New quality productivity enables the development of artificial intelligence enterprises -- taking Alibaba as an example

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ABSTRACT

New quality productivity is a kind of innovative and advanced productivity covering new fields and new technologies. A manufacturing enterprise hopes to improve the market competitiveness by introducing new quality productivity technology. Through the construction of mathematical model and the analysis of market economy, this paper provides the basis of technology selection decision and production plan formulation, and carries out risk assessment and risk management for enterprises, so as to help enterprises achieve long-term and high-quality development.

In order to comprehensively evaluate the impact of new technologies on enterprise production, we selected four indicators of production efficiency, product quality and cost saving as measures. Given that the selection and evaluation of new technologies is a multi-scheme and multi-criterion decision problem, and it is difficult to directly quantify and compare each evaluation index, hierarchical analysis is used to design the evaluation scheme. By establishing the hierarchical structure model, constructing the judgment matrix and testing the consistency of the matrix, using the *MATLAB* calculation, the total weight of each new quality productivity technology is obtained. Among them, the total weight of artificial intelligence technology is 0.2662, ranking the first place, providing a strong basis for enterprises to make decisions.

Considering that the application of new technology should bring better production benefits, benefits and technological innovation to enterprises, the rate of scientific and technological progress, capital output, labor output and other indicators are introduced to judge the expected effect of the application of new technology. Combined with the results of market research, this paper analyzes the challenges that enterprises may face, such as the sharp rise in cost and the difficulties in market investment. For the specific application of artificial intelligence technology, considering the combination of science and technology with labor and capital, this paper selects the Cobb-Douglas production function to determine the contribution of scientific and technological progress, capital growth and labor growth to the output growth.

In terms of risk assessment, this paper focuses on the risks of the introduction of artificial intelligence technology, such as increased R & D investment and management expenses. Due to the great uncertainty in the risk assessment, and the artificial intelligence is in the initial stage, the available sample data is limited, so the grey association analysis method is used to build the risk assessment model, determine the analysis sequence, and calculate the correlation degree of each risk factor. The results showed that the correlation degree of R & D investment risk, administrative expense risk, fixed asset risk and market risk were 0.7717,0.5084,0.715 and 0.5411, respectively. This provides a basis for enterprises to develop targeted risk management strategies.

Make a long-term technology update and business development plan for the rapid development of new quality productivity technology and the change of industry competitive environment. Considering the limited operating cost of an enterprise, it is necessary to maximize the return on investment under the limited cost, the multi-objective optimization model is adopted to provide decision support for enterprise planning business development. By setting goals for the allocation optimization of technology iteration, market expansion and product innovation investment, the objective function and multi-objective optimization model are established, and then the target approximation method is used to solve them. The reform scheme helps enterprises to adjust the cost allocation scheme in real time according to the dynamic changes of the market and technology, so as to achieve higher investment benefits.

Keywords: Hierarchical Analysis, Cobb-Douglas Production Function, Gray Correlation Analysis, Multi-Objective Optimization Model

1 RESTATEMENT OF THE PROBLEM

1.1 The problem background

In the digital era with the rapid development of information technology, the new quality productive forces, with scientific and technological innovation as the engine, have got rid of the traditional growth path and become an important driving force for the high-quality development of China's economy. New-quality productivity technologies, such as artificial intelligence, blockchain, cloud computing, and intelligent manufacturing, have been widely used in various production fields to promote technological progress, optimize resource allocation, bring about significant improvements in total factor productivity, and are closely linked to the demand for high-quality development.

Therefore, on the new journey of the new era, the key to liberating and developing productive forces is to speed up the formation of new quality productive forces. Accelerating the formation of new quality productive forces is not only an important way for China to break through the dilemma of low end and low end of the value chain and realize the rise of the global value chain, but also can promote the deepening of the domestic value chain and realize the positive interaction between the global value chain and the domestic value chain.

At present, the academic research on new productive forces is still in the exploratory stage, and the existing research mainly focuses on the theoretical logic, connotation characteristics and value significance of new productive forces, as well as the theoretical elaboration around Marx's classical theory, Lack of its actual quantitative research on enterprise productivity, so this paper through the solution of four problems, build different models to solve, put forward the optimization scheme.

1.2 Problem is put forward

In order to cope with market challenges and enhance competitiveness, a manufacturing enterprise plans to introduce new quality productivity, so as to expand market share, enhance industrial position and achieve sustainable growth.

Based on the above background, this paper builds a mathematical model to solve the following core problems:

Question 1: Design the evaluation scheme to evaluate the impact of different new quality productivity technologies on enterprise production efficiency, product quality, cost saving and market competitiveness. Based on the evaluation results, we choose to invest and apply a technology, in order to improve the output of the enterprise, product quality, and occupy the dominant position in the market.

Question 2: Design the production scheme, integrate the selected new technology with the existing production system of the enterprise, clarify the specific steps, expected effects and possible challenges of the technology application, and put forward the optimization scheme to ensure that the advantages of the new technology can be given full play.

Question 3: Judge the risks that may be encountered in the introduction of new technologies, including technology, market, management and other aspects, build risk assessment models, and develop risk management strategies to reduce the possibility of risk occurrence and losses caused.

Question 4: Develop a long-term technology update and business development plan for enterprises to ensure that enterprises can keep up with the development pace of new quality productivity technology and flexibly respond to the constant changes in the industry environment.

