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Research article

Assessing the competitiveness of listed Chinese high-growth companies in the STAR market

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ABSTRACT

This paper aims to assess the competitiveness of 68 high-growth enterprises listed on China's STAR market and explore the combination of antecedent conditions that led to their listing using fuzzy set qualitative comparative analysis. The interpretive structure model was utilized to identify the factors influencing their competitiveness, and the listing index weight for the STAR market was determined using the analytic hierarchy process. The competitiveness of the listed enterprises was found to be promising, with new energy, next-generation IT, and high-end equipment manufacturing being the most prominent fields. However, energy conservation and environmental protection exhibited relatively weak listed competitiveness. The listing of these enterprises was the result of multiple factors rather than a single factor. The listing paths of high-growth enterprises in China were classified into three types: well-operated with high technical competence and innovation-led, high-profit with low growth and innovation, and large-scale, high-profit, and innovation-led.

1. Introduction

The new development pattern, in which the domestic market serves as the mainstay and domestic and foreign markets complement each other, is an important strategic move for China to counter the global impact of the COVID-19 pandemic and the resurgence of anti-globalization sentiment [1]. Although China has a large domestic market, it is insufficient to support the entire production capacity of export-oriented enterprises. China has been an innovator in many fields over the last two decades. Nonetheless, a large portion of it is based on the massive demographic dividend, and the pursuit of advanced technological innovation necessitates ongoing and unwavering efforts [2]. Only by relying on independent innovation and by solving deadlocked technical problems can the domestic economic cycle be truly unblocked without being controlled by other countries. As a result, mobilizing and utilizing the capital market, stabilizing social and economic development, and encouraging continuous innovation of small and medium-sized enterprises are critical to a country's long-term economic growth.

The Chinese Science and Technology Innovation Board (STAR market) is concerned with high-tech and strategic emerging industries. It differs from the Main Board market, which is intended for public offerings of large and medium-sized businesses, and the Second Board market, which is intended for growth-oriented start-ups. The STAR market is a financing platform for small and medium-sized enterprises that focus on technological innovation, as well as a breeding ground for new innovative companies that lead the way

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in cutting-edge technology and boost their core competitiveness. Recently, researchers have shown an increased interest in enterprise competitiveness [3]. Previous studies have confirmed that technological development is a significant factor that affects the competitiveness of companies [4]. It has been suggested that marketing innovation is identified as a search for creative and new solutions to competitiveness [5]. Several cross-sectional studies have found a positive association between strategic management and competitiveness, suggesting that the competitiveness of an enterprise is contingent on factors such as the complexity of strategic reforms, the clarity of modernization tasks, the speed of adaptation to the external environment, and the coherence of reform levels [6,7].

Meanwhile, a considerable body of literature has grown around the theme of the process of bid evaluation [8]. For example, Chen et al. developed an ELECTRE III-based group decision-making approach for bid evaluation involving HFLTS possibility distributions [9]. Chen et al. also introduced a combination of online review analysis and large-scale group decision-making to determine passenger demands and to evaluate passenger satisfaction [10]. It is noteworthy, however, that the current literature on enterprise competitiveness still lacks a systematic and integrated approach to analyze the listing competitiveness of China's high-growth enterprises on the STAR market and to explain the internal logic and path for enterprises to initiate public offerings from the perspective of configuration.

The aim of this article is therefore to examine the factors that determine the competitiveness of small and medium-sized science and innovation enterprises. To do this, we undertake an analysis using the explanatory structural model. Additionally, we establish the evaluation index weights of the listing competitiveness of China's high-growth enterprises on China's STAR market based on the hierarchical analysis method. Finally, the configurations to IPO are then compiled using the fuzzy set qualitative comparative research approach (fsQCA). This study makes three main contributions. First, it develops the first evaluation index for measuring the competitiveness of science and innovation enterprises that go public, thereby enriching the literature on enterprise competitiveness. Second, the study validates the complex causal relationship between enterprise competitiveness evaluation and confirms the asymmetric view of complexity theory. The findings are expected to make a significant contribution to understanding the internal mechanism of initial public offerings (IPOs), in which the convergence of multiple factors plays a critical role in driving enterprises to go public. Third, this research provides a deeper understanding of the decision-making process for the listing and financing of China's

Table 1
Index system of listed competitiveness of high-growth enterprises.

Focus	Criteria	Sub-Criteria	Definition
Index System of Listed Competitiveness of High-growth Enterprises (Q)	Enterprise Scale (C_1)	Total assets (I_1)	The total amount of assets
		Net assets (I_2)	Total assets minus total liabilities
		Number of employees (I_3)	The total number of individuals who work for a company
	Profitability (C_2)	Operating revenue (I_4)	Sales revenue
		Net profit (I_5)	Net income
		Profit per capita (I_6)	The average amount of profit earned per person
		Net asset margin (I_7)	A financial ratio that measures the profitability of a company based on its net assets
	Business Growth (C_3)	Revenue growth rate (I_8)	The annual percentage change in the turnover of a company
		Net profit growth rate (I_9)	The annual percentage increase or decrease in a company's net profit
		Total assets growth rate (I_{10})	The annual percentage increase or decrease in a company's total assets
		Taxation growth rate (I_{11})	The annual percentage increase or decrease in a company's taxation
	Operating Capacity (C_4)	Total assets turnover rate (I_{12})	Calculated by dividing the net sales by the average total assets
		Current asset turnover rate (I_{13})	Calculated by dividing the net sales by the average current assets
		Fixed asset turnover rate (I_{14})	Calculated by dividing the net sales by the fixed assets
		Accounts receivable turnover rate (I_{15})	The number of times a company collects its accounts receivable balance in a year
	Technical Competence (C_5)	Technical level (I_{16})	5 for international leading, 4 for international advanced, 3 for domestic advanced, 2 for domestic average and 1 for domestic backward
		Industry ranking (I_{17})	1-5 represents the market share percentages of 10%, 20%, 30%, 40% and 70%.
		High-level team (I_{18})	Number of individuals holding a doctoral degree or senior professional title
		Number of patents (I_{19})	The number of patents includes invention patents, utility model patents, and design patents
	Innovation Capacity (C_6)	R&D input (I_{20})	The annual total R&D expenditure
		Scientific researchers (I_{21})	Research personnel
		Intangible assets (I_{22})	Including intellectual property such as patents, trademarks, and copyrights, brand recognition, customer relationships, and goodwill

