9-2022

A study on the impact of technological innovation attributes on listing success rate and post-listing performance

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2022

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Submitted to the School of Accountancy of Singapore Management University (SMU) SMU-ZJU DBA(Accounting and Finance)
To meet the Doctoral Degree Requirements in Business Administration

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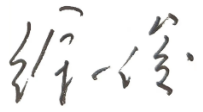
2022

Declaration

I hereby declare
that this thesis is my original work and has been written entirely by me.
I have appropriately noted all sources of information used in this thesis.

Previously, the thesis has never been used to obtain a degree at any university.



Xu Yi Jun

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15th September, 2022

Abstract

"Key and core technology" enterprises form the backbone of great powers. China's STAR Market (technological innovation board) is committed to implementing strategies that will lead to technological innovation-driven sustainable development and strengthen the country by building a secure and independent industrial chain that can support the development of cutting-edge technology. From the outset, the STAR Market put forward clear requirements for "key and core technology" enterprises. The technological innovation attributes of the enterprises listed on the STAR Market are the most essential core characteristics, but a question arises as to how best to evaluate their technological innovation attributes. Are these related to their listing success rate or their post-listing performance? In addition, is there a significant difference in the influence of technological innovation attributes on the listing success rate for different types of enterprises or enterprises with different kinds of property rights? The answers to these questions are of potentially enormous significance to government departments, investment institutions, enterprises, *etc*.

Few Chinese scholars have studied the listing success rate of enterprises. In this study, principal component analysis (PCA) was used to transform various specific evaluation indicators of technological attributes into a comprehensive index: the Technological Innovation Index (*TII*). By controlling factors such as asset size, asset-liability ratio, net profit, and the year of listing, a regression analysis model was constructed that was then used to empirically analyze the

influence of the TII on the listing success rate, post-listing performance, and growth of different enterprises.

The results show that positive technological innovation attributes significantly improve the listing success rate of enterprises and are positively correlated to their long-term post-listing performance, though they suppress their short-term performance. The impact of technological innovation attributes on the listing success rate does not vary according to the type of enterprise or its property rights. However, there are significant differences in the contribution of each technological innovation attribute to the TII. In order from high to low, these are: the intensity of R&D investment; the level of R&D investment; the personnel structure; and the number of patents held.

The TII and related findings can help enterprises to improve their own technological innovation attributes so as to increase their listing success rate. They can also help policy makers to ongoingly improve and optimize the TII, so that it can assist with identification of the most promising high-tech enterprises and the promotion of a national strategy towards establishing China as a science and technology giant. The TII can also help investors to screen technological enterprises and ensure they make the most effective investments by improving the efficiency of their use of capital and maximizing their return on investment.

Overall, the results of this study not only enrich theoretical research on the listing success rate of enterprises, but also encourage enterprises, investors, financial institutions, *etc*., to pay more attention to technological innovation. This may encourage enterprises to increase their R&D investment and technological

innovation. Beyond this, the study aims to contribute to the transformation and upgrading of the Chinese economy and to stimulate capital market reform and development, in terms of both theory and practice.

Keywords: registration system, STAR Market, technological innovation attributes, listing success rate, post-listing performance

目录

Acknowledgment

The completion of this thesis represents the honor that I keep to pursue academically. Looking into the past, my learning experience can be roughly divided into two stages as before and after work. When I was a child, reading was the only way out for rural children like me, while few of us could actually change our fate by it. A Technical Secondary School was my choice after my College Entrance Examination. I started in university only after work. Over years, I earned a Master's Degree first by studying in Junior College, then by studying as an Undergraduate, an Engineering Graduate. After that I went to a Business Administration President Class and a Finance Class, and then gained EMBA. Finally, I had the opportunity to study SMU-ZJU/DBA for MBA. For me, 27 years of work means 27 years of study. I worked so hard and so tirelessly through good and bad, day and night. My initial incentive of study was going to university, but gradually and eventually studying and learning have become part of me and my life. Studying and Learning do not only improve my ways of thinking and cognizing the world, but also have been verified to help with my career and have influence on people around me.

As this thesis is completed, my gratitude first and foremost goes to Ms. Wang Rong, my Advisor. Ms. Wang Rong is a Professor of Lee Kong Chian Business School, Singapore Management University, and she has been helping me ever since

the beginning of my DBA program. She is always there at each and every important step of my study, from my independent research to my thesis topic selection, from research analysis, drafting and revision and finally to the completion of this thesis. Professor Wang Rong's profound knowledge and her academic rigor will benefit me for life. She has trust and faith in me, and urges me to conquer my fear and anxiety about exploring unknown areas with no sluggishness.

My gratitude also goes to my co-advisor, Professor Wei Jiang, Dean of the School of Management, Zhejiang University. Professor Wei Jiang was my advisor when I studied for EMBA at Zhejiang University. He did not only always care about my studies, but also helped me with my career by planning for a long-term development of the company I founded. Professor Wei has been initiating enterprise innovation for years, calling on entrepreneurs to play a leading role in China's development. He encourages entrepreneurs and scholars to learn more about "useless truths".

I am also grateful to Professor Chen Xia from the SMU School of Accountancy. Professor Chen is the second advisor of my thesis and provided me with a lot of good suggestions and ideas on the research of the topic, which further enriched the content outline and research results of the thesis.

In addition, I would like to thank Professor Han Hongling of the School of Management of Zhejiang University, who gave me clear and precise guidance when

I was confused about this thesis research in the early days, enabling me to continue with my climbing. Thanks to Ms. Liu Fei at the DBA Program Office of Singapore Management University, she has been always there for me to complete my studies and has provided me with a lot of assistance and convenience in course arrangements, thesis defense process and degree application. In addition, there are many teachers and classmates who helped me a lot during my doctoral studies, and I would like to thank them all!

My Special gratefulness goes to Mr. Huang Chaocai, my research assistant, who has invested a lot of time and energy in the preparation of thesis materials, data collection and research. Mr. Huang has sided with me all the time, and is my best study pal and working partner. I would like to thank my assistant Ms. Li Zhiping for completing the relevant procedures for my school, assisting me in collecting materials and reviewing the manuscript, as well as my colleague Mr. Sun Xinli for collecting a large number of references for me. In addition, I would also like to thank Mr. Yan Ying and Mr. Zhu Honghua of Haitong Securities, who have been assisting me in collecting relevant information on the capital Market, so that I can keep abreast of the latest information. They all have made important contributions to the completion of this thesis.

Last but not least, I would like to show my gratefulness to my family. I am lucky to have a warm and loving family, with a gentle and considerate wife and

cheery and confident kids. My mother-in-law lives with us and takes care of my kids. She does such a good job that I am freed from many of the family responsibilities and is able to devote myself more to my studies and career. Thanks to my parents and brothers. Ever since my childhood, they have been idols and examples by teaching my so much, I look up to them. My brothers are diligent and devoted, friendly and helpful, and they work hard in their own successful careers after grown up.

"Learning and diligence are lifelong wealth" is my self-portrayal. I believe diligence makes success. I shall always be tireless to learn and seek truth, and give back to society by entrepreneurship and innovation, for I believe the meaning of life is nothing more than this!

Chapter I. Introduction

1.1 Research content, ideas, and methods

1.1.1 Main research content

All enterprises applying for listing on the STAR Market (technological innovation board) were considered in this research, except for those that had not been explicitly listed. The four conventional indicators for measuring technological innovation attributes in the *Guidelines for Evaluation of Technological Innovation Attributes (Trial)* were used as the main research variables when studying the correlations between the technological innovation attributes and the listing success rate, the post-listing performance, and growth.

1.1.1.1 Technological innovation attributes and listing success rate

Generally speaking, enterprises with stronger technological innovation attributes have a higher listing success rate on the STAR Market. A quantitative evaluation was therefore undertaken of the four conventional indicators of technological innovation to empirically verify whether technological innovation attributes have a significant impact on the listing success rate.

1.1.1.2 Technological innovation attributes and post-listing performance and growth

According to the TII, enterprises with stronger technological innovation attributes have greater R&D investment together with other indicators. This can have a negative influence on the short-term performance of enterprises but, in the long run, an increase in R&D investment and technological innovation is likely to result in enterprises enhancing their long-term core competitiveness, performance and growth. A quantitative evaluation was therefore also undertaken of the four conventional indicators

of technological innovation with regard to whether technological innovation attributes can have a significant impact on the long-term and short-term post-listing performance and growth of enterprises.

1.1.2 Conceptual framework

The research presented here consists of two parts: 1) an analysis of the correlation between technological innovation attributes and the listing success rate; and 2) an analysis of the correlation between technological innovation attributes and post-listing performance and growth. The compound growth rate of an enterprise's operating revenue and its net profit over different time spans were used as explanatory variables to study how technological innovation attributes could be influencing its post-listing performance and growth.

First, the research scope governing the samples to be used was defined. This was set to be all enterprises applying for listing on the STAR Market, apart from those that had not then been explicitly listed. After this, principal component analysis (PCA) and mathematical dimensionality reduction were undertaken to transform the four conventional indicators into a single overall indicator, *i.e.*, the Technological Innovation Index (*TII*). This can then be used to measure the strength of an enterprise's technological innovation attributes. Factors with the greatest influence on an enterprise's initial public offering (IPO) success rate and post-listing performance were selected, such as its asset size, asset-liability ratio, net profit, and the year in which it was established. A logistic regression model was then constructed, so that an empirical analysis of the influence of the TII on the IPO success rate and post-listing performance and growth could be undertaken.

1.1.3 Research methods

1.1.3.1 Case analysis

Case analysis is a scientific approach that seeks to obtain an overall understanding through a detailed and in-depth study of representative things or phenomena. Case analysis can involve examining both common and typical cases. The specific steps are as follows: (1) According to its purpose, representative events or phenomena are selected for analysis; (2) All the data relating to the selected events, direct or indirect, are collected; (3) The collected data are systematically sorted and classified according to their character and the purpose of the analysis; (4) Requisite elements (features, attributes, correlations, *etc.*) are analyzed and studied one by one; (5) The overall results are analyzed to capture the wider regularities of the events or phenomena being examined.

1.1.3.2 Empirical research

Empirical research is a method that provides valid, useful, definite, and accurate knowledge by providing an understanding of objective phenomena. It focuses on figuring out "what" a phenomenon itself is. Empirical studies attempt to transcend or exclude value judgments, with the sole purpose of revealing the universal connection between the internal components and elements of objective phenomena and summarizing their nature and operational rules. Here, the evaluation indicators of the attributes of technological innovation were analyzed by means of PCA and dimensionality reduction. The TII was then obtained to measure the relative import of the technological innovation attributes. Logistic regression analysis was used to study the influence of the technological innovation attributes on the listing success rate of enterprises on the STAR Market and their post-listing performance. PCA and logistic regression analysis are as follows:

A. Principal component analysis

PCA is a statistical method that transforms a set of possibly correlated variables into a set of linearly

uncorrelated variables through orthogonal transformation. These transformed variables are then termed the principal components. There can be multiple variables, with the complexity of the subject often depending on just how many there are. PCA reduces the dimensionality of datasets by excluding variables that contain overlapping information while retaining those that contribute the most to the degree of variance. As far as possible, the remaining variables preserve the original information about a subject. The approach is as follows:

First, the dataset is assumed to be $(X_1, X_2, \ldots X_n)$ and is standardized:

$$x_i = \frac{X_i - \overline{X}_i}{S_i}$$

The correlation coefficient matrix is then:

$$r_{ij} = \frac{\sum_{k=1}^{n}(x_{ki} - \overline{X}_i)(x_{kj} - \overline{X}_j)}{\sqrt{\sum_{k=1}^{n}(x_{ki} - \overline{X}_i)^2 \sum_{k=1}^{n}(x_{kj} - \overline{X}_j)^2}}$$

$$R = \begin{bmatrix} r_{11} & r_{12} & \ldots & r_{1p} \\ r_{21} & r_{22} & \ldots & r_{2p} \\ \ldots & \ldots & \ldots & \ldots \\ r_{p1} & r_{p2} & \ldots & r_{pp} \end{bmatrix}$$

e_i, which corresponds to the eigenvalue, λ_i, of the correlation coefficient matrix, is taken to be $\|e_i\|$=1 (namely, $\sum_{j=1}^{p} e_{ij}^2 = 1$).

The principal component contribution rate and accumulated contribution rate are now obtained as follows:

$$\text{Principal component contribution rate} = \frac{\lambda_i}{\sum_{k=1}^{p} \lambda_k}$$

$$\text{Accumulated contribution rate} = \frac{\sum_{k=1}^{pi} \lambda_k}{\sum_{k=1}^{p} \lambda_k}$$

Finally, the principal component load and the score of each component are calculated, using:

$$I_{ij} = p(z_i, x_j)\sqrt{\lambda_i} e_{ij}$$

$$Z = \begin{bmatrix} z_{11} & z_{12} & \dots & z_{1m} \\ z_{21} & z_{22} & \dots & z_{2m} \\ \dots & \dots & \dots & \dots \\ z_{n1} & z_{n2} & \dots & z_{nm} \end{bmatrix}$$

B. Logistic regression

Logistic regression is a generalized linear regression model that is typically applied to datasets containing an explanatory variable "yes" or "no". It is often used in fields such as data mining, disease diagnosis, and economic forecasting. The coefficient of each explanatory variable is calculated by logistic regression to obtain the influence of each factor on a designated set of samples.

Logistic regression is essentially linear regression with a sigmoid function. Given the dataset $(x_i, y_i), i = 1,2\dots,N,$ wherein y is 0 or 1, the logistic regression model is:

$$p(y = 1|x) = \sigma(\omega^T \phi) = \frac{1}{1 + \exp(-\omega^T \phi)}$$

where, ω is the substitution coefficient $\omega = (\omega_0, \omega_1, \dots, \omega_D)$; and b_i can be defined as:

$$b_i = p(y_i = 1|x_i)$$

The maximum likelihood probability is:

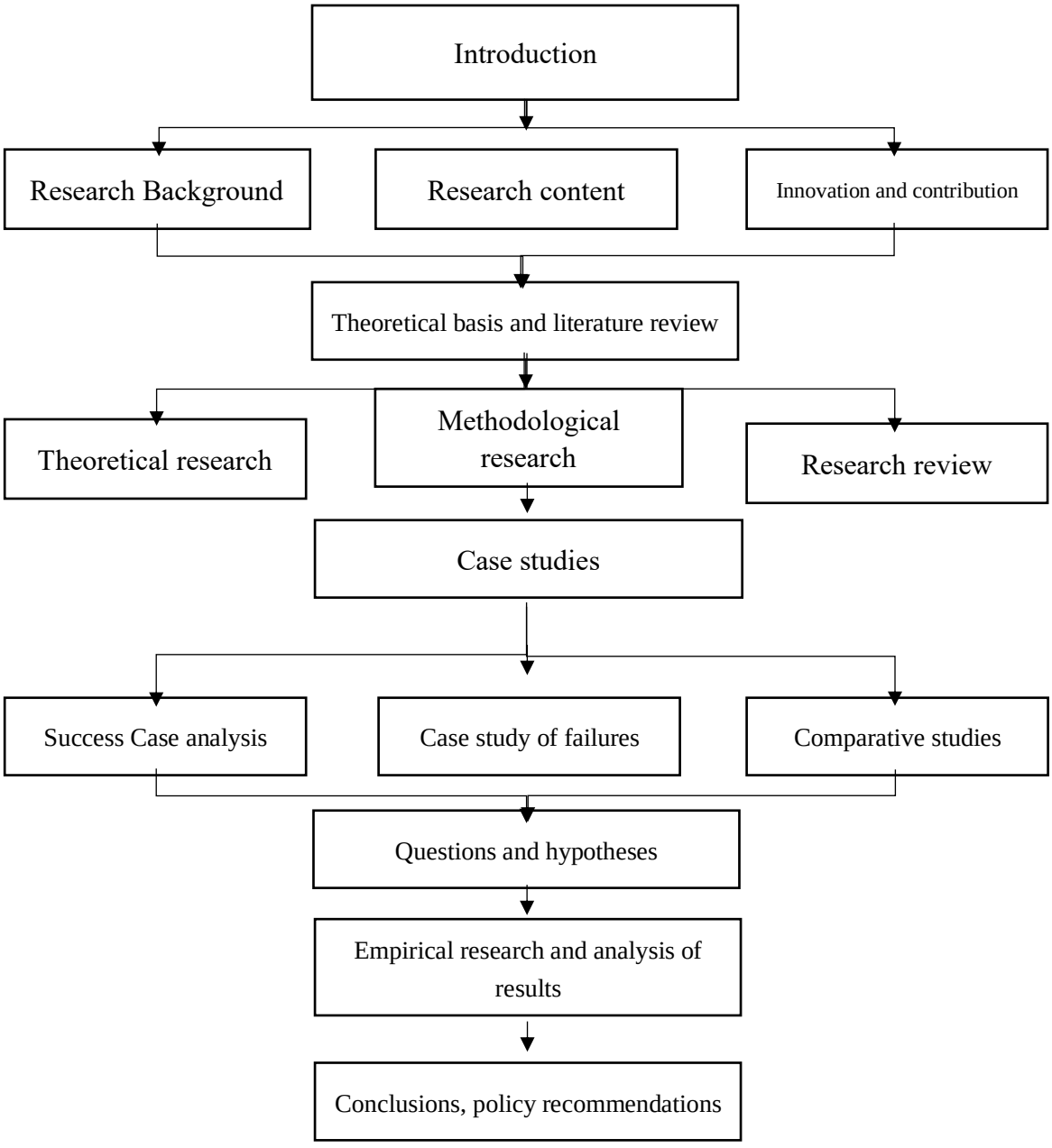
$$p(y|\boldsymbol{\omega}) = \prod_{i=1}^{N} b_i^{y_i}(1 - b_i)^{1-y_i}$$

This can be reformulated as a way of minimizing the negative maximum likelihood probability by obtaining its derivative, i.e.:

$$\frac{\partial E(\boldsymbol{\omega})}{\partial \boldsymbol{\omega}} = \sum_{i=1}^{N} (b_i - y_i)\phi(\boldsymbol{x}_i)$$

The estimated value of the logistic regression coefficient can then be obtained by gradient descent.

1.1.3.3 Research framework



1.2 Analysis of the research background

1.2.1 Analysis of the historical development and current situation of the Chinese capital market

Since the establishment of the Shanghai Stock Exchange (SSE) and the Shenzhen Stock Exchange (SZSE), the Chinese capital market has developed for 32 years, going through a series of major changes, such as the split-share structure reform and the reform of the registration system. The overall scale has grown from a total market value of less than RMB 3 billion in the initial period to about RMB 90 trillion with 4,800 A-share listed enterprises in June 2022. The structure of the overall capital market has also gradually developed from a relatively simple one to a diversified one, and a multi-level capital market in China has gradually taken shape. In addition, development can be clearly seen in many aspects. More specifically, the institutional team is expanding, the market acceptance is improving, the product categories are increasing, and the overall trading mechanism is also developing. The development of the entire issuance system is clear and perfect, experiencing a due course of examination and approval system, approval system and registration system, the direction is clearer and market-oriented. What's more, the laws and regulations are also in the process of improvement and integration with the progress of the whole market. The supervision mode is becoming more and more mature and will gradually shift from substantive supervision to transparent supervision. The functions of the Chinese capital market are mainly financing, with an emphasis on investment and financing. The wealth management function is becoming increasingly obvious as well, contributing more to economic growth. Moreover, technological innovation is increasingly driving the improvement and evolution of the governance of listed enterprises.

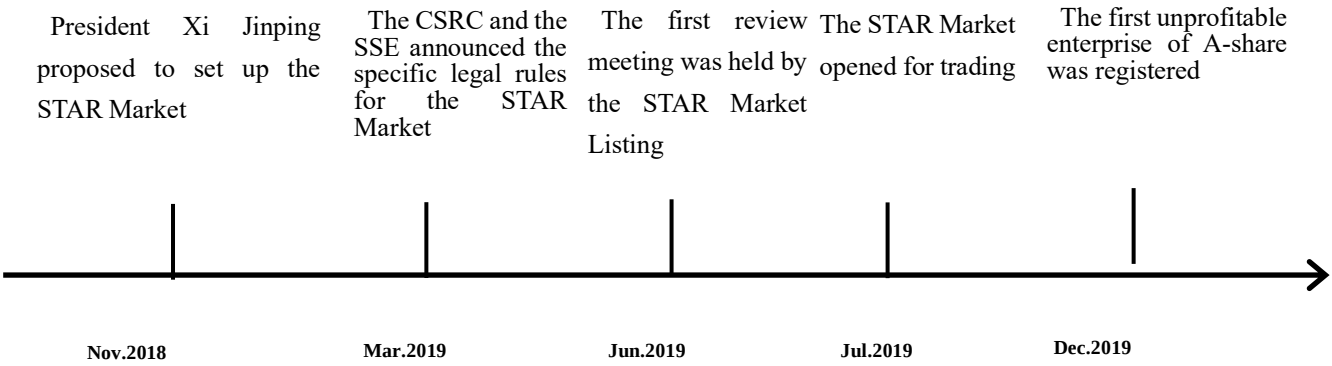
The establishment of SSE and SZSE is of significance and is the first milestone in the development history of the Chinese capital market. Before 1990, bank loan was the main form of enterprise financing. However, debt financing was usually short-term, which was not conducive to the long-term development

of enterprises. Besides, banks preferred to lend to enterprises with heavy assets and stable income, which greatly restricted the development of private enterprises, small and medium-sized enterprises (SMEs), and technological innovation enterprises. Therefore, the establishment of SSE and SZSE has opened the prelude to financial "disintermediation", allowing enterprises to conduct equity financing through the capital market, thus broadening the financing channels for enterprises.

The split-share structure reform, initiated in 2005, is the second milestone in the development of the Chinese capital market. The split-share structure consists of mainly non-tradable shares and tradable shares. State-owned shares and corporate shares account for a large proportion of non-tradable shares, while the majority of tradable shares are public shares. Non-tradable shares have the same rights per share as tradable shares, but the cost of holding shares varies greatly, resulting in inequality between the two types of shareholders and a failure to protect the public. In the split-share structure, the interest demands of the two types of shareholders have a certain degree of differentiation. The majority of controlling shareholders in listed enterprises are non-tradable shareholders, who are more concerned about the improvement of the value of net assets than future profit growth or even stock price decline, which does not favor the interests of small and medium-sized investors. In addition, it is increasingly affecting the purpose of the asset allocation of listed enterprises, making it hard to be achieved through equity transactions. Moreover, it goes against the direction of China's economic deepening reform. Hence, if great success could be achieved in the split-share structure reform, it would mark the standardization of the Chinese capital market system and the arrival of the full circulation era of the Chinese capital market.

The third milestone in the Chinese capital market is the reform of the registration system for stock issuance in 2019. [1] As early as November 2018, General Secretary Xi Jinping formally proposed to set up the STAR Market and launch the pilot registration system on the SSE. On March 2, 2019, the China

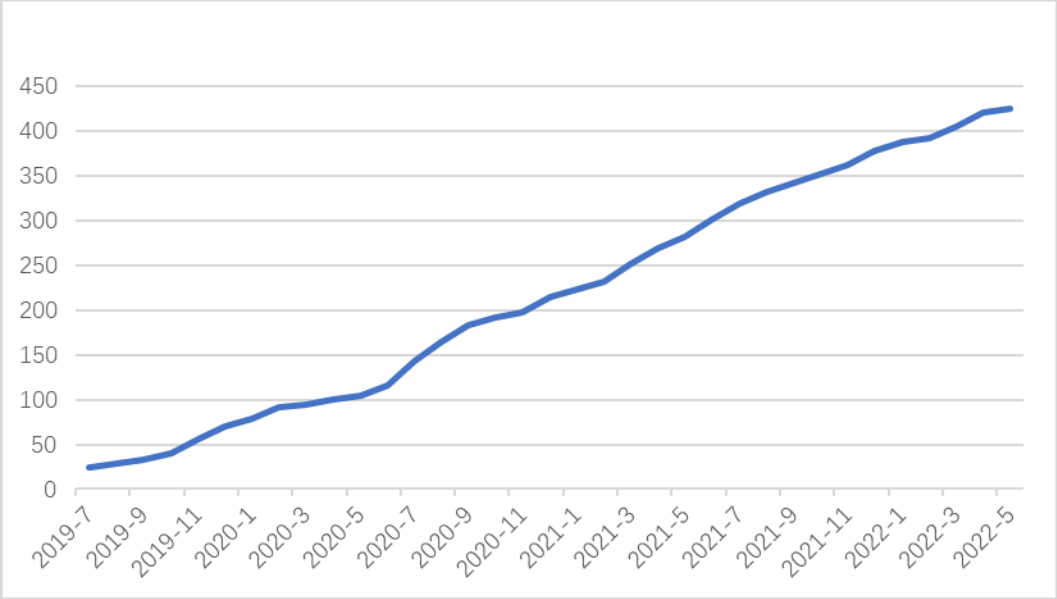
Securities Regulatory Commission (CSRC) and the SSE announced the specific legal rules for the STAR Market. The speed and depth of innovation of the STAR Market reform are unprecedented in the reform history of the Chinese capital market. On March 8, the trading authority on the STAR Market was officially launched. On March 18, the information disclosure system for listing approval on the STAR Market was opened, and the SSE officially began to accept listing declarations. On March 22, the applications of the first batch of 9 enterprises to be listed on the STAR Market were accepted by the SSE. On June 5, the first review meeting in 2019 was held by the STAR Market Listing Committee, which approved three enterprises to be listed on the STAR Market as the first batch, namely Chipscreen Biosciences, TZTEK Technology, and Anji. On July 22, the STAR Market opened for trading and the first batch of twenty-five enterprises were collectively listed on the STAR Market for trading.