2 PROBLEM ANALYSIS

2.1 Analysis of question 1

The new technology of manufacturing enterprises should cover three aspects: digitalization, greening and technology, so as to improve productivity and achieve sustainable development. Technological innovation and organizational innovation play a key role in improving the production efficiency and competitiveness of enterprises and promoting economic transformation and upgrading [1]. Through searching for information and collecting data, the new quality productivity technologies introduced by manufacturing enterprises mainly include the following five kinds:

(1) Big data analysis
(2) artificial intelligence
(3) Internet of Things
(4) Blockchain
(5) Cloud computing

At the same time, in order to evaluate the benefit of new quality productivity to enterprises, the new quality productivity technology is measured by four indicators of production efficiency, product quality, cost saving and market competitiveness.

Thus, to evaluate the influence of different new quality productivity technology on the enterprise production, is a scheme, more criterion decision problem, at the same time due to the evaluation index is difficult to quantify comparison, and choose to use hierarchical analysis of the new technology of enterprise production evaluation design, thus the practical evaluation of the new quality productivity technology [2].

2.2 Analysis of question two

According to question 2, it is required to design the production plan after the integration of the new technology with the existing production system of the enterprise, including the specific steps of technology application, expected effects and possible challenges. For the design of production scheme, the advantages of new technology should be applied to production.

We conducted market research on possible challenges. The results show that in the process of introducing new technologies, the sharp cost rise is the primary problem, including the cost of capital and human costs. The increase of capital cost mainly comes from the investment and maintenance cost of high-tech equipment, while the labor cost mainly depends on the cultivation and attraction of high-quality talents and the continuous development and innovation of technology. In addition, the challenge may lie in the market investment stage, and the uncertain factors in the market such as the rapid change of consumer demand lead to the failure of enterprises to adjust the production mode in time.

For the expected effect, we take into account that the application of new technologies should bring better profit effect to the enterprise, so we introduce the elasticity coefficient of capital growth and capital growth to express the income status of enterprises. Secondly, new technologies need to improve the production quality and production efficiency of enterprises. In this regard, we introduce two indicators: labor output elasticity coefficient and the contribution rate of labor growth to output growth [3]. Finally, the application of new technologies can bring technological progress to enterprises, enable them to open up new fields and new tracks, and shape new drivers and new advantages of industrial development. We introduce the scientific and technological progress rate as the index of enterprise innovation and development.

Based on the results of question 1, we believe that artificial intelligence is the new quality productivity technology that is most conducive to the development of enterprises, so we choose to analyze the impact of its application process on enterprise production.

Because Cobb-Douglas production function is mainly used to determine the amount of production process of capital input and labor input influence on output, is a can say how technology and labor and capital production function, can reflect the relationship between the three and production: scientific and technological progress, capital growth, labor growth contribution rate of output growth [4].

We use the relevant knowledge of finance to collect the financial statement data of Alibaba, a representative enterprise —— in the field of artificial intelligence, Non-current assets represent the amount of capital, the number of employees represents the number of labor force, and operating income represents the amount of output, as shown in Table 1.

Table 1: Data diagram of output, capital and labor in financial statements

Year	Output-input ratio		Capital input		Labor input	
	Increase (100 Million)	Output growth rate	The amount of capital(100 million yuan)	Capital growth rate	The number of workers (Thousand people)	Employee growth rate
2015	249.3900	0.3273	2303.8000	1.0329	34.9850	0.5850
2016	571.3000	0.5648	3242.9600	0.4077	36.4460	0.0418
2017	919.9300	0.5812	4602.6900	0.4193	50.0970	0.3746
2018	1265.7800	0.5058	6948.0300	0.5096	66.4210	0.3258
2019	1328.6700	0.3526	8500.6200	0.2235	101.9580	0.5350
2020	2075.7800	0.4072	10468.5800	0.2315	117.6000	0.1534
2021	1357.7300	0.1893	10570.1800	0.0097	251.4620	1.1383
2022	156.2500	0.0183	10550.7800	-0.0018	254.9410	0.0138

Based on the above analysis, we established the Cobb-Douglas function model, using the data of corporate financial statements to evaluate the impact of scientific and technological progress, capital growth and labor growth on production growth, and gave specific optimization plans for different results.

2.3 Analysis of problem three

In question 3, it is necessary to discuss the selected new technologies, namely, the risks encountered in the process of introducing artificial intelligence technology. By reviewing the literature, the possible risks of introducing artificial intelligence technology mainly include:

(1) R & D investment risk

(2) Increase the risk of administrative costs

(3) Increased risk of fixed assets such as equipment

(4) Market risk

In view of the above risk, in order to ensure that the artificial intelligence technology can truly for enterprise development, must evaluate the risks faced, and due to the artificial intelligence in the initial stage, can use sample data is less, at the same time, there are many unexpected problems for risk assessment, there are great uncertainty, using grey correlation analysis, build risk assessment model, with the enterprise production efficiency as the reference sequence, the main comparison for the risk sequence, the risk assessment, so as to be targeted to put forward a set of production process optimization scheme.