high-growth enterprises and offers a new theoretical basis for the listing and financing of science and innovation enterprises.

This article continues with Section 2, which briefly reviews the relevant literature on the evaluation index system of listed enterprise competitiveness. Section 3 discusses the evaluation and ranking of the listed competitiveness of high-growth enterprises. Section 4 presents the empirical analysis of the fuzzy set qualitative comparative analysis. Conclusions and implications are presented in Section 5.

2. Structure of the index system for the competitiveness of listed high-growth companies

According to the endogenous theory of competitive advantage, when compared to external conditions, a company's internal needs are the deciding factors in whether it can obtain a competitive market advantage, and the accumulation of a company's internal resources and capabilities is the key to explaining a company's excess earnings and maintaining its competitive advantage [11]. Labor investment, on the one hand, is a means to increase human capital, which can be acquired through various means, such as learning, education, and training. Enterprises, on the other hand, are likely to make advances in material capital accumulation through activities such as research and development, innovation, and invention. Through this process, technological progress is internalized and transformed into long-term core competitiveness. As a result, a company's competitive advantage is derived from its resources, particularly those that are heterogeneous in nature [12].

The capacity of an enterprise to secure listed financing is its listed competitiveness, which represents the degree of that enterprise's competitiveness. As indicated by prior research, organizations that exhibit higher levels of technical innovation output tend to attract more clients and consumers, thereby enhancing their overall competitiveness [13]. Specifically, a firm's core competitiveness is largely determined by the heterogeneity of its corporate resources, which is a crucial factor in securing equity financing. In practice, the selection of influencing factors serves as the basis for outcome evaluation in the assessment and analysis of a firm's listed competitiveness, and different combinations of elements can lead to varied assessment outcomes.

Previous research on the development of competitiveness evaluation indicators has primarily emphasized factors such as profitability, potential for growth, market control, and corporate governance levels. However, these studies have often overlooked the importance of the integrity of the evaluation process, specifically the distinctiveness and leadership qualities of the organization [14]. In the *Opinions on the Implementation of Establishing a Science and Technology Innovation Board and Piloting a Registration-based IPO System in the Shanghai Stock Exchange*, the China Securities Regulatory Commission (CSRC) has stated that issuers' applications for stocks' initial public offerings (IPO) should align with the focus of the STAR market. This includes targeting the forefront of the world's science and technology, which serves as the main battleground of the economy and satisfies primary national needs. The competitiveness of companies is evaluated based on the classification of enterprise competitiveness, which includes value, leadership, uniqueness, and growth. In this study, we identified 6 first-level indicators and 22 s-level indicators to assess the listed competitiveness of companies. The specific evaluation index system is shown in Table 1.

2.1. Enterprise scale

The size of an enterprise can serve as an indicator of the abundance of resources available to the organization. Large-scale enterprises typically possess ample innovation resources, such as knowledge and technology, which can provide essential support for innovation activities. Furthermore, high-growth enterprises with a larger scale are more capable of bearing the risks associated with innovation activities [15]. Conversely, enterprises with limited resources must exercise greater caution and control when engaging in innovation activities due to their higher costs and risks [16]. As a result, the scale of enterprises plays a pivotal role in promoting economic growth, which is an endogenous process that relies on innovation and efficiency improvements [17]. The organic growth of large-scale enterprises has resulted in heightened competitiveness within market competition while simultaneously fortifying the microfoundations for sustainable growth. According to Aral and Walker, an enterprise's financial strength and market position tend to strengthen as it expands in scale, thereby increasing its access to social relations and channels for acquiring resources [18]. Therefore, we select the company's scale as one of the core indicators of the listed competitiveness of high-growth companies.

2.2. Profitability

Profitability refers to the ability of an enterprise to use its advantages and capital to obtain profit, also known as the enterprise's ability of capital appreciation [19]. Companies with high profitability usually have higher internal and external financing efficiency, and they can provide stable and continuous financial support for implementing innovative strategies [20]. The profitability of an enterprise reflects its overall development and work results, and it can also measure the level of enterprise management. To improve their profitability, companies need to enhance the value of their products and establish scientific and practical financial forecasting and risk monitoring mechanisms. At the same time, reasonable asset allocation can further optimize the company's asset structure to maximize its profitability and promote its long-term development.

2.3. Business growth

Relevant research has revealed that an enterprise's growth influences its survival and development at an early stage [21]. Growth capability indicates not only new businesses' product competitiveness but also a vital capability for startups to achieve a competitive edge. It is feasible to create superior business plans and build competitive advantages by boosting the company's growth capabilities

[22]. As a result, we utilize the revenue growth rate, net profit growth rate, total asset growth rate, and tax growth rate to define the company's growth condition.

