

**TECHNOLOGICAL INNOVATION AND FIRM
VALUE AMONG SMES IN CHINA: EVIDENCE
FROM THE STAR MARKET**

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**TECHNOLOGICAL INNOVATION AND FIRM
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FROM THE STAR MARKET**

by

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INOVASI TEKNOLOGI DAN NILAI FIRMA DALAM KALANGAN PKS DI CHINA: BUKTI DARIPADA PASARAN STAR

ABSTRAK

Kajian ini mengkaji Kesan inovasi teknologi terhadap nilai firma dalam Perusahaan kecil dan sederhana (PKS) di sektor teknologidi China, dengan memberi tumpuan kepada perbezaan antara syarikat milik kerajaan (SOE) dan Syarikat bukan milik kerajaan (NSOE). PKS menghadapi ketidakpastian yang ketara akibat perubahan pesat dalam pasaran ekonomi global, menjadikan peranan inovasi teknologi penting untuk Pembangunan mampan dan daya saing negara. Kajian ini menggunakan 1622 sampel data daripada 566 perusahaan di PASARAN STAR dari 2019 hingga 2023 untuk membina model kesan tetap untuk meneroka kesan input inovasi teknologi (seperti intensiti R&D dan nisbah kos R&D) dan output inovasi teknologi (seperti aset tidak ketara dan paten). Kajian ini mendapati bahawa output inovasi teknologi, seperti paten, memberi kesan negatif terhadap nilai firma, manakala pelaburan berintensiti tinggi dalam R&D (intensiti R&D) memberi Kesan positif. Walau bagaimanapun, Nisbah perbelanjaan R&D berbanding kos lain memberi kesan negatif terhadap nilai firma. Apabila dianalisis mengikut jenis pemilikan, dapatan bagi NSOE selari dengan trend keseluruhan ini, manakala dalam SOE, hanya aset tidak ditaip (aset tidak ketara yang tidak dikelaskan) menunjukkan kesan yang signifikan secara statistik terhadap nilai firma, manakala pembolehubah lain tidak signifikan. Keputusan ini menekankan hubungan yang kompleks antara inovasi teknologi dan nilai firma, mencadangkan

keperluan strategi yang lebih didasarkan dalam pengurusan pelaburan inovasi, khususnya dalam konteks pemilikan yang berbeza.

TECHNOLOGICAL INNOVATION AND FIRM VALUE AMONG SMES IN CHINA: EVIDENCE FROM THE STAR MARKET

ABSTRACT

This study investigates the impact of technological innovation on the firm value of small and medium-sized enterprises (SMEs) in China's technology sector, with a focus on differences between state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs). SMEs face significant uncertainties due to the rapidly evolving global economic market, making the role of technological innovation crucial for sustainable development and national competitiveness. This study uses 1622 sample data from 566 enterprises on the STAR MARKET from 2019 to 2023 to construct a fixed-effect model to explore the impact of technological innovation inputs (such as R&D intensity and the proportion of R&D costs) and outputs (such as intangible assets and patents). The study finds that technological innovation outputs, such as patents, negatively affect firm value, whereas high-cost investments in R&D (R&D intensity) have a positive impact. However, the proportion of R&D spending relative to other costs negatively influences firm value. When examining the results by ownership type, the findings for NSOEs align with these overall trends, while in SOEs, only untyped assets (intangibles not classified) show a statistically significant effect on firm value, with other variables being insignificant. These results highlight the complex relationship between technological innovation and firm value, suggesting the

need for targeted strategies in managing innovation investments, particularly in different ownership contexts.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In recent years, technological innovation has become an increasingly important factor for enterprises in gaining a competitive advantage and improving their performance. Unlike large enterprises that can achieve profit growth through economies of scale and synergy effects, for small and medium-sized enterprises, technological innovation is the only important source of profit growth for high-tech enterprises. Therefore, technological innovation is particularly important to them. With the rise of technology innovation SMEs, technology innovation small and medium-sized enterprises (SMEs) have played a crucial role in driving technological innovation and contributing to economic growth. China is in dire need of technological innovation to propel high-quality economic growth in an increasingly competitive marketplace (Wang, 2022). As China's economy transitions from rapid growth to high-quality development, industry competition is intensifying and the demand for innovative products and technologies is exploding. As a result, technological innovation has evolved into a potent tool for many businesses seeking to expand and become more competitive. Technological innovation is the embodiment of an enterprise's fundamental strength, which can generate exorbitant profits and play a vital role in the development of the enterprise (Liu et al., 2019). By increasing R&D investment, accelerating technological innovation, and boosting product-added value, businesses can provide the market with products that have shorter production cycles, greater