Since its establishment, the STAR Market has played a very important role in promoting the Chinese capital market and effectively connecting capital and industry. Besides, it has created good opportunities for the sustainable and efficient development of high-tech enterprises, bringing a driving force to promote China to be a technological power. As of June 2022, there are nearly 500 listed enterprises on the STAR

Market, raising more than RMB 600 billion through initial public offerings (IPOs), with a total market value of more than RMB 5 trillion.

Cumulative number of enterprises listed on the STAR Market



At present, for the development of the Chinese capital market, the constant improvement in the construction of a multi-level capital market system is still required to improve the efficiency of market resource allocation. Besides, it is necessary to develop institutional investors energetically to promote the positive interaction between long-term funds and capital markets. At the same time, the strength of financial supervision needs to be enhanced constantly to fully protect the rights and interests of small and medium-sized investors, and to ensure fairness, impartiality and openness. The right to know, supervision, and participation should be given to everyone. A more robust multi-level capital market will also bring more energy to enterprises and effectively connect capital, funds and resources, thus promoting the transformation and upgrading of China's economy to achieve high-quality economic development.

1.2.2 Changes in the audit system of new stock issuance

Since the establishment of China's stock market, with the promotion of marketization, the audit system of new stock issuance has experienced a process of adjustment, from the examination and approval system to the approval system, and then to the registration system. Quota management and indicator management are in the phase of the examination and approval system, and the passage system and the sponsor system are in the phase of the approval system.

1.2.2.1 Examination and approval system

The examination and approval system went through two periods of development, starting from the quota management period (1993-1995) to the indicator management period (1996-2000). In 1993, the *Interim Provisions on the Management of the Issuing and Trading of Stocks* was issued by the State Council, which legally defined the functions of the relevant departments, namely, [2] the Securities Committee of the State Council (hereinafter referred to as "SCSC") and CSRC. The promulgation of the Provisions is of great historical significance, representing the establishment of a unified audit system of stock issuance in China and the beginning of the examination and approval system for stock issuance.

A. Quota management period (1993-1995)

During the quota management period, the SCSC firstly determined the total quota mainly on the basis of the development of the national economy and the actual situation of the capital market. Secondly, the provincial administrative regions and industries further determined the total quota allocated according to the stage and actual needs of all aspects in the development of the entire national economy. Finally, the enterprises that could issue stocks were determined, among which most were state-owned enterprises, and the relevant confirmation work was determined by the provincial government or the industry authorities. In the whole period, the issuance quota of RMB 10.5 billion shares was confirmed in total. However, only the issuance scale was determined but not the number of listed enterprises. Hence, a large

number of enterprises were recommended, among which most were small in size. Enterprises of great significance to the development of the national economy did not get better development opportunities, resulting in an average distribution pattern in different regions and industries.

B. Indicator management period (1996-2000)

To solve the problem that the listed enterprises were generally small in size in the quota management period, the SCSC began to adjust its policies by limiting the total number of enterprises on the basis of total quantity control. The audit system of new stock issuance ushered in the indicator management period. During this period, the overall scale of the stock issuance was firstly determined by the State Planning Commission and the SCSC, and then the CSRC, according to the actual situation, issued the total number of enterprises that could issue stocks to the provincial government and the industry authorities. Secondly, outstanding enterprises were recommended without surpassing the total number determined below. After verifying whether the declared enterprises met the requirements, the CSRC notified the enterprises to sort out the materials for stock issuance and file a formal declaration. Finally, the CSRC reviewed the materials and made a decision on approving the listing and approved the issuance scale for the enterprises within the total scale. Based on the quota management, the indicator management had been better improved and the problem of the small scale of listed enterprises had also been solved to some extent, but there were also drawbacks. Due to the fact that no limit was set on the scale of an individual declared enterprise, bundled listing was employed to solve the problem of state-owned enterprises by part of local governments, ultimately leading to the uneven quality level of listed enterprises.

1.2.2.2 Approval system

There are also two periods in the development of the approval system: the passage system period (2001-2004) and the sponsorship system period (2004 to today). Owing to the strong administrative color

of the approval system and the obvious government intervention, the capital market failed to play an important role in value discovery and effective resource allocation. In 1999, with the release of the *Securities Law of the People's Republic of China*, the stock issuance system entered a new stage of development, from the examination and approval system to the approval system. Compared with the examination and approval system, the approval system no longer uses indicators for control. Moreover, government intervention is reduced and market-oriented policies are applied. More specifically, outstanding enterprises are explored by the market itself and cultivated, recommended and sponsored by professional institutions that assume relevant legal liabilities.

A. Passage system period (2001-2004)

Prior to the passage system period, the pre-examination of the enterprises was mainly carried out by the government authorities. After the passage system, securities enterprises qualified as lead underwriters were asked to judge whether the enterprises met the standards of stock issuance in terms of historical development, enterprise governance, enterprise performance, *etc.*, so as to select the enterprises and recommend stock issuance. The CSRC determined the number of shares to be issued by each securities enterprise in advance according to its strength and performance, and the latter enterprise could only be declared after the issuance of the former enterprise was completed. As a result, the speed of stock issuance was restricted and the market demand could not be fulfilled.

B. Sponsorship system period (2004 to today)

The *Interim Measures for the Stock Issuance and Listing Sponsorship System* [3] and other regulations were formulated and issued by the CSRC in 2004, opening the prelude to the sponsorship system. The introduction of the sponsorship system has played a clear role in regulating the responsibilities of the sponsor institutions and the sponsor representatives. Enterprises needed to ensure the authenticity, accuracy and completeness of their issuance documents. Sponsor institutions and

sponsor representatives are required to assist enterprises to establish a standardized disclosure mechanism and formulate risk prevention measures after the listing, making sure the enterprises comply with the relevant provisions of the listing. Besides, sponsor institutions and sponsor representatives should bear certain joint liabilities for the relevant commitments in the prospectus. Hence, the two should fully assume their responsibilities and continue to guide enterprises to compliance within a certain period of time. If collusion with enterprises is discovered, they will face severe penalties from the market. Hence, it is impossible to break through the difficulties of securities issuance to improve the quality of securities issued by the enterprises, raise market integrity and enhance market attractiveness.

1.2.2.3 Registration system

General Secretary Xi Jinping attended the opening ceremony of the 1st China International Import Expo in November 2018. In the keynote speech at the ceremony, he officially announced the establishment of the STAR Market on SSE and launched the pilot registration system at the same time. This important speech raised the banner of the reform of the registration system of the capital market. In April 2020, the *Overall Implementation Plan for ChiNext Reform and Pilot Registration System* was reviewed and approved at the 13th meeting of the Central Committee for Deepening Overall Reform. In October 2020, the State Council issued the *Opinions for Further Improving the Quality of Listed Enterprises*, representing that the audit system of new stock issuance developed towards a comprehensive registration system, and the reform of the registration system for the issuance of new stocks on the main board was steadily promoted. In November 2021, the Beijing Stock Exchange (BSE) started trading and more outstanding technological enterprises were served by the registration system. The development of the registration system has witnessed the development of the Chinese capital market from the pilot of the STAR Market, to the implementation of the ChiNext and to the full rollout of the BSE.

1.2.3 Technological innovation and national strategy

At present, China's economic development has shifted from a phase of rapid growth to a phase of high-quality development at which technological innovation is crucial to building an economic and technological power. China has continuously emphasized the strategic significance of technological innovation and further strengthened policy support in response to the current economic development and the new requirements of the times. The *National Medium- and Long-Term Program for Science and Technology Development (2006-2020)* put forward a new development strategy with the technological innovation as the priority. At the Fifth Plenary Session of the 19th CPC Central Committee, it was formally proposed that "Making self-reliance in science and technology s strategic support for national development". The *Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China* once again outlined the concept of making self-reliance in science and technology be strategic support for national development, further promoting scientific and technological forces, giving priority to the construction of key laboratories and innovation bases for technological innovation platforms, striving to tackle key core technologies, increasing investment in basic research, and taking various measures to promote the transformation of technological achievements.

The Law of the People's Republic of China on Scientific and Technological Progress (Order No. 103 of the President of the People's Republic of China), as revised and adopted at the 32nd Session of the Standing Committee of the Thirteenth National People's Congress on December 24, 2021, was issued and came into force on January 1, 2022. After the amendment, four new chapters were added to the Law, namely, basic research, regional technological innovation, international technological cooperation, and supervision and management. They were added to the law as key points, fully emphasizing the lofty status and importance of technological personnel in the development of science and technology, which

was of great significance to promoting technological innovation.

Since 2016, a number of support policies in the field of technological research and innovation have been put forward in China, covering various aspects such as the transformation of technological achievements, technological innovation incentive, capital management and financing, and technological finance and taxation.

In terms of transformation of technological achievements, the two documents have played a certain role in encouraging scientific and technological researchers: the *Law of the People's Republic of China on Promoting the Transformation of Scientific and Technological Achievements* issued in 2016 and the *Several Opinions on Strengthening the Transfer and Transformation of Scientific and Technological Achievements in Institutions of Higher Learning* promulgated in 2017 [4], which stipulated the rewards and remuneration of technological personnel, and the open use of scientific and technological facilities and instruments, effectively promoting the sharing of scientific research resources and the transformation of technical achievements.

In terms of technological innovation incentive, measures such as expanding the implementation of equity incentives for enterprises were specifically stipulated in the *Interim Measures for the Equity and Dividend Incentives for State-owned Technological Enterprises* issued in 2017 and the *Matters Concerning Expanding the Implementation Scope of the Interim Measures for the Equity and Dividend Incentives for State-owned Technological Enterprises* issued in 2018 [5], effectively bringing more technological enterprises into the scope of incentives. Relevant measures to increase incentives for technological innovation have further stimulated the transformation of state-owned enterprises and technological innovation.

In terms of capital management and financing, in September 2021, the General Office of the Ministry of Science and Technology and the Office of the China Development Bank issued a notice on

special debts for industrialization of major technological achievements, with a focus on supporting the demonstration projects for industrialization of technological achievements and the construction of major national capacity platforms. In December 2021, the Ministry of Finance and the Ministry of Science and Technology of China jointly issued the *Measures for the Administration of Central Funds Guiding the Local Science and Technology Development* to guide the use and performance appraisal of funds, and promote the rational allocation of funds.

In terms of technological finance and taxation, along with the State Administration of Taxation issuing the *Notice on Issues concerning Increasing the Proportion of the Weighted Pre-tax Deduction of Research and Development Expenses of Technology-based Small and Medium-sized Enterprises* in 2017, more tax preferential policies were carried out to benefit enterprises [6]. In 2018, the State Council published the *Opinions on Promoting the High-Quality Development of Innovation and Entrepreneurship and Creating an Upgraded Version of "Entrepreneurship and Innovation among All the People"*, which further expanded the applicable scope. Under the original policy, the preferential tax policy of the proportion of the weighted pre-tax deduction of R&D expenditure up to 75% could only be enjoyed by technology-based SMEs. After the introduction of the Opinions, all other enterprises can benefit from the preferential tax policy. In the executive meeting of the State Council in March 2021, the deployment of the proportion of the weighted pre-tax deduction of R&D expenditure of manufacturing enterprises was discussed, further encouraging enterprises to invest in research and development (R&D), integrating innovation into every link of production, and increasing the proportion of the weighted pre-tax deduction of R&D expenditure from 75% to 100%. On April 1, 2022, the issues concerning raising the proportion of weighted pre-tax deduction of R&D expenditure of technology-based SMEs were announced for encouraging enterprises to further attach importance to technological innovation, increase R&D investment, and take a better path of innovation and development.

1.2.4 Background and significance of the establishment of the STAR Market

1.2.4.1 Background and significance

A. Background of the establishment of the STAR Market

(1) The needs of development of China's emerging industries and economic transformation and upgrading

With the support of China's policies and strategies, the technological industries have achieved staged catch-up and transcendence. At present, China's economy is in a new stage transformed from high-speed development to high-quality development, during which the role of technological progress in promoting economic development will be more obvious and the development of technological innovation is inseparable from financial support. However, China's traditional indirect financing model dominated by bank loans cannot adapt to the characteristics of technological innovation enterprises, such as light assets, poor or low profit, high growth but high risk, and large fund demand. In recent years, high-tech enterprises, especially Internet high-tech enterprises such as BATJ (Baidu, Alibaba, Tencent, and JD.com), chose to list overseas rather than in the Chinese market, which attracted public attention.

(2) Needs of capital market reform

Although China's capital market has developed into the second-largest one in the world, it is still in the process of development, with problems such as an imperfect system, non-implementation of a registration system, and a lax delisting system. Nonetheless, there is no advanced experience in the world that can be learned from. The first pilot of system reform such as marketization and implementation of the registration system and rigorous delisting on the STAR Market will facilitate experience accumulation, so as to achieve a comprehensive reform of the capital market.

Against the above background, for the purpose of further implementing technological innovation, promoting the long-term stable and high-quality development of enterprises, and improving the market

system and capital activity, [7] in January 2018, two opinions were deliberated and passed at the sixth meeting of the Central Committee for Deepening Overall Reform, namely the *Overall Implementation Plan for Setting up the STAR Market and Launching the Pilot Program of the Registration System on the Shanghai Stock Exchange* and the *Implementation Opinions on Setting up the STAR Market and Launching the Pilot Program of the Registration System on the Shanghai Stock Exchange*. In November 2018, China officially announced the establishment of the STAR Market and began to implement the pilot registration system.

B. Significance of the establishment of the STAR Market

(1) It is conducive to promoting the rapid development of China's technological innovation enterprises

Over the past 30 years since the establishment of the SSE in 1990, China's capital market has gradually matured, with improvement in relevant laws and regulations. However, restricted by the listing system and financial requirements, many high-tech enterprises in Internet and other sectors can only be listed overseas. The setting up of the STAR Market can contribute to the diversity and inclusiveness of the capital market, providing direct financing channels for Chinese enterprises with technological innovation capabilities and core technologies. Besides, the more transparent and flexible pricing mechanism of the STAR Market provides more technological innovation enterprises with a better platform to connect them with the market, capital and resources, thereby driving their rapid development.

(2) It is conducive to promoting and improving the reform of China's capital market

The STAR Market carries the heavy responsibility of capital market reform. Its establishment is conducive to improving the construction of China's multi-level capital market, and the STAR Market resolves the existing drawbacks of the approval system through a marketization approach. It is of importance to enhancing the long-term investment value of the capital market and further playing the

role of the financial market. Since the implementation of the registration system, the listing speed, costs and efficiency of enterprises have been greatly improved, which helps to speed up new stock issuance, deepen price marketization, alleviate the distortion of new stock pricing, and reduce the negative impact of new stocks on the secondary market. Furthermore, the registration system does not need the approval of the CSRC, and there are no requirements for profit standards and asset scale of enterprises, but the registration information of enterprises must be comprehensive, authentic, accurate and complete, and the authenticity and comprehensiveness of information disclosure in all aspects are more focused. Also, post-event control is emphasized by establishing strict and complete punitive measures, to help investors expand their investment in enterprises that are still in the growth stage, but belong to a sound development track and have well-developed norms and certain technological content, thus promoting ongoing improvement and development of the capital market.

(3) It is conducive to improving China's competitiveness in the global capital market

Capital market rules commensurate with its economic volume should be improved in China, the world's second largest economy, to boost financial and technological innovation industries. A proper match between them will play a positive role in the development of the capital market. Since China is in the stage of rapid development, high-tech enterprises should be focused to improve the national comprehensive strength. Therefore, the establishment of the STAR Market will provide better development platforms and opportunities for these outstanding high-tech enterprises, and help them embark on the passage of rapid development. Moreover, as a milestone in the development of the capital market, the establishment of the STAR Market is of great significance for absorbing global capital and building a global financial center.

In summary, the launch of the STAR Market is of great significance and is a milestone in China's capital market reform, as it can further meet the financing demands of technological innovation

enterprises, enhance the serviceability of the financial industry to the technological innovation industry, improve and promote the capital market reform, and upgrade China's competitiveness in the global capital market.

1.2.4.2 Industry selection

Sector	Content
New-generation information technology	Semiconductors and integrated circuits, electronic information, new-generation information networks, artificial intelligence, big data, cloud computing, software, the Internet, the Internet of Things, and intelligent hardware, *etc*.
High-end equipment	Intelligent manufacturing, aerospace, advanced rail transportation, marine engineering equipment, and related services, *etc*.
New materials	Advanced steel materials, advanced non-ferrous metal materials, advanced petrochemical and chemical new materials, advanced inorganic non-metallic materials, high-performance composite materials, cutting-edge new materials, and related services, *etc*.
New energy	Advanced nuclear power, large wind power, high-efficiency photothermic and photoelectric energy, high-efficiency energy storage, and related services, *etc*.
Energy saving and environmental protection	High-efficiency energy-saving products and equipment, advanced environmental protection technology and equipment, advanced environmental protection products, resource recycling, new energy vehicles, key components of new energy vehicles, power batteries, and related services, *etc*.

Biomedicine	Biological products, high-end chemical drugs, high-end medical equipment and instruments, and related services, *etc*.
Other sectors in line with the positioning of the STAR Market	

1.2.4.3 Evaluation indicators of technological innovation attributes

According to the description of the technological innovation attributes in the *Evaluation Instructions of Technological Innovation Attributes (Trial)*, the evaluation indicators of technological innovation attributes shall satisfy the following four items simultaneously[1]:

Item 1	The proportion of R&D investment to operating revenue in the last three years is over 5%, or the accumulated amount of R&D investment in the last three years is more than RMB 60 million.
Item 2	The proportion of R&D personnel to the total number of employees in the year is not less than 10%.
Item 3	More than 5 patents for inventions form the main business revenue.
Item 4	The compound growth rate of operating revenue in the last three years has reached 20%, or the operating revenue in the last year has reached RMB 300 million.

Enterprises that do not satisfy the conditions of the above indicators, but meet one of the following five standards, are also regarded as meeting the evaluation indicators of technological innovation

[1] According to the listing standards in Clause (5), Article 22 of the *Rules of the Shanghai Stock Exchange Governing Review of the Issuance and Listing of Stocks on the Sci-tech Innovation Board*, enterprises applying for listing on the STAR Market may not be applicable to the "operating revenue" in the above-mentioned Item 4 stipulations; the software industry is not applicable to the requirements of the above-mentioned Item 3, and the proportion of R&D investment shall be more than 10%.

attributes[2]:

Standard 1	The core technology owned by the enterprise has been recognized by the national authorities to be in an internationally leading role, or of great significance to the national strategy.
Standard 2	The enterprise as the main participant or its core technician as the main participant has won the National Technological Progress Award, the National Natural Science Award, or the National Technological Invention Award, and has applied related technologies to the enterprise's main business.
Standard 3	The enterprise independently undertakes or leads the major national technology special projects related to its main business and core technology.
Standard 4	The main products (services) based on core technologies of the issuer are key equipment, products, parts and materials, etc. that the country encourages, supports and promotes, and are able to achieve import substitution.
Standard 5	More than 50 invention patents (including national defense patents) constitute core technology and main operating revenue.

1.2.4.4 Standards for registration on the STAR Market

A. Standards for listing on the STAR Market

According to the *Rules Governing the Listing of Stocks on the Science and Technology Innovation Board of Shanghai Stock Exchange*, an enterprise applying for listing on the STAR Market of the SSE

[2] The financial technology and model innovation enterprises are restricted to list on the STAR Market. Enterprises of real estate, and enterprises mainly engaged in financial and investment businesses are prohibited from listing on the STAR Market. Therefore such enterprises do not satisfy the conditions of evaluation indicators of technological innovation attributes.

shall satisfy the following conditions:

(1) Market values and financial standards of general enterprises applying for listed on the STAR Market

In the case of a general enterprise applying for listing on the STAR Market of the SSE, one of the following standards shall be satisfied in terms of its market value and financial indicators[3]:

I	The expected market value is not less than RMB 1 billion, the net profit is positive and the accumulated net profit is not less than RMB 50 million in the last two years, or, the expected market value is not less than RMB 1 billion, the net profit is positive and the operating revenue is not less than RMB 100 million in the latest year.
II	The expected market value is not less than RMB 1.5 billion, the operating revenue in the latest year is not less than RMB 200 million, and the accumulated R&D investment in the last three years accounts for not less than 15% of the accumulated operating revenue in the last three years.
III	The expected market value is not less than RMB 2 billion, the operating revenue in the latest year is not less than RMB 300 million, and the accumulated net cash flow from operating activities in the last three years is not less than RMB 100 million.
IV	The expected market value is not less than RMB 3 billion, and the operating revenue in the latest year is not less than RMB 300 million;

[3] The net profit mentioned below is the lower one between the values before and after deducting non-recurring gains and losses, and the net profit, operating revenue, and net cash flow from operating activities all refer to audited values.

V	[8] The expected market value is not less than RMB 4 billion, and the main business or products shall be approved by the relevant national departments, with large market space and phased achievements have been achieved. Pharmaceutical enterprises shall have at least one core product approved to carry out phase II clinical trials, and other enterprises that satisfy the positioning of the STAR Market shall have obvious technological advantages and satisfy corresponding conditions.

(2) Market values and financial standards of red chip enterprises applying for listing on the STAR Market

[9] According to the *Notice of the General Office of the State Council on Forwarding Several Opinions of the China Securities Regulatory Commission on Launching the Pilot Program of Innovative Enterprises Domestically Issuing Stocks or Depository Receipts* (G.B.F. [2018] No. 21), a red chip enterprise that is not listed, applies for issuing stocks or depositary receipts overseas can be listed on the STAR Market. The market values and financial indicators of such enterprises shall at least satisfy one of the following standards:

I	The expected market value is not less than RMB 10 billion.
II	The expected market value is not less than RMB 5 billion, and the operating revenue in the latest year is not less than RMB 500 million.

(3) The market values and financial standards of enterprises applying for listing on the STAR Market with arrangements of voting rights difference[4]

[4] Arrangement of voting rights difference means that the enterprise, in accordance with Article 131 of the *Company Law of the People's Republic of China*, issues shares with special voting rights (referred to as special voting rights shares) in addition to the common stocks in general provisions. The number of voting rights for each special voting right is greater than the number of voting rights held by each common stock, and other shareholders have the same rights as common stocks.

For enterprises with arrangements of voting rights difference to apply for listing on the STAR Market, the market values and financial indicators of the enterprises shall at least satisfy one of the following standards:

I	The expected market value is not less than RMB 10 billion.
II	The expected market value is not less than RMB 5 billion, and the operating revenue in the latest year is not less than RMB 500 million.

B. Standards for issuance on the STAR Market

According to the *Measures for the Administration of the Registration of Initial Public Offerings of Stocks on the STAR Market (Trial)*, enterprises shall satisfy the following issuance conditions [10]:

(1) The enterprises are limited by shares, established in accordance with the law and have been operating continuously for more than 3 years. They have a sound and well-operated organizational structure, and the relevant institutions and personnel are able to perform their duties in accordance with the law. In the case of limited liability enterprises converted into those limited by shares as a whole based on the original book value of net assets, the duration of continuous operation can be calculated from the date of establishment of limited liability enterprises.

(2) Enterprises have standardized basic accounting work. The preparation and disclosure of financial statements comply with the provisions of the Accounting Standards for Enterprises and relevant information disclosure rules, their financial status, operating achievements, and cash flows in all material aspects can be fairly reflected, and a standard unqualified audit report is issued by a certified public accountant (CPA). The internal control system of the enterprises is sound and effectively implemented, which can guarantee their operating efficiency, compliance with laws and regulations, and the reliability of financial reports, and an internal control assurance report with unqualified conclusions is issued by a

CPA.

(3) The enterprises have a complete business scope and the ability to operate independently and continuously on a direct-to-market basis:

A) The enterprises have complete assets, independent business, personnel, finance, and organization. There is no horizontal competition with the controlling shareholders, actual controllers and other enterprises controlled by them that will have a material adverse impact on the enterprises, and there are no affiliated transactions that seriously affect the independence or are unfair.

B) The enterprises have a stable main business, control rights, management team and core technical personnel. There are no major adverse changes in the main business, directors, senior executives and core technical personnel in the last two years. The share ownership of enterprises held by the controlling shareholders and shareholders at the disposal of the controlling shareholders and the actual controllers is clear. The actual controllers have not changed in the last two years, and there is no major ownership dispute that may lead to a change in control rights.