2.4. Operating capacity

Operational capacity primarily relates to the efficiency and value of a company's operating assets, as well as its own financing capacities and ability to handle finances [23]. The expansion of the company's operational capacity contributes to a better knowledge of its operations. When confronted with unknown hazards, businesses might change their business plans and improve to achieve long-term growth. Studies have shown that operating capability plays a prominent intermediary role in the relationship between asset structure and company value [24]. The improvement of operating capacity is conducive to the advancement of company value.

2.5. Technical competence

Technology is one of an enterprise's key competitive advantages. In comparison to resources and markets, technology has the characteristics of irreplaceability and imitation [25]. Technological innovation has the potential to increase earnings and competitive advantages for businesses. Technological innovation may represent a company's technological ability, increasing its competitive advantage [26]. Meanwhile, an enterprise's technical level might have an impact on its innovation and survival. The underlying rationale is that a firm's technological level greatly affects the efficiency of its financial flexibility policy, encouraging R&D investment and progressively strengthening the firm's core competitiveness [27].

2.6. Innovation capacity

R&D ability has direct and indirect effects on the competitiveness of enterprises. Those R&D capabilities have a significant positive effect on innovation performance and will directly affect corporate competitiveness [28]. Studies have shown that R&D capabilities have a significant positive impact on innovation performance and directly affect corporate competitiveness. A strong R&D team is essential support for the technical level of an enterprise [29]. The scale and quality of the R&D team can reflect the technical level of the enterprise and indirectly affect the competitiveness of the enterprise. R&D capabilities are essential for companies to maintain their competitive advantages [30]. Innovation and development ability is a crucial factor in the listing verification of growth companies. The output result of enterprise R&D investment and R&D personnel quality is innovation, which is usually reflected in intangible assets. Enterprise R&D capital usually increases with an increase in intangible assets. The R&D output result has a positive correlation

Table 2
Summary of descriptive statistics.

Variables	Mean	S.D.	Max	Min
Total assets (Ten thousand RMB)	105163.21	101145.25	682254.69	21004.89
Net assets (Ten thousand RMB)	67708.32	72280.20	383544.60	9368.43
Number of employees	660.00	468.38	3448.00	114.00
Operating revenue (Ten thousand RMB)	64213.89	58851.11	304126.01	11064.80
Net profit (Ten thousand RMB)	11214.54	11328.13	73687.84	351.19
Profit per capita (Ten thousand RMB)	21.98	15.50	97.38	1.87
Net asset margin (%)	19.55	10.04	153.57	0.27
Revenue growth rate (%)	0.35	0.28	1.47	−0.27
Net profit growth rate (%)	0.57	1.49	6.75	−5.62
Total assets growth rate (%)	0.34	0.35	1.84	−0.39
Taxation growth rate (%)	0.70	1.80	10.53	−0.92
Total assets turnover rate (%)	0.77	0.36	2.02	0.16
Current asset turnover rate (%)	1.13	0.13	1.51	0.66
Fixed asset turnover rate (%)	1.15	0.29	1.89	0.000
Accounts receivable Turnover rate (%)	9.36	30.08	253.08	0.86
Technical level	3.82	0.82	5.00	2.00
Industry ranking	3.43	1.14	5.00	1.00
High-level team	4.49	7.53	61.00	0.00
Number of patents	212.00	251.00	3559.00	8.00
R&D input (Ten thousand RMB)	6554.60	7640.68	42753.58	970.44
Scientific researchers	217.00	227.00	1411.00	15.00
Intangible assets (Ten thousand RMB)	5598.66	12657.61	116240.40	15.67

Note: Profit per capita is calculated as total revenue divided by the number of employees. Net asset margin is calculated as net profit divided by total assets. Revenue growth rate = (current year revenue/last year total revenue) - 1; Net profit growth rate = (current year net profit/last year net profit) - 1; Total asset growth rate = (current year total assets/last year total assets) - 1; Taxation growth rate = (current year taxes/last year taxes) - 1; Total asset turnover ratio = 2 × revenue/(beginning total assets + ending total assets); Current asset turnover rate = 2 × current assets/(beginning total assets + ending total assets); Fixed asset turnover rate (%) = 2 × fixed assets/(beginning total assets + ending total assets); Accounts receivable Turnover rate (%) = 2 × sales/(beginning accounts receivable + ending accounts receivable).
Source: Except for patent data from Qichacha, all other data is derived from statistics and calculations given in prospectuses of firms listed on the Science and Technology Innovation Board that were publicly available on the Shanghai Stock Exchange.

with the company listing.

3. Assessment and classification of the competitiveness of listed high-growth companies

3.1. Data source and preprocessing

According to the STAR market's listing standards, we have classified the listed firms into six core sectors: next-generation information technology, new materials, high-end equipment, new energy, energy conservation and environmental protection, and biomedical. As of December 31, 2019, the Shanghai Stock Exchange approved 250 STAR market listing applications, of which 80 were in the registration phase and 24 had been rejected or cancelled.

With the exception of patent data, which are sourced from Qichacha, all other data are derived from the statistics and calculations disclosed in the company's prospectus. The above data were extracted from the 2019 prospectuses of companies listed on the Science and Technology Innovation Board, which were publicly available on the Shanghai Stock Exchange. We followed the established criteria for listed firms operating in the aforementioned sectors for our study and removed firms that had insufficient information or were undergoing listing verification before the sample index information gathering period expired. Finally, 68 firms were chosen as the sample for our investigation, including 26 new-generation information technology companies, 10 new materials companies, one new energy company, 12 biomedical companies, 18 high-end equipment companies, and one energy-saving and environmental protection company. Table 2 displays the sample's descriptive statistics. Because of the disparity in assessment index units, it is critical to normalize the data to reduce the influence of dimensionality on the final findings. Normalization of the company's original data is required to assure index comparability. Once standardized, the indices will be of comparable magnitude, fulfilling the requirements for thorough comparative evaluation.

