Research on the evaluation of marketing performance influencing factors of high-tech enterprises based on AHP and factor analysis

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Abstract. This article explores the elements impacting the marketing performance of listed high-tech firms with regard to their marketing data from 2000 to 2020 in order to serve as an effective reference for the management and development choices of high-tech enterprises. The final weights of the influence of each level element on marketing performance are derived through the hierarchical analysis method (AHP) by reviewing pertinent literature and expert research, and the significant indicators of various factors are derived from the analysis of the actual operational data of high-tech enterprises using the validated factor analysis method. The findings demonstrate that, among the elements affecting the marketing performance of high-tech businesses, marketing innovation capacity has the highest impact.

Keywords: AHP; factor analysis; marketing performance; influencing factors; high-tech enterprises.

1. Introduction

This article explores the elements impacting the marketing performance of listed high-tech firms with regard to their marketing data from 2000 to 2020 in order to serve as an effective reference for the management and development choices of high-tech enterprises. The final weights of the influence of each level element on marketing performance are derived through the hierarchical analysis method (AHP) by reviewing pertinent literature and expert research, and the significant indicators of various factors are derived from the analysis of the actual operational data of high-tech enterprises using the validated factor analysis method. The findings demonstrate that, among the elements affecting the marketing performance of high-tech businesses, marketing innovation capacity has the highest impact.

The study of high-tech enterprise marketing performance in China primarily focuses on enterprise performance, marketing management challenges, and assessment of the existing environment. Zhu [1] conducted an analysis of the marketing management issues high-tech firms faced and made nine specific recommendations; Sun [2] examined the conditions and issues surrounding the marketing performance evaluation of Chinese businesses and suggested a system of marketing performance evaluation indexes that would work for them; Zhong [3] conducted an analysis of the variables affecting Shanghai's high-tech companies' performance. Li [4] discusses the issues with high-tech companies' marketing management and makes recommendations; Jiang [5] makes recommendations for enhancing the marketing effectiveness of businesses based on demand orientation; Guo [6] studies the relationship between the marketing performance of high-tech enterprises and R&D investment and technology accumulation; Yang [7] constructs an evaluation model for the marketing performance of small and medium-sized high-tech enterprises and evaluates it. There have been extensive prior studies on the marketing performance of high-tech enterprises, but while the issues with marketing management and the current state of the evaluation of the marketing performance of high-tech enterprises have been examined, no systematic research on the factors that influence the marketing performance of high-tech enterprises has been conducted, and the results have not been visualized.

This study develops 20 evaluation indices of the influencing factors of the marketing performance of high-tech enterprises from five perspectives: financial index evaluation, marketing capability,

market competition, internal enterprise, and consumer behavior. It then uses hierarchical analysis and factor analysis to assess the influencing factors of the marketing performance of high-tech enterprises both horizontally and vertically, and it calculates the impact of each index on the market. It offers a strong reference point for decision-making for the operation and development of high-tech companies through the investigation and classification of the elements impacting the marketing performance of high-tech enterprises.

2. High-tech enterprise marketing performance influence factors index system construction

2.1. Problems in the marketing of high-tech enterprises

The emergence of the digital economy has accelerated the digital transformation of businesses, increased competitiveness in the market for high-tech companies, and increased focus on marketing as a key component of corporate strategy[8]. Examples of these digital technologies include 5G, AI, and big data.

A high-tech business either creates new fields through research, technology, or scientific discoveries, or it innovates in an already-existing sector. High-tech companies are prone to the dilemma of "being technically proficient but confined to marketing"[9] during the digital transformation process. This refers to a focus on the pursuit of good product quality and technical excellence, which ignores changes in market conditions and places the company in a challenging position.

2.2. Indicators affecting the marketing risk of high-tech enterprises

A review of data shows that the success rate of implementing marketing strategies in high-tech enterprises worldwide is less than 30%, and a great deal of research has been carried out on the evaluation of marketing performance. However, high-tech enterprises [10] are different from traditional enterprises and general evaluation methods do not apply to them.