2.4 Analysis of question four

In question 4, we need for the rapid development of new quality productivity technology and the change of industry competition environment to specify a long-term technology update and business development planning, covering various planning, considering the enterprise operating cost is limited, in the limited operating costs, reasonable allocation of capital investment makes enterprise benefit maximization, must be targeted investment, in order to solve the problem, choose to use multi-target optimization model, the technology iteration, market expansion, product innovation three aspects [4]. Find solutions to maximize benefits with limited investment to plan for business development.

3 MODEL HYPOTHESIS

The source of the scores in the judgment matrix in Problem 1 is assumed to be authoritative.

Suppose that the scale reward in problem 2 is unchanged.

Assume that problem 3 focuses on major risks and ignores other unpredictable situations.

Suppose that the various parameters of problem 4 conform to the market law.

4 SYMBOL DESCRIPTION

Symbol	Explain	Unit
C_i	Each criterion	-
P_i	Each new quality productivity technology	-
O	Target layer	-
$\lambda_{\max}$	The biggest characteristic root	-
CI	Degree of inconsistency index	-
RI	Random consistency index	-
CR	Test coefficient	-
Q_i	Weight	-
Y	Output growth rate	-
a	Science and technology progress rate	-
β_1	The elasticity coefficient of capital output	-
L	Labor growth rate	%

β_2	The elasticity coefficient of labor output	-
α_1	The contribution rate of scientific and technological growth to output growth	%
α_2	The contribution rate of capital growth to output growth	%
α_3	The contribution rate of labor growth to output growth	%
r_1	Correlation degree	-
γ	Market growth factor	-
η	Innovation index	-
ρ	Market risk	-
τ	Technological progress factor	-
z	Competitor influence coefficient	-
λ	Product life cycle	
σ	Customer satisfaction	-
ε	Economic environment variables	-

5 MODEL BUILDING AND SOLUTION

5.1 Establishment and solution of the problem 1 model

5.1.1 Establish a hierarchical structure model

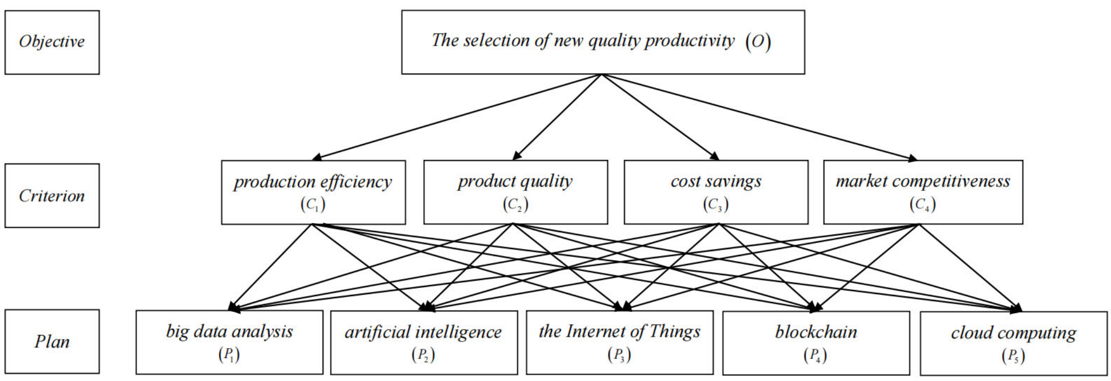

Fig.1: A Structural hierarchy model

5.1.2 Construct a judgment (pairwise comparison) matrix

When comparing the importance of the i element with the j factor in the previous layer, the quantitative relative weight a_{ij} is used to describe the value. If there are n elements participate in the comparison, $A = (a_{ij})$ becomes a pairwise comparison matrix. Reference to the proposal of Satty and assign values according to the scale of Table 2.

Table 2: Importance levels and their assignments

Scale	Meaning
1	Compared to the two elements, the former is slightly more important than the latter
3	Compared to the two elements, the former is significantly more important than the latter
5	Compared to the two elements, the former is significantly more important than the latter

7	Compared with the two elements, the former is extremely important than the latter
9	Two elements are compared to the former being more strongly important than the latter
2,4,6,8	The median of the judgment adjacent as described above

To construct the judgment matrix for the scheme layer and the criterion layer, see Table 3, Table 4, Table 5, Table 6 and Table 7

Table 3: The criterion layer judgment matrix

O	C_1	C_2	C_3	C_4
C_1	1.0000	1.5000	1.2857	1.8000
C_2	0.7778	1.0000	0.8571	1.2000
C_3	0.7500	1.5000	1.0000	1.4000
C_4	0.4444	1.0000	0.6667	1.0000

Table 4: Judgment Matrix under productivity criteria-Table 5: Judgment matrix under product quality criteria

C_1	P_1	P_2	P_3	P_4	P_5	C_2	P_1	P_2	P_3	P_4	P_5
P_1	1.0000	0.7500	0.8571	1.2000	2.0000	P_1	1.0000	0.7143	0.8333	0.8333	1.0000
P_2	1.5000	1.0000	1.1429	1.6000	2.6667	P_2	2.0000	1.0000	1.1667	1.1667	1.4000
P_3	0.8333	0.5556	1.0000	1.4000	2.3333	P_3	1.0000	0.5000	1.0000	1.0000	1.2000
P_4	1.0000	0.6667	1.0000	1.0000	1.6667	P_4	1.7500	0.8750	1.4000	1.0000	1.2000
P_5	0.6667	0.4444	0.6667	0.6667	1.0000	P_5	1.5000	0.7500	1.2000	0.8571	1.0000