3.2. AHP empirical results

A crucial prerequisite and foundation for the systematic evaluation and enhancement of a listed corporation's competitiveness is a scientifically sound evaluation index system. The analytical hierarchy process (AHP) is a systematic method for analyzing attributes that constructs a hierarchical comparison matrix and determines the weight value through pairwise comparison of indicators [31,32]. Based on the evaluation index system obtained, we established a three-layer analysis model. The top layer focuses on the comprehensive evaluation of high-growth companies' listed competitiveness on the STAR market. The middle layer comprises six secondary indices, including enterprise scale, profitability, growth ability, operating capacity, technological level, and R&D ability. The index layer includes 22 third-level indicators ($I_1, I_2, \ldots, I_{22}$). For our panel, we hand-picked eleven distinguished individuals with extensive experience and expertise in the field of entrepreneurial investment.

They are experts and academics from university technology transfer offices, officials from local financial supervision authorities, deans of technology business incubators, and investment analysts from securities firms.

To guarantee a complete and fair portrayal, our specialists have been carefully chosen. Our respected panel of eleven experts responded to an internet questionnaire that was sent to them, and a 1–9 priority ratio scale was used to conduct the poll. After

Table 3
Hierarchy of the index system of listed competitiveness.

Focus	Criteria	Weight	Sub-criteria	Sub-weight	Weighted Average
Index System of Listed Competitiveness of High-growth Enterprises	Enterprise Scale	0.08	Total assets	0.57	0.05
			Net assets	0.29	0.02
			Number of employees	0.14	0.01
	Profitability	0.31	Operating revenue	0.47	0.14
			Net profit	0.28	0.09
			Profit per capita	0.10	0.03
			Net asset margin	0.16	0.05
	Business Growth	0.17	Revenue growth rate	0.51	0.09
			Net profit growth rate	0.28	0.05
			Total assets growth rate	0.14	0.02
			Taxation growth rate	0.07	0.01
	Operating Capacity	0.09	Total assets turnover rate	0.14	0.01
			Current asset turnover rate	0.51	0.04
			Fixed asset turnover rate	0.07	0.01
			Accounts receivable Turnover rate	0.28	0.02
	Technical Competence	0.25	Technical level	0.28	0.07
			Industry ranking	0.51	0.13
			High-level team	0.14	0.03
			Number of patents	0.07	0.02
	Innovation Capacity	0.11	R&D input	0.57	0.06
			Scientific researchers	0.29	0.03
			Intangible assets	0.14	0.02

completing Cronbach's *alpha* test on the content validity and structure validity of the questionnaire, it was found that the importance evaluation coefficient *alpha* of the first-level index was 0.835, and the importance evaluation coefficient *alpha* of the secondary index was 0.871, indicating that the questionnaire has high reliability. To determine the weight of each assessment index, we coupled the Delphi technique with the associated judgment matrix to examine the variables in accordance with the evaluation principles of orientation, measurability, effectiveness, and operability. The results are shown in Table 3.

The maximum eigenvalue λ_{max} and the CR value of the consistency check are presented in Table 4. As shown in Table 4, the visible CR values are all close to 0.1, and the consistency of the matrix is acceptable, which means that the weights are reasonable.

In this study, we classified a total of 68 companies into distinct fields and examined their competitive landscapes based on the average values of several indicators. Considering that evaluation indicators may have disparate units, we standardized the raw enterprise data to minimize the effect of scale disparities on the outcomes. Specifically, we computed the mean score of enterprise size, profitability, growth potential, operational capability, technological sophistication, and R&D proficiency within each industry after standardizing the data. Our analysis revealed that the six fields ranked in the following order of competitiveness: new energy, new material, high-end equipment, biomedical, new-generation information technology, and energy saving and environmental protection. The findings of this study, as presented in Table 5, demonstrate that Chinese high-growth companies listed on the STAR market exhibit strong performance in terms of competitiveness. Furthermore, our analysis suggests that certain fields, such as new energy, new-generation information technology, and high-end equipment, exhibit more prominent competitiveness when compared to energy-saving and environmental protection companies, which displayed relatively weaker competitiveness.

4. Fuzzy set qualitative comparative analysis

The establishment of the STAR market has provided a new financing avenue for Chinese science and technology firms. Compared to other boards, the STAR market has higher inclusiveness, making it an attractive option for numerous high-growth companies seeking to go public. This increased listing path has not only drawn diverse companies but has also alleviated the challenge of financing difficulties. To identify the specific features of companies that are favored by the STAR market, this study employs fuzzy-set qualitative comparative analysis (fsQCA) to analyze the antecedents that influence a company's decision to initiate an initial public offering (IPO) from six dimensions: enterprise size, profitability, growth potential, operational capacity, technological proficiency, and R&D capability. Based on our findings, we provide an overview of the IPO listing process for high-growth firms on the STAR market and explain the internal reasoning behind the success of these companies in going public.

4.1. Variables selection

Qualitative comparative analysis (QCA) is a research method that combines both qualitative and quantitative approaches through case studies. It was first proposed by American sociologist Ragin in the 1980s. Unlike traditional quantitative research, QCA is based on set theory and the Boolean operation algorithm. It explores nonlinear causality and multiple concurrent conditions on the basis of complex theory, which makes it particularly useful for analyzing complex causal relationships in various fields such as sociology, medical treatment, and entrepreneurship [33].