In this paper, a total of 20 factors affecting the marketing performanceof high-tech enterprises are selected from five perspectives[11]: financial indicators, marketing innovation capability, market competition, internal enterprise and consumer behaviour. Among them, financial indicators are$S_1 \backsim S_4$ The financial indicators are $S_5 \backsim S_9$, market competition is $S_{10} \backsim S_{13}$ and the internal influence of enterprises is $S_{14} \backsim S_{17}$and consumer behaviour is $S_{18} \backsim S_{20}$. To sum up, the index system of marketing performance influencingfactors of high-tech enterprises constructed in this paper is shown in the followingTable 1 .

Table 1. Evaluation index of influencing factors of marketing performance of high-tech enterprises

Level 1 indicators	Secondary indicators	code	Explain the instructions
Financial indicators	Sales	S_1	The full price and out-of-the-money fees charged by the corporate taxpayer to the purchaser
	Net profit margin	S_2	The net profit from the operation of the enterprise as a percentage of the net sales amount
	Gearing ratio	S_3	Total year-end liabilities divided by year-end total assets
	Marketing expenses	S_4	Expenses used by businesses for marketing-related services
	R&D investment ratio	S_5	The ratio of R&D investment ingredients to total product sales revenue
Marketing innovation capabilities	Number of patents obtained	S_6	The total number of patents granted by the enterprise
	New product revenue	S_7	Revenue realized from the sale of new products
	Market research capabilities	S_8	Ability to collect, sort out and analyze market conditions
	Customer analytics capabilities	S_9	The ability to assess value based on data analysis of customer characteristics
Market competition indicators	market share	S_{10}	The proportion of sales volume of a certain category in the market of similar products
	Consumer satisfaction	S_{11}	Key concepts in the field of marketing and consumer behaviour
	Brand awareness	S_{12}	Potential buyers recognize the ability of a certain type of branded product
Inside the enterprise	Quality of service	S_{13}	The sum of the characteristics of the service that meet a specified or potential need
	Employee quality	S_{14}	The knowledge and abilities of employees
	Departmental coordination capacity	S_{15}	The degree of cooperation between the internal parts of the enterprise
	Employee job satisfaction	S_{16}	Employees' satisfaction with work and related aspects in the process of work
	corporate culture	S_{17}	The various aspects that a business exhibits in its day-to-day operations
Consumer behaviour	Customer loyalty	S_{18}	Customers form a preference and repeat the product or service for a long time
	The new customer development rate	S_{19}	The proportion of businesses that get a successful portion of acquiring new customers
	After-sales service	S_{20}	Various service activities are provided after the product is sold

3. Hierarchical analysis model construction

The hierarchical analysis is a multi-criteria decision-making method combining qualitative and quantitative approaches proposed by Professor T.L. Saaty, a famous American operations researcher. AHP [12] is a way to decompose the elements related to decision deployment into objective, criterion and solution layers, and apply quantitative analysis to calculate the weights ofindicators in each layer.

Based on the complexity and diversity of factors influencing the marketing performance of high-tech enterprises, the hierarchical analysis method is used to analyse them. The operational steps of the hierarchical analysis method are as follows.

STEP1: Building a multi-level structure model

By analysing the factors influencing the marketing performance of high-tech enterprises, the influencing factors are organised, making the evaluation model hierarchical. The criterion level constructs 20 indicators from five levels: financial indicators, marketing innovation[13] capability, market competition, internal company and consumer behaviour.

STEP2 constructs the judgment matrix for each level

The elements in each level are compared two by two according to their importance, comparing the importance of each element in the upper level of the structural model with that of the elements in the lower level, and the elements in the same level are compared two by two and quantified to constructa judgement matrix.