production capacity, greater profitability, and better satisfy the specific needs of consumers (Wen, 2020).

In addition to being crucial to the development of human society, technological innovation has a substantial impact on economic expansion. China has selected a strategy based on innovation to increase the level of innovation among domestic enterprises (Wang et al., 2022). However, the high risk associated with enterprises' innovation activities and the positive characteristics of innovation outcomes have resulted in a lack of innovation among enterprises. China's present innovation capacity is not yet suited for high-quality development (Wang et al, 2022). There are a vast number of high-quality resources at the disposal of technology innovation small and medium-sized enterprises (SMEs) that can contribute significantly to technological innovation operations. The R&D capabilities of technology innovation SMEs have become a critical factor in determining the country's strategic transformation, as well as the improvement of the enterprises' innovation, competition, development, and value creation capacities (Wen, 2020).

1.2 Background of the Study

Small and medium-sized enterprises (SMEs) have always played a vital role in China's economy. They provide employment for a large labor force and are one of the main drivers of China's economic growth. At the same time, technology innovation enterprises are emerging, especially in the fields of information technology, biotechnology, new energy, and artificial intelligence (Huang et al., 2019).

Government policy support and investment have fueled the development of technology innovation enterprises, making them a key sector in China's economic upgrading. Technology innovation SMEs not only actively participate in technological innovation, but also seek opportunities in market competition. They usually possess high growth potential, can expand rapidly in a short period of time, and provide a driving force for the upgrading of the Chinese economy. However, they also face a series of challenges, such as technological risks and financing problems (Wang et al., 2019). Therefore, this study aims to delve into the impact of STAR MARKET on the firm value of technology innovation SMEs in China in order to better understand the role of technology innovation SMEs in the Chinese economy. By analyzing their innovation activities, market position and financial performance, we can reveal the impact of STAR MARKET on these enterprises and provide valuable references for the Chinese government, investors and enterprises. This will help promote the sustainable development of technology innovation SMEs and provide more opportunities for the future of China's economy.