This paper adopts the fuzzy-set qualitative comparative analysis method, which conceptualizes cases as combinations of attributes and emphasizes that these combinations give the case's uniqueness so that the classification of case analysis conditions and results is no longer limited to binary division. Thus, fsQCA makes the calibration of variables more flexible, reduces the occurrence of contradictory configurations, and dramatically expands the application scope and applicability of qualitative comparative analysis [34]. The use of fsQCA provides companies with a more specific and effective combination of IPO conditions to a certain extent. It is more practical to study the influence of different combinations of factors on decision-making goals. Therefore, based on the establishment of an index system by the AHP, this paper uses fsQCA to conduct an empirical analysis of the selected samples.

4.2. Variable calibration

The process of assigning set membership to a case is calibration, which generally converts the original data into a set between 0 and 1 [35]. This paper draws on the direct method proposed by Beynon et al. to determine the full-nonmembership, crossover point, and full-membership anchor points of the seven conditional variables and outcome variables through the 5th, 50th, and 95th quantiles [36]. Using the growth ability calibration process as an example, we follow a specific operational procedure. Initially, all samples are

Table 4
Maximum eigenvalue and consistency test.

B	λ_{max}	CR
Listed Competitiveness	6.11	0.02
Enterprise Scale	3.00	0.00
Profitability	4.03	0.01
Business Growth	4.01	0.00
Operating Capacity	4.01	0.00
Technical Competence	4.01	0.00
Innovation Capacity	3.00	0.00

Table 5
Competitiveness of listed companies in different fields in the STAR market.

Indicators	Enterprise Scale	Profitability	Business Growth	Operating Capacity	Technical Competence	Innovation Capacity	Competition Index
New Energy	53.80	44.29	34.30	41.88	50.98	38.30	44.17
New Information Technology	18.54	33.24	35.24	35.64	55.21	18.40	37.57
High-end Equipment	21.58	27.88	46.60	50.82	52.66	9.52	36.56
Biomedical	20.98	29.68	31.60	44.31	54.43	9.68	34.42
New Material	22.91	29.16	29.11	47.35	54.18	13.88	34.73
Environmental Protection	9.64	11.94	28.25	41.62	34.42	2.30	21.51
Average	24.58	24.51	34.18	43.60	41.54	15.30	34.83

arranged and analyzed using Origin 2018 software to fit a probability density curve that corresponds to the data characteristics. Next, we construct the probability distribution curve using the *B*-spline function. Thus, we can obtain anchor points corresponding to each variable at different percentiles in Table 6.

4.3. Analysis of necessary conditions

Before constructing the truth table, the necessary conditions must be checked, which helps to make appropriate assumptions about the logical remainder in the process of logic minimization [37]. From a set theory perspective, the analysis required to assess a single condition involves determining whether the resulting set is a subset of a specific set of conditions. Typically, if a particular condition variable is considered necessary for the outcome variable, the condition's consistency score should be no less than 0.9 [38]. As shown in Table 7, none of the conditions exhibit a consistency score greater than 0.90. Thus, there is no single necessary condition for the listing path in these six indicators.

4.4. Results of qualitative comparative analysis

Drawing on the previous research, a truth table was developed to illustrate the logical outcome of meeting the condition combination. Table 8 presents the logarithm by taking one case as a unit and provides an inventory of all conceivable combinations of the antecedent and outcome variables. Consistency thresholds were determined in this study using break points and were set at 0.8. The case threshold was established at 1, and the proportional reduction of inconsistency (PRI) was calculated using these thresholds. Through the use of fsQCA3.0, we were able to analyze the data and ascertain that both the single solution (configuration) and the overall solution demonstrated a consistency level that surpassed the minimum acceptable standard of 0.75, with the overall solution consistency reaching 0.94 and the coverage being 0.46. We have identified seven configurational paths for the IPO of STAR market companies under sufficient conditions, which are presented in Table 8.

4.4.1. High operating capacity, technical competence and innovation capacity

(1) 1a = ~Profitability × Operating Capacity × Technical Competence × Innovation Capacity.

The core conditions of this configuration are a high technical level and high R&D capabilities. This configuration shows that regardless of the size and growth capacity of the company, as long as the company maintains a cutting-edge technology level and a continuous high investment environment for R&D, supplemented by an excellent operating level, even if the level of profitability is average, the company can also achieve IPO.

Taking QuantumCTek as an example, this company is the first enterprise in China to engage in the industrialization of quantum communication technologies. QuantumCTek is primarily involved in the research and development, production, sales, and technical services of quantum communication products. They offer both software and hardware products to construct various types of optical fiber quantum secure communication networks and satellite-ground wide-area quantum secure communication ground stations. QuantumCTek also provides network application and quantum security application solutions for various industries, including

Table 6
Summary of the calibration of all variables.

Conditions	Calibration		
	Crossover point	Nonmembership	Full membership
IPO	0.50	0.00	1.00
Enterprise Scale	1.59	0.16	7.34
Profitability	26.20	9.60	55.80
Business Growth	101.70	60.78	163.11
Operating Capacity	53.50	33.10	78.00
Technical Competence	205.40	62.70	330.00
Innovation Capacity	17.63	1.57	68.19

Table 7
Analysis summary of necessary conditions.