Hierarchical analysis for the judgment matrix wants to define the criteria for the importance scale.The following table is Table 2

Table 2. Hierarchical analysis importance scale definition criteria

Scale	Meaning
1	Indicates that two factors are of equal importance compared to each other
3	Indicates that the former is slightly more important than the latter when compared the two factors
5	Indicates that the former is significantly more important than the latter when compared to the two factors
7	Indicates that the former is more strongly important than the latter when compared the two factors
9	Indicates that the former is more extremely important than the latter when compared the two factors
2,4,6,8	Median of the above two adjacent judgements
Countdown	If the ratio of the importance of factor I to j is aij, then the ratio of the importance of factor j to i is 1/aij

STEP3 Computational analysis and consistency check

Firstly, the maximum eigenvalue A of the judgement matrix is found and the eigenvector correspondsto the maximum eigenvalue and the weight vector formed by normalising the eigenvector is the relative importance of the elements; secondly, the matrix is tested for consistency.

(1)Calculation of consistency indicator CI

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{1}$$

(2)Find consistency indicators RI as Table 3

Table 3. Average random consistency indicators

Number of steps	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.89	1.12	1.26	1.32	1.41	1.45

(3)Calculate the consistency ratio CR, the

$$CR = CI/RI \tag{2}$$

When the CR is less than 0.10, the judgement matrix's consistency is considered acceptable.

STEP4 Calculate synthetic weights for each level

The calculation of the ranking weights of all factors at the same level relative to the importance of the highest level is called the synthetic weight of the level. This process is carried out from top to bottom, layer by layer, and the synthetic weights for the levels are

$$W = \sum a_i b_j \tag{3}$$

4. Factor analysis model construction

Factor analysis [14] was first proposed by the British psychologist C.E. Spielman and refers to a multivariate statistical analysis method that startsby studying the dependencies within the correlation matrix of indicators and reduces the number of variables with overlapping information and intricate relationships to a small number of uncorrelated composite factors. The basic idea is that variables are grouped according to the magnitude of their correlation so that variables within the same group are highly correlated with each other, but variables in different groups are uncorrelated or less correlated, and each group represents a basic structure one, the common factor. The steps of the analysis are as follows.

STEP1 Standardisation of data samples

STEP2 Calculate the correlation matrix R of the sample

STEP3 Find the eigenroots and eigenvectors of the correlation matrix R STEP4 Determine the number of master factors based on the cumulative

contribution required by the system

STEP5 Calculate the factor loading matrix A

STEP6 Determining the factor model

5. Empirical analysis

5.1. Hierarchical Analysis of Factors Influencing Marketing Performance of High-Tech Enterprises Constructed

5.1.1 Establishing the judgment matrix corresponding to each level

This paper makes judgments on the weights of the evaluation indicators of the marketing performance impact factors of high-tech enterprises. Starting with the secondary indicators, 10 experts in the field were invitedto score [15] the importance and the data were collated to produce the judgment matrix between the criterion level A, criterion level A and indicator level S, as shown Table 4.

Table 4. Judgement matrix of influencing factors (C) and criterion layers (A)

C	A_1	A_2	A_3	A_4	A_5
A_1	1	1	1.286	2.25	1.5
A_2	1	1	1.286	2.25	1.5
A_3	0.778	0.778	1	1.75	1.167
A_4	0.444	0.444	0.571	1	0.667
A_5	0.667	0.667	0.857	1.5	1

The judgment matrix is obtained, and the maximum eigenvalue is calculated by the operationλ_{max} = 5, the weight vectorw_1 = (0.2571, 0.2000, 0.2571, 0.11429, 0.1714), so the weights of financial indicators, marketing innovation, market competition, intra-firm and consumer behaviour on the influencing factors were 0.257, 0.200, 0.257, 0.114, 0.171 respectively. andthe consistency test was conducted. rI=1.11, CI=O, CR=CI/RI=0<0.1 and passedthe consistency test.

The same research methodology was applied to the financial indicators to produce a judgement matrixA_1 which includes sales, net profit margin, gearing and marketing expenses, as Table 5 shown.

