection

As the leader of China's wine-making industry, Moutai Group has been selected as one of the top 500 global brand value companies many times. And in recent years, Maotai Group has grown rapidly and has been the number one high-priced stock in Shanghai and Shenzhen for a long time. Moreover, Maotai is not only a wine product company, but also has the special nature of a currency-like product in China. Therefore, an empirical study with data from Maotai Group is a good guide and reference for other companies. For these reasons, this paper intends to select the relevant index data of Guizhou Maotai Group from 2001 to 2020 for empirical analysis.

The exogenous opportunity data of the explanatory variables, the data of the explanatory variables and the endogenous causal data of Maotai Group, were collected through the Guotaian CSMAR database, the RESSET database, and the national database. In order to standardize the indicator

measure, this paper standardized the data with Z-score. Some of the data completed by the standardization are shown in Table 1.

Table 1. Selected data tables for standardized completion

Company Name	Stock Code	Period	Net Profit	Revenue from main business	Number of employees	Total assets growth rate	Growth rate of main business revenue
Guizhou Maotai	600519	2001	-0.880	-0.878	-1.174	0.176	0.000
		2002	-0.864	-0.871	-1.124	1.340	-0.751
		2003	-0.856	-0.852	-1.071	-0.755	0.401
		2004	-0.841	-0.831	-0.994	1.557	0.038
		2005	-0.821	-0.799	-0.923	-1.017	0.383

5.2 Metrics downscaling

The presence of multicollinearity in the indicators makes it difficult to distinguish the individual effects of each explanatory variable and can make the model unstable, etc. Therefore, to reduce the impact of multicollinearity of variables and indicators on the model, it is necessary to reduce the dimensionality of the indicators.

This paper uses the Kendall correlation coefficient to measure the correlation between indicators. For the explanatory variables, this paper divides them into two parts: endogenous causes and exogenous opportunities for correlation analysis separately.

The correlation analysis was first performed on the internal and external factors, and the correlation matrix is shown in Table 2.

Table 2. Endogenous correlation coefficient matrix

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
x_1	1.00	-0.04	0.50	0.10	-0.23	-0.06	0.42	0.12	-0.03	0.06
x_2	-0.04	1.00	0.21	-0.19	-0.43	0.31	0.26	-0.38	0.32	0.33
x_3	0.50	0.21	1.00	-0.20	-0.38	0.36	0.91	-0.24	0.41	0.51
x_4	0.10	-0.19	-0.20	1.00	0.57	-0.36	-0.19	0.35	-0.31	-0.23
x_5	-0.23	-0.43	-0.38	0.57	1.00	-0.33	-0.35	0.27	-0.27	-0.24
x_6	-0.06	0.31	0.36	-0.36	-0.33	1.00	0.37	-0.42	0.42	0.41
x_7	0.42	0.26	0.91	-0.19	-0.35	0.37	1.00	-0.32	0.48	0.58
x_8	0.12	-0.38	-0.24	0.35	0.27	-0.42	-0.32	1.00	-0.79	-0.70
x_9	-0.03	0.32	0.41	-0.31	-0.27	0.42	0.48	-0.79	1.00	0.88
x_{10}	0.06	0.33	0.51	-0.23	-0.24	0.41	0.58	-0.70	0.88	1.00

According to the above table, this paper removes the internal factors with strong covariance. Finally, it retains only capital intensity, cash ratio, inventory, accounts receivable, inventory turnover, return on capital, and gearing ratio.

Next, a correlation analysis was performed on the exogenous opportunity indicators, and the calculated results are shown in Table 3.