Conditions	IPO		Conditions	IPO	
	Consistency	Coverage		Consistency	Coverage
Enterprise Scale	0.46	0.91	~Enterprise Scale	0.59	0.88
Profitability	0.52	0.94	~Profitability	0.54	0.85
Business Growth	0.49	0.87	~Business Growth	0.56	0.91
Operating Capacity	0.51	0.88	~Operating Capacity	0.55	0.90
Technical Competence	0.56	0.93	~Technical Competence	0.50	0.85
Innovation Capacity	0.42	0.88	~Innovation Capacity	0.63	0.90

Table 8
Configurations for the high-growth enterprise IPO path.

Conditions	Configuration						
	M1			M2		M3	
	1a	1b	1c	2a	2b	3a	3b
Enterprise Scale		⊗				●	●
Profitability	⊗		⊗	●	●	●	●
Business Growth			●	⊗	⊗	⊗	●
Operating Capacity	●	●	●	⊗	●	⊗	●
Technical Competence	●	●	●	⊗	●		●
Innovation Capacity	●	●	●	⊗	⊗	●	●
Consistency	0.92	0.92	0.92	0.92	0.93	0.92	0.93
Raw coverage	0.25	0.28	0.16	0.17	0.17	0.15	0.17
Unique coverage	0.013	0.018	0.024	0.026	0.013	0.019	0.032
Overall solution consistency				0.93			
Overall solution coverage				0.46			

Notes: Black circles ● indicate the presence of a condition, and circles with ⊗ indicate its absence. Moreover, large circles indicate core conditions, and small circles refer to peripheral conditions. Blank spaces in a solution indicate a "don't care" situation in which the causal condition may be either present or absent.

government affairs, finance, power, defense, and others. Although the company's per capita profit margin (14.2%) and net profit margin (7.9%) were relatively low in 2018, they have a stable and high-level R&D team (42.0% of R&D staff) and an advanced R&D platform. With 194 domestic and foreign patents related to core technologies of practical quantum secure communication with independent intellectual property rights, QuantumCTek maintains a sustainable competitive advantage by optimizing asset turnover rates and enhancing the efficiency of corporate asset management while adhering to the overall layout of preresearching one generation, developing one generation, and producing one generation. Finally, QuantumCTek was listed on the STAR market of the Shanghai Stock Exchange under the institutional background facing the frontiers of world science and technology, the main economic battlefield, and major national needs.

(2) 1b = ~Enterprise Scale × Operating Capacity × Technical Competence × Innovation Capacity.

The core conditions of this configuration are a high technical level, strong R&D ability, and a small-scale enterprise. This configuration shows that regardless of whether a company's profitability and growth are at a high level, as long as it maintains a strong level of technology and R&D capabilities, supplemented by good operation management, even if the scale of the company is relatively small, it can be publicly issued and listed on the STAR market.

In terms of this business model, TZTEK technology, for instance, focuses on machine vision as its core technology and independently develops vision equipment to offer relevant technical services for industrial usage. Between 2016 and 2018, the company's operating income grew from RMB 180.85 million to RMB 319.20 million and then to RMB 508.28 million. Although TZTEK is a small- to medium-sized enterprise, its scientific and technological innovation capabilities are remarkable. The company places great emphasis on the introduction and training of technical talents, with 36.3% of its R&D staff in 2018 being technical experts. In the past three years, TZTEK invested RMB 47.42 million, RMB 59.56 million, and RMB 79.60 million in R&D, resulting in core technological breakthroughs that have been safeguarded through patent applications and software copyright. To date, TZTEK has filed for a total of 117 patents, with 65 being granted, and has also secured 68 software copyrights. Furthermore, the company has proactively adjusted its organizational structure, improved overall operational efficiency, and implemented efficient and flexible corporate management, eventually achieving a successful listing on the STAR market of the Shanghai Stock Exchange.

(3) 1c = ~Profitability × Business Growth × Operating Capacity × Technical Competence × Innovation Capacity.

Without considering the size of the company, this company relies on high technology and high R&D capabilities, coupled with its high growth. This configuration shows that the technological level positively regulates the enterprise competitive advantage, and the R&D capability positively promotes the innovation performance of the enterprise, which in turn continues to affect the enterprise competitiveness [39,40]. We may take Piesat Information Technology, which is a leading service provider of remote sensing and the Beidou Satellite Navigation System in China, as an example. The company is committed to the localization of satellite application software and the industrialization of satellite applications and has developed and mastered primary software platforms with independent intellectual property rights. The core technology relies on the platform to provide system design, development and data analysis services to government and enterprises. Despite the company's low net profit margin of 14.8% in 2018, its net profit growth rate was 40.0% in the same year. Piesat Information Technology has a leading domestic and international primary software platform in China. In 2017, its independently innovated and developed remote sensing image processing software platform, PIE, was selected for the list of software agreement supplies for the central government departments in China. The company's scientific and technological achievements have been appraised and approved by industry experts from the Chinese Society of Geodesy, Photogrammetry and Cartography. In addition, the company has undertaken several major national scientific research projects and has strong research and development (R&D) and innovation capabilities. The company has been approved for listing on the Star market.

4.4.2. M2: high profitability, low business growth and innovation capacity

(1) 2a = Profitability × ~Business Growth × ~Operating Capacity × ~Technical Competence × ~Innovation Capacity.

The core conditions leading to IPO competitiveness are high profitability, low growth, and operation. Path 2a is exemplified by the successful IPO of Hopechart IoT Technology, which specializes in leveraging artificial intelligence and big data in the commercial vehicle sector to design, manufacture, and sell intelligent enhanced and advanced assisted driving systems, as well as other intelligent networked automotive equipment. The company has been able to maintain an average gross profit margin of 49.8% during the reporting period, which is higher than the industry average, despite a decreasing proportion of scientific research personnel and low investment in research and development expenses, with an average proportion of only 13.9% of operating income during the reporting period. Despite these challenges, Hopechart IoT Technology demonstrated strong profitability and went public on the STAR market.