Table 5. Financial indicators (A_1) and indicator layer ($S_1 - S_4$) of the judgment matrix

A_1	S_1	S_2	S_3	S_4
S_1	1	0.625	0.833	0.556
S_2	1.6	1	1.333	0.889
S_3	1.2	0.75	1	0.667
S_4	1.8	1.125	1.5	1

To obtain the judgment matrixA_1, and the maximum eigenvalue is calculated as λ_{max} = 4, The weight vector isw_2 = (0.185, 0.333, 0.260, 0.222), i.e. the weights of sales, net profit margin, gearing and marketing expenses are 0.185, 0.333, 0.260, 0.222. and tested for consistency. RI=0.882, CI=0, CR=CI/RI=0< 0.1, passed the consistency test.

The same research methodology was applied to the marketing innovation indicators to obtain a judgement matrixA_2 which includes the R&D investment ratio, number of patents obtained, new product revenue, market research capability and customer analysis capability, as Table 6 shown in

Table 6. Marketing Innovation (A_2) and the indicator layer ($S_5 - S_9$) of the judgment matrix

	S_5	S_6	S_7	S_8	S_9
S_5	1	1.333	1.143	1.6	1.6
S_6	0.75	1	0.857	0.714	0.714
S_7	0.875	1.167	1	1.4	1.4
S_8	0.625	1.4	0.714	1	1
S_9	0.625	1.4	0.714	1	1

To obtain the judgment matrixA_2 and the maximum eigenvalue is calculated by λ_{max} = 5.043 , the weight vector w_3 =RI=1.11,CI=0.011,CR= CI/RI=0.01< 0.1,passed the consistency test.

The same research methodology was applied to the market competition indicators to obtain a judgement matrix A_3 which includes market share, consumer satisfaction, brand awareness and service quality, as Table 7 shown.

Table 7. Market competition (A_3) and the indicator layer ($S_{10} - S_{13}$) of the judgment matrix

A_3	S_{10}	S_{11}	S_{12}	S_{13}
S_{10}	1	0.714	0.833	0.714
S_{11}	1.4	1	1.167	1
S_{12}	1.2	0.857	1	0.857
S_{13}	1.4	1	1.167	1

To obtain the judgment matrixA_3 and the maximum eigenvalue is calculated byλ_{max} = 4, the weight vectorw_4 =RI=0.882, CI=0, CR=CI/RI=0<0.1, and passed the consistency test.

The same research methodology was applied to the intra-company indicators to obtain a judgement matrixA_4 that includes employee quality, coordination, employee satisfaction and corporate culture, as Table 8 shown.

Table 8. Intra-company (A_4) and indicator level ($S_{14} - S_{17}$) judgment matrix

A_4	S_{14}	S_{15}	S_{16}	S_{17}
S_{14}	1	0.714	0.833	1.25
S_{15}	1.4	1	1.167	1.75
S_{16}	1.2	0.857	1	1.5
S_{17}	0.8	0.571	0.667	1

The judgment matrix A4 is obtained, and the maximum eigenvalue is calculated asλ_{max} = 4, the weight vectorw_5 =RI=0.882,CI=0,CR=CI/RI=0<0.1,and passed the consistency test. The same research methodology was applied to consumer behaviourindicators to obtain a judgement matrixA_5 including customer loyalty, new customer development rate and after-sales service, as Table 9 shown.

Table 9. Judgement matrix of consumer behaviour (A_5) and indicator layers (S18-S20)

A_5	S_{18}	S_{19}	S_{20}
S_{18}	1	1.167	1.333
S_{19}	0.857	1	0.75
S_{20}	0.75	1.333	1

The judgment matrix is obtained$A5$, and the maximum eigenvalue is calculated asλ_{max} = 3.02 weight vector w_6 =RI=0.525,CI=0.01,CR=CI/RI=0.019<0.1,which passed theconsistency test.

5.1.2 Combined weights of impact factor evaluation indicators

In this paper, we analyse the data of listed high-tech enterprises from 2000 to 2020, invite experts to score them, apply the hierarchical analysis method to study them, confirm the values in the judgment matrix and, after passing the consistency test, calculate the evaluation index weighting data as shown in the Table 10 below.