Table 3. Exogenous correlation coefficient matrix

	x_{12}	x_{14}	x_{15}	x_{16}	x_{17}	x_{19}	x_{20}	x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}	x_{27}
x_{12}	1.00	0.53	0.53	0.53	0.46	0.63	0.56	0.53	0.50	0.54	0.21	0.21	0.33	0.58
x_{14}	0.53	1.00	1.00	1.00	0.68	0.87	0.97	1.00	0.95	0.99	0.50	0.26	0.78	0.91
x_{15}	0.53	1.00	1.00	1.00	0.68	0.87	0.97	1.00	0.95	0.99	0.50	0.26	0.78	0.91
x_{16}	0.53	1.00	1.00	1.00	0.68	0.87	0.97	1.00	0.95	0.99	0.50	0.26	0.78	0.91
x_{17}	0.46	0.68	0.68	0.68	1.00	0.62	0.67	0.68	0.65	0.67	0.31	0.31	0.61	0.65
x_{19}	0.63	0.87	0.87	0.87	0.62	1.00	0.91	0.87	0.86	0.88	0.45	0.20	0.67	0.91
x_{20}	0.56	0.97	0.97	0.97	0.67	0.91	1.00	0.97	0.94	0.98	0.48	0.25	0.77	0.92
x_{21}	0.53	1.00	1.00	1.00	0.68	0.87	0.97	1.00	0.95	0.99	0.50	0.26	0.78	0.91
x_{22}	0.50	0.95	0.95	0.95	0.65	0.86	0.94	0.95	1.00	0.96	0.48	0.23	0.79	0.87
x_{23}	0.54	0.99	0.99	0.99	0.67	0.88	0.98	0.99	0.96	1.00	0.48	0.25	0.79	0.92
x_{24}	0.21	0.50	0.50	0.50	0.31	0.45	0.48	0.50	0.48	0.48	1.00	0.01	0.53	0.48
x_{25}	0.21	0.26	0.26	0.26	0.31	0.20	0.25	0.26	0.23	0.25	0.01	1.00	0.32	0.17
x_{26}	0.33	0.78	0.78	0.78	0.61	0.67	0.77	0.78	0.79	0.79	0.53	0.32	1.00	0.73
x_{27}	0.58	0.91	0.91	0.91	0.65	0.91	0.92	0.91	0.87	0.92	0.48	0.17	0.73	1.00

Based on the above correlation matrix, this paper finally retains employment, GDP venture capital intensity, labor dispute mediation rate, and patent administration closure rate as indicators of exogenous opportunities.

Combining the results of the above dimensionality reduction, the explanatory and explanatory variables after removing the covariates are as follows.

Table 4. Indicator system after screening indicators

Explained variables		Explanatory variables		
y_1	Net Profit	Internal vibrancy	x_1	Capital Intensity
			x_2	Cash Ratio
y_2	Revenue from main business		x_3	Inventory
			x_4	Accounts Receivable
y_3	Number of employees		x_5	Inventory turnover rate
			x_6	Return on Assets
y_4	Total assets growth rate		x_7	Gearing ratio
		Exogenous Opportunities	x_8	Employment
y_5	Growth rate of main business revenue		x_9	Gross Domestic Product
			x_{10}	Venture Capital Intensity
y_6	Profit growth rate		x_{11}	Labor dispute mediation rate
			x_{12}	Patent Administration Case Closure Rate

5.3 ANN-MLP algorithm construction

In this paper, based on SPSS, 12 explanatory variables such as endogenous causes and exogenous opportunities are used as input layers and six explanatory variables are used as output layers for ANN-

MLP training. After adjusting the parameters manually and by software, it is found that when the hidden layer is one layer, the number of hidden layer units is 9, and the activation functions of both hidden layer and output layer are hyperbolic tangent. When the scalar conjugate gradient method is used in the optimization algorithm, the minimum error sum of squares is obtained. The mean squared error MSE and the coefficient of determination R2 for each explanatory variable are shown in Figure 3.

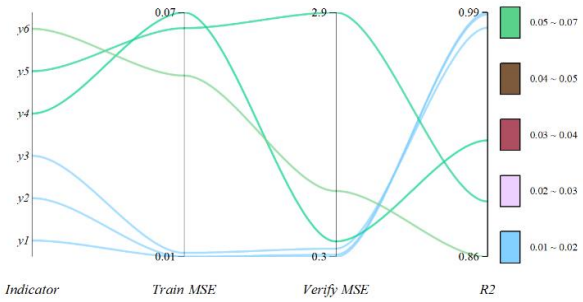

Figure 3. Sample line diagram of progress

From Figure 3, the MSEs of y_1, y_2 and y_3 are relatively small, and the R2 is relatively large and very close to 1. This indicates that the explanatory variables have a stronger explanatory power for the three explanatory variables of net profit, main business income, and the number of employees than for the growth rate of total assets, main business income and profit. The maximum training MSE of these six explanatory variables is 0.07, and the minimum R^2 is 0.86, so the explanatory variables have a strong overall explanatory power for all the explanatory variables.