Table 6: Judgment matrix under the cost saving criteria-Table 7: judgment matrix under the market competitiveness criteria

C_3	P_1	P_2	P_3	P_4	P_5	C_4	P_1	P_2	P_3	P_4	P_5
P_1	1.0000	0.6667	1.2000	0.8571	1.0000	P_1	1.0000	0.5556	1.2500	0.7143	0.6250
P_2	1.5000	1.0000	1.8000	1.2857	1.5000	P_2	2.0000	1.0000	2.2500	1.2857	1.1250
P_3	1.0000	0.6667	1.0000	0.7143	0.8333	P_3	1.0000	0.5000	1.0000	0.5714	0.5000
P_4	1.3333	0.8889	1.3333	1.0000	1.1667	P_4	1.7500	0.8750	1.7500	1.0000	0.8750
P_5	1.0000	0.6667	1.0000	0.7500	1.0000	P_5	2.0000	1.0000	2.0000	1.1429	1.0000

5.1.3 consistency check

If the matrix, there should be

$$a_{ij}a_{jk} = a_{ik}, 1 \leq i, j, k \leq n \tag{1}$$

But in fact, restricted by the subjective factors, it is impossible to satisfy the above equation, so the consistency test of the judgment matrix can allow the pairwise comparison matrix to have a certain degree of inconsistency.

The steps to test the consistency of the pairwise comparison matrix are as follows:

For the maximum feature root of the judgment matrix λ_{max}, the index of the degree of inconsistency *CI* is introduced:

$$CI = \frac{\lambda_{max}(A) - n}{n - 1} \tag{2}$$

CI=0, full consistency; *CI* close to 0, satisfactory consistency; *CI* the larger, the worse the inconsistency. To measure the size of *CI*, the stochastic consistency index *RI* is introduced:

$$RI = \frac{CI_1 + CI_2 + \cdots + CI_n}{n} \tag{3}$$

Among them, the stochastic consistency index RI is related to the order of the judgment matrix. Generally, the larger the order of the matrix, the greater the possibility of random deviation of consistency. The corresponding relationship is shown in Table 8:

Table 8: Standard values of mean random consistency indicators RI

order	1	2	3	4	5	6	7
RI	0	0	0.58	0.90	1.12	1.24	1.32

Considering that the deviation of consistency may be caused by random reasons, it is necessary to compare *CI* with the random consistency index *RI* and get the test coefficient *CR* The formula is as follows:

$$CR = \frac{CI}{RI} \tag{4}$$

Generally, if *CR<0.1*, the judgment matrix passes the consistency test, otherwise there is no satisfactory consistency.

5.1.4 The hierarchical total sorting results

Using the MATLAB calculation (see Appendix 1) under the different criteria and the weights of the different criteria, we obtain Table 9:

Table 9: Weighting table of new quality productivity technology evaluation

	weight (Q)	P_1	P_2	P_3	P_4	P_5
C_1	0.3259	0.2031	0.2772	0.2070	0.1892	0.1235
C_2	0.2261	0.1627	0.2462	0.1725	0.2259	0.1926
C_3	0.2697	0.1799	02699	0.1618	0.2196	0.1689
C_4	0.1783	0.1447	0.2659	0.1241	0.2171	0.2482

At the same time, the calculation of each weight is consistently tested, and we obtain Table 10:

Table 10: Results of the consistency judgment

	O	C_1	C_2	C_3	C_4
CI	0.0298	0.0581	0.0764	0.0160	0.0594
CR	0.0035	0.0519	0.0682	0.0143	0.0530

The observation results CR were less than 0.1, indicating that each judgment matrix passed the satisfactory consistency test.

Therefore, the weight evaluation results of each new quality productivity technology can be obtained, and the calculation formula is as follows:

$$Q_{Total} = Q_1 \times P_i + Q_2 \times P_i + Q_3 \times P_i + Q_4 \times P_i \tag{5}$$

From the total weight of the final new productivity technology, see Table 10:

Table 10: Total weight of each new quality productivity technology

	P_1	P_2	P_3	P_4	P_5
Q_{Total}	0.1773	0.2662	0.1722	0.2107	0.1736

According to Table 10, it is concluded that the choice of investment and application of AI technology is the most favorable choice for enterprises

5.2 Establishment and solving of the problem 2 model

5.2.1 The Cobb-Douglas production function

Cobb-inverted Las production function is mainly used to determine the influence of capital input and labor input on output in the production process, and can also determine the contribution rate of scientific and technological progress, capital growth and labor growth to output growth [5]. The Cobb Douglas production function is:

$$Y = ak^{\beta_1}L^{\beta_2} \tag{6}$$

Among them: Y represents the output growth rate, a represents the scientific and technological progress rate, β_1 represents the capital output elasticity coefficient, L represents the labor growth rate, and β_2 represents the labor output elasticity coefficient

5.2.2 The regression estimation method is used to calculate each growth rate and *contribution rate*

Under the assumption that the scale reward is constant ($\beta_1 + \beta_2 = 1$), estimate the parameters a and, β_1 and β_2 then determine the contribution rate of scientific and technological progress, capital growth and labor growth to output growth.