C) There are no major ownership disputes over main assets, core technologies, trademarks, *etc.*, major debt repayment risks, major guarantees, litigation, arbitration, and other contingent matters, and significant changes in the business environment that have or will have a material adverse effect on the going concern.

D) The production and operation of the enterprises comply with laws, administrative regulations, and national industrial policies. In the last three years, the enterprises and their controlling shareholders and actual controllers have not committed any criminal offenses of corruption, bribery, embezzlement, misappropriation of property, or disrupting the economic order of the socialist market, and there have been no fraudulent issuances, major information disclosure violations, or other issues involving national security, public safety, ecological safety, production safety, public health and safety and other major

violations. None of the directors, supervisors and senior executives has been subject to administrative penalties by the CSRC within the last three years, or has been investigated by judicial authorities for suspected crimes or investigated by the CSRC for suspected violations of laws and regulations, and no clear conclusion has been reached.

1.3 Definition of research concepts

1.3.1 Approval system and registration system

1.3.1.1 Approval system

The approval system refers to the securities issuance management system in which enterprises to be listed must be approved for listing, with authenticity as the primary principle. Securities issuance applicants shall disclose relevant information in accordance with the regulations and requirements, and comply with laws and regulations. The final decision that whether it satisfies the relevant requirements and whether it is approved for issuance shall be made by the securities examination authorities. The core of the securities issuance approval system lies in the public and complete disclosure of the real situation of the enterprises and compliance with relevant laws and regulations. The characteristics of the approval system include [11]:

(1) Under the approval system, the right to issue securities is obtained with the approval of securities examination authorities.

(2) Under the approval system, the public information disclosure of the enterprise is not excluded.

(3) The approval system stipulates the substantive conditions for securities issuance, and emphasizes the substantive management principle.

(4) The approval system advocates combination of prior-listing and post-listing measures.

1.3.1.2 Registration system

The registration system means that an enterprise to be listed prepares legal documents upon the disclosure of relevant information and submits it to the competent authority for review, while the competent authority only reviews the conformity of the relevant information with the information disclosure requirements. The characteristics of the registration system include [12]:

(1) Under the registration system, the rights to issue securities are obtained naturally without special authorization from the government.

(2) Information disclosure is the core of the registration system.

(3) Under the registration system, the securities issuance examination authorities only conduct a formal review of the registration documents, rather than substantive judgments.

(4) The registration system emphasizes post-listing control.

1.3.2 Technological innovation attributes

[13] The technological innovation attributes refer to the characteristics of technological innovation that listed enterprises applying for listing on the STAR Market combined with the board positioning of the STAR Market. The enterprises shall have core technologies, rely on which they carry out production and operation, with a position in good track and great growth potential.

[14] Based on the *Implementation Opinions on Setting up the STAR Market and Launching the Pilot Program of the Registration System on the Shanghai Stock Exchange* and the *Measures for the Administration of the Registration of IPO Stocks on the Science and Technology Innovation Board (Trial)*, the *Evaluation Instructions of Technological Innovation Attributes (Trial)* (hereinafter referred to as "the *Instructions*") was launched by the CSRC on March 20, 2020, which first proposed a specific evaluation indicator system for technological innovation attributes, thus clarifying the standards for technological innovation attributes. On April 16, 2021, the CSRC revised the *Instructions*, and four general indicators

and five exception clauses were finally formulated. [15] The four general indicators refer to the amount of R&D investment or the proportion of R&D investment to operating revenue", "the proportion of R&D personnel", "invention patents", and "operating revenue or the compound growth rate of operating revenue". [16] The five exception clauses are mainly the further refinement and implementation of the statement in the *Measures for the Administration of the Registration of IPO Stocks on the Science and Technology Innovation Board (Trial)*, *i.e.*, "give priority to supporting enterprises that conform to the national strategies, have core technologies and outstanding technological innovation capabilities to issue and list on the STAR Market", and are supplements to the four general indicators.

1.3.3 Listing success rate

Listing, also known as IPO, refers to the process in which an enterprise raises funds for its development through the IPO of shares to investors *via* a stock exchange. Therefore, the listing success rate of the enterprises indicates the probability of successful listing after the restructuring stage, counseling stage, declaration stage, stock issuance, and listing stage based on the relevant regulations of the CSRC and the *Company Law of the People's Republic of China*.

In this paper, the post-listing performance of enterprises was evaluated *via* the financial indicators of operating revenue growth rate and net profit growth rate. The changes in the operating revenue growth rate compared to the previous year are an important indicator to evaluate the growth status and growth capabilities of enterprises. As for the net profit growth rate, the greater increase in net profit in the current period compared to that of the previous period means the higher profitability of the enterprise. [17] Net profit refers to the balance of the total profit after payment of income tax, which is the net profit that can be distributed by the contributors (shareholders) in the year, also known as after-tax profit. It is the embodiment of the final achievements of enterprise operations, so the amount of net profit directly

represents the current overall operating conditions of the enterprises.

1.4 Novelty and contribution

1.4.1 Novelty

This study offers several points of novelty. First of all, by undertaking a quantitative evaluation of the selected enterprises' technological innovation attributes, it was possible to empirically examine the influence of the four different dimensions of the attributes on the enterprises' listing success rate. Very little research has so far explored listing success rates, so the study reported here is able to both augment the limited existing theoretical research on this topic and to help enterprises, investors, financial institutions, *etc.*, to better understand the potential significance of paying attention to technological innovation. Secondly, the post-listing performance and growth of the listed enterprises over different periods was studied and was found to indicate that increasing R&D investment and technological innovation may help to enhance long-term performance and growth. This finding may serve to encourage enterprises to increase their R&D investment and technological innovation and contribute more broadly to Chinese economic growth.

1.4.2 Contribution

In recent years, much attention has been given to technological innovation by the capital market. The rapidity with which China's STAR Market has been established reflects its urgent need for technological innovation as a feature of its economic development. In comparison to other developed countries, the Chinese economy needs more enterprises focused on technological innovation. Looking at the technological innovation attributes of IPO enterprises on the STAR Market therefore offers an important way for enterprises to be able to use tools such as statistical analysis to quantitatively explore

whether the strength of their own technological innovation attributes will meet the favor of the regulatory authorities and the capital market.

From a theoretical point of view, since the *Evaluation Instructions for Technological Innovation Attributes (Trial)* first put forward its "4+5" evaluation indicators of technological innovation, enterprises, investors and intermediaries have gradually come to accept the key importance of an enterprise's technology. However, there is no consensus yet as how to ensure recognition and eligibility. Here, taking data regarding China's STAR Market as an example, the influence of the four technological innovation attributes (in order, from high to low: the intensity of R&D investment; level of R&D investment; personnel structure; and number of patents held) on the listing success rate and post-listing performance is explored. In doing so, it adds new insight regarding the quantitative relationship between technological innovation attributes and long-term economic performance.

From a practical point of view, it has been less than three years since the *Evaluation Instructions for Technological Innovation Attributes (Trial)* was published. Hence, the exact import of the various indicators is still at a formative stage and they are still undergoing trial implementation. By focusing on the technological innovation attributes, this study may not only establish a direction for development and increase investors' enthusiasm for technologically innovative enterprises, but also enhance the capacity of financial intermediaries to judge such enterprises more objectively and effectively during the selection process. This study offers four important contributions. First, it provides technologically innovative enterprises that have yet to be listed or that are still engaged in the listing process some specific indicators regarding how they might improve their technological level and understand the significance of the established technological innovation attributes. The research presented here suggests that the understanding of enterprises regarding the importance of the technological innovation attributes can be improved and there is value in instructing them as to how to rationally organize their plans for listing and

the future development of their innovation strategy. Second, enterprises that are already listed can better appreciate that "it takes a good blacksmith to make steel" on the basis of this research. Only by constantly cultivating technological innovation and seeking to maintain and improve its impact, can they be recognized by investors and thus enhance their core competitiveness, achieve long-term stable development and become better and stronger. Third, for intermediaries, this work provides insight into how to reasonably select technologically innovative enterprises, successfully complete pre-listing tutoring, and predict whether they will be able to go public, thereby decreasing the degree of uncertainty in the process. Resources are also offered here that can help investors to visually judge the strength of the technological innovation attributes of specific enterprises and predict their listing success rate and post-listing performance. This will help them, in turn, to estimate the potential return on their investment and improve capital efficiency. Fourth, the effectiveness of the evaluation indicators presented in the *Evaluation Instructions for Technological Innovation Attributes (Trial)* is subjected here to empirical testing, which can then serve as a reference for regulatory agencies as they further develop their system for the evaluation of technological innovation attributes.

Up to now, the STAR Market has not only provided financing for hundreds of technologically innovative enterprises and kick-started a deep reform of the Chinese capital market, it has also significantly advanced the marketization of new listings and given a positive impetus to the market cycle. As there are few studies of "new markets" such as the STAR Market, this study, in its own right, is able to contribute to China's economic transformation and the reform and development of its capital market by enhancing how technological innovation attributes may be best understood and applied.

Chapter II. Literature Review

2.1 Relevant research overseas

2.1.1 IPO listing success rate

Beatty [18] (2000) concluded after research that the choice of an enterprise's listing method is greatly affected by its operating revenue, book value, and other important financial indicators. Financial information can provide investors with an important reference basis for their decision-making.

Rachel [19] (2011) came to the same conclusion as Batty through research that major financial indicators such as total revenue, total assets, and asset-liability ratio of an enterprise have a greater impact on the choice of its listing method.

The research by Peng [20] *et al.* (2009) found that enterprises listed overseas can better explore successful IPO cases under the combined effect of external regulations and internal corporate governance. In addition, there is other related literature on the factors that affect the value of enterprises.

Rajesh [21] (2009) *et al.* argued that the number of personnel with higher education backgrounds, operating revenue, and management's ability to run the business contribute to the IPO listing success rate of some enterprises with low technological attributes but high profitability.

Bancela [22] (2009) analyzed and studied the 34-year historical data of 19 European countries, and the IPOs of enterprises in the U.S., the U.K., and Germany. The results showed the locations, industries of enterprises, relevant national policies, investment institutions, and venture capital funds have a significant impact on the listing success rate of enterprises.

2.1.2 Post-listing performance

The focus on the post-listing performance of enterprises in developed countries began with the research of Ritter [23], who examined the Buy-and-hold Abnormal Returns (BHARs) of 1,526 listed enterprise samples in the U.S. from 1975 to 1984. Among them, the mean value of BHARs on the sample portfolio of newly listed enterprises after holding for 3 years was 34.47%, while that on the sample portfolio of listed enterprises could reach 61.86%. Moreover, the stock price of IPO enterprises showed long run underperformance of IPO.

Yang [24] (2012) revealed that some non-mainstream accounting firms will significantly increase their IPO audit fee, and the proportion of audit business, and tend to lower clients' IPO rejection rates when a partner is appointed as a member of the Issuance Examination Committee. However, these phenomena are not obvious in mainstream accounting firms.

Murray [25] *et al.* researched the performance of listed enterprises in the U.K. from 1980 to 1990. They experienced a temporary increase in post-listing performance, but then a prolonged decline in performance and an "inverted U-shaped" trend.

Ahmad-Zaluki [26] used operating revenue and profit to measure the main operating performance indicators of enterprises. It was found that the post-listing performance of 254 enterprises listed in Malaysia from 1990 to 2000 declined for three years, and manipulation of enterprise profits by the management at the time of IPO was the most fundamental cause of performance deterioration.

Brycz [27] *et al.* studied the enterprises listed on the Warsaw Stock Exchange from 1998 to 2011, and found that the post-listing operating performance of many of them was not better than that before listing.

By analyzing the IPO performance of enterprises listed on the Italian Stock Exchange from 2000 to 2009, Bonaventura and Giudici [11] found that compared with comparable listed enterprises, listed enterprises surveyed had better performance before listing, as well as no significant difference in their

post-listing performance.

Jain and Kini [28] (1994) researched the 5-year post-listing performance of American enterprises, and the following findings were obtained: First, the management of the enterprises engage in earnings management before their listing for various motives to make the operating performance look better, which leads to the amplification of their operating performance before listing. Second, the management of enterprises with poor expectations of their future performance tends to adjust the timing of listing and choose to list when their operating performance is good. Third, the agency costs and expenses of enterprises will increase significantly after going public, resulting in increased operating costs and decreased operating performance.

Jain and Kini [29] studied the data of 682 successful IPO enterprises in the U.S. market from 1976 to 1988, and analyzed the changes in major financial indicators in the year before listing and three years after listing. The results showed that the operating performance in the year of listing dropped by 3.58%, compared with the financial data of the year before listing, while the first to third years after listing dropped by 7.60%, 10.53%, and 9.9%, respectively. Moreover, their performance also displayed the same change trend after industry corrections.

Mikkelson, Partch and, Shah [30] (1997) extended the observation period of the samples, and studied the changes in the 10-year post-listing operating performance of 283 enterprises listed in the U.S. from 1980 to 1983. The results showed that it was common to experience a decline in operating performance in the first year after listing, but there was no evident downward trend after that.

Cai and Loughran [31] (1998) conducted a comparative study on the long-term operating performance of Japanese search engine optimization (SEO) enterprises and that in the capital market. The results were the same as the low return on stocks. It was shown from various financial indicators that Japanese enterprises also experienced dropped operating performance after the completion of

additional stock issuance, suggesting that the decline in stock returns is not simply a problem caused by the standards used to calculate abnormal stock returns.

By researching overseas enterprises listed on the European stock markets, Pagano [32] (2002) found some commonalities in the performance changes before and after listing. Although the operating revenue increased after listing, the profitability did not improve, and the overall performance continued to go down.

Sarkissan [33] (2009) studied 1,676 enterprises in 25 countries and revealed that the growth opportunities of most enterprises did not last after their listing in overseas stock markets.

Goergen and Renneboog [34] (2013) studied the impact of changes in the shareholder structure on operating performance after listing. The result showed that factors such as enterprise growth, participation of the entrepreneurial team, and share voting rights will all affect enterprise performance.

2.1.3 Research on the listing of technological enterprises

Maksimovic and Pichler [35] (2001) pointed out that the time selection of an enterprise's listing and financing was related to its industry, life cycle and development stage. For example, in the early development stage, most enterprises listed for financing are in industries with low development costs and a low likelihood of being replaced. In contrast, for some start-ups in the high-tech industry with high risks, key information such as technology determines their future and it needs to be kept strictly confidential if necessary. The listing time of such enterprises should be determined between financing and information disclosure. If information disclosure in this stage put pressure on their competition, the listing will be postponed.

Chemmanur and He [36] (2011) adopted U.S. manufacturing data from 1972 to 2000 to confirm that competition in product and stock market values will drive the emergence of IPO waves. In equilibrium,

even with sufficient internal capital to support subsequent growth, an enterprise may still choose to list, driven by the likelihood of the listing of its product market rivals, which in turn leads to a wave of IPOs.

According to the "long purse story", an enterprise's financing capacity is its competitive strength, and the greatest utility of IPO is to raise funds for enterprise development through the capital market. Accordingly, IPO can provide strong competitiveness for the sustainable development of enterprises. In addition to financing advantages, IPO can also be regarded as a competitive strategy. Stoughton *et al.* (2001) suggested that for high-tech enterprises to achieve long-term success, the market competition mechanism is the most important factor that cannot be ignored. IPO will effectively promote the product quality of high-tech and start-up Internet enterprises and assist them in obtaining independent certification on product quality, which contributes to the customers' perception of their product quality and has an impact on the product prices.

Chod and Lyandres [37] (2011) believed that the IPO listing has important strategic significance to the development of enterprises. On the one hand, listing is conducive to the diversification of shareholders, and the owners will have higher risk tolerance. On the other hand, after listing, a more open market strategy can be adopted to improve the market share of products and bring equilibrium or constraints to competitors. The impact is more pronounced in a fully competitive free-trade market for industries with high demand uncertainty and low organizational uncertainty.

Jong [38] *et al.* (2012) measured product market characteristics with industry profit, capital intensity, Herfindahl index, and market share. According to the results, enterprises from industries with high profits and low barriers to entry prefer to list. In these industries, listing can not only enhance their competitive position, but also effectively prevent the entry of new competitors.

Hellmann and Puri [39] (2000) conducted research on 173 high-tech enterprises in Silicon Valley and discovered that the behavioral requirements of venture capital institutions will stimulate the innovation

of the invested enterprises, and the start-ups that have accepted venture capital will spend a shorter time launching their products to market, thus allowing an IPO more possible.

2.2 Domestic research

2.2.1 Approval system and registration system

On the basis of the current situation of China's audit system, Gu L S, Wang H L and Wang H X [40] (2012) summarized the advantages of the past system as well as the existing difficulties and problems, perceiving that the registration system was the ultimate direction and goal of capital market reform in the future. They suggested making a clear statement to the market by performing well in propaganda work, standardizing the information disclosure content of listed enterprises by learning from the registration systems prevailing in mature economies, and controlling pilot risks by setting up investor access thresholds. Moreover, they also put forward pilot measures and system design suggestions for establishing a registration board by setting up investor risk funds to control systemic risks.

Cai X Y [41] (2013) conducted the factor analysis of China's current approval system and the reform of the registration system in the capital market. The advantages of the approval system lie in its strict audit of the investment value of the securities to be issued, preventing enterprises with poor performance and low quality from entering the capital market, maintaining the good order of the securities market, and protecting the legitimate rights and interests of investors. Its shortcomings are interfering with the self-adjustment function of the capital market, which is not conducive to the optimized allocation of resources. The advantages of the registration system are that it simplifies the review procedures, lowers the listing threshold and financing costs and avoids excessive intervention of administrative departments in securities issuance, which facilitate enterprises with development potential to raise funds through the

capital market and obtain development opportunities. However, complete information disclosure cannot fully protect the interests of investors, especially in emerging markets.

Taking the ChiNext as an example, Chen J L [42] (2015) analyzed and studied the impact of two audit systems of new stock issuance, *i.e.,* the approval system and the registration system, on the IPO, and pointed out that the strict supervision of the IPO by the approval system can easily cause power rent-seeking. If there was doubt about the accuracy of the substantive review of the Issuance Examination Committee, the results will affect the efficiency of the issuance and review, restrict the optimization of capital market resources, and increase the risk of stock market bubbles. In the registration system, the formal review is carried out on the IPO and the substantive judgment of underlying securities is made by the market, which eliminates the opportunity of power rent-seeking from the system design, improves the efficiency of issuance and review, and promotes the optimization of resources in the capital market.

Feng W L and Wen X [43] (2021) analyzed the overall quality of listed enterprises in the capital market based on the 2020 annual report and conducted a comparative analysis of the financial data of enterprises implementing the registration system and enterprises on the ChiNext under the approval system from 2019 to 2020. The results showed that the reform of the registration system improved the quality of listed enterprises. Judging from the specific mechanism, the formation of a "survival of the fittest" mechanism under the registration system, strict supervision during and after the process, and enhancement of external constraints improved the ecological environment of listed enterprises' operations, thus upgrading the quality of listed enterprises.

Taking BioPerfectus and Wantai BioPharm as examples and two cases listed on the ChiNext and main board as the research objects, Zhang W Q [44] (2021) found that biomedical enterprises still take the

main board as the first choice for listing after comparing the financial situation and financing methods before and after listing. The results showed that listing indeed brings positive growth to enterprises. Most importantly, it helps enterprises improve their capital structures and increase financial leverage. Under the parallel conditions of the approval system and registration system, this paper provides some suggestions on how to optimize the financing arrangements of high-tech enterprises: equity financing is the first choice, and enterprises are suggested to be listed on the STAR Market.

2.2.2 IPO listing success rate

Li M C and Liu F [45] (2012) conducted research from the perspective of social capital of the Issuance Examination Committee, finding that the listing success rate will be improved if the intermediaries have relatively good social relations with the Issuance Examination Committee when the enterprises apply for IPO listing.

Through the research and analysis of the grouped data from 2000 to 2003 and from 2004 to 2007, Chen H F [46] *et al*. (2012) found that the earnings quality of the accounting firms of the enterprises to be listed was relatively high if the accounting firms owned the social capital of the Issuance Examination Committee whose identity was disclosed during the period from 2004 to 2007.

Research conducted by Chen Y S, Zheng D J and Li L [47] (2014) showed that the IPO listing success rate is increased when intermediaries of enterprises have social relations with the Issuance Examination Committee, but this effect is mainly generated by the social relations of accounting firms and it has strong timeliness. Further research revealed the higher IPO underpricing range and performance in that year for enterprises possessing social relations with the Issuance Examination Committee. However, their business performance and growth are relatively low in the next two years, indicating that such enterprises

are suspected of "packaging" in the IPO process, and have the opportunity of power rent-seeking of social relations with the Issuance Examination Committee.

2.2.3 Post-listing performance

The study by Lu D, Wan L M and Yang D [48] (2015) found that social relations with the Issuance Examination Committee that are relatively easy to obtain and only play a role in listing will not cause post-listing performance deterioration of enterprises. The impact of political associations on the performance of listed enterprises on the ChiNext is greater than that on the SME Board, indicating the existence of a certain institutional premise for the impact of political associations on listed enterprises, and high demand for the performance growth on the ChiNext. It was further found from the research on the political associations of enterprises on the ChiNext that "packaging" listing through earnings management is the main reason for the post-listing performance deterioration, resulting in the reduced R&D expenditure and weakened innovation ability in the long run.

To observe the significance of venture capital in promoting IPO listing and the impact of earnings management of enterprises with venture capital participation on future growth, Zhang Y [49] (2018) selected 333 enterprises listed on the ChiNext from 2011 to 2015 as the research samples and incorporated the innovation ability of enterprises into the performance evaluation indicators according to the industry attributes of the ChiNext. It was found that enterprises on the ChiNext with venture capital participation reduced the degree of earnings management in the year before listing, but dramatically increased the earnings management in the year of listing. The degree of venture capital participation is positively correlated to the level of earnings management of enterprises after listing, while the correlation

is weakened.

The study by Wang S [50] (2019) showed that the listing success rate has a significantly positive correlation with the performance changes of enterprises before and after listing. In other words, the higher the listing access requirements are, the more serious the post-listing performance deterioration will be. This phenomenon is obvious on the SME Board and ChiNext, but not on the main board.

The study by Li G, Chen H H and Xiang K [51] (2021) revealed that the A-share market under the audit system embraces an obvious IPO effect, and the decline in post-listing performance reflects the possibility of earnings management and timing listing. Improving the listing review system of enterprises and the transparency of the review can help reduce earnings management, speculation of enterprises as well as the IPO effect.

Jia X X and Qian X L [52] (2021) found that the performance of SME enterprises declines frequently after listing through the analysis and comparison of solvency, profitability, operating ability and growth. Based on the analysis of various indicators such as R&D investment, it was found that the proportions of R&D investment, operating revenue, R&D personnel, intangible equity and net equity were not significantly correlated with post-listing performance deterioration, while the number of valid patents represents a significantly negative correlation with post-listing performance deterioration.

2.2.4 Research on the listing of technological enterprises

After systematically analyzing the internal and external factors affecting the selection of listing methods by China's technological enterprises, Chen M L, Dang X H and Wu X Q [53] (2014) found that the technological enterprises choose different listing methods based on the venture capital participation, R&D abilities, growth, and management operating level, *etc*.

After employing a dynamic model to describe the capital structure adjustment behavior and characteristics of technological enterprises, Chen S K [54] (2015) found that a good capital structure is positively correlated with growth, operating revenue scale and R&D expenditure of enterprises, while negatively correlated with profitability and current ratio.

The research by Zhuo Q Y [55] (2017) showed that the funds of technology-based SMEs mainly come from internal and external financing, with the latter relying largely on IPO listing. Listed enterprises needed to disclose information on a regular basis, investors pay attention to short-term financial indicators, which influences management's long-term operation decisions, and some enterprises cut R&D investment in pursuit of profits. Thus, the scholar suggested that the best time for technological enterprises to go public is after they enter the stage of stable development.

By studying the enterprises submitting the listing application on the STAR Market from March 2019 to February 2020, Jia Y H and Ning J H [56] (2021) analyzed the performance at the time of listing and in the pre-listing period with innovation and financial indicators according to Cox survival analysis, factor analysis and cluster analysis methods. They figured out that R&D investment and innovation ability can advance the issuance and listing of enterprises on the STAR Market, and enterprises with good growth of performance seem to have a higher listing success rate. Moreover, it was also found that there are large differences in the performance of enterprises to be listed, as well as unbalanced sub-value of innovation and growth abilities. Hence, in order to further enrich the capital market level through the establishment of the STAR Market, much attention should be paid to the industry aggregation, high-quality development of enterprises and the scientific design of the STAR Market system in the listing process.

By analyzing and deliberating the model of the financial system boosting the transformation of technological achievements and the current situation, Liu Y [57] (2019) put forward countermeasures and suggestions such as constructing a financial integration platform, building an indirect financing

organization system and a direct financing market, and improving market intermediary services so as to promote the transformation of enterprise achievements.