(2) 2b = Profitability × ~Business Growth × Operating Capacity × Technical Competence × ~Innovation Capacity.

This configuration suggests that regardless of the size of the firm, a company with high profitability and high technological capabilities, combined with good operational capabilities, can still have a successful IPO even with low growth and R&D capabilities. We may take MicroPort Endovascular MedTech, which is a representative company primarily involved in researching, developing, producing, and selling medical devices for aortic and peripheral vascular intervention, as a typical case. In 2018, the company attained a remarkable market share ranking first, with a net profit of 90 million RMB. It is noteworthy that despite a modest R&D investment of only 29.03 million RMB and scientific personnel constituting 26.1%, the company successfully achieved a listing on the Star market.

4.4.3. M3: large enterprise scale, high profitability and innovation capacity

(1) 3a = Enterprise Scale × Profitability × ~Business Growth × ~Operating Capacity × Innovation Capacity.

This configuration suggests that regardless of a company's skill level, even if the company's operating and growth capabilities are weak, the company can still go public with an IPO as long as its asset size expands and its profitability increases. As an example for analysis, the China National Electric Apparatus Research Institute provides a compelling case. Over the course of more than three decades, the company has achieved impressive net assets of 1.04 billion RMB and total assets of 2.64 billion RMB. In 2018, the company generated a net profit of 210 million RMB. While the pace of growth has slowed somewhat, the enterprise has still managed to achieve a successful IPO due to its robust capital and high profitability. The firm's size likely played a role in its financing and innovation success, enhancing its competitive position and ability to access key social resources.

(2) 3b = Enterprise scale × Profitability × Business Growth × Operating Capacity × Technical Competence × Innovation Capacity.

This configuration is a typical path of positive investment of all elements, which reflects the crucial role of high profitability, high technology, and high R&D and the auxiliary effect of large scale, high growth, and high operation on the company's listing. Kingsoft Office is a prominent provider of office software and services in China. The company specializes in designing, developing, and promoting office software products and services, providing customers with one-stop, multiplatform application solutions. Its business

model primarily encompasses value-added services based on the company's products and related documents, as well as internet advertising and promotion. With more than 30 years of research and development experience and technological accumulation in the field of office software, Kingsoft Office has already established itself as a leading domestic technical competence in China. In the period from 2016 to 2018, the company's operating income increased yearly, reaching 543.0 million RMB, 753.0 million RMB, and 1.13 billion RMB, respectively. Furthermore, the company has allocated 38% of its operating revenue to R&D investment annually. The company's success in technology utilization and development has facilitated its expansion and increased its capital accumulation, which, in turn, has further strengthened its technological breakthroughs and competitiveness in the industry.

Through a comparison of the seven configurations, it was discovered that Path 1a and Path 1b have a higher coverage than the other paths. Specifically, the raw coverage of these two paths is 0.528, with a total of thirty-five cases, indicating that half of the companies achieved IPO through these paths. On the other hand, Paths 1c, 2a, 2b, 3a, and 3b have raw coverage of 16.2%, 17.4%, 17.3%, 15.4%, and 16.8%, respectively, covering a total of thirty-three cases. Path 1c emphasizes the significance of high growth in the corporate listing process, while Paths 2a, 2b, 3a, and 3b highlight the core requirement of high profitability. A strong operational capability is a fundamental indication of good business status and can lead to significant and sustainable progress. Higher operational capacity means that the company will have considerable operating income in the future. Even though the profitability of Path 1a is currently low, its better operational capabilities may compensate for this deficit.

R&D capabilities are crucial for a company's successful innovation. Technological innovation is an essential source for technology-based companies to maintain their competitive advantage, and higher technological innovation implies greater competitiveness and higher investment potential. Companies listed on the Shanghai Stock Exchange Star market are generally invisible champions in emerging industries. They uphold the development concept of specialization, specialization, and innovation and are characterized by small size but high R&D intensity and rapid growth. Paths 1b and 1c are typical cases that reflect the advantages of high R&D and high growth, respectively.

Paths 2a and 2b represent two viable strategic paths for publicly traded companies that exhibit high levels of profitability. Among the two paths, Path 2a stands out as a unique configuration that is not dominant in terms of growth, technical proficiency, or innovation performance. Nevertheless, Path 2a has gained market and investor recognition through its remarkable market share and stable profitability. Path 2b, on the other hand, boasts high levels of technical competitiveness and operational support, supported by strong profitability. However, its growth and innovation performance are not exceptional, possibly due to a significant amount of R&D investment resulting in anticipated sunk costs and short-term patent export challenges.

Path 3a and Path 3b are similar in that they are both large-scale, highly profitable and high innovation performance companies. Paths 3a and 3b are similar in that they are both large-scale, high-profit, high-R&D companies. It is clear that the 3a configuration is relatively weak in terms of operations and growth due to the organizational redundancy and diminishing marginal returns associated with large scale. The study of Dang et al. on the other hand, indirectly explains that the growth factor does not have any impact on enterprise value, which suggests that profitability is the principal factor for corporate IPOs [41]. Path 3b companies are relatively outstanding companies that are well developed in all aspects. These companies are both highly competitive and growing rapidly. All of the above configurations are the leading paths for companies to achieve IPO. Meanwhile, they all show the core competitiveness of the company from different advantages, and they are also the best choice of financing strategy under comparative advantage.