Both garithm for formula 6:

$$lg\frac{y}{K} = lga + \beta_1 lg\frac{K}{L} \tag{7}$$

A linear regression model can be used to estimate the β_1 $1-\beta_1$ β_2, and then to determine the contribution rate of scientific and technological progress and capital growth to output growth.

$$\frac{a}{y} + \frac{\beta_1\bar{K}}{y} + \frac{\beta_2\bar{K}}{y} = 1 \tag{8}$$

From the data in Table 1, $MATLAB$ calculated using formula 8 (see Appendix 2), see Table 11:

Table 11: Growth rates and contribution rates

a	β_1	β_2	α_1	α_2	α_3
0.3180	0.2603	-0.1056	67.2851	55.0672	-22.3523

a_1 is the contribution rate of scientific and technological progress to output growth, a_2 is capital growth to output growth, and a_3 is labor growth to output growth.

According to the results, technology has the largest contribution to output growth, reaching 67.2851%; capital to output growth contributed 55.0672%, ranking second; finally, the largest contribution to output growth, which showed negative value in the study. This represents an unscientific and potentially counterproductive practice of blindly using labor growth to boost output growth [6]. Therefore, enterprises that choose ai development should focus their resources on science and technology investment, followed by capital, so as to achieve the purpose of promoting the production and development of enterprises.

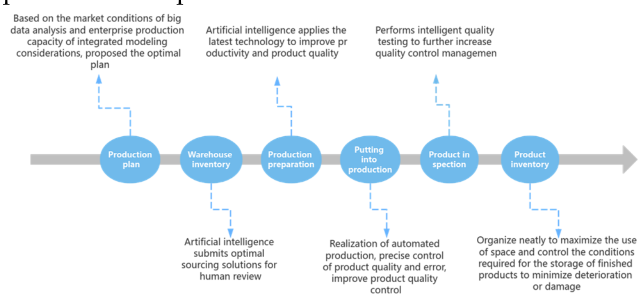

Fig.3: Technical application and production flow chart

Therefore, the integration of AI into the existing production system, including the specific steps of technology application and the specific process of the expected effect, can be seen from Figure 3. From the production plan, AI can analyze the market conditions, comprehensively model the production capacity of enterprises, and put forward the optimal solution. The next step is to purchase warehouse materials, that is, in terms of production raw materials, AI can submit the optimal procurement plan to relevant procurement personnel for reference and review. After the purchase, AI can apply the latest technology to improve production efficiency and product quality. In the process of production and production, to achieve automatic production, accurate control of product quality and error, improve the quality control of products [7]. In the process of product inspection, intelligent quality testing can be carried out to further increase the quality control management. Finally, in the product storage, artificial intelligence can maximize the use of space, control the conditions required for finished product storage, and reduce damage or deterioration. It can be seen that technology can be applied to the specific production process and plays a great role in promoting production development, so we can conclude that it is feasible and effective to use artificial intelligence to promote the production development of enterprises. However, there may still be challenges in the application process: AI may have a series of problems such as leaking corporate trade secrets and algorithm bias, so we still need to continue to improve it, meet these challenges with our wisdom, and finally use it to promote enterprise production development.

5.3 The establishment and solution of problem three model

5.3.1 The analysis sequences were determined

$Z = \{Z(k) | k = 1,2,\ldots,n\}$ Set the production efficiency of reference sequence as, compare the risk of r & D investment, increased risk of management cost, equipment and other fixed assets, and increased risk of market risk $H_i = \{H_i(k) | k = 1,2,\ldots,n\}$, Got the Table 12:

Table 12: Expenses and their risks

A give n year	produce producti veness	do business prime cost (100 million)	do business income (100 million)	research and develop ment cost (100 million)	R & D investm ent risk	adminis tration cost (100 million)	Manage ment expense risk	fixed propert y (100 million)	Fixed asset risk	MARKE TING cost (100 million)	market house risk
2022	0.6327	5496.9	8686.87	567.44	0.1032	421.83	0.0767	176.031	0.3202	103.496	0.1882
2021	0.62323	5394.5	8530.62	554.65	0.1028	319.22	0.059	171.806	0.3184	119.799	0.2220
2020	0.5872	4212 . 0	7172.89	572.36	0.1358	552.24	0.131	147.412	0.3499	81.519	0.1935
2019	0.5539	2823.6	5097.11	430.80	0.1525	281.9	0.0998	103.387	0.3661	50.673	0.1794
2018	0.5491	2069 . 2	3768.44	374.35	0.1809	248.8	0.1207	92.030	0.4447	39.780	0.1922
2017	0.4277	1070 . 4	2502.66	227.54	0.2120	162.41	0.1517	66.489	0.6211	27.29	0.2550
2016	0.3758	594.83	1582.73	170.60	0.2860	122.39	0.205	20.206	0.3396	16.314	0.2742
2015	0.3396	343 . 55	1011.43	137.88	0.4013	92.00	0.2679	13.629	0.3967	11.307	0.3291
2014	0.3127	238 . 34	762.04	106.58	0.4470	78.00	0.3272	9.139	0.3834	8.513	0.3571