5.4 Contribution Analysis

After the analysis of the artificial neural network model, the contribution of each explanatory variable indicator was derived as shown in Figure 4.

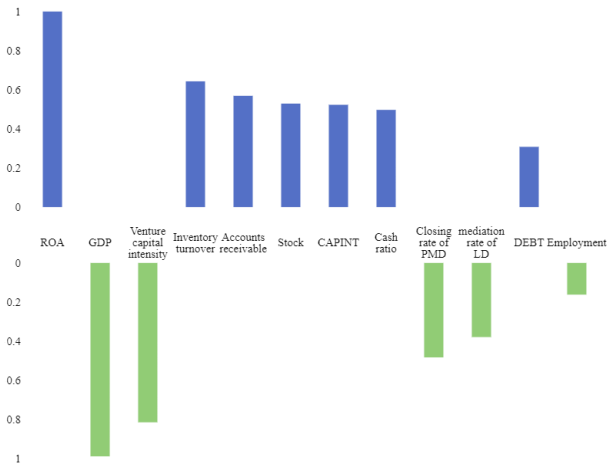

Figure 4. Graph of the contribution of each variable index

Through Figure 4, it can be found that factors such as return on assets (1.000), GDP (0.989), venture capital intensity (0.815) and inventory turnover (0.643) have a relatively large impact on firm growth; In contrast, indicators such as employment (0.162), the gearing ratio (0.308) and labor dispute mediation rate (0.379) are smaller.

From the results of the contribution measure derived from this empirical modeling, it is clear that the return on assets of a firm and the GDP of the country as a whole have an exceptionally high impact on the growth of a firm itself. Return on assets represents the ratio of net profit to the total average assets of a company. The higher the indicator, the more profitable the company is, and the growth of

a company is essentially the steady growth of its profit, so the return on assets can reflect the growth of a company to a great extent. A high GDP indicates that the country's overall economy is in good shape, and the company's growth will be better under a good macroeconomic environment.

Employment reflects the total number of people employed in the country as a whole, which is really of little relevance for a given company and therefore has the lowest contribution to the company's growth. If the growth of profits is greater than the growth of gearing, it will bring positive benefits to the company, and if not, it will be detrimental to the company. Therefore, it is impossible to judge a company's growth by looking at the gearing ratio alone, which is the reason for its low contribution.

6. Conclusion

For a company, the most important thing is the growth of the company itself, because the growth of the company often means that it can bring greater market share and more income to the owners. Meanwhile, it also improves the company's position in the industry. Based on the ANN-MLP model, this paper tries to study the factors that affect the company's growth. This paper also conducts an empirical study based on the Guizhou Maotai Group. Through the empirical study, this paper draws the following conclusions.

(1) Return on assets and GDP have the greatest impact on firm growth. In other words, the profitability of a company and the prosperity of the country's overall economy can, to a large extent, positively influence the growth of a company.

(2) Employment and gearing have a relatively small impact on firm growth.

(3) Generally speaking, the endogenous causes of a company itself contribute more to its growth than the exogenous causes of the whole social environment, which means that the better growth of a company depends on its ability.

Based on the above conclusions, this paper provides the following suggestions and policy references for enterprises and governments on improving the growth ability of enterprises.

(a) For enterprises themselves, to improve their growth capacity, they need to improve their profitability, represented by return on assets, because they can have more capital to expand their production capacity and thus gain more income after their profitability is improved.

(b) The government should formulate appropriate policies to guide the country's economy and the GDP to grow steadily and consistently.

7. Authors' contributions

Haozhe Sun: Data Curation, Software.
Yanshan Li: Investigation, Writing-Reviewing and Editing.
Xu Tang: Methodology, Validation

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