2.2.5 Research methods (PCA and logistic regression methods)

(1) PCA method

In order to identify the development situation and investment value of logistics enterprises, Zhang S Z and Zhang C N [58] (2013) selected 40 domestic listed enterprises in the logistics industry as analysis samples to study their performance in 2010 with the PCA method, finding a relatively huge difference of performance among different types of listed logistics enterprises under the background of the international financial crisis. The listed enterprises with relatively good performance were as follows: some railway freight logistics enterprises with resource advantages, some terminal operating enterprises with obvious efficiency and cost advantages as well as some comprehensive logistics enterprises with the focus on high-end industrial logistics services and with specialized logistics facilities.

By means of studying 354 enterprises on the ChiNext *via* IPO listing during 2009-2012 and analyzing from the perspective of their intrinsic value and market risk, Liu Q Q and Huang S W [59] (2016) employed the Value-at-Risk (VaR) model, the PCA method and efficiency (EFF) value to analyze the rationality of the listing and issuance pricing process on the ChiNext. It was found that IPO pricing efficiency can be effectively enhanced when market risk is taken into consideration in the issuance mechanism, which also has a positive reinforcing correlation with the intrinsic stock value. Compared with the stock market price, its issue price cannot effectively embody the real core value of the stock. The phenomenon that stock prices on the first day are below the issue prices will appear when stock market investors notice that stock prices are inflated.

Aiming at the relatively high premium of new stocks in the secondary market, Wang R F and Lu Z

H [60] (2017) conducted empirical research on the post-listing excess returns of 158 enterprises in SSE over the past three years with the PCA method. It was found that the premium of new stocks is mainly affected by the quotations of institutional investors, the net assets per share of listed enterprises, the share issuance proportion of listed enterprises, and the overall return on equity (ROE) of second new stocks. In addition, the irrational subscription behavior of both institutional investors and ordinary market investors is likely to advance high premiums for IPOs.

By analyzing and studying the operating data of backdoor enterprises in the China Stock Market & Accounting Research (CSMAR) Database in 2012, Liu Q and Yang Z F [61] (2018) calculated the enterprises' operating performance based on the PCA method, and analyzed their financial data trends before/in the year of/ after backdoor listing. It was found that the performance of enterprises showed an upward trend after the success of backdoor listing. Backdoor listing is very attractive in the Chinese capital market because it can help enterprises improve their operating conditions and performance.

(2) Logistic regression method

Under the condition of weak-form efficiency in the capital market, Jiang H, Kong R, and Dai W [62] (2012) carried out an empirical analysis of the factors affecting the quality of enterprises' profits through factor analysis and logistic regression methods. It was found that the quality of enterprises' profits is positively correlated with the cash flow per share and profit growth rate, negatively correlated with current and quick ratios, debt ratio of enterprises, and cash ratio per share, and insignificantly correlated with the turnover rate of inventories, profit excluding extraordinary profit and loss, operating profit ratio, and return per share and return on equity.

Zheng L (2013) [63] investigated the factors affecting the underpricing on the ChiNext with the logistic regression model, finding that the subscription rate of new stocks and the turnover rate on the first day are two significant factors affecting the issue underpricing of issurance as they reflect the

investors' willingness to invest. In other words, the underpricing on the ChiNext is greatly affected by the emotions of investors.

By constructing a real options model for China's existing issue price restriction measures, Zhu W D, Li J, and Hu Z Q [64] (2021) obtained the listing profit threshold under price regulation, and analyzed the relationship between pricing regulation and enterprise listing decisions and the impact on the quality of new stocks. Based on the empirical test by means of the factor analysis and logistic regression methods, it was found that pricing regulation elevates the option value and critical value of listing of well-performed enterprises to be listed, and results in a decrease in the number of IPO enterprises, embodying the similar profitability of well-performed listed enterprises to that of overall enterprises under the issue price regulation.

Regarding the split share structure as an important reason affecting the development of China's capital market, Xu S X and Liang S X [65] (2008) conducted empirical research on the causes of IPO underpricing of listed enterprises in SSE and SZSE after full circulation with logistic regression and other methods, finding that the full circulation resulting from the split-share structure reform failed to reduce the underpricing of new stock issuance. During the period of the split-share structure reform, not only the mature western capital market theory could not explain the formation mechanism of the underpricing of stock issuance in China, but also the reputation theory of underwriters could not be applied to China's capital market.

2.3 Literature review

2.3.1 Research on the correlation between technological innovation attributes and the listing success rate

Technological innovation attributes are the essential features that distinguish technological

enterprises from listed enterprises. Since the STAR Market was established two years ago, there are still relatively few related academic studies. Academia usually perceives that enterprises with technological innovation attributes will have better performance in the listing process and has implemented relevant research on the influencing factors. Through observing the correlation between R&D investment of A-share listed data governance research enterprises and tobinQ, Zhang Q Q [66] *et al.* (2017) found that capitalized R&D expenditure can significantly bring future effect onto corporate value and further transmit positive signals to the market, which contributes to the listing success rate. Tang G L and Lou S Q [67] (2020) found that the equity structures of enterprises on the STAR Market are diverse. Compared with the enterprises on the ChiNext and the main board, the average asset-liability ratio of enterprises on the STAR Market in the past three years is generally lower. Gui Y J [68] (2019) pointed out the minor correlation between the existing financial abilities and the estimated market value, and long-term low debt ratio, failing to embody the financial leverage effect.

In addition, wide attention in academia has been paid to the mechanism by which the technological innovation attributes improve the growth and profitability of enterprises. Taking China's technological listed enterprises as samples, Cheng H F and X Y [69] (2003) conducted regression analysis on the three aspects of the enterprise capital structure, revenue scale and growth. The results revealed a significantly positive correlation between the former two factors and growth. Based on the IPO data on the STAR Market, Zhang L C and Xia P [70] (2020) conducted regression analysis of financial performance on the condition that net asset growth rate represents the growth of enterprises. The main influencing factors on the growth of enterprises on the STAR Market were identified to be solvency, current ratio of operating capacity and profitability, turnover rate of accounts receivable, and return on equity.

2.3.2 Research on the correlation between technological innovation attributes and post-listing performance

Overseas scholars have done extensive research on whether the technological innovation attributes of technological enterprises can improve their post-listing performance. Based on empirical research, Deng [71] *et al*. (1999) found that the patent output of enterprises with high R&D investment is a positive predictive indicator of enterprise performance in the capital market. Hirshleifer [72] *et al*. (2018) claimed that the originality of technology is a crucial determinant of enhancing enterprises' profitability and stability of profits. Hence, technological innovation attributes enable listed enterprises to acquire excess returns from the capital market through their high-quality profits.

At present, domestic research on enterprises with technological innovation attributes is concentrated in 2020. The majority states that the registration system is one of the factors for the high price earnings ratio on the STAR Market, but the post-listing research is still in the initial stage. Taking the listed enterprises on the ChiNext as the research objects, Zhou M S [66] *et al*. (2017) found that the R&D investment of enterprises on the ChiNext can bring more excess returns to investors, which is consistent with the overall trend of the stock market. Wu L [73] (2020) focused on the excess returns of enterprises with technological innovation attributes on the STAR Market on the first day of listing. Through the research of the excess returns on the first day of IPOs on the STAR Market, he perceived that the asset-liability ratio and issue price are negatively correlated with the excess returns of the IPOs, while the R&D investment, listing waiting time, offline subscription ratio, and turnover rate are positively correlated. Lin Y [74] (2020) analyzed the current situation of the market valuation of the STAR Market. As the profit indicator is no longer the only threshold for listing on the STAR Market and the participation of the marketization inquiry mechanism makes the listed enterprises with technological innovation attributes more special, it was suggested to add industry factors to the valuation indicators and construct a

diversified valuation system so as to improve the market operation efficiency of the STAR Market, which is more conducive to the post-listing performance of enterprises with technological innovation attributes.

It has not reached a consensus on the post-listing performance of enterprises with technological innovation attributes after the reform of the registration system. Dong X L [75] *et al*. (2020) tested the pricing efficiency of IPOs on the STAR Market through a stochastic frontier model (SFA) and believed that the pricing of the next-level market and the stock price in the secondary market are overestimated on the STAR Market under the registration system, thus the regulatory authorities should emphasize the quality of the enterprises with technological innovation attributes and ethical risks of underwriters. According to the research on the IPOs of the enterprises on the ChiNext and STAR Market under the registration system, Wu X H and Zhang C [76] (2022) noticed a higher underpricing rate of the enterprises with technological innovation attributes under the registration system due to the irrationality of secondary market investors and primary market's behavior of seeking risk premium compensation. However, Zhang Z X [77] *et al*. (2020) believed that the reform of the registration system reduces the IPO underpricing rate of technological innovation attributes, and the background of implementing marketization inquiry reforms during the registration enables investors to be rational gradually and improves the effectiveness of the A-share market pricing mechanism. Through the empirical research of panel data regression of listed enterprises on the STAR Market, Zhang Z X and Kong R F (2022) found that the technological innovation attributes can significantly add the market value of listed enterprises on the STAR Market and further improve it by attracting investors to deliver information to the market, which is conducive to the resource allocation efficiency of the STAR Market.

2.3.3 Limitations of the existing research

It can be obviously seen from the above literature review that relatively rich research results have

been obtained on topics such as listing cases and post-listing performance of technological enterprises. With various methods, scholars from various countries have studied the IPO listing success rate and post-listing performance from different perspectives, making prominent contributions to the theoretical construction and practical guidance of similar topics. It has been less than five years since the STAR Market was established, thus the related research in this area is still in the initial stage. In the process of reviewing the existing literature, the following three limitations were found in the literature related to this research subject:

First, there is insufficient research on the listing success rate of technological enterprises on the STAR Market in China.

As an important measure for China to implement the innovation-driven development strategy and deepen the reform of the capital market, the establishment of the STAR Market is of prime importance. Although some scholars have analyzed the reasons for the listing failures through the research on the failure cases on the STAR Market, they cannot sum up or point out the specific factors leading to the listing failures of all technological innovation enterprises. In fact, there are many reasons for that. In this paper, the technological innovation attributes were selected as the entry point to study their impact on the listing success rate on the STAR Market.

Second, there is insufficient empirical research on the correlation between technological innovation attributes and the listing success rate.

Technological innovation attributes are of a prominent guiding role in the industrial optimization of listed enterprises in China and the formation of emerging technologies, clarifying the critical location of developing “Key & Core Technology” on the STAR Market. Since they are important indicators, many scholars believe that the technological innovation attributes impose an impact on the enterprises' post-listing underpricing and can enhance investors' recognition of their market value. Unfortunately, certain

research results have not been achieved on the correlation between the technological innovation attributes and the listing success rate. It remains to be studied on which aspects technological innovation enterprises should improve their technological strength so as to lift the listing success rate.

Third, there is insufficient quantitative research on the correlations of technological innovation attributes with the listing success rate and post-listing performance of enterprises.

PCA and logistic regression are important statistical tools, which have been widely applied to the research of IPO pricing and post-listing performance. However, in view of technological innovation attributes as the quantifiable indicators, their influences on the listing success rate of China's technological innovation enterprises and on the post-listing performance of enterprises by year have not been explored by means of quantitative analysis.

Chapter III. Correlation between Technological Innovation Attributes and Listing Success Rate: Case Analysis

3.1 Case study

In June 2019, China's STAR Market was officially launched at the opening ceremony of the 11th Lujiazui Forum, symbolizing that the capital market in China had truly entered the "STAR Market Era". The subsequent three years have passed in a flash. The STAR Market has strived to support technologically innovative enterprises that conform to the national strategy, to tackle the bottlenecks induced by the problems associated with core and key technologies, and to win the approval of the larger market to be greater, stronger, bigger, and enduring. At its birth, the STAR Market put forward specific technological innovation requirements that enterprises would have to meet to be listed.

In March 2020, the China Securities Regulatory Commission (CSRC) issued a document entitled *Guidelines for the Evaluation of Technological Innovation Attributes (Trial)* [78], which clearly proposed a system of specific evaluation indicators relating to various technological innovation attributes. Meanwhile, the Shanghai Stock Exchange (SSE) also issued the *Interim Provisions of the Shanghai Stock Exchange on the Declaration and Recommendation of Technological Innovation Board Enterprises' Issuance and Listing*, strengthening the positioning of the STAR Market and putting forward more exact and transparent operating principles and requirements. Specifically, to be listed on the STAR Market, enterprises had to be in “6+1” scope industries and had to meet the specific indicator requirements of "3 items + 5 articles" of the technological innovation attributes originally designated by the STAR Market.

In April 2021, the Deputy Director of the Issuance Department of the CSRC said at a press conference that the revised *Guidelines for Evaluation of Technological Innovation Attributes (Trial)* provided a perfect evaluation indicator system regarding technological innovation attributes. After this revision, the evaluation indicator requirements increased from the previous "3 items + 5 articles" to "4 items + 5 articles".

In June 2021, the *Instructions on Application of Self-Regulatory Rules for Listed enterprises on the Technological Innovation Board No. 3 - Continuous Disclosure and Related Matters of Technological Attributes* issued by the SSE further stressed that STAR market listed enterprises should focus on the specific need for information disclosure regarding their technological innovation attributes after they went public. It also urged enterprises listed on the SSE STAR Market to persist in adhering to the positioning of technological innovation and promoted the healthy development and growth of higher quality enterprises.

It can be deduced from above that the various SSE STAR Market policies and systems are still subject to testing and that the registration system will continue to be improved and optimized by the state in order to cultivate more high-tech enterprises with technological innovation attributes. This study drew on the information contained in publicly available materials such as the prospectuses of enterprises to be listed on the STAR Market and the feedback and inquiry letters of the STAR Market listing committee since 2021 to analyze how enterprises to be listed were "hindered" or "facilitated" by their technological innovation attributes. A more in-depth analysis of the technological innovation attributes was also undertaken to gain a deeper command and understanding of the direction of China's technological innovation, which might then serve as a source of reference or advice for enterprises seeking listing on the STAR Market.

3.1.1 Analysis of successful cases

1. Shaanxi Light Optoelectronics Material Co., Ltd. (LTOM)

Prospectus: The enterprise accorded with the technological innovation attributes.

LTOM complied with the requirements for technological innovation capabilities in article 5 of the *Interim Provisions of Shanghai Stock Exchange on Declaration and Recommendation of Technological Innovation Board Enterprises' Issuance and Listing*. That is to say, it met evaluation criterion I of the technological innovation attributes in following ways:

Technological innovation attribute indicators I	Conformity	Specific Indicators
R&D investment has accounted for more than 5% of the operating revenue in the last three years or R&D investment has reached more than RMB 60 million in the last three years	√Yes □No	The enterprise's accumulated R&D investment in the last 3 years accounted for 9.99% of its accumulated operating revenue in the last 3 years
R&D personnel has accounted for no less than 10% of the total number of employees in that year	√Yes □No	By June 30, 2021, the number of R&D personnel in the enterprise was 80, and the ratio of R&D personnel to the total number of employees was 26.06%
5 or more invention patents (including national defense patents) constitute the main operating revenue	√Yes □No	By June 30, 2021, the enterprise held 61 invention patents, all of which played into the main operating revenue

The compound growth rate of the operating revenue in the last three years is 20% or above, or the operating revenue in the latest year is more than or equal to RMB 300 million	√Yes □No	The enterprise's operating revenue in 2018, 2019 and 2020 was RMB 1.124404 billion, RMB 2.017986 billion and RMB 2.746279 billion, respectively, and the compound growth rate of operating revenue in the last three years was 56.28% or above

LTOM's listing results on the STAR Market:

LTOM was listed on the SSE STAR Market on March 18, 2022. Its initial public offering of A shares was about RMB 40.24 million common stocks. After this public offering, its capitalization was approximately RMB 402 million common stocks. The initial offering price was RMB 22.05 per share with a price earnings ratio of 133.71. The total funds raised in the issuance was about RMB 887 million.

2. Guangzhou Sanfu New Material Technology Co., Ltd. (Sanfu Tech.)

Prospectus: Sanfu Tech. complied with the relevant provisions of the *Evaluation Instructions of Technological Innovation Attributes (Trial)* and the *Interim Provisions of Shanghai Stock Exchange on Declaration and Recommendation of Technological Innovation Board Enterprises' Issuance and Listing*.

The specific details relating to the technological innovation attribute evaluation indicators were as follows:

1. From 2017 to 2019, the enterprise's yearly R&D expenditure amounted to RMB 8.488 million, RMB 10.9835 million and RMB 11.9376 million, respectively, resulting in an accumulated R&D expenditure over those three years of RMB 31.4091 million. The ratio of R&D expenditure to the

accumulated operating revenue over the three-year period was 5.62%, which exceeded the specified requirement of 5%. Thus, the enterprise met the related provisions in Clause 1, Article 1 of the *Guidelines for Evaluation of Technological Innovation Attributes (Trial)* and in Clause 1, Article 4 of the *Interim Provisions of Shanghai Stock Exchange on Declaration and Recommendation of Technological Innovation Board Enterprises' Issuance and Listing.*

2. By the date the prospectus was signed, a total of 24 invention patents had been obtained by the enterprise and its subsidiaries, on the basis of which they were able to generate main operating revenue *via* product sales, which is in accord with Clause 2, Article 1 of the *Evaluation Instructions of Technological Innovation Attributes (Trial)*, Clause 1-1-27 of the Sanfu Tech. prospectus (registration draft), and Clause 2, Article 4 of the *Interim Provisions of Shanghai Stock Exchange on Declaration and Recommendation of Technological Innovation Board Enterprises' Issuance and Listing*.

3. In 2017, 2018 and 2019, the enterprise's operating revenue was RMB 148.9154 million, RMB 188.4866 million and RMB 221.3609 million, respectively. Moreover, the operating revenue compound growth rate over those three years reached 21.92%, exceeding the required 20% specified according to the curriculum attribute evaluation indicators. As a result, the enterprise was in line with Clause 3, Article 1 of the *Evaluation Instructions of Technological Innovation Attributes (Trial)* and Clause 3, Article 4 of the *Interim Provisions of Shanghai Stock Exchange on Declaration and Recommendation of Technological Innovation Board Enterprises' Issuance and Listing*.

Listing results on the STAR Market:

Sanfu Tech. was successfully listed on the SSE STAR Market on May 21, 2021. Its initial public offering of common stocks was RMB 23.0464 million shares, accounting for 25% of the capitalization after the issuance. The issuance price per share was RMB 11.03 and the price earnings ratio of the initial issuance was 22.30.

3.1.2 Analysis of failed cases

1. Guangzhou Shine Polymer Technology Co., Ltd (Shine Polymer)

Prospectus: The enterprise was in line with the relevant technological innovation attribute indicators.

It conformed to 3 technological innovation attribute indicators in evaluation criterion I, but failed to meet all 4 indicators simultaneously.

Technological innovation attribute indicators I	Conformity	Specific Indicators
The accumulated R&D investment in the last 3 years accounts for 5% or above of the accumulated operating revenue in the last 3 years, or the accumulated R&D investment in the last three years is more than or equal to RMB 60 million	□ Yes √ No	The enterprise's accumulated R&D investment in the last three years was RMB 25.7317 million, and the accumulated R&D expenditure ratio was 4.16%.
R&D personnel has accounted for no less than 10% of the total number of employees in that year	√Yes □ No	By December 31, 2020, the enterprise had 27 R&D personnel, accounting for 15.00% of the total number of employees.

5 or more invention patents (including national defense patents) constitute the main operating revenue	√ Yes □ No	By December 31, 2020, the enterprise had 17 authorized invention patents, 11 of which constituted the main operating revenue.
The compound growth rate of the operating revenue in the last three years is 20% or above, or the operating revenue in the latest year is more than or equal to RMB 300 million	√ Yes □ No	The compound growth rate of operating revenue over the last three years was 32.82%, higher than the requirement of 20%.

Listing results on the STAR Market:

On August 9, 2021, Shine Polymer and the recommending agency, Minsheng Securities, applied to the SSE for withdrawal of the application document in accordance with *Guangzhou Shine Polymer Technology Co., Ltd. on the Withdrawal of the Application for its Initial Public Offering and Listing on the Technological Innovation Board (*2021 Certificate No. 03) and *Minsheng Securities Co, Ltd. and Guangzhou Shine Polymer Technology Co., Ltd. on the Withdrawal of the Application for the Initial Public Offering and Listing on the Technological Innovation Board* (Minsheng Certificate [2021] No. 467). According to the relevant provisions in Article 67 of the *Review Rules for Stock Issuance and Listing on the Technological Innovation Board of Shanghai Stock Exchange*, SSE decided to terminate the review of the IPO of Shine Polymer's shares and listing on the STAR Market.

2. Lontium Semiconductor (Hefei) Co., Ltd (Lontium)

Prospectus: The enterprise was in line with the requirements of the technological innovation attributes.

The enterprise met two of the technological innovation attribute indicators in evaluation criterion I, but failed to meet all three simultaneously.

Technological innovation attribute indicators I	Conformity	Indicators
The accumulated R&D investment in the last 3 years accounts for 5% or above of the accumulated operating revenue in the last 3 years, or the accumulated R&D investment in the last 3 years is more than or equal to RMB 60 million	√ Yes □ No	The enterprise's accumulated R&D investment in the last three years was RMB 73.842 million and the accumulated operating revenue was RMB 262.368 million. The accumulated R&D investment accounted for 28.14% of the accumulated operating revenue in the last 3 years.
5 or more invention patents (including national defense patents) constitute the main operating revenue	√ Yes □ No	By the signing date of the prospectus, the issuer had 71 invention patents, which constituted its main operating revenue, including 44 domestic invention patents and 27 overseas invention patents.
The compound growth rate of the operating revenue in the last three years is 20% or above, or the operating	□ Yes √ No	From 2017 to 2019, the compound growth rate of the operating revenue was 16.44%, which was lower than the

revenue in the latest year is more than or equal to RMB 300 million		required 20%. In 2019, the annual operating revenue was RMB 104.5477 million, lower than the required RMB 300 million.

On January 26, 2021, Lontium and the recommending agency, Huaan Securities, applied to the SSE for withdrawal of the application document in accordance with *Lontium Semiconductor (Hefei) Co., Ltd. on the Withdrawal of the Application for its Initial Public Offering and Listing on the Technological Innovation Board* (LSB [2021] No. 001) and *Lontium Semiconductor (Hefei) Co., Ltd. on the Withdrawal of the Application for the Initial Public Offering and Listing on the Technological Innovation Board by Huaan Securities Co., Ltd.* (Huazheng Investment Bank [2021] No. 3). According to the relevant provisions in Article 67 of the *Review Rules for Stock Issuance and Listing on Technological innovation board of Shanghai Stock Exchange*, SSE decided to terminate the review of the IPO of Lontium's shares and listing on the STAR Market.

On the basis of the above case analysis, it was found that:

	Case analysis findings
I	Even if some enterprises do not meet all the requirements in the four technological innovation attribute evaluation indicators, there are still cases of successful listing. At the same time, even if some enterprises are in line with all four technological innovation attribute evaluation indicators, the listing can still fail.

II	There are differences in the same technological innovation attribute evaluation indicators for different enterprises whose influence on the enterprises' listing success rate remains to be further studied.
III	There are significant differences between the various technological innovation attribute evaluation indicators that require further study to assess whether these lead to significant differences in the listing success rate.
IV	At this point, there remained a need to study how to replace the technological innovation attribute indicators with a more comprehensive indicator, so as to eliminate any overlap in the variable information for the different indicators, avoid multicollinearity problems, reduce the dimensionality of the datasets, and reveal the overall structure of the multiple evaluation indicators of technological innovation attributes.

An important question to address is whether enterprises meeting all the requirements of the technological innovation attribute evaluation indicators manage to be listed and whether those that failed to do so therefore fail to be listed. It was also found that, among the enterprises to be listed that met the requirements of the technological innovation attribute evaluation indicators, there were important differences in the value of the indicators. This raises the question of whether such differences influence the successful listing of the enterprises, and, if so, how? It is also important to understand whether the differences between the various technological innovation attribute indicators affect the successful listing of the enterprises and the extent to which each technological innovation attribute affects their listing success. Do they each have the same influence, for instance? Beyond this, is it possible to build a

comprehensive indicator to eliminate the differences between the various indicators so that the influence of the technological innovation attributes on the listing success rate can be further analyzed?

Chapter IV. Research Hypotheses and Research Design

4.1 Research hypotheses

"Key & Core Technology" is important to a country's development. Chinese enterprises are still not strong in high-end technology, especially with regard to basic technology research. There is therefore an urgent need to give greater priority to the support and development of the independent industrial chains that can give rise to cutting-edge technological innovation. The mission and hope of China's economic transformation and elevation lie in technological innovation. Tasked with the historical mission of reforming a currently troubled zone in China's capital market, innovation-driven sustainable development and technological innovation strategy, China's STAR Market was officially launched in Shanghai in June 2019.