Among them, the production efficiency is η, operating cost is σ, operating income is ω, the calculation formula of production efficiency is

$$\eta = \frac{\sigma}{\omega} \tag{9}$$

Remember each item, the cost is F_1, then the risk calculation formula is

$$H_i = \frac{F_i}{\sigma} \tag{10}$$

5.3.2 Nondimensionalization of the variables

Because of the different data dimensions, it is not convenient for comparison, so it needs to be dimensionless

$$h_i(k) = \frac{H_i(k)}{H_i(L)}, k = 1,2 \dots, n; i = 1,2, \dots, m \tag{11}$$

5.3.3 Calculate the correlation degree

Solve the correlation degree r_i , and sort it out with the following formula:

$$\xi_i(k) = \frac{\min_i \min_k |Z_i(k) - h_i(k)| + \rho \max_i \max_k |Z_i(k) - h_i(k)|}{|Z_i(k) - h_i(k)| + \rho \max_i \max_k |Z_i(k) - h_i(k)|} \tag{12}$$

ρ is the correlation coefficient, and generally it is taken as 0.5.

Then the calculation formula of the correlation degree is:

$$r_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k), k = 1,2, \dots, n \tag{13}$$

Using *MATLAB* calculations (see Appendix 3), the results are shown in Table 13:

Table 13: Correlation degree of each risk

Various risks	R & D investment risk	Management expense risk	Fixed asset risk	Market risk
Correlation degree	0.7717	0.5084	0.7165	0.5411

From the above results, the *MATLAB* calculation results show that:

(1) Technology iteration: Enterprises need to improve the research & development system, establish the technology reserve system, improve the research & development ability of technology iteration, aim at the pain points, and accurately invest funds. If the final technology iteration should be the most investment, the enterprise can increase the investment in research and development, such as hiring high-tech talents to carry out relevant research, using the development of artificial intelligence to apply the latest technology to the actual production of the enterprise, to improve the production efficiency and production quality of the enterprise [8].

(2) Market expansion: Enterprises first do market research, understand the target market size, competitors, consumer preferences, etc.; then do product positioning, determine the core competitive advantages and unique products, clear the advantages of attracting consumers and the direction of market development. If the final market expansion should be the most investment, we can expand the channel construction, establish appropriate sales channels and partners, and choose the channels such as cooperation with dealers, opening offline stores, expanding e-commerce platforms, so that the products can be sold more widely [9].

(3) Product innovation: enterprises need to build an open innovation ecosystem and accelerate its formation. Through open source and openness, enterprises can attract more developers, partners and customers to participate in the design and development of products, and jointly create a benign ecosystem. If the final product innovation should be invested the most, the enterprise needs to increase the investment in product analysis, expand the market data research and analysis, improve and optimize the product, so that the product is more in line with the market demand and consumer

needs, in order to win the favor of customers.

For the above risks, corresponding risk management strategies are formulated, as shown in Figure 4:

(1) R & D investment: Enterprises need to strengthen R & D project management, improve r & d related management system; strengthen inter-departmental work coordination mechanism, strengthen project control, and make a good project budget.

(2) Administrative expenses: enterprises need to adjust the management structure, reduce cumbersome procedures, and streamline the work procedures.

(3) Equipment and other fixed assets: enterprises need to strengthen the planning and management of fixed assets, improve the level of equipment update and maintenance; promote the information construction, improve the level of information system construction and management level, and strengthen the asset management mechanism [10].

(4) Market risk: enterprises need to streamline marketing and choose the most efficient marketing plan.

This is the basic scheme for these four risks to be achieved, but more prominent risks can be found in the study, so different schemes can be increased according to different prominent risks:

(1) If the enterprise R & D risk is the highest: it is necessary to strengthen the construction of enterprise informatization and improve the accuracy of R & D accounting.

(2) If the administrative cost increases, the risk is the highest: the enterprise needs to use professional technology to maintain the artificial intelligence system, improve the technical level, and avoid invalid expenditure.

(3) If fixed assets such as equipment increase the highest risk: it is necessary to enhance personnel awareness and ability of fixed assets management, strengthen the publicity and education of fixed assets management, enhance the awareness and responsibility of all participation in fixed assets management; and add additional performance appraisal mechanism to incorporate fixed assets management into performance appraisal.

(4) If the market risk is the highest: it requires enterprises to apply additional artificial intelligence to process data, analyze the past and predict the future trend, reasonable sales, reduce inventory accumulation and unnecessary marketing expenses, manufacturing expenses and storage expenses.

R&d investment risk

R&d investment: enterprises need to strengthen the management of R&D projects and improve the management system related to R&D; Strengthen the inter-departmental work coordination mechanism, strengthen project control, and do a good job in project budget

If the final R&D investment risk is the greatest, it is necessary to strengthen the enterprise information construction and improve the accuracy of R&D accounting; We will improve tax incentives for R&D investment

Administrative costs increase the risk

Management costs: enterprises need to streamline the administrative structure, simplify procedures, and reduce cumbersome conditions

If the final management cost is the most at risk: it is necessary for enterprises to use professional technology to maintain the artificial intelligence system, improve the technical level, and avoid ineffective expenditure.

Fixed assets such as equipment are at increased risk

Equipment and other fixed assets: enterprises need to strengthen the planning and management of fixed assets, improve the level of equipment update and maintenance; promote information construction, improve the level of information system construction and management; and strengthen the asset management mechanism

If this risk is the greatest in the end, it is necessary to increase the performance appraisal mechanism and include the management of fixed assets in the performance appraisal.