5. Conclusions and implications

5.1. Conclusions

Based on ISM and AHP, this paper constructs an evaluation system for the listed competitiveness of high-growth companies in China from the enterprise scale, profitability, business growth, operating capacity, technical competence and innovation performance. We analyzed the IPO paths of companies applying for listing on the Science and Technology Innovation Board of China, and the results are as follows:

Chinese firms listed on the STAR market have performed well overall in terms of competitiveness. Companies in the new energy, new-generation information technology, and high-end equipment industries exhibit relatively outstanding listed competitiveness, while those in the energy-saving and environmental protection sectors exhibit relatively weak competitiveness. Additionally, firms registered on the Science and Technology Innovation Board generally demonstrate high growth and technical capability. Among these, firms in the new energy industry are the most competitive in terms of corporate scale, profitability, and innovation capacity. This study applies fsQCA to analyze the listing paths of high-growth firms. The listing of a firm is the result of a combination of multiple factors rather than a single factor. Empirical findings reveal that the configurations of China's STAR market listing paths can be classified into several types, including well-operated, high-technical competence and high-innovation-led; high-profit, low-growth, and low-innovation-led; and large-scale, high-profit, and high-innovation-led.

5.2. Theoretical contributions

The findings from this study make several contributions to the current literature. First, this paper contributes to expanding the perspective of enterprise competitiveness research. Most of the literature starts from technical development [4], modernization [7,40], and marketing innovation [5], and there is little literature discussing the listed competitiveness of China's high-growth enterprises on the STAR market. Second, the paper verifies the complex causal relationship of enterprise competitiveness evaluation and confirms the asymmetric view of complexity theory. The findings make an important contribution to revealing the internal mechanism of IPOs,

where the concurrency of multiple factors is the key to driving enterprises to go public. Third, this study has also provided a deeper insight into providing decision-making reference for the listing and financing of China's high-growth enterprises and providing a new theoretical basis for the listing and financing of science and innovation enterprises. Therefore, our study contributes to the literature on competitiveness evaluation by proposing a novel approach that combines AHP with FsQCA. This approach provides a more comprehensive and accurate evaluation of enterprise competitiveness than traditional methods. Our study also highlights the importance of considering multiple dimensions of competitiveness, such as the technical level, industry ranking, and venture team, in the evaluation process.

5.3. Practical implications

This study has important management insights and guidance for high-growth enterprises in the IPO process. In terms of practical implications, our study offers valuable insights for decision-makers in enterprises, as it provides a systematic and effective approach for evaluating competitiveness. By utilizing the proposed approach, enterprises can identify their strengths and weaknesses in terms of competitiveness and make informed decisions to enhance their competitive advantage. To further accelerate the listing of high-growth enterprises in the Star market, this paper has the following implications.

To achieve successful operation and growth, companies with high technical competence and innovation must rely on technological breakthroughs and disruptive innovations to be listed on the Science and Technology Innovation Board. Enterprises can leverage their unique strengths to develop core technology strategies that enhance competitiveness and solidify their leading positions within the industry. Furthermore, activating the entrepreneurial team's scientific spirit and social mission is crucial for sound corporate governance and operations. For instance, effective solutions include strengthening the procedural management of R&D project budgets, planning, scheduling, and technology transfer, as well as improving the quality and marketability of innovations.

For high-profit, low-growth, and low-innovation-led companies, the focus should be on adhering to innovation investment, knowledge accumulation, and technology leadership principles to sustain market stability and profitability. Dynamic capabilities can be achieved through knowledge accumulation, which is achieved by strengthening the integration of external knowledge acquisition and independent internal innovation. Furthermore, companies may need to be market demand-oriented, introduce strategic investors with complementary resources, and create a more innovative atmosphere to enhance vitality.

For large-scale, high-profit, and high-innovation-led companies, maintaining sustained profitability and expanding scale is crucial for listing. Technological innovation and supply chain deepening are the foundation for maintaining sustained profitability, as embeddedness in the organizational network allows companies to access valuable resources to compensate for organizational redundancy and provide the impetus for rapid growth. Digital transformation enables resource sharing and information exchange among organizations within the enterprise, facilitating a specialized division of labor and collaboration, which improves innovation efficiency. Continuous investment in R&D is necessary for companies to maintain ongoing R&D momentum and dynamic competitiveness by gaining environmental insight, technological flexibility, organizational agility, and self-transformation.

5.4. Limitations

This study has certain limitations that should be noted. First, in constructing the competitiveness evaluation system, we did not utilize objective methods such as principal component analysis, the entropy method, and the LBWA model. Instead, expert scoring methods were adopted for assessing technical level, industry ranking, and venture team, which may lead to selection bias. Second, this study only considers the total number of patents without distinguishing between types of patents, such as invention patents, utility patents, and design patents. Therefore, the potential value of patents is not fully considered in the evaluation of the innovation capacity of enterprises.

Future research could explore the paths of IPOs for firms in different capital markets or utilize multiperiod qualitative comparative analysis to identify antecedent conditions for IPO paths from a configuration perspective. Specifically, future research could also explore the application of the AHP-fsQCA approach in different industries and regions to evaluate the competitiveness of enterprises in various contexts. Moreover, researchers could investigate the relationship between competitiveness and other factors, such as innovation, sustainability, and corporate social responsibility, to provide a more comprehensive understanding of enterprise competitiveness.

Author contribution statement

Wei Zhang and Zhiguang Li: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Shuo Li and Hui Feng: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

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