The STAR Market had clear "Key & Core Technology" requirements from the outset. The CSRC issued the *Guidelines for Evaluation of Technological Innovation Attributes (Trial)* and the *Decision on the Revision of the Evaluation Guidelines of Technological Innovation Attributes (Trial)* in March 2020 and April 2021, respectively. These documents clarified and extended what counted as enterprises with technological innovation attributes and formulated and optimized an elaborate evaluation indicator system relating to these attributes.

On the basis of this, two hypotheses relating to enterprises seeking listing on the STAR Market can be proposed:

Hypothesis 1: With all other conditions under control, the technological innovation attributes of an enterprise on the STAR Market can improve its listing success rate.

As noted above, the STAR Market was launched in June 2019 with a mission to provide a service

to technologically innovative enterprises generating breakthroughs in key and core technologies and attaining high levels of market recognition. The CSRC also issued the *Guidelines for Assessment of Technological Innovation Attributes (Trial)* and the *Decision on the Revision of the "Evaluation Instructions of Technological Innovation Attributes (Trial)"*, which implied that enterprises that conformed to the requirements of the technological innovation attribute evaluation indicator system would have a higher listing success rate.

The TII that will be presented below is not a single indicator, but an indicator system composed of four general evaluation indicators and five exception clauses. Enterprises to be listed need to meet all standards in the four general evaluation indicators and one of the standards in the five exception clauses. The five exception clauses serve as a supplement to the four general indicators. The specific content of the system is as follows:

General indicators (Enterprises need to meet all of these requirements)	(1) R&D investment accounts for more than 5% of the operating revenue in the past three years, or the accumulated R&D investment in the past three years is more than RMB 60 million. (2) The R&D personnel account for more than 10% of the total number of employees per year. (3) More than five invention patents form the basis of the main operating revenue. (4) The compound growth rate of the operating revenue over the past three years has reached 20% or the recent annual operating revenue has reached

	RMB 300 million.
Exception clauses (Enterprises should meet at least one of these)	(1) The core technology owned by the enterprise has been recognized by the national authorities to have an internationally leading role or is of great significance to national strategy. (2) The enterprise as a main participant, or one of its core technicians as a main participant, has won the National Technological Progress Award, the National Natural Science Award, or the National Technological Invention Award, and has applied related technologies to the enterprise's main business. (3) The enterprise independently undertakes or leads specific major national technology projects related to its main business and core technology. (4) The main products (services) based on the core technologies of the enterprise are considered key equipment, products, parts, and materials, *etc*., that receive active national encouragement, support and promotion, and that are able to achieve import substitution. (5) More than 50 invention patents (including national defense patents) constitute the core technology and main operating revenue.

In this study, the four general evaluation indicators of the enterprises to be listed on the STAR Market were examined. As there are differences in value for the same indicator or across various indicators amongst the four evaluation indicators, it is difficult to measure the strength of each enterprise's

technological innovation attributes through direct research. As it stands, it is also hard to analyze the influence of the technological innovation attributes on the enterprise's listing success rate. PCA and mathematical dimensionality were therefore used to transform the four general indicators into a comprehensive indicator - the TII. The indicator covers the content of the original four general indicators as much as possible. In addition, it exposes the internal structure of the four general indicators. It also makes it easier to explore the correlations between the technological innovation attributes and the listing success rate, as well as the post-listing performance and growth.

Generally speaking, the higher the TII, the stronger the enterprise's technological innovation attributes and the higher the probability of it achieving listing success on the STAR Market. The post-listing performance and growth of enterprises on the STAR Market can be analyzed to evaluate and verify the above statement. First of all, any enterprise with a high TII can be expected to have stronger "Key & Core Technology", and higher post-listing growth, and *vice versa*. Secondly, an enterprise with a high TII and stronger "Key & Core Technology" may nonetheless have poor short-term financial performance. In this regard, a second hypothesis in the form of a null hypothesis is required:

Hypothesis 2: With all other conditions under control, the technological innovation attributes of an enterprise on the STAR Market can significantly affect its post-listing performance and growth.

4.2 Research design

4.2.1 Correlation between single technological attribute evaluation indicators and the listing success rate

The STAR Market officially opened in July 2019. The capital market personnel began by implementing a reform of the STAR Market registration issuance system. The STAR Market was ideally suited to registration system reform and this was highly complementary with the ongoing specification of technological innovation attributes. The essential and key features of most of the enterprises initially listed on the SSE STAR Market were their technological innovation attributes and these attributes became the defining characteristic of the listed enterprises.

So, what exactly is a "technological innovation attribute"? Based on the current regulation and audit rules issued by the SSE, technological innovation attributes can be generalized as "industry + direction + general indicators + exception indicators". "Industry" refers to any field supported by the STAR Market and "Direction" refers to directions supported by the STAR Market. The "general indicators" are the four general evaluation indicators. "Exception indicators" refers to five exception indicators that are turned to for reference when the four general indicators are not satisfied. Here, the four general evaluation indicators excluding revenue were taken to be:

General indicators (Excluding the indicator related to operating revenue)	(I) R&D investment in the past three years is above 5% of the operating revenue. (II) The accumulated R&D investment in the last three years is above RMB 60 million.

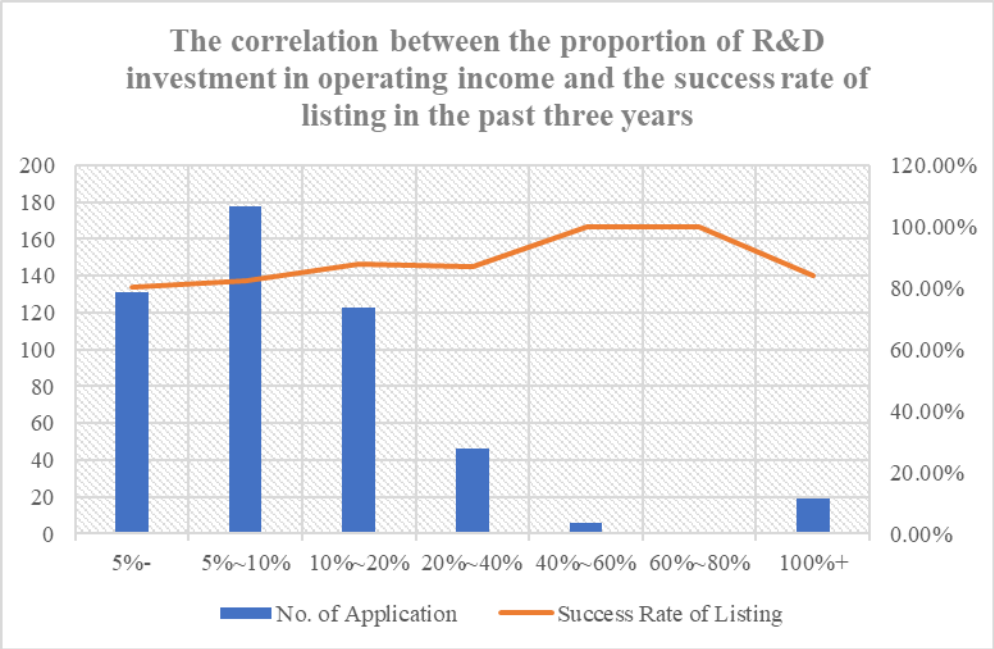
	(III) The ratio of R&D personnel to the total number of employees per year is no less than 10%. (IV) More than 5 invention patents constitute the main operating revenue.

To facilitate the research and analysis, the intensity of R&D investment was defined as the ratio of R&D investment to operating revenue being above 5% over the past three years. The level of R&D investment was defined as the accumulated R&D investment being above RMB 60 million over the past three years. The personnel structure was defined as the ratio of R&D personnel to the total number of employees during a year being above 10%, and the invention patent level was defined as the main operating revenue being made up of more than five invention patents.

(1) Correlation between the ratio of R&D investment to operating revenue and the listing success rate over the last three years:

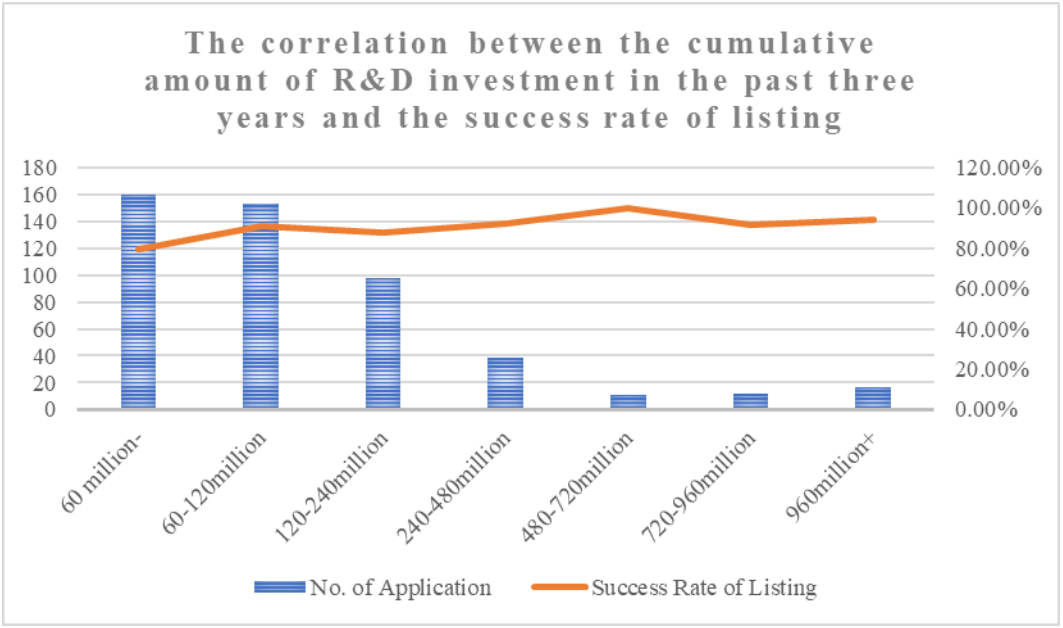
R&D investment is the most important indicator of technological attributes for listing on the STAR Market. By December 2021, the average R&D investment of the sample enterprises applying for listing on the STAR Market had reached RMB 102 million, with the ratio to the operating revenue being above 18.52% on average, which is much higher than the evaluation guideline requirements. The sample enterprises differed from each other in terms of the actual amount of R&D investment, as well as the ratio to operating revenue. On the basis of an initial analysis of the samples, there is no obvious correlation between the listing success rate and the sum of R&D investment or the ratio of R&D investment to operating revenue. In other words, an increase in R&D investment does not directly lead to an increase in the listing success rate. Nor does an increase in the ratio of R&D investment to operating revenue.

Figure 1:



(2) Correlation between the accumulated sum of R&D investment over the last three years and the listing success rate

Figure 2:

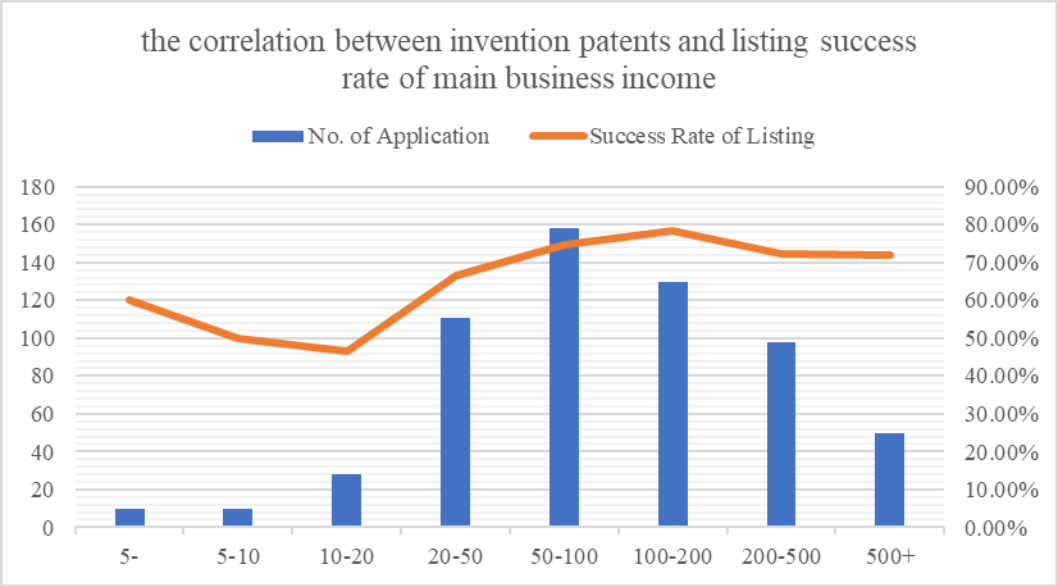


(3) Correlation between the number of invention patents generating operating revenue and the listing success rate

One of the requirements of the SSE STAR Market's technological innovation evaluation system is that enterprises to be listed have "more than five invention patents generating the main operating revenue". According to the statistics up until December 2021, there were 188,785 invention patents associated with 707 enterprises applying for listing on the STAR Market, giving an average of 267.40 for each. To understand how large or small this figure might be, up to the end of 2021 Huawei had applied for over 200,000 patents around the world, out of which more than 110,000 were authorized.

With regard to whether there is a correlation between the number of invention patents and the listing success rate, it was found that, if the number of invention patents was less than 20, an increase in the number did not directly result in an increase in the listing success rate. The listing success rate also displayed a downward trend. When the number of patents exceeded 20, most particularly between 50 and 100, an increase in the number of invention patents was correlated with the increase in the listing success rate, but there was a downward trend as soon as the number exceeded 200. The influence of invention patents on the listing success rate therefore requires further research.

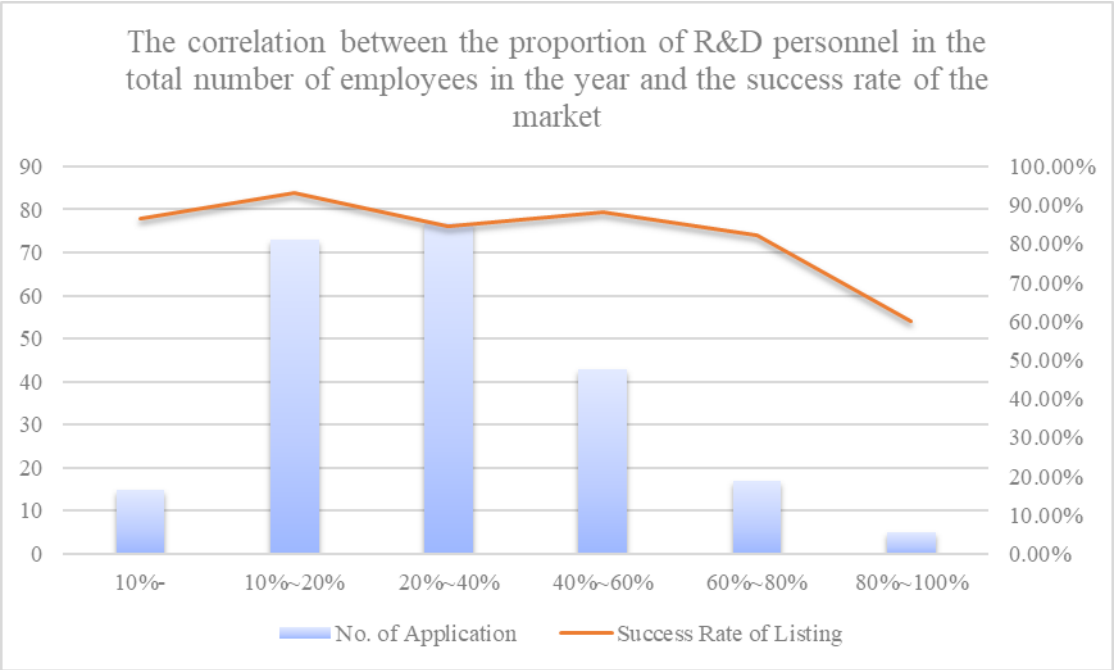
Figure 3:



(4) Correlation between the ratio of R&D personnel to the total number of employees in a year and the listing success rate

On April 16, 2021, the revised *Evaluation Instructions for Technological Innovation Attributes (Trial)* issued by the CSRC contained a new indicator: "the ratio of R&D personnel to the total number of employees in a year should be above 10%". This indicator was one of the new "4+5" technological attribute evaluation indicators. Up to the end of 2021, the ratio of R&D personnel to the total number of employees in a year amongst the enterprises applying for listing was 19.14% on average. However, closer inspection of the sample data revealed that, as the ratio of R&D personnel to the total number of employees in a year increased, the listing success rate actually displayed a downward trend.

Figure 4:



A preliminary analysis of the samples revealed no obvious positive correlation between any single TII and an increase in the listing success rate, with some indicators even showing a negative correlation instead.

4.2.2 Principal component analysis method

The SSE STAR Market amounts to being an incremental reform. As a newly-established market sector, it is completely independent from the existing main SSE board, the main Shenzhen Stock Exchange (SZSE) board and the SZSE GEM. At its inception, the STAR Market was chosen to try out a pilot reform of the Chinese capital market registration system. The orientation of the STAR Market is towards the frontiers of global technological, which has become a major economic battlefield and a focus of the Chinese national technological strategy along with other major concerns. It seeks to support

enterprises that: adhere to national scientific and technological strategies; are involved in the development of key and core technologies; display a strong capability for technological innovation; aim to promote their development and growth through key and core technologies; have built a stable business model; occupy a high market share; want to create a good social image; and have great potential for growth and development.

Analysis of the enterprises applying for listing on the STAR Market up to the end of 2021 reveals that an increased ratio of R&D investment to operating revenue over the last three years did not significantly improve the listing success rate. Nor did an increase in the accumulated sum of R&D investment over the last three years. An increase in the total number of invention patents forming the main operating revenue presented a decrease - increase - slight decrease trend. Moreover, a negative correlation was found between the ratio of R&D personnel to the total number of employees in a year and the listing success rate.

There are differences in the technological innovation attribute evaluation indicators of enterprises on the STAR Market. This relates to indicators for both different enterprises and the same enterprise. The TII offers a firm way of specifying the requirements for listing on the STAR Market and can also serve as a good basis for measuring whether an enterprise owns a core technology. This study sought to not only understand how technological innovation attributes might affect the listing success rate but also whether all attributes have the same or a different influence and, in the case of the latter, to identify which TIIs have the greatest and smallest influence.

To explore these concerns, PCA and dimensionality reduction for the different technological innovation attributes were used to convert the various independent indicators into one comprehensive indicator. The conversion was carried out while keeping the total variance of the variables unchanged. The item with the largest variance, i.e., the first variable, was called the first principal component. The

one with the second largest variance or second variable, was called the second principal component, and should be completely uncorrelated with the first variable. Principal component identification then continued in the same way. The greater the contribution of a principal component, the more significant its role in the overall evaluation was taken to be. When the contribution rate of the accumulated principal components reached a certain value, it was assumed that these principal components provided enough information to address the above-mentioned concerns.

4.2.3 Regression model

(1) Sample selection

532 enterprises applying for listing on the STAR Market after the launch of the registration system, between June 2019 and December 2021, were used as the original research samples for this study. Enterprise data relating to the three years before the issuance of listing on the STAR Market and data for the period subsequent to the listing were manually sorted. The financial and stock price data were based on the WIND database.

(2) Model construction

To study the correlation between the TII and the listing success rate as well as the post-listing performance and growth, the coefficients of all the explanatory variables were calculated by means of logistic regression. This made it possible to obtain the influence of each element on the sample. The model was constructed as follows:

$$\mathbf{LR\ (IPO = 1)} = \alpha_0 + \alpha_1 \mathbf{technology} + \alpha_2 \mathbf{Controls} + \varepsilon \qquad \mathbf{Model\ (1)}$$

Linear regression: After the relevant variables were controlled, there was found to be a positive

correlation between the listing success rate and the technological innovation attributes.

Hypothesis 1 (with all other conditions under control, the technological innovation attributes of an enterprise on the STAR Market can improve its listing success rate) was verified, with the main explanatory variable being the TII. In detail, following the CSRC's technological innovation attribute evaluation criteria for the STAR Market, and based on the market value and financial indicators in the WIND database, SPSS was used to carry out a PCA for the technological innovation attributes, then the relative strength of the technological innovation attributes was evaluated. The basic factors were controlled, such as the scale of the enterprise, its asset-liability ratio, net profit, and years of operation prior to the IPO.

$$\textbf{Growth}_{t/t+1/t+2} = \delta_0 + \delta_1 \textbf{ technology} + \delta_2 \textbf{ Controls} + \varepsilon \qquad \textbf{Model (2)}$$

After the successful listing, to control the relevant variables, the "compound growth rate of the operating revenue and compound growth rate of the net profit" was adopted as an indicator to test the growth and performance of each enterprise in the year of listing, one year after the listing, and two years after the listing.

Linear regression: After the relevant variables were controlled, there was a positive correlation between the post-listing performance and growth and the existence of the technological innovation attributes.

Hypothesis 2 (with all other conditions under control, the technological innovation attributes of an enterprise on the STAR Market can significantly affect its post-listing performance and growth) was therefore also confirmed. In detail, following the CSRC's technological innovation attribute evaluation

criteria for the STAR Market, and using the enterprises' market value and financial indicators in the WIND database, SPSS was used to carry out a PCA of the technological innovation attributes. The strength of the technological innovation attributes was then evaluated, with the basic factors being again controlled.

Table 1: Definition of the variables

IPO	A dummy variable, which has a value of 1 if an enterprise succeeds in registration and listing, and a value of 0 if its registration fails.
Technology	The comprehensive indicator acquired by PCA relating to the four general indicators, *i.e.*, the TII.
Growth	(Operating revenue or net profit for that year - Operating revenue or net profit for the previous year) / Operating revenue or net profit for the previous year.
Size	LnAssets.
Lev.	Total liabilities/total assets. Lower net profit/total assets.
Year	Dummy yearly variable.

Chapter V. Results and Analysis

5.1 Descriptive statistics

A descriptive analysis of the technological innovation attributes of the enterprises to be listed on the STAR Market was performed. The results are shown in Table 2. They are divided up according to whether the enterprises seeking listing on the STAR Market were successful cases, failed cases, and all of the cases together. The indicators are as follows:

Table 2: Descriptive statistics for the technological innovation attribute evaluation indicators

		All cases	Successful cases	Failed cases
		2019.06-2021	2019.06-2021	2019.06-2021
N		532	386	146
IPO	Mean	-	0.7119	0.2881
$technology_{1.1}$	Mean	8.20%	10.77%	2.22%
	Median	6.39%	8.38%	0.00%
	Maximum	30.93%	33.25%	17.56%
	Minimum	0.00%	3.28%	0.00%
$technology_{1.2}$	Mean	12674.84	17722.76	1961.67
	Median	8217.85	11268.17	0
	Maximum	40620.06	49282.92	9124.2
	Minimum	0	4537.39	0
$technology_{2}$	Mean	28.46%	27.96%	36.60%
	Median	23.36%	23.15%	33.93%
	Maximum	58.47%	63.46%	17.26%
	Minimum	11.19%	10.81%	53.76%
$technology_{3}$	Mean	142.44	148.85	131.72
	Median	93	97.5	80.5
	Maximum	409	451	386
	Minimum	23	29	14
$technology_{4.1}$	Mean	28.22%	32.21%	15.53%
	Median	23.34%	26.56%	1.68%

	Maximum	83.05%	85.36%	60.39%
	Minimum	0.00%	1.56%	0.00%
$technology_{4.2}$	Mean	5.85	7.09	2.38
	Median	4.01	4.89	1.55
	Maximum	16.99	20.11	8.81
	Minimum	0	2.07	0

Notes:

$technology_{1.1:}$	R&D investment has accounted for more than 5% of the operating revenue over the last three years, or
$technology_{1.2:}$	Cumulative R&D investment over the last three years exceeds RMB 60 million.
$technology_{2:}$	R&D personnel has accounted for no less than 10% of the total number of employees in the year.
$technology_{3:}$	More than 5 invention patents form the basis of the main operating revenue.
$technology_{4.1:}$	The compound growth rate of the operating revenue has reached 20% over the last three years, or
$technology_{4.2:}$	The total operating revenue has reached RMB 300 million in the last year.

As can be seen in Table 2, the mean values of the four technological innovation attributes for all the enterprises to be listed on the STAR Market were higher than the required indicators set out in the *Evaluation Instructions of Technological Innovation Attributes (Trial)* and the *Decision on Revision of <Evaluation Instructions of Technological Innovation Attributes (Trial)>* issued by the CSRC. The mean values for the four technological innovation attributes of the successful enterprises were higher than those of the failed enterprises. The same holds for the median, maximum and minimum. This suggests that there is some degree of correlation between the technological innovation attribute evaluation indicators and the listing success rate. However, this alone does not reveal whether the four evaluation indicators are equally vital to the listing success rate. One thing to understand is whether the difference in the listing success rate for each year directly correlates to the quality of the technological innovation attribute

evaluation indicators of the listed enterprises for that year. Another question is whether the evaluation indicators are at all correlated with the future performance of the successfully listed enterprises? These questions are explored below.