Market risk

Market risk: enterprises need to streamline marketing and choose the most efficient marketing scheme

If in the end, the risk is the biggest: enterprises need to apply artificial intelligence to process data, analyze the past and predict the future trend, and sell reasonably, and reduce inventory accumulation and unnecessary marketing expenses, manufacturing expenses and storage expenses.

Fig.4: Risk management strategy

5.4 Establishment and solution of the problem four model

5.4.1 Determine the decision objective and establish the objective function

The goal of decision-making is to provide business development planning for enterprises, so that enterprises can optimize the investment distribution in technology iteration, market expansion and product innovation at a limited cost, and obtain the maximum benefits.

By collecting data, the objective function is established

Establishment of the investment return function for the cost of market size expansion:

$$f_1(x) = -x_1 \cdot log(x_2) \cdot \gamma \cdot e^{-\rho \cdot \lambda} \cdot \eta \quad (14)$$

Among them, γ corresponds to market growth factor, λ to supply chain efficiency, η to supply chain efficiency, and ρ to market risk

The ROI function establishment of the technology iteration cost:

$$f_2(x) = -x_2 \cdot log(x_3) \cdot \tau \cdot (1 - z) \cdot \Phi \quad (15)$$

Among them, τ corresponds to the technological progress factor, z to the competitor influence coefficient, and Φ to the production efficiency

The ROI function of product innovation cost is established:

$$f_3(x) = -x_3 \cdot log(x_1) \cdot \iota \cdot \sigma \cdot \varepsilon \cdot \alpha \quad (16)$$

Among them, σ corresponds to customer satisfaction, ε to economic environment variables, ι to innovation index, and α to market prediction accuracy

In order to calculate the model and make reasonable assumptions about various parameters, see Table 14:

Table 14 Sets the parameters

γ	τ	ι	ρ	η	σ	ε	η	Φ	α
1.05	1.10	1.20	0.03	5.00	0.90	0.95	0.90	0.85	0.90

5.4.2 Determine the deviation amount

Since the model solution and data introduction, the objective function value will always have some bias, so positive and negative deviations are added. The weight represents the tolerance of the decision maker to the deviation, which can be expressed as:

$$min \sum_i (w_i^+ d_i^+ + w_i^- d_i^-) \quad (17)$$

$$s.t. f_i(x) + d_i^+ - d_i^- = g_i \forall_i \quad (18)$$

$$d_i^+, d_i^- \geq 0, \forall_i \quad (19)$$

ω_i^+ and ω_i^- is the weights associated with both positive and negative bias

5.4.3 A multi-objective optimization model is established by using objective approximation method

The formula of the target approximation method can be expressed as follows:

$$L(f(x), f^0) = \|f(x) - f^0\|_2^\lambda = \sum_{k=1}^{K} \lambda_k \, (f_k(x) - f_k^0)^2, \lambda \in \Lambda^{++} \quad (20)$$

Among them, $f(x)$ is the objective function vector x under the decision variable, f^0 is the objective value vector under the decision variable, λ is the weight vector, and meets $\lambda_k > 0$ and $\sum_{k=1}^{K} \lambda_k = 1$. The purpose of the target approximation method is to make each objective function $f_k(x)$ approximate the corresponding target value f_k^0 as much as possible.

5.4.4 Solving for the multi-objective optimization model

Taking the total cost of RMB 1 million as an example, use the matlab is calculated (see Appendix 4) to obtain the following results, see Table 15:

Table 15: Calculation results of target approximation method

Total cost of instance	Market expansion costs	Technology iteration cost	Product innovation cost	return of investment
one million yuan	six hundred and eighty-eight thousand, nine hundred yuan	73,600 yuan	two hundred and thirty-seven thousand, five hundred yuan	three million, four hundred and forty-seven thousand, three hundred yuan

The optimization process of the model is shown in Figure 4:

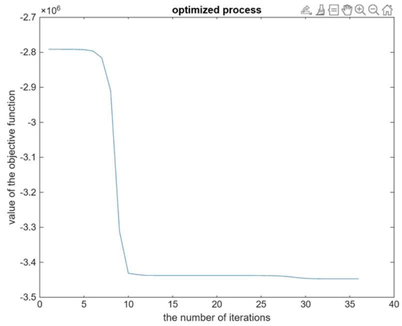

Fig.4: Optimization process of the model

The resulting optimal cost allocation is shown in Figure 5:

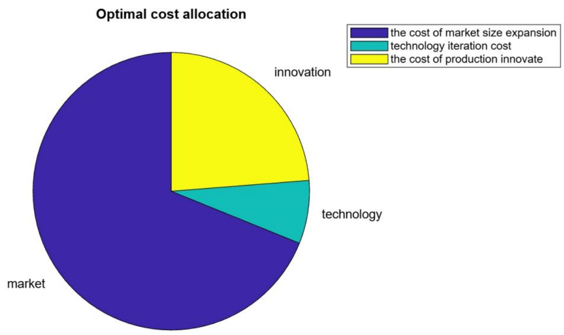

Fig.5: A. Optimal cost allocation

To sum up, if the total cost of 1 million yuan is taken as an example, the optimal distribution result of the technology update and business development planning of the enterprise is: the market scale expansion cost is 688,900 yuan, the cost of technology iteration is 73,600 yuan, the cost of product innovation is 237,500 yuan, and the available investment return is 3,447,300 yuan.