Table 10. Weighting table for evaluation indicators of marketing performance impact factors

Marketing performance evaluation C	A_1	A_2	A_3	A_4	A_5	Final weight
The weight of criterion layer A	0.2571	0.2000	0.2571	0.1142	0.1714	W_i
S_1	0.1786					0.0459
S_2	0.2857					0.0735
S_3	0.2143					0.0550
S_4	0.3214					0.0826
S_5		0.2583				0.0517
S_6		0.1574				0.03148
S_7		0.2260				0.0452
S_8		0.1791				0.0358
S_9		0.1791				0.0358
S_{10}			0.2000			0.0514
S_{11}			0.2800			0.0720
S_{12}			0.2400			0.0617
S_{13}			0.2800			0.0720
S_{14}				0.2273		0.0260
S_{15}				0.3182		0.0363
S_{16}				0.2727		0.0311
S_{17}				0.1818		0.0208
S_{18}					0.3835	0.0657
S_{19}					0.2856	0.0490
S_{20}					0.3309	0.057

5.1.3 Analysis of the results of the hierarchy scores

According to the results of the comprehensive weighting table of marketing performance impact factors, it can be seen that the weighting of marketing performance impact factors of high-tech enterprises is marketing expenses[16], net profit margin, consumer satisfaction, service quality, customer loyalty,brand awareness, after-sales service, asset and liability ratio, R&Dinvestment ratio, market share, new customer development rate, sales, new product revenue, departmental coordination

ability, market research capability, customer analysis capability, patent acquisition, employee job satisfaction, employee quality and corporate culture.

From the distribution of weights in the criterion level, marketing innovation ability and financial indicators have the largest weight, 25.71%,while internal factors have the smallest weight, 11.429%. Therefore, high-tech enterprises should pay more attention to the marketing innovation ability of enterprises, such as the investment in marketing expenses and R&D, as well as consumer satisfaction, improving service quality and customer loyalty playa key role in improving marketing performance.

5.2. Validation factor analysis

The factors influencing the marketing performance of high-tech enterprises[17] were analysed and studied by conducting factor analysis on the operational data of listed high-tech enterprises from 2000-2020 and obtaining their factor and composite scores.

5.2.1 Test of applicability of factor analysis

In this paper, 15 variable indicators, such as cost rate during sales, administrative expenses, total profit and net profit, were selected from five aspects, including financial indicators, marketing innovation, market competition, intra-firm and consumer behaviour, as an evaluation system for this paper to study the impact factors of marketing performance indicators of high-tech enterprises.

The KMO and Bartlett tests were performed on the data using SPSS software and yielded a KMO value of 0.687, which is greater than 0.5. The approximatechi-square of Bartlett's test was 149210.43, with a significance of 0.000, which is less than 0.05. There is a strong correlation between the indicators and is suitable for factor analysis.

5.2.2 Factor interpretation

The analysis of the data resulted in five principal components with a cumulative factor contribution of 70.63%, indicating that these factors are sufficiently representative to evaluate the factors influencing the marketing performance of high-tech enterprises. The sums of squares of the extracted loadings were rotated and are shown in the Table 11below.

Table 11. Rotated factor loading matrix

	1	2	3	4	5
Expense ratio during sales	0	1	0.001	0.006	-0.005
Overheads	0.851	0.008	0.003	0.218	-0.085
Total profit	0.959	-0.008	0.001	0.033	0.104
Net profit	0.956	-0.007	0.001	0.023	0.111
Overhead rate	0	1	0.001	0.005	-0.005
R&D investment intensity	0.584	-0.017	-0.013	0.642	-0.087
Intangible assets	0.004	0.006	0.709	-0.103	0.008
Government grants	-0.003	-0.006	0.802	0.02	0.003
Net cash flows from operating activities	0.738	0.013	-0.007	0.283	0.178
Shareholding of institutional investors	0.02	0.007	-0.026	0.74	0.292
Company size	0.401	0.017	-0.021	0.778	-0.235
Return on net assets	0.173	-0.009	-0.003	-0.021	0.498
Cash flow ratio	0.082	0.004	0.015	0.184	0.692
Degree of shareholding checks and balances	-0.108	-0.002	-0.008	-0.079	0.698
The total market capitalisation of individual shares in the year	-0.005	0.002	0.787	0.048	-0.011

The coefficient table for the coefficient is obtained as follows Table 12.