5.1.1 Descriptive statistics and analysis of successful cases

First, a descriptive analysis was performed on the technological innovation attributes of the successful cases. The results are shown in Table 3. The listing success rate for enterprises successful in being listed on the STAR Market was 71.19%, which means that 28.81% of the enterprises failed to be listed. The analysis revealed that the mean values of indicators 1, 2, 3 and 4 were 10.77% (or RMB 177,227,600), 27.96%, 148.85, and 32.21% (or RMB 709 million), respectively. In terms of years, the probability of successful IPO listing dropped significantly before and after the modification of the technological innovation attributes by the CSRC in April 2021, from 77.20% in 2020 to 65.06% in 2021 (by 12.14%), with a drop range of 15.73%.

Table 3: Descriptive statistics for the technological innovation attribute evaluation indicators for successful cases

		2019.06-2021	2019	2020	2021
	N	386	77	146	163
IPO=1	Mean	0.7119	0.7476	0.7720	0.6506
$technology_{1.1}$	Mean	10.77%	11.44%	11.37%	9.69%
	Median	8.38%	9.11%	7.98%	7.51%
	Maximum	33.25%	32.85%	33.55%	31.48%
	Minimum	3.28%	3.59%	3.10%	3.59%
$technology_{1.2}$	Mean	17722.76	16473.61	17008.98	17325.28
	Median	11268.17	10909.96	11303.01	10726.63

	Maximum	49282.92	41900.46	49282.92	43066.60
	Minimum	4537.39	3609.79	4468.43	4833.74
$technology_2$	Mean	27.96%	30.54%	28%	26.11%
	Median	23.15%	23.28%	21.72%	23.01%
	Maximum	63.46%	73.78%	63.46%	55.47%
	Minimum	10.81%	8.51%	10.81%	11.14%
$technology_3$	Mean	148.85	212.94	145.33	135.07
	Median	97.50	138.00	95.00	92.00
	Maximum	451.00	780.00	517.00	397.00
	Minimum	29.00	33.00	27.00	25.00
$technology_{4.1}$	Mean	32.21%	36.18%	28.59%	29.53%
	Median	26.56%	32.48%	25.37%	22.41%
	Maximum	85.36%	70.56%	70.84%	91.39%
	Minimum	1.56%	11.53%	0.00%	0.00%
$technology_{4.2}$	Mean	7.09	6.31	7.00	7.46
	Median	4.89	4.32	4.66	4.96
	Maximum	20.11	16.39	19.16	21.20
	Minimum	2.07	1.95	1.95	2.10

Notes:

$technology_{1.1}$	R&D investment has accounted for more than 5% of the operating revenue over the last three years, or
$technology_{1.2}$	Cumulative R&D investment over the last three years exceeds RMB 60 million.
$technology_2$	R&D personnel has accounted for no less than 10% of the total number of employees in the year.
$technology_3$	More than 5 invention patents form the basis of the main operating revenue.
$technology_{4.1}$	The compound growth rate of the operating revenue has reached 20% over the last three years, or
$technology_{4.2}$	The total operating revenue has reached RMB 300 million in the last year.

It can be seen from Table 3 that, apart from $technology_{1.2}$ and $technology_{4.2}$, all of the four technological innovation attribute evaluation indicators for successfully listed enterprises showed a decreasing trend. In other words, the TII of enterprises applying for listing in the first year was the largest,

while that of enterprises applying for listing in the third year was the smallest. This suggests that superior enterprises seeking listing were quicker to seize the STAR Market dividend policy.

5.1.2 Descriptive statistics and analysis of failed cases

A descriptive analysis was next carried out on the technological innovation attributes of failed cases. The results are shown in Table 4. Across all the samples, the listing failure rate was 28.81%. Analysis of the four conventional technological innovation attribute evaluation indicators for the failed enterprises revealed that the mean values of indicators 1, 2, 3 and 4 were 2.22% (or RMB 19.6167 million), 36.60%, 131.72, and 15.53% (or RMB 238 million), respectively. In terms of years, before and after modification of the technological innovation attributes by the CSRC in April 2021, the probability of IPO listing failure rose significantly, from 22.80% in 2020 to 34.94% in 2021 (a rise of 12.14%), with a range of 53.25%. In other words, the probability of failure rose significantly.

Table 4: Descriptive statistics for the technological innovation attribute evaluation indicators for failed cases

		2019.06-2021	2019	2020	2021
	N	146	18	43	85
IPO=0	Mean	0.2881	0.2524	0.2280	0.3494
$technology_{1.1}$	Mean	2.22%	11.01%	4.43%	0.52%
	Median	0.00%	9.28%	3.09%	0.00%
	Maximum	17.56%	29.45%	24.62%	8.39%
	Minimum	0.00%	2.86%	0.00%	0.00%
$technology_{1.2}$	Mean	1961.67	14382.73	4038.32	424.41
	Median	0.00	6516.87	2676.21	0.00
	Maximum	9124.20	31780.64	13687.57	3685.07

	Minimum	0.00	2978.15	0.00	0.00
$technology_2$	Mean	36.6%	39.94%	19.47%	20.08%
	Median	33.93%	39.15%	19.47%	20.08%
	Maximum	17.26%	84.05%	#NUM!	#NUM!
	Minimum	53.76%	9.47%	#NUM!	#NUM!
$technology_3$	Mean	131.72	173.78	112.67	130.95
	Median	80.50	39.50	77.50	89.00
	Maximum	386.00	1395.00	336.00	406.00
	Minimum	14.00	3.00	11.00	17.00
$technology_{4.1}$	Mean	15.53%	71.33%	18.70%	9.90%
	Median	1.68%	50.73%	13.43%	0.00%
	Maximum	60.39%	190.08%	60.39%	39.56%
	Minimum	0.00%	-6.67%	-7.29%	0.00%
$technology_{4.2}$	Mean	2.38	8.34	3.64	1.85
	Median	1.55	4.35	2.23	0.00
	Maximum	8.81	43.28	11.10	7.97
	Minimum	0.00	1.42	0.00	0.00

Notes:

$technology_{1.1}$	R&D investment has accounted for more than 5% of the operating revenue over the last three years, or
$technology_{1.2}$	Cumulative R&D investment over the last three years exceeds RMB 60 million.
$technology_2$	R&D personnel has accounted for no less than 10% of the total number of employees in the year.
$technology_3$	More than 5 invention patents form the basis of the main operating revenue.
$technology_{4.1}$	The compound growth rate of the operating revenue has reached 20% over the last three years, or
$technology_{4.2}$	The total operating revenue has reached RMB 300 million in the last year.

It can be seen from Table 4 the mean values of all four evaluation indicators for the failed cases showed a downward trend. So, the TII of enterprises that failed to meet the minimum technological innovation attribute requirements for the STAR Market when applying for listing in the first year was the largest and in the third year it was the smallest.

5.1.3 Descriptive statistics and analysis of all cases

Finally, a descriptive analysis was undertaken for the technological innovation attributes across all of the cases. The results are shown in Table 5. Analysis of the four conventional technological innovation attribute evaluation indicators for both the successful and failed cases revealed that the mean values of indicators 1, 2, 3 and 4 were 8.20% (or RMB 126,748,400), 28.46%, 142.44, and 28.22% (or RMB 585 million), respectively. In terms of years, before and after the modification of the technological innovation attributes by the CSRC in April 2021, there was a significant difference in the probability of achieving a successful IPO listing on the STAR Market. By inference, the *Decision on Revision of <Evaluation Instructions of Technological Innovation Attributes (Trial)>* further strengthened the orientation of enterprises on the STAR Market towards technological innovation and improved the quality of the listed enterprises.

Table 5: Descriptive statistics for the technological innovation attribute evaluation indicators for all cases

		2019.06-2021	2019	2020	2021
	N	532	95	189	248
IPO	Mean	0.7119	0.7476	0.7720	0.6506
$technology_{1.1}$	Mean	8.20%	11.23%	9.26%	6.45%
	Median	6.39%	9.11%	7.21%	5.24%
	Maximum	30.93%	29.78%	32.85%	25.02%
	Minimum	0.00%	3.32%	0.00%	0.00%
$technology_{1.2}$	Mean	12674.84	15345.04	13742.48	10521.33
	Median	8217.85	9751.83	9363.05	7139.82
	Maximum	40620.06	36491.02	41568.87	36287.62
	Minimum	0.00	3424.40	1986.92	0.00
$technology_{2}$	Mean	28.46%	31.85%	28%	26.02%
	Median	23.36%	26.89%	22.43%	22.86%

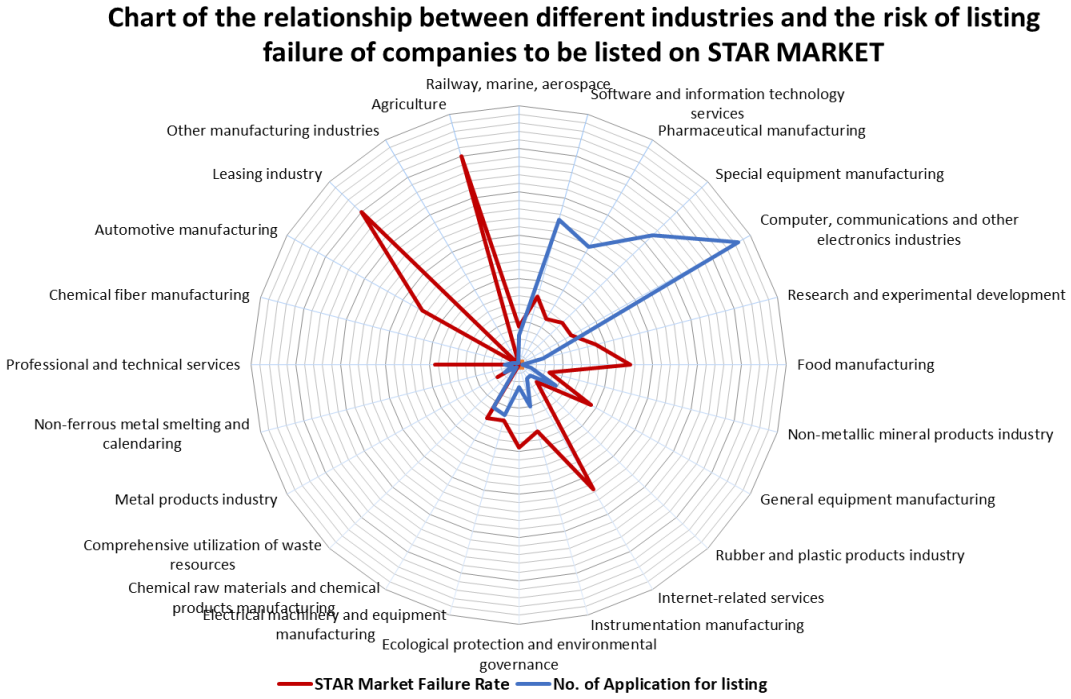
	Maximum	58.47%	80.94%	62.36%	53.89%
	Minimum	11.19%	9.43%	11.72%	11.21%
$technology_3$	Mean	142.44	193.86	136.16	133.66
	Median	93.00	120.00	88.50	89.50
	Maximum	409.00	773.00	450.00	397.00
	Minimum	23.00	22.00	24.00	21.00
$technology_{4.1}$	Mean	28.22%	40.35%	26.99%	22.24%
	Median	23.34%	34.79%	23.81%	17.30%
	Maximum	83.05%	92.98%	70.84%	76.56%
	Minimum	0.00%	12.27%	0.00%	0.00%
$technology_{4.2}$	Mean	5.85	6.28	6.12	5.41
	Median	4.01	4.32	4.04	3.66
	Maximum	16.99	16.39	15.88	16.99
	Minimum	0.00	1.87	1.07	0.00

Notes:

$technology_{1.1}$	R&D investment has accounted for more than 5% of the operating revenue over the last three years, or
$technology_{1.2}$	Cumulative R&D investment over the last three years exceeds RMB 60 million.
$technology_2$	R&D personnel has accounted for no less than 10% of the total number of employees in the year.
$technology_3$	More than 5 invention patents form the basis of the main operating revenue.
$technology_{4.1}$	The compound growth rate of the operating revenue has reached 20% over the last three years, or
$technology_{4.2}$	The total operating revenue has reached RMB 300 million in the last year.

5.1.4 Descriptive statistics and analysis of the industries covered by the sample

The sample covered 24 industries in total (see Fig. 5).



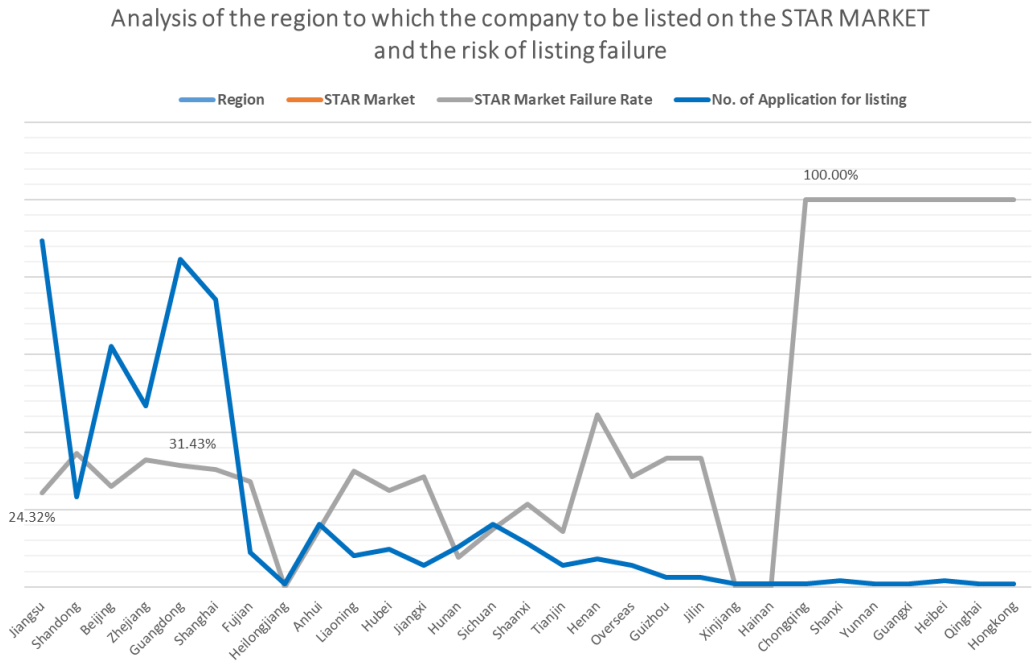
Looking at Fig. 5: (1) there were numerous industries represented by the enterprises seeking listing, including computing, communications, other electronics manufacturing, dedicated equipment manufacturing, pharmaceutical manufacturing, software, and IT services, *etc.*, that had a higher probability of successful listing and a lower risk of failure. They all belong to a new generation of industries, such as information technology, energy conservation and environmental protection, high-end equipment, new energy, new materials and bio-medicine. These are strongly supported by the STAR Market. (2) There were fewer successful listings in the leisure industries, with their probability of failure being apparently higher.

In the "1+1+4+5" regulatory review standard for verifying the technological innovation attributes

of enterprises applying for listing on the STAR Market, the first "1" refers to it being an industry supported by the STAR Market, and the second "1" refers to it being an orientation supported by the STAR Market. The regulatory review rules were revised for the following reasons: "To discourage Fintech and model innovation enterprises from seeking listing on the STAR Market, and prohibit enterprises largely engaged in real estate or finance and investment activities".

5.1.5 Descriptive statistics and analysis of the regions covered by the sample

Analysis of the sample shows that enterprises listed on the STAR Market over the past three years come from almost every region in China (including Hong Kong). Regions with the largest number of listed enterprises include Jiangsu, Beijing, Zhejiang, Guangdong and Shanghai. This accounts for about 2/3 of the enterprises, with the highest value belonging to Guangdong, followed by Shanghai and Jiangsu in order (see Fig. 6).



It can be seen from Fig. 6 that the numbers of enterprises listed on the STAR Market in Chongqing, Shanxi, Yunnan, Guangxi, Hebei, Qinghai, Hong Kong, were the smallest, with relatively few successful listings so far. Jiangsu had the largest number of enterprises applying for listing on the STAR Market, with an average failure probability of about 24%, or a listing success rate of nearly 76%. The number of enterprises applying for listing on the STAR Market in Guangdong was second only to Jiangsu, followed by Shanghai, Beijing, and Zhejiang, in order. The listing success rate was approximately 75% in Jiangsu and Beijing, and about 70% in Zhejiang, Guangdong, and Shanghai. The number of enterprises to be listed in the rest of the regions was significantly less than it was in Jiangsu, Guangdong, Shanghai, Beijing and Zhejiang, and their listing success rate was generally lower. This suggests that Beijing, Shanghai, Guangzhou, Jiangsu, and Zhejiang, being the most economically developed regions in China, are also the most dynamic regions in terms of technological innovation and the regions with the most pronounced interest in establishing the STAR Market.

5.2 Construction of the technological attribute evaluation indicators

PCA aims to reduce the dimensionality of datasets, eliminate the variables that reflect overlapping data, and retain the features in datasets that contribute the most to variance. To this end, the retained variables need to preserve the original data as much as possible, simplify the problem and avoid multicollinearity. In view of the multiple technological innovation attribute evaluation indicators for enterprises seeking listing, PCA was used to reduce their dimensionality, then the evaluation indicators were compiled. The relevant steps were as follows:

(1) The dataset was assumed to be $(X_1, X_2, ..., X_n)$, and the original sample data was normalized as follows:

$$x_i = \frac{X_i - \bar{X}_i}{S_i}$$

Z refers to a normalized variable. The resulting values were as follows:

R&D investment has accounted for more than 5% of the operating revenue over the last three years	The cumulative R&D investment over the last three years is more than RMB 60 million	R&D personnel account for no less than 10% of the total number of employees in a year	More than 5 invention patents have made up the main business revenue	Zscore: R&D investment has accounted for more than 5% of the operating revenue over the last three years	Zscore: The cumulative R&D investment over the last three years is more than RMB 60 million	Zscore: R&D personnel account for no less than 10% of the total number of employees in a year	Zscore: More than 5 invention patents have made up the main business revenue
18.99	8.61	54.59	3.74	0.4494	-0.9356	1.6465	-0.9064
14.29	8.40	18.71	4.16	0.1573	-1.1835	-0.1258	-0.4985
10.18	8.15	29.17	3.61	-0.0981	-1.4891	0.3908	-1.0291
124.39	10.36	53.89	2.40	6.9999	1.1753	1.6119	-2.2036
23.46	8.90	84.05	3.76	0.7272	-0.5854	3.1017	-0.8836
32.93	9.33	28.03	4.04	1.3158	-0.0654	0.3346	-0.6107
32.99	8.85	-	3.76	1.3195	-0.6465	-1.0500	-0.8836
17.04	8.39	-	3.93	0.3282	-1.2062	-1.0500	-0.7184
6.77	7.87	19.47	3.58	-0.3100	-1.8261	-0.0882	-1.0557
8.45	8.01	-	3.09	-0.2056	-1.6571	-1.0500	-1.5325
8.97	8.04	-	3.22	-0.1733	-1.6170	-1.0500	-1.4087
8.44	8.18	18.86	3.43	-0.2063	-1.4588	-0.1184	-1.2005
……	……	……	……	……	……	……	……

(2) A correlation coefficient matrix was established as follows:

$$R=\begin{bmatrix} r_{11} & r_{12} & \wedge & r_{1p} \\ r_{21} & r_{22} & \wedge & r_{2p} \\ M & M & & M \\ r_{p1} & r_{p2} & \wedge & r_{pp} \end{bmatrix}$$

where, r_{ij} (i, j=1,2,……,p) is the correlation coefficient of the original variables x_i and y_i (r_{ij}= r_{ji}), and is calculated as follows:

$$r_{ij}=\frac{\sum_{k=1}^{n}(x_{ki}-\bar{X}_i)(x_{kj}-\bar{X}_j)}{\sqrt{\sum_{k=1}^{n}(x_{ki}-\bar{X}_i)^2\sum_{k=1}^{n}(x_{kj}-\bar{X}_j)^2}}$$

Correlation matrix [a]

		Zscore: (R&D investment has accounted for more than 5% of the operating revenue over the last three years	Zscore: The cumulative R&D investment over the last three years is more than RMB 60 million	Zscore: R&D personnel account for no less than 10% of the total number of employees in a year	Zscore: More than 5 invention patents have made up the main business revenue
Correlation	Zscore: (R&D investment has accounted for more than 5% of the operating revenue over the last three years	1.000	0.353	0.270	-0.058
	Zscore: The cumulative R&D investment over the last three years is more than RMB 60 million	0.353	1.000	0.232	0.417
	Zscore: R&D personnel account for no less than 10% of the total number of employees in a year	0.270	0.232	1.000	0.076
	Zscore: More than 5 invention patents have made up the main business revenue	-0.058	.417	0.076	1.000
a. Determinant factor = .616					

(3) The eigenvalues and eigenvectors were then calculated as follows:

(1) First, the eigen equation $|\lambda I - R|$=0 was solved. Generally, the eigenvalues were calculated using a comparable method and ordered according to their magnitude, i.e.:

$\lambda 1 \geq \lambda 2 \geq \wedge \geq \lambda p \geq 0$

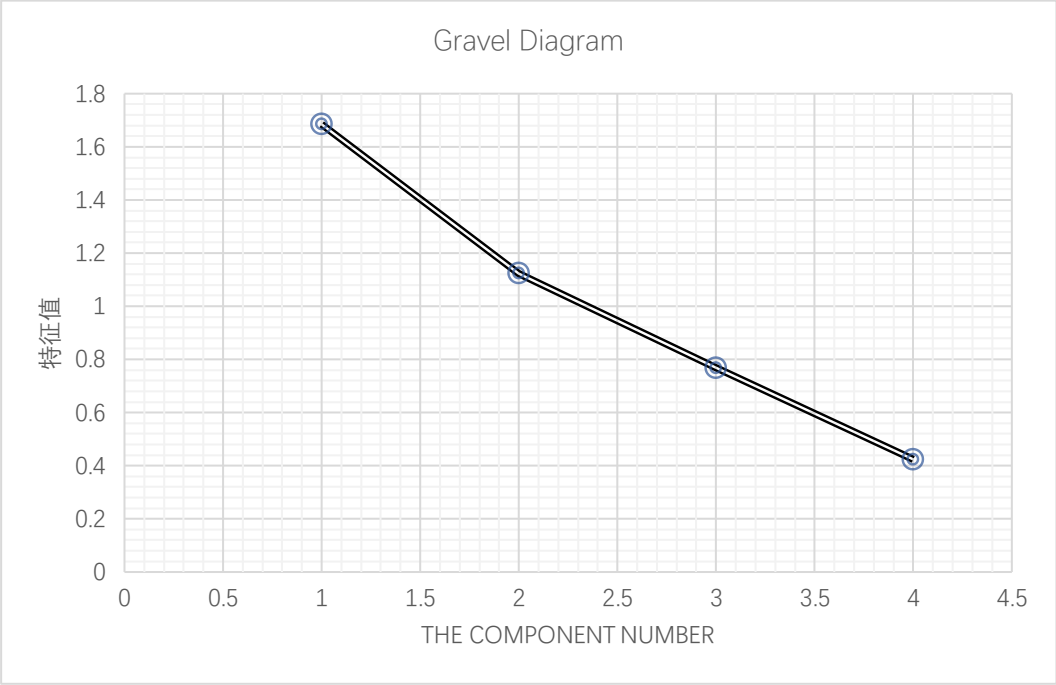
(2) Then, the eigenvectors, e_i (i=1,2, …, p), for the eigenvalues, $\lambda_{i,}$, of the corresponding values were solved, where $\|e_i\|$=1, i.e., $\sum_{j=1}^{p} e_{ij}^2 = 1$, e_{ij} represents the j^{th} component of vector e_i.

(3) Finally, the principal component contribution rate and accumulated contribution rate were calculated:

Contribution rate: $\frac{\lambda_i}{\sum_{k=1}^{p} \lambda_k}$ (i=1, 2, ∧, p)

Accumulated contribution rate: $\frac{\sum_{k=1}^{pi} \lambda_k}{\sum_{k=1}^{p} \lambda_k}$ (i=1, 2, ∧, p)

Generally, the 1st, 2nd, ..., m^{th} ($m \leq p$) principal components corresponding to eigenvalues λ_1, λ_2, ∧, and λ_m, with an accumulated contribution rate of 85%-95% were taken.