Therefore, by using this model, enterprises can change the cost allocation scheme in real time according to the dynamic changes of the market and technology to obtain a higher return on investment, so that the enterprise technology update and business development planning can respond dynamically, and realize the sustainable development of enterprises.

6 TEST OF THE MODEL

6.1 Significance test and F-value test of Cobb-Douglas production function

Total sum of squares represents the sum of squares of the deviation of all data points from the population mean, calculated by the formula:

$$SST = \sum (y_i - \bar{y})^2 \tag{21}$$

The sum of squares represents the sum of squares explained by the regression line:

$$SSR = \sum (\hat{y}_i - \bar{y})^2 \tag{22}$$

The sum of error represents the sum of squares of the deviation between the observed and predicted values:

$$SSE = \sum (y_i - \hat{y}_i)^2 \tag{23}$$

The mean square error is the sum of error divided by the degree of freedom, the calculation formula is:

$$MSE = \frac{SSE}{n-k-1} \tag{24}$$

The mean square regression is the sum of squares divided by its degree of freedom (number of predicted variables) using the formula:

$$MSR = \frac{SSR}{k} \tag{25}$$

F The statistic is the ratio of mean square regression and mean square error, and the calculation formula is:

$$F = \frac{MSR}{MSE} \tag{26}$$

p is the probability that the observed statistic F or more extreme value will occur if the null hypothesis is true. It is calculated by the F cumulative distribution function of the distribution as follows:

$$p = P(F > F_{observed}) \tag{27}$$

Calculated using the formula (see Appendix 2):

$F_{statistic} = 7.8122$, $p = 0.0289$

The significance level is typically set at 0.05, meaning that there is a 5% probability of rejecting a truly correct null hypothesis. The model's p value of 0.0289 is less than 0.05, indicating the probability of an observed F statistic or more extreme value being 0.0289 if the null hypothesis (no predictor variable in the model has on the response variable) is true.

The model has a molecular degree of freedom of 2 and a denominator degree of 5. In this case, the F-cut-off at a significance level of 0.05 can usually be obtained by consulting the F distribution cutoff of about 5.791, while the F-value of 7.8122 is greater than the distribution cutoff.

In summary, since the F statistic is larger than the critical value and the P-value is smaller than the significance level, the model can be considered statistically significant. This means that the predictor variables in the model do provide useful information about the response variables.

6.2 Sensitivity analysis of multiple-objective optimization models

Set p to parameter, p_0 is its reference value, Δp is the range of parameter change. Sensitivity analysis is designed to assess the impact p on total costs C .

Values after parameter change: Values p after increasing and decreasing parameter change are respectively:

$$p_+ = p_0(1 + \Delta p) \tag{28}$$

$$p_- = p_0(1 - \Delta p) \tag{29}$$

Change of the objective function: set $f(p)$ as the objective function, it changes with the change of parameters. p The variation in the objective function can be expressed as $f(p_+)$ and $f(p_-)$.

Sensitivity coefficient: The sensitivity coefficient S_p represents the degree of influence of the parameter p on the objective function $f(p)$. It can be calculated by the p partial derivative of the objective function with respect to the parameter:

$$S_p = \frac{\partial f(p)}{\partial p} \tag{30}$$

Change in total cost: The change in total cost C can be estimated by sensitivity coefficient S_p and parameter change Δp:

$$\Delta C = S_p \cdot \Delta p \tag{31}$$

Use *MATLAB* take the data into the formula (see Appendix 5) to analyze the parameter variation range $\pm 10\%$, see Table 16:

Table 16: Results of the sensitivity analysis for the variation range of the parameters

Parameter	Increase the change (RMB 100,000)	Base line value	Reduce change (RMB 100 thousand)
Market growth factor	3.7594	−1.0500	3.2736
Technological progress factor	3.4524	−1.1000	3.4422
Innovation index	3.6107	−1.2000	3.4216
Market risk	3.4123	−0.0300	3.4878
Product life cycle	3.4123	−5.0000	3.4878
Competitor influence coefficient	3.4279	−0.8000	3.4688
Customer satisfaction	3.6107	−0.9000	3.4216
Economic environment variables	3.6107	−0.9500	3.4216
Supply chain efficiency	3.7594	−0.9000	3.2736
Production efficiency	3.4524	−0.8500	3.4422
Market forecast accuracy	3,6107	−0.9000	3.4216

Plot the results as shown in Figure 6:

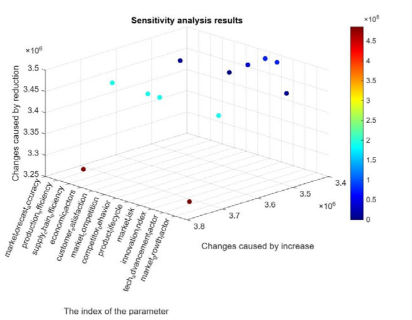

Fig.6: Sensitivity analysis results

Looking at the data, changes in most parameters are relatively consistent, indicating that the model is relatively stable for changes in these parameters.

However, the market growth factor and the supply chain efficiency have the greatest impact on the total return on investment when they increase or decrease the changes, and the model is more sensitive to the changes in these parameters. Therefore, when the market growth factor or the supply chain efficiency fluctuates greatly, the planning of technology update and business development should be more carefully considered.

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