Table 12. Table of factor score coefficients

	Financial Indicators	Marketing Innovation	Market Competition	In-house	Consumer behaviour
Expense ratio during sales	0.000	0.498	0.000	0.002	-0.002
Overheads	0.183	0.004	0.001	0.079	-0.039
Total profit	0.206	-0.004	0.000	0.012	0.048
Net profit	0.206	-0.003	0.000	0.008	0.051
Overhead rate	0.000	0.498	0.000	0.002	-0.002
R&D investment intensity	0.126	-0.008	-0.006	0.231	-0.040
Intangible assets	0.001	0.003	0.316	0.037	0.004
Government grants	-0.001	-0.003	0.358	0.007	0.001
Net cash flows from operating activities	0.159	0.006	-0.003	0.102	0.083
Shareholding of institutional investors	0.004	0.003	-0.012	0.266	0.135
Company size	0.086	0.008	-0.009	0.280	-0.109
Return on net assets	0.037	-0.004	-0.001	-0.008	0.231
Cash flow ratio	0.018	0.002	0.007	0.066	0.321
Degree of shareholding checks and balances	-0.023	-0.001	-0.004	-0.028	0.324
The total market capitalisation of individual shares for the year	-0.001	0.001	0.351	0.017	-0.005

5.2.3 Analysis of the results of the factor scores

The expressions for the five principal components based on the component coefficient score matrix are as follows

$$F_1 = 0.000x_1 + 0.183x_2 + 0.206x_3 + \cdots - 0.001x_{15} \quad (4)$$

$$F_2 = 0.498x_1 + 0.004x_2 - 0.004x_3 + \cdots + 0.001x_{15} \quad (5)$$

$$F_3 = 0.000x_1 + 0.001x_2 + 0.000x_3 + \cdots + 0.351x_{15} \quad (6)$$

$$F_4 = 0.002x_1 + 0.079x_2 + 0.012x_3 + \cdots + 0.017x_{15} \quad (7)$$

$$F_5 = -0.002x_1 - 0.039x_2 + 0.048x_3 + \cdots - 0.005x_{15} \quad (8)$$

The expression of the integrated evaluation indicator function is as follows.

$$F = 0.345F_1 + 0.189F_2 + 0.167F_3 + 0.165F_4 + 0.135F_5 \quad (9)$$

The ranking of the actual operating data in terms of weighting on marketing performance was derived through validated factor analysis as cost ratio during sales, administrative expense ratio, net cash flow from operating activities, total profit, net profit, R&D investment intensity, management expenses, institutional investor shareholding, cash flow ratio, company size, total annual individual share market capitalisation, government subsidies, intangible assets, return on net assets and equity Balance of Payments.

6. Conclusion

The factors affecting the marketing performance of high-tech enterprisesare complex and diverse. This paper divides them into 20 influencing factorsfrom five perspectives: financial indicators, marketing innovation, market competition, intra-company and consumer behaviour, combining the

actual operational data of listed high-tech enterprises and using hierarchical analysis and factor analysis to analyse them in depth.

(1) Using the hierarchical analysis method, the weight size of 20 influencing factors of the marketing risk of high-tech enterprises was derived. By inviting experts to score, establishing a judgment matrix and conducting consistency tests, the comprehensive weight of the evaluation index of influencing factors was calculated and the ranking of the size of influencing factors was carried out.

(2) Factor analysis was conducted on the actual operating data of listed high-tech enterprises using factor analysis, and five common factors were extracted according to the total variance explanation table, namely F_1, F_2, F_3, F_4, F_5. and rotate the sum of squares of the loadings to conduct factor analysis to derive the weight size of each indicator.

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