(4) After this, the principal component load and the scores of each component were calculated as follows:

$$I_{ij} = p\,(z_i, x_j) = \sqrt{\lambda_i} e_{ij}\ (i, j = 1, 2, \wedge, p)$$

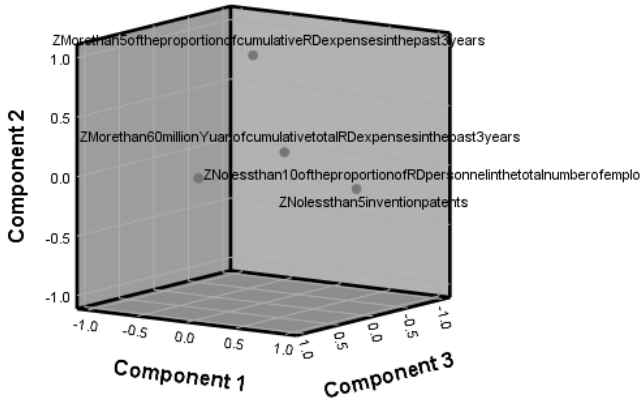
$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & z_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix}$$

Component matrix [a]				
	Components			
	1	2	3	4
Zscore: (R&D investment has accounted for more than 5% of the operating revenue over the last three years)	0.616	-0.580	-0.431	0.315
Zscore: (The cumulative R&D investment over the last three years is more than RMB 60 million)	0.833	0.217	-0.247	-0.445
Zscore: (R&D personnel account for no less than 10% of the total number of employees in a year)	0.583	-0.385	0.715	-0.015
Zscore: (More than 5 invention patents have made up the main business revenue)	0.521	0.769	0.103	0.356

Extraction method: PCA.

a. A total of 4 components were extracted.

Diagram of components in the rotated space



(5) The score of each principal component was now synthesized using the following:

$$Z=\begin{bmatrix} z_{11} & z_{12} & \Lambda & z_{1m} \\ z_{21} & z_{22} & \Lambda & z_{2m} \\ M & M & & M \\ z_{n1} & z_{n2} & \Lambda & z_{nm} \end{bmatrix}$$

$$Y=\frac{\lambda_1}{\lambda_1+\lambda_2+\lambda_3+\lambda_4}Y_1+\frac{\lambda_2}{\lambda_1+\lambda_2+\lambda_3+\lambda_4}Y_2+\frac{\lambda_3}{\lambda_1+\lambda_2+\lambda_3+\lambda_4}Y_3+\frac{\lambda_4}{\lambda_1+\lambda_2+\lambda_3+\lambda_4}Y_4$$

The score was obtained by substituting in the above contribution rate, i.e.:

The technological attribute evaluation indicator =

42.114% * intensity of R&D investment + 28.082% * level of R&D investment + 19.209% * personnel structure + 10.596% * patent level

According to the above results, the influence weights of the four principal components, i.e., the four

technological attribute evaluation indicators, in descending order were: the intensity of R&D investment (No. 1); the level of R&D investment (No. 2); the personnel structure (No. 3); and the patent contribution to revenue (No. 4). The weight of No. 1 was about 3 times that of No. 3, and about 5 times that of No. 4. No. 1 contributed 42.114%, or nearly 50%, of the overall score. Thus, the intensity of R&D investment is the core attribute of enterprises being listed on the STAR Market.

For enterprises listed on the STAR Market, the strength of technological innovation is a significant factor, with it being of particular concern to the public, including investors. According to the 2021 statistics, the R&D expenditure of 10 listed enterprises on the STAR Market, including Asieris, Dizal Pharmaceutical, Mabwell Bioscience, Shouyao Holdings, and SinoCellTech, accounted for more than 100% of their operating revenue. Indeed, the R&D expenditure of Dizal Pharmaceutical, Asieris, Shouyao Holdings, and Mabwell Bioscience accounted for more than 1,000%, so, R&D investment far exceeded their operating revenue in that year. In particular, in 2021, as the only listed enterprise on the STAR Market with an R&D investment of more than RMB 5 billion, BeiGene invested about RMB 9.538 billion in R&D. In order of R&D investment, after BeiGene came SMIC, TopAlliance Biosciences, QI-ANXIN, and CSR TIMES ELEC, who invested between RMB 1 billion and RMB 5 billion in R&D. However, the R&D expenditure of KEDE CNC and *ST Niutech was relatively low, at RMB 3.49 million and RMB 8.25 million, respectively.

Given the huge difference in the scale of the enterprises listed on the STAR Market, the intensity of R&D investment is more useful when making a comparison between them than just the level of R&D investment. As the level of R&D investment is expressed as an absolute amount, it is not conducive to the making of a comparison between enterprises of different scales. So, the weight of the intensity of R&D investment is greater in the model than the level of R&D investment, which is in line with the basic rules of data statistics and analysis.

The R&D expenditure data that was collected, included but was not limited to the following content:

Main R&D expenditure content:
1) Material costs directly consumed by R&D
2) Fuel and power costs directly consumed by R&D
3) Wages, bonuses, allowances, subsidies, social insurance premiums, housing provident funds of in-service R&D personnel, as well as labor costs for employing R&D personnel
4) Depreciation or rental costs of fixed assets used in R&D, such as instruments, equipment, houses, and their operation, maintenance, or repair costs
5) Amortization costs of intangible assets, such as software, patent rights and non-patented technologies used in R&D
6) Development and manufacturing costs of molds and technical equipment for pilot tests and trial production, as well as equipment adjustment and inspection costs
7) Fees paid to other units or individuals or in collaboration with them for R&D by outsourcing or through joint R&D
8) Other costs directly related to R&D, including fees for technical books, data translation, conferences, business travel, office work, foreign affairs, training of R&D personnel, expert consultation, as well as insurance fees for high-tech R&D, *etc.*

The personnel structure largely reflects the ratio of R&D personnel to the total number of employees and the cost for R&D personnel forms only part of the total R&D expenditure. Thus, the weighting for R&D personnel (the personnel structure) in the model is relatively low when compared to the intensity and level of R&D investment. This is in line with the actual components of R&D expenditure.

When it comes to the relative weight for patent contributions to revenue and the personnel structure,

invention patents are largely applied for directly by the applicants and then obtained after review by the Chinese National Intellectual Property Administration (CNIPA). Patents can also be obtained by assignment or inheritance. However, the R&D level and capability of applicants is only truly reflected in invention patents that arise through their own R&D activities. Thus, the weight assigned to the patent level in the model is relatively low.

To sum up, the weights of the four technological attribute evaluation indicators in the model are, in descending order: the intensity of R&D investment; the level of R&D investment; the personnel structure; and the patent level. The specific weights for the intensity and level of R&D investment are 42.11% and 28.08%, respectively, (over 70% in total), while the weights for the personnel structure and patent level are 19.21% and 10.60%, respectively. This captures the importance and influence of the intensity and relative scale of R&D expenditure on the technological strength of a technological innovation enterprise. The intensity of R&D investment for all enterprises on the STAR Market reached 10.08% in 2021, twice that of enterprises on the Growth Enterprise Market (GEM) and four times that of enterprises on the main board. This fully respects the new emphasis on "key & core technology" in the STAR Market.

The comprehensive scores for the principal components, i.e., the technological attribute evaluation indicators, for the sample enterprises are as follows:

Listing success rate (1: success, 0: failure)	Intensity of R&D investment	Level of R&D investment	Personnel structure	Patent level	Evaluation indicator of technological attributes
1	4.399	0.332	0.913	0.284	2.151
1	4.574	1.268	-0.972	-0.212	2.073
1	7.411	-3.627	-2.091	3.358	2.056
1	2.256	2.962	-0.412	-0.005	1.702
1	3.412	0.025	1.729	-0.965	1.674
1	2.254	1.253	0.114	0.745	1.402
1	2.276	1.355	0.287	-0.014	1.393

1	2.031	1.657	0.515	-0.437	1.374
1	1.769	1.793	0.204	0.499	1.341
1	2.277	0.825	0.469	-0.207	1.259
1	1.652	1.962	-0.374	-0.237	1.150
1	1.699	2.178	-1.267	-0.479	1.033
1	0.986	1.673	0.150	0.725	0.991
1	1.306	1.256	0.400	0.076	0.988
1	1.352	0.231	1.683	0.141	0.972
1	1.299	0.609	1.077	-0.017	0.924
……	……	……	……	……	……

On the basis of these comprehensive scores, the technological innovation attribute evaluation indicators for enterprises seeking to be listed on the STAR Market can be ranked. The top three evaluation indicators were 2.151, 2.073 and 2.056, respectively.

Generally, the higher the TII, the stronger the technological innovation attributes, and the greater the focus on "key & core technology" and core competitiveness of the enterprises to be listed on the STAR Market.

5.3 Correlation between technological attributes and listing success rate

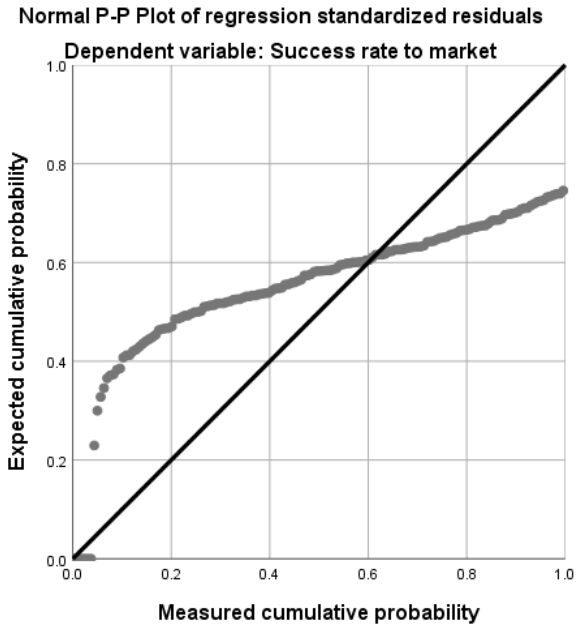
The influence of the technological innovation attributes on the listing success rate is represented in Table 3:

Table 3:

Coefficient [a]								
Model		Unstandardized coefficient		Standardized coefficient	*t*	Significance	95.0% confidence interval for *B*	
		B	Standard deviation	Beta			Lower limit	Upper limit
1	(Constant)	0.963***	0.085		11.397	0.000	0.796	1.130
	TII	0.074**	0.029	0.244	2.512	0.013	0.016	0.131
	LnAssets	0.006	0.026	0.024	0.219	0.827	-0.045	0.056
	Asset-liability ratio	-0.001	0.001	-0.063	-0.741	0.460	-0.003	0.001
	Return on total assets	0.001	0.002	0.061	0.599	0.550	-0.003	0.006
	@Year 2020	-0.020	0.036	-0.048	-0.551	0.583	-0.092	0.052

a. Dependent variable: listing success rate

Note: ***, ** and * represent a statistical significance of 1%, 5% and 10%, respectively.



From Table 3 it can be seen that, in terms of the TII (independent variable) in the second row, the

standardization coefficient Beta in the third column is 0.244. This indicates that, out of the many factors affecting the probability of IPO success, the influence of the technological innovation attributes accounts for 24.40%, with a significant positive correlation at 5%. It can be concluded from this that, if the enterprises on the STAR Market have relatively strong technological innovation attributes, their listing success rate will be higher, which confirms Hypothesis 1.

As the IPO qualification of enterprises can benefit from their technological innovation attributes, the remaining research regarding technological innovation attributes and post-listing performance and growth were largely based on the comprehensive technological innovation attribute score, i.e., the TII.

5.4 Influence of the technological innovation attributes on post-listing performance

5.4.1 Regression analysis of the correlation between the TII and post-listing performance

1. Influence of the technological innovation attributes on the post-listing growth and performance of the listed enterprises

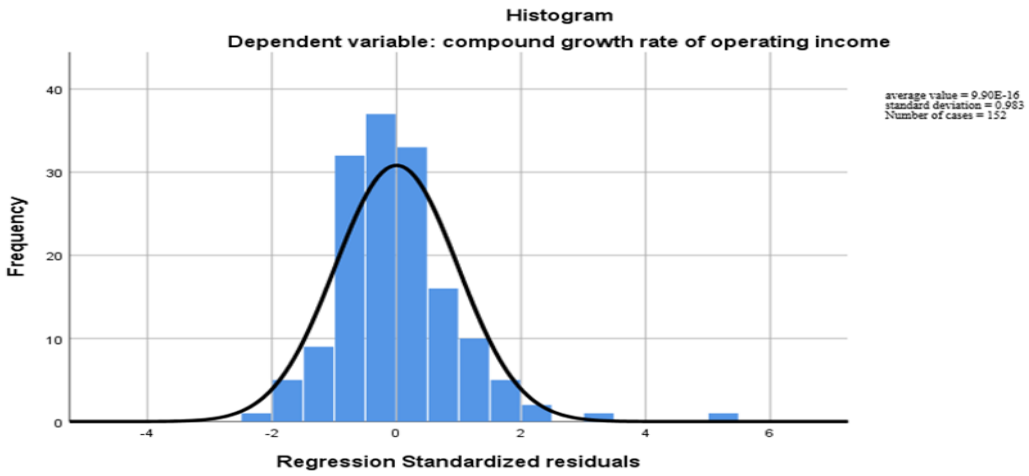
(1) Compound growth rate of the operating revenue after listing:

Table 4:

Coefficient [a]								
Model		Unstandardized coefficients		Standardized coefficients	*t*	Significance	95.0% confidence interval of B	
		B	Standard deviation	Beta			Lower limit	Upper limit
1	(Constant)	25.984***	8.548		3.040	0.003	9.091	42.877
	Technological innovation attribute evaluation indicators	6.151**	2.959	0.204	2.079	0.039	0.303	11.999
	LnAssets	-0.842	2.597	-0.036	-0.324	0.746	-5.975	4.292
	Asset-liability ratio	0.029	0.109	0.023	0.268	0.789	-0.187	0.245
	Return on total assets	-0.117	0.232	-0.052	-0.504	0.615	-0.576	0.342
	@Year 2020	-2.190	3.687	-0.053	-0.594	0.553	-9.477	5.097

a. Dependent variable: compound growth rate of the operating revenue

Note: ***, ** and * represent a statistical significance of 1%, 5% and 10%, respectively.



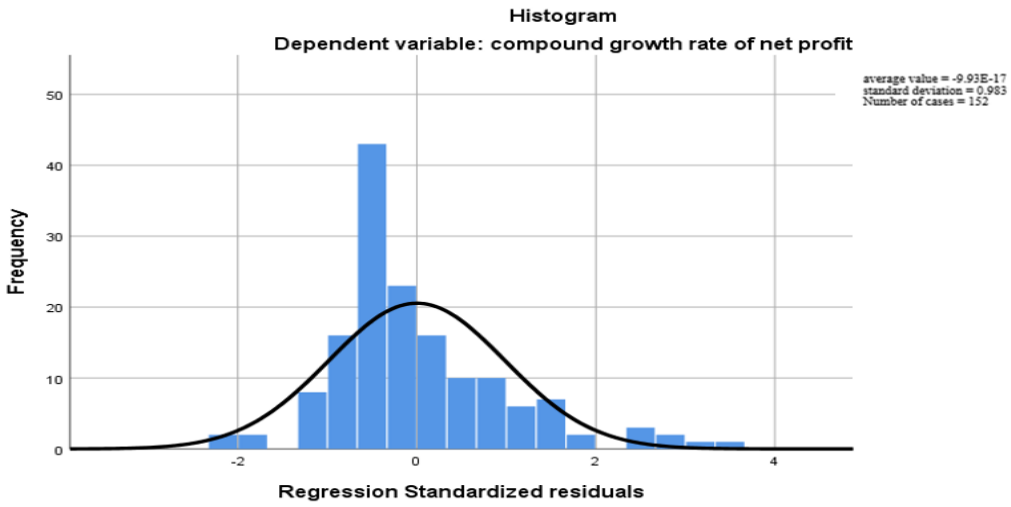
(2) Compound growth rate of the net profit after listing

Table 5:

Coefficient [a]								
Model		Unstandardized coefficient		Standardized coefficient	*t*	Significance	95.0% confidence interval of B	
		B	Standard deviation	Beta			Lower limit	Upper limit
1	(Constant)	1.016	14.574		0.070	0.945	-27.787	29.819
	TII	9.576*	5.045	0.188	1.898	0.060	-0.395	19.547
	LnAssets	0.993	4.429	0.025	0.224	0.823	-7.760	9.745
	Asset-liability ratio	0.102	0.187	0.047	0.547	0.585	-0.267	0.471
	Return on total assets	0.564	0.396	0.147	1.423	0.157	-0.219	1.346
	@Year 2020	5.819	6.287	0.083	0.926	0.356	-6.606	18.243

a. Dependent variable: compound growth rate of the net profit

Note: ***, ** and * represent a statistical significance of 1%, 5% and 10%, respectively.



Tables 4 and 5 show the correlation between the technological innovation attributes and the post-listing growth and performance of the listed enterprises. From these two tables, it can be seen that the standardization coefficients Beta in the third column in terms of the TII (independent variable) in the second row are 0.204 and 0.188, respectively, which corresponds to the compound growth rates for the operating revenue and net profit. In other words, enterprises listed on the STAR Market have higher rates of growth and performance. Moreover, the stronger the technological innovation attributes, the higher the rates of growth and performance, with a significant positive correlation at 5%. This implies that, if enterprises listed on the STAR Market have relatively strong technological innovation attributes, their post-listing growth and performance will be higher. This confirms Hypothesis 2.

2. Influence of the technological innovation attributes on the growth and performance of the listed enterprises one year after listing

(1) Compound growth rate of the operating revenue one year after listing:

Table 6:

Coefficient [a]								
Model		Unstandardized coefficient		Standardized coefficient	*t*	Significance	95.0% confidence interval of B	
		B	Standard deviation	Beta			Lower limit	Upper limit
1	(Constant)	23.414**	9.551		2.452	0.016	4.470	42.358
	TII	5.085	3.266	0.179	1.557	0.123	-1.393	11.563
	LnAssets	-3.125	2.921	-0.142	-1.070	0.287	-8.918	2.669
	Asset-liability ratio	0.078	0.120	0.068	0.649	0.518	-0.161	0.317
	Return on total assets	0.056	0.263	0.026	0.212	0.833	-0.466	0.577
	@Year 2020	3.017	3.636	0.084	0.830	0.409	-4.195	10.229

a. Dependent variable: compound growth rate of the operating revenue one year after listing

Note: ***, ** and * represent a statistical significance of 1%, 5% and 10%, respectively.

(2) Compound growth rate of the net profit one year after listing:

Table 7:

Coefficient [a]								
Model		Unstandardized coefficient		Standardized coefficient	*t*	Significance	95.0% confidence interval of B	
		B	Standard deviation	Beta			Lower limit	Upper limit
1	(Constant)	-9.124	19.793		-0.461	0.646	-48.384	30.136
	TII	5.793	6.769	0.098	0.856	0.394	-7.632	19.219
	LnAssets	5.932	6.053	0.129	0.980	0.329	-6.074	17.939
	Asset-liability ratio	0.195	0.250	0.081	0.781	0.437	-0.300	0.690

	Return on total assets	0.323	0.545	0.072	0.594	0.554	-0.757	1.404
	@Year 2020	9.301	7.535	0.124	1.234	0.220	-5.646	24.247

a. Dependent variable: compound growth rate of the net profit one year after listing

Note: ***, ** and * represent a statistical significance of 1%, 5% and 10%, respectively.

3. Influence of the technological innovation attributes on the growth and performance of listed enterprises two years after listing

(1) Compound growth rate of the operating revenue two years after listing:

Table 8:

Coefficient [a]								
Model		Unstandardized coefficient		Standardized coefficient	*t*	Significance	95.0% confidence interval of B	
		B	Standard deviation	Beta			Lower limit	Upper limit
1	(Constant)	7.912	7.398		1.070	0.293	-7.157	22.981
	TII	-1.741	2.925	-0.111	-0.595	0.556	-7.698	4.217
	LnAssets	1.494	2.246	0.153	0.665	0.511	-3.080	6.068
	Asset-liability ratio	0.094	0.089	0.195	1.055	0.299	-0.088	0.276
	Return on total assets	0.242	0.215	0.241	1.122	0.270	-0.197	0.680

a. Dependent variable: compound growth rate of the operating revenue two years after listing

Note: ***, ** and * represent a statistical significance of 1%, 5% and 10%, respectively.

(2) Compound growth rate of the net profit two years after listing

Table 9:

Coefficient [a]								
Model		Unstandardized coefficient		Standardized coefficient	*t*	Significance	95.0% confidence interval of B	
		B	Standard deviation	Beta			Lower limit	Upper limit
1	(Constant)	-2.345	18.442		-0.127	0.900	-39.911	35.220
	TII	6.347	7.291	0.161	0.871	0.391	-8.504	21.198
	LnAssets	1.721	5.598	0.070	0.307	0.761	-9.682	13.123
	Asset-liability ratio	0.239	0.223	0.196	1.073	0.291	-0.215	0.693
	Return on total assets	0.090	0.537	0.036	0.168	0.868	-1.003	1.184

a. Dependent variable: compound growth rate of the net profit two years after listing

Note: ***, ** and * represent a statistical significance of 1%, 5% and 10%, respectively.

From Tables 6-9, it can be seen that both the compound growth rate of the operating revenue and the compound growth rate of the net profit were not significant at the 5% level one or two years after listing. In other words, enterprises listed on the STAR Market did not show higher growth and performance in the short term.

5.4.2 Influence of the TII on post-listing performance

In July 2019, some lucky enterprises were successfully listed in the first batch of enterprises shown on the launch board of the STAR Market. Were all of them necessarily top-quality enterprises in the economic climate at the time? According to the WIND 2019 annual report, 25 of the listed enterprises in

the first batch were profitable and had accumulated net profits of up to RMB 8.303 billion, with an average net profit of RMB 332 million per listed enterprise. According to the SZSE statistics, the average net profit of the 805 listed enterprises on the SZSE in 2019 was RMB 64 million. So, the average net profit of the first batch of listed enterprises on the STAR Market was more than five times that of enterprises listed on the SZSE over the same period. In 2020, the net profit of the first batch of listed enterprises on the STAR Market totaled RMB 9.467 billion, up 14% year on year, and the average net profit of each enterprise was RMB 379 million, which is 2.81 times that of GEM listed enterprises for the same period. According to the WIND 2021 annual report, the net profit of the first batch of listed enterprises on the STAR Market totaled RMB 10.613 billion, increasing 12.1% year on year, while the average net profit of each enterprise was RMB 425 million, which is 2.51 times that of GEM listed enterprises for the same period. Due to unfavorable factors, such as an economic downturn at home and abroad and the global pandemic over the past two years, the first batch of 25 listed enterprises on the STAR Market have managed to maintain positive growth in their performance, but their growth rate has declined slightly. In 2020 and 2021, only 7 of the 25 listed enterprises achieved positive growth in their performance every year, namely: Ronbay Technology; Endovastec; AMEC; HYC Technology; PIE-Engine; Traffic Control Technology; and Western Superconducting Technologies. The other enterprises suffered a drop in net profit in 2020 or in 2021. Enterprises that suffered two consecutive drops in performance in 2020 and 2021 included Xinguang Optic-Electronics, RICOM, and Fangbang Electronics.

According to WIND, nearly 10 of the listed enterprises have spent an average of more than RMB 100 million annually on R&D in the last three years. Here, the CRSC R&D expenditure was the highest, reaching RMB 1.9 billion in 2021. Meanwhile, the R&D expenditure of listed enterprises such as TZTEK Technology, Montage Technology, HYC Technology, ArcSoft Technology, Espressif, AMEC, Ronbay Technology, Raytron Technology, Traffic Control Technology and Western Superconducting

Technologies, has been growing. Despite the high R&D expenditure of many of the3 listed enterprises, this continuously high level of investment has not been reflected in their operating performance and stock price in the short term. This is probably because the R&D investment has yet to produce results, but it certainly demonstrates that these kinds of enterprises are high levels of R&D technology content. This is why the STAR Market was set up by the state. They form a group of top-quality enterprises with "key & core technology", that are ideally positioned to realize the mission of boosting national technological innovation.

Ongoing R&D investment, plus higher technological innovation attribute evaluation indicators, will certainly bring about higher growth and prominent operating performance for enterprises in the near future. Take Ronbay Technology (stock code SH688005; stock price of around RMB 100; market value of around RMB 50 billion) as an example. According to the WIND 2019 annual report, Ronbay Technology invested a total of RMB 165 million in R&D, while its R&D investment was RMB 146 million in 2020. In 2021, its R&D investment increased to RMB 359.5 million, exceeding the combined figures for 2019 and 2020. Ronbay Technology achieved a net profit of RMB 87 million in 2019 and RMB 213 million in 2020, increasing by 143% year on year. In 2021, it achieved a net profit of RMB 911 million, increasing by over 300% year on year to 327.70%. At this point, Ronbay Technology was achieving really high levels of performance and growth. If we take Western Superconducting Technologies (stock code SH688122; stock price of around RMB 100; market value of around RMB 50 billion) as another example, it achieved a year-on-year increase of 141% in net profit according to the WIND 2020 annual report and 101% in 2021. Over the last three years, it has invested a total of RMB 424 million in R&D. Judging from these two cases, continuous R&D investment is indispensable to maintaining high performance and growth and makes such enterprises quintessential "key & core

technology" enterprises on the STAR Market. In other words, they will maintain higher technological attribute evaluation indicators, rather than just staying at their pre-IPO level.

5.5 Influence of technological innovation attributes on the listing success rate of enterprises

Three years ago, as the sound of a series of gong strokes echoed around the banks of the Huangpu River in Shanghai, the STAR Market, with its mission to "open up domestic listing and financing channels for tech enterprises, highlight the importance of 'key & core technologies', and give impetus to new growth", was established. Since that time, as a testing ground of registration system reform in China's capital markets, the STAR Market has not only pioneered a series of improvements but also managed to grow at a staggering speed by attracting a large number of high-quality enterprises that are focused on technological innovation.

Listing status is a scarce resource in China's capital markets. Fan Yun, a delegate to the National People's Congress (NPC) and the Chinese People's Political Consultative Conference (CPPCC) in 2002, pointed out that, in 2021, when the SSE released the *Guidelines for Assessment of Technological Innovation Attributes* (version 2.0) and the number of "hardware technology" indicators increased from three to four (version 1.0), the listing requirements became more demanding. Fan Yun also noticed that, during the IPO listing application process, some enterprises have to obtain various certificates and endorsements from related ministries and departments. Worse still, some to-be-listed private enterprises with a focus on technological innovation find it quite difficult to get endorsements from the government.

This being the case, is there a significant difference in the STAR Market listing success rate for enterprises with different kinds of property rights?

5.5.1 The influence of property rights on the listing success rate

China's stock market was established to help state-owned enterprises overcome difficulties by enhancing their capacity to reform. To boost the healthy growth of China's capital market as well as its economic restructuring and progress, a large number of regulations used to be implemented, especially with regard to the qualification for IPO listing. However, over the longer term, it is unreasonable to maintain easier access to IPO listing for state-owned enterprises. In particular, with their access to governmental support, state-owned enterprises have more scope to raise money directly from the primary market than private and non-state-owned enterprises.

Over time, China's economic restructuring and reform has become more profound. The reform of state-owned enterprises, which was a challenging task, was largely completed by the end of the 20th century. To continue to smoothly bring about the desired economic restructuring and progress, it is now necessary to boost private enterprises, given their broad coverage. This necessitates facilitating direct financing for them from the capital market. In relation to this, on January 31, 2004, the State Council issued *Some Opinions on Promoting the Reform, Opening Up, and Steady Growth of Capital Markets* (referred to as the "Nine Articles" of the capital market), which pointed out that the auditing system for the issuing of stock and listing needed to be enhanced, so that all kinds of high-quality enterprises would have an equal chance to thrive by raising money from the capital market. On February 19, 2005, the State Council issued *Suggestions of the State Council on Encouraging, Supporting, and Guiding the Development of the Non-Public Sector of the Economy Including the Individual Sector and Private Sector* (known as the "Thirty-six Articles about Non-public Economy"). This highlighted the need to "remove

as soon as possible the 'invisible and enduring obstacles in the mechanism' that hamper non-public economy development, so as to establish a fair and equal environment for market competition for private enterprises". From the perspective of rules and regulations, this further highlighted the need for non-public enterprises to have an equal chance to apply for an IPO by raising money from the capital market. Later, the CSRC implemented a series of major reforms including deeper reform of the issuance system. This included implementation of the newly revised *Company Law* and *Securities Law* in 2006 as well as the *Opinions on Supporting Private Enterprises in Accelerating Reform, Development, Transformation, and Upgrading* issued by the State Council in 2019. A number of propositions were put forward, such as: opening up the market admittance channels for non-public and private enterprises; creating a market, policy, and rule of law environment based on equal competition; protecting the legitimate property rights of private enterprises and entrepreneurs according to the law; and actively supporting and encouraging eligible high-quality private enterprises to go public and raise money from the STAR Market. This poses a question as to whether, as a result of the capital markets entering a new stage of development, the nature of the property rights of enterprises seeking to be listed might also affect their IPO applications?

Some light is thrown on this by the following table:

Table : Influence of technological innovation attributes on the listing success rate of private enterprises

Technological innovation attribute evaluation indicators	LnAssets	Asset-liability ratio	Return on total assets	Year	@ 2019	@ 2020	Private enterprise	TII * private enterprise
-0.20	0.65	12.08%	26.68%	2019	1	0	1	-0.20
-0.49	0.99	17.92%	22.93%	2020	0	1	0	0.00
-0.21	1.97	33.43%	4.35%	2019	1	0	0	0.00
-0.87	1.36	28.22%	11.06%	2020	0	1	1	-0.87
-1.22	1.15	21.43%	23.37%	2020	0	1	1	-1.22
-0.47	1.07	35.59%	21.14%	2020	0	1	1	-0.47
-0.41	0.99	16.44%	21.64%	2020	0	1	1	-0.41
0.16	1.28	17.91%	14.39%	2019	1	0	1	0.16
-0.47	1.93	5.58%	9.59%	2020	0	1	1	-0.47
0.44	1.14	17.48%	19.14%	2019	1	0	1	0.44
0.09	1.07	28.18%	14.45%	2019	1	0	1	0.09
0.69	1.49	14.02%	14.33%	2019	1	0	1	0.69
-0.21	1.36	11.37%	16.31%	2020	0	1	1	-0.21
0.23	1.19	22.94%	16.92%	2019	1	0	1	0.23
-0.73	1.46	39.52%	11.14%	2020	0	1	1	-0.73
-0.06	1.97	16.43%	-4.79%	2020	0	1	1	-0.06
-0.85	1.45	12.19%	16.65%	2020	0	1	1	-0.85
-0.12	0.99	19.59%	33.72%	2019	1	0	0	0.00
-0.67	1.33	24.93%	14.31%	2020	0	1	1	-0.67
-0.57	1.76	21.81%	10.49%	2020	0	1	1	-0.57
0.58	1.56	38.48%	9.32%	2020	0	1	1	0.58
-0.16	1.30	20.74%	38.05%	2019	1	0	1	-0.16
0.20	0.69	36.12%	23.03%	2020	0	1	1	0.20
0.36	1.12	18.18%	18.62%	2019	1	0	1	0.36
……	……	……	……	…	…	…	…	……

The regression results are shown below:

Table: Descriptive statistics

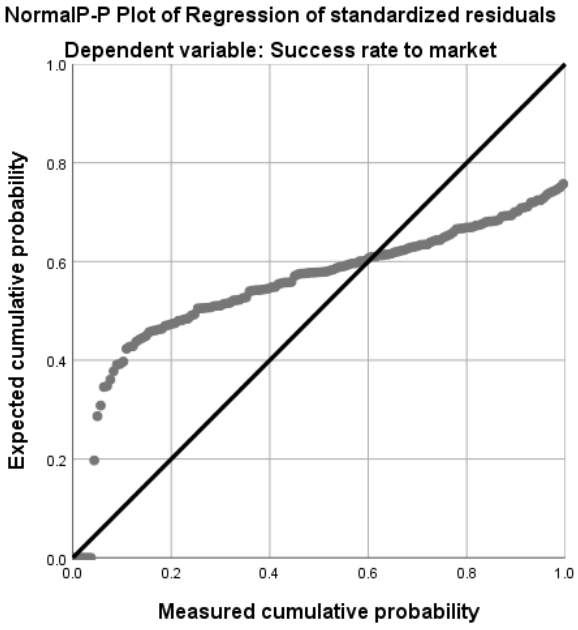
	Mean value	Standard deviation
Listing success rate	.96	.195
TII * private enterprise	.0429	.56693
TII	0.1125201561	0.6487312378
LnAssets	2.227609917420836	.839059060756246
Asset-liability ratio	33.4394%	15.37499%
Return on total assets	12.1715%	8.62480%
Year	2019.67	.471
@2019	.33	.471
@2020	.67	.471

Table: Coefficients [a]

Model		Unstandardized coefficient		Standardized coefficient	*t*	Significance	*B*'s 95% confidence interval	
		B	Standard deviation	Beta			Lower limit	Upper Limit
1	(Constant)	.958***	0.085		11.267	0.000	0.790	1.126
	TII * private enterprise	0.039	0.056	0.114	0.699	0.485	-0.072	0.151
	TII	0.041	0.055	0.137	0.759	0.449	-0.066	0.149
	LnAssets	0.009	0.026	0.040	0.357	0.721	-0.043	0.061
	Asset-liability ratio	-0.001	0.001	-0.065	-0.766	0.445	-0.003	0.001
	Return on total assets	0.001	0.002	0.064	0.632	0.528	-0.003	0.006
	@2020	-0.022	0.037	-0.053	-0.596	0.552	-0.094	0.051

a. Dependent variable: Listing success rate

Note: ***, **, and * mean a statistical significance of 1%, 5%, and 10% respectively.



According to the above, the significance of technological innovation attributes to private enterprises' listing success rate was 0.485, with the regression analysis results not being significant. It turned out that there was no evident difference between the influence of technological innovation attributes' on the listing success rate of private enterprises on the STAR Market and that of non-private enterprises. This therefore confirms that the registration system reform underpinning the STAR Market, with its focus on fairness, transparency, and the authenticity of information disclosure, provides a much fairer chance for the listing of all enterprises according to their level of technological innovation.

5.5.2 Influence of the technological innovation attributes on the listing success rate of different types of enterprises

See the table below:

Influence of the technological innovation attributes on the listing success rate of large-scale enterprises

TII	LnAssets	Asset-liability ratio	Return on total assets	Year	@2019	@2020	Large-scale enterprise	TII * private enterprise
-0.20	0.65	12.08%	26.68%	2019	1	0	1	-0.20
-0.49	0.99	17.92%	22.93%	2020	0	1	1	-0.49
-0.21	1.97	33.43%	4.35%	2019	1	0	1	-0.21
-0.87	1.36	28.22%	11.06%	2020	0	1	1	-0.87
-1.22	1.15	21.43%	23.37%	2020	0	1	1	-1.22
-0.47	1.07	35.59%	21.14%	2020	0	1	1	-0.47
-0.41	0.99	16.44%	21.64%	2020	0	1	1	-0.41
0.16	1.28	17.91%	14.39%	2019	1	0	1	0.16
-0.47	1.93	5.58%	9.59%	2020	0	1	0	0.00
0.44	1.14	17.48%	19.14%	2019	1	0	1	0.44
0.09	1.07	28.18%	14.45%	2019	1	0	0	0.00
0.69	1.49	14.02%	14.33%	2019	1	0	1	0.69
-0.21	1.36	11.37%	16.31%	2020	0	1	0	0.00
0.23	1.19	22.94%	16.92%	2019	1	0	1	0.23
-0.12	0.99	19.59%	33.72%	2019	1	0	0	0.00
……	……	……	……	……	……	……	……	……

The regression results are listed below:

Table: Descriptive statistics

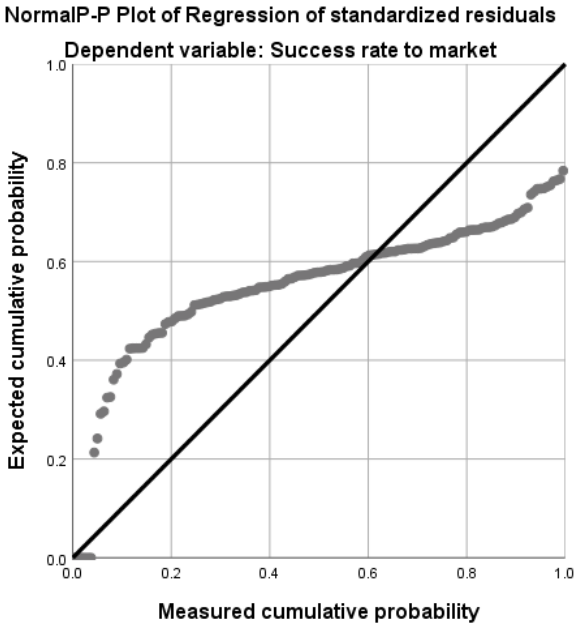
	Mean value	Standard deviation
Listing success rate	.96	.195
TII * large-scale enterprise	.0138	.45227
TII	0.1125201561	0.6487312378
LnAssets	2.227609917420836	.839059060756246
Asset-liability ratio	33.4394%	15.37499%
Return on total assets	12.1715%	8.62480%
Year	2019.67	.471
@2019	.33	.471
@2020	.67	.471

Table: Coefficient [a]

Model	Unstandardized coefficient		Standardized coefficient			*B*'s 95% confidence interval	
	B	Standard deviation	Beta	*t*	Significance	Lower limit	Upper limit
1 (Constant)	0.967***	0.084		11.461	0.000	0.800	1.134
TII * large-scale enterprise	0.066	0.050	0.152	1.309	0.193	-0.033	0.165
TII	0.043	0.037	0.143	1.158	0.249	-0.030	0.117
LnAssets	0.005	0.026	0.021	0.187	0.852	-0.046	0.055
Asset-liability ratio	-0.001	0.001	-0.065	-0.762	0.447	-0.003	0.001
Return on total assets	0.001	0.002	0.040	0.389	0.698	-0.004	0.005
@2020	-0.009	0.037	-0.022	-0.247	0.805	-0.083	0.065

a. Dependent variable: listing success rate

Note: ***, **, and * mean a statistical significance of 1%, 5%, and 10%, respectively.



According to the above, the influence of the technological innovation attributes on the listing success rate for large, micro, and small to medium-sized enterprises had a significance of 0.193, with the regression analysis result again not proving to be significant. Thus, it can be seen that the technological innovation attributes had no obvious correlation with the listing success rate of different types of enterprises on the STAR Market. The STAR Market reform advocated fully inclusive market admittance and market-oriented principles that, in essence, give the market the final say. This would appear to have had the desired effect.

Generally, having different property rights or being of a different nature or scale does not lead to enterprises' technological innovation attributes generating different listing success rates. This is in line with the original intention and mission of the STAR Market.

Under the STAR Market registration system, any enterprise that meets the requirements can go public. As a matter of fairness, the market will give different enterprises different market prices. In a fair market environment, listed enterprises have to focus on their performance. If an enterprise does not perform well, it will have a very low market price and may even be removed from the market. The ultimate purpose of the stock issuance system reform is to give the market the final say, so that enterprises who are performing well will continue to thrive, while those that are not will be eliminated. By analogy, encouraging bad kids will hurt well-behaved ones, so the STAR Market aims to be a paradise for excellent enterprises according to their degree of technological innovation. This applies regardless of whether they are private or state-owned, large, micro, small, or medium-sized. For a good enterprise, listing is just a new starting point, even if it is still at a very early stage.

The STAR Market registration system is characterized by inclusive listing conditions, transparent assessment standards, predictable assessment timelines, and refined supervision and management services. Under this system, high-quality enterprises from a range of industries, of different sizes and modalities, can all use the capital market to raise capital, grow and develop. By the same token, the capital market itself will continue to thrive and develop by attracting a large number of high-value and high-growth enterprises from the new-generation of information technology and high-end equipment manufacturing industries. In this way, the STAR Market is seeking to open a new chapter for all kinds of enterprises on the basis of technological innovation.

Chapter VI. Research conclusions, recommendations, and outlook

6.1 Conclusions

In March 2020, the CSRC issued the *Guidelines for Evaluation of Technological Innovation Attributes* (*Trial*) that built on the experience gained from previous reviews and registrations. These guidelines introduced a revised technological innovation attribute evaluation indicator system and strengthened the review and registration criteria for the STAR Market. The STAR Market plays an important role in gathering together high-quality enterprises on the basis of their technological innovation. In April 2021, the CSRC revised the *Guidelines for Evaluation of Technological Innovation Attributes* (*Trial*) and introduced additional assessment rules to further improve the evaluation indicator system and uphold the emphasis on "Key & Core Technology".

According to an initial analysis of enterprises who applied for listing on the STAR Market up to the end of 2021, an increase in the ratio of R&D investment to operating revenue over the last three years did not lead to an obvious increase in their listing success rate. Increases in the cumulative R&D investment over the last three years did not have an obvious impact on the listing success rate either. An increased number of invention patents associated with the main operating revenue was first negatively, then positively correlated with the listing success rate. The ratio of R&D personnel to the total number of employees in a specific year was negatively correlated with the listing success rate. Thus, no single technological innovation attribute was significantly correlated with the listing success rate and some indicators were even negatively correlated with it.

This article has reported an empirical study of data relating to enterprises who applied for listing on the STAR Market between June 2019 and December 2021, drawing upon the four general indicators and five exception clauses in the *Guidelines for Evaluation of Technological Innovation Attributes (Trial)* as basic indicators of an enterprise's technological innovation attributes. The dimensionality of the multiple technological innovation attribute evaluation indicators was mathematically reduced using PCA. A revised indicator of the "technological innovation attributes", the TII, was developed to replace the multiple evaluation indicators, thus avoiding multicollinearity and simplifying their use. Finally, regression analysis was used to identify how the strength of an enterprise's technological innovation attributes might influence its listing success rate on the STAR Market, as well as its post-listing performance.

It turned out that the TII made a significant difference to the story told by the evaluation indicators, with the intensity of R&D investment now sitting at the top of the list, followed by the level of R&D investment, personnel structure, and patent level. The empirical study showed that the weights of the intensity of R&D investment and the level of R&D investment were 42.11% and 28.08%, respectively, with a total combined weight of over 70%. In comparison, the weights of the personnel structure and patent level were 19.21% and 10.60%, respectively. Thus, it was found that the intensity and relative level of R&D expenditure was playing a significant role in the technological prowess of enterprises focused on technological innovation. In terms of the intensity of R&D investment for enterprises listed on the STAR Market in 2021, the figure reached 10.08%, which is twice as much as that of enterprises listed on the GEM and four times as much as that of enterprises listed on the main board. This is a perfect

demonstration of the effectiveness of the STAR Market to encompass enterprises with an interest in "Key & Core Technology".

When the strength of the influence of the technological innovation attributes on the listing success rate was studied, the listing success rate was found to be positively correlated with the strength of the technological innovation attributes. In other words, the stronger the technological innovation attributes, the better the listing success rate on the STAR Market. When it came to how the strength of the technological innovation attributes might have an impact on the post-listing performance of enterprises, it was found that the stronger the technological innovation attributes, the better the enterprises' development and post-listing performance. Examination of the enterprises' performance over the following two years revealed that their growth and post-listing performance were not significant and could even be considered poor over the shorter term. This suggests that enterprises listed on the STAR Market are more focused on long-term development than short-term profit. In other words, the technological innovation attributes can significantly increase the listing success rate of enterprises and are positively correlated with their long-term post-listing performance, but they may have to put up with a drop in short-term performance to achieve this goal.

Further research showed that the technological innovation attributes don't have a significant impact on the listing success rate of different types of enterprises or enterprises with different types of property rights. The STAR Market advocates a fully inclusive market admittance system and the preservation of market-oriented principles, which gives the market the final say and reinforces the market's status as the

final arbiter of admittance. On these grounds, the STAR Market is set to open up a new chapter for all kinds of enterprises that are focused on technological innovation.

In summary, while no single technological evaluation indicator is significantly related to the listing success rate of enterprises, according to the research reported here, the stronger the technological innovation attributes of an enterprise overall, the higher their listing success rate is likely to be and the better their long-term post-listing performance will be, even if their short-term performance is less satisfactory. Meanwhile, the technological innovation attributes have no significant impact on the listing success rate of different types of enterprises with different kinds of property rights.

Overall, the comprehensive TII that was first developed during this study can help enterprises to improve their technological innovation attributes and increase their likelihood of listing success. It can also assist policymakers in continuously revising and optimizing the technological innovation attribute evaluation indicators, so that they are better able to select enterprises with a true focus on technological innovation, thereby promoting the national strategy of transforming China into a science and technology giant. Finally, the TII may facilitate investors' selection of high-quality technological-innovation-driven enterprises for future investment, thus improving the efficiency of capital usage and return on investment.

6.2 Policy recommendations

The introduction of the technological innovation attribute evaluation indicator system in the *Guidelines for Evaluation of Technological Innovation Attributes* (*Trial*) was based on the STAR Market's positioning and a comprehensive analysis of the current situation of enterprises seeking listing.

As well as helping enterprises to strengthen their innovation investment, technological development, and research ability, the TII can help regulators, such as stock exchanges and the CSRC, to select enterprises with strong technological innovation attributes.

This study has confirmed that the technological innovation attributes can significantly increase the listing success rate for enterprises. The technological innovation attributes are positively correlated with long-term post-listing performance, but short-term performance may be less satisfactory, while the technological innovation attributes have no significant impact on the listing success rate of different types of enterprises with different kinds of property rights. In addition, the four technological innovation attribute indicators contribute to the comprehensive evaluation indicator to different degrees, with the intensity of R&D investment being at the top of the list, followed by level of R&D investment, personnel structure, and patent level. In view of these findings, the following recommendations should be given consideration:

1) *Strengthen the technological innovation policy support and encourage enterprises to continuously improve their technological innovation attributes.*

The government can provide better policy support for tech enterprises by formulating policies and measures relating to technology, finance, and taxation. Enterprises need to improve their technological innovation attributes and create better development conditions by increasing their technological innovation and R&D investment. They also need to introduce and cultivate technological talent and expand the level of R&D.

2) *Dynamically adjust the technological attribute evaluation indicators to improve the quality of enterprises to be listed*.

The government should continue to dynamically adjust relevant policies and guidance and refine the technological innovation attribute evaluation indicator system to further improve the selection of enterprises for STAR Market listing and to enhance the IPO application verification experience, while also improving the guidance given to tech enterprises who wish to go public.

3) *Strengthen promotion of the important role technological innovation attributes play in enterprise development*.

It is suggested that the government raise enterprises' awareness of the significance of the technological innovation attribute evaluation indicators and the impact technological innovation can have on the listing success rate of enterprises and their long-term post-listing performance, so that they are encouraged to pay more attention to technological innovation and R&D investment.

4) *Boost technological innovation by promoting the STAR Market listing*.

The government should enhance the investigation of unlisted enterprises that meet the technological innovation attribute evaluation criteria and seek to attract more high-quality enterprises focused on technological innovation to go public on the STAR Market, thereby improving the quality of their financing, promoting the STAR Market listing, helping tech enterprises to develop more rapidly, and, ultimately, strengthening the competitiveness of Chinese technology enterprises.

5) *Continuously evaluate the listed enterprises' technological innovation attributes so as to maintain the STAR Market's status and position*.

Since its establishment, the STAR Market has always adhered to the principle of supporting the development of "Key & Core Technology" and it has encouraged "Key & Core Technology" enterprises to go public. Continuous evaluation of the listed enterprises' technological innovation attributes will further encourage the listed enterprises to uphold the positioning and requirements of the STAR Market by constantly seeking to improve their quality.

6.3 Limitations

1) *Discrepancies in the samples*: Enterprises in different industries may have different technological innovation attribute evaluation criteria, thus leading to limitations in the indicators screened through PCA. For example, the quantity of patents and the ratio of R&D personnel may vary significantly in different industries. It is easier to obtain patents in some industries, and some industries need more salesmen, thus lowering the ratio of R&D personnel. In subsequent studies, samples need to be grouped according to industry.

2) Insufficient sample data: Unlike the SSE and SZSE main board, China's STAR Market has only been established for a few years, so the sample size of listed enterprises is small, though it is rapidly increasing. As a result, the evaluation of technological innovation attributes is somewhat at the mercy of current changes in policy. As the STAR Market continues to operate and the volume of basic data expands, more comprehensive evaluation indicators will become available.

6.4 Research Outlook

When compared to research on IPO and listing success rates by scholars in various countries, this study has pioneered the use of PCA to quantitatively evaluate technological innovation attributes and has applied linear regression to develop an analytic model. This has created a new research framework and theory for future scholars to refer to. The regression coefficients have revealed the limitations and areas for improvement in the current study. In the future, research should focus on selecting enough samples and other explanatory variables to enrich the quantitative explanation of the listing success rate. In addition, as the number of listed enterprises focused on technological innovation keeps increasing, the sample size regarding their post-listing performance is also growing. Future studies will therefore be able to measure enterprises' post-listing performance over a longer time scale, which may then provide additional insight for regulators, investors, and corporate managers.

Emphasis has also been placed here upon the impact that the strength of enterprises' technological innovation attributes can have on their listing success rate and post-listing performance. This is mainly based on data relating to enterprises who have applied for IPO under the current registration system. Future research could expand upon this by including enterprises that have applied for IPO under the audit system. By evaluating the strength of enterprises' technological innovation attributes using the comprehensive TII developed during this study, an investigation of the impact of enterprises' technological innovation attributes on their IPO application success rate and post-listing performance under the audit system could be launched. Ultimately, it should be possible to assess whether the capital market operating under the current registration system is genuinely offering more resources to enterprises

with stronger technological innovation attributes and whether the capital market could be more effective in how it underpins the national strategy of making China a science and technology giant.

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