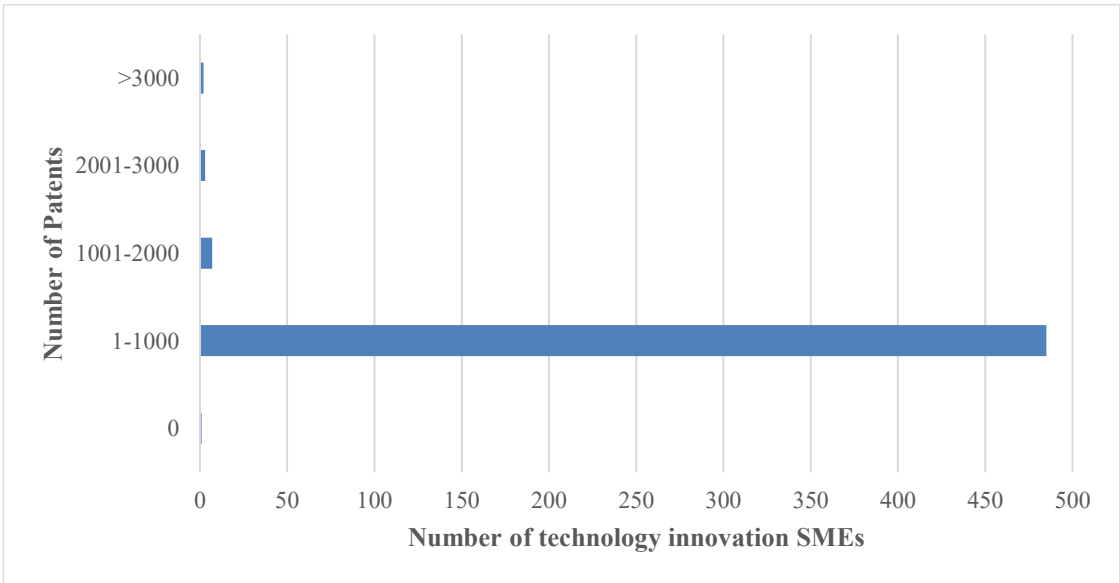


Figure 1.1 Number of patents for technology innovation SMEs

Source: Wind Database (2024)

The Science and Technology Innovation Board (STAR Market) is a small, innovative board established in China in 2019, alongside the Main Board. Its purpose is to provide listing opportunities for high-tech enterprises with limited financial resources but strong research capabilities, allowing more high-quality enterprises to be discovered by investors. As a result, since its launch, this board has represented China's most cutting-edge biopharmaceutical, high-tech, and other cutting-edge technology enterprises.

Technological innovation is very important to technology innovation SMEs. Figure 1.1 shows the distribution of the number of patents of enterprises listed on the STAR market. There are 566 enterprises listed on the Science and Technology Innovation Board studied in this article. As can be seen from the figure, the majority of enterprises have a number of patents in the range of 1-1000, with a total of 498 technology innovation SMEs. The lowest number of patents is 0, with a total of one enterprise. There are two enterprises with a total of 3,000 or more patents. This shows that the majority of listed enterprises in China do not have a large number of patents. The number of patents is an important indicator to assess the technological innovation capability of technology innovation SMEs and the same can be tested to technology innovation SMEs for the process of technological innovation, which has a long way to go.

The impact of technological innovation on the firm value of technology

innovation SMEs is multifaceted. Technological innovation can assist technology innovation SMEs in developing new products or enhancing existing ones, thereby increasing their competitiveness in the market (Zhang et al., 2021). This aids in attracting more customers and business opportunities, ultimately elevating the technology innovation SMEs' market position.

The study of firm value is a long-standing one. As an enterprise's most important operating objective, corporate development is synonymous with the growth of its value. Therefore, the study of firm value undoubtedly plays a crucial role in corporate governance. General economic growth theory holds that the growth of firm value is inseparable from labor, capital, and innovation. Therefore, exploring the relationship between innovation and firm value has always been crucial in contemporary academic research.

Furthermore, new technologies and innovative processes typically enhance production efficiency, leading to reduced production costs (Liu et al., 2021). This contributes to improved gross profit margins, resulting in increased profitability (Vătămănescu et al., 2021). Technology innovation SMEs can also enter new markets or expand their share in existing ones, facilitating growth and boosting their market value (Civelek, M. et al., 2023). It's worth noting that technology innovation SMEs showcasing the potential for technological innovations often find it easier to capture the attention of investors and financing institutions (Modi et al., 2021). This in turn, helps enhance the technology innovation SMEs' valuation and access to funding.

In general, technological innovation has a positive impact on the firm value of

technology innovation SMEs (Hamburg, I., 2020). It bolsters competitiveness, expands market share, reduces costs, attracts investment, and enhances the value of intellectual property rights. However, effective management and resource allocation are essential to ensure successful innovation and the subsequent growth of firm's value.

1.3 Problem Statement

In an era of rapid technological advancement, China has positioned itself as a global leader in innovation-driven development. The government's emphasis on technological innovation as a foundation for economic growth has led enterprises to increase their research and development (R&D) investments to maintain competitiveness (Xiong, 2017; Sun et al., 2022). However, despite these efforts, the relationship between technological innovation and firm value remains complex and inconclusive. Because some studies believe that the relationship between innovation and firm value is positive, while some studies believe that the relationship between innovation and firm value is negative, this contradictory influence increases the necessity of exploring this issue.

China's R&D spending has grown steadily over the years, demonstrating a strong commitment to promoting technological innovation. As shown in Table 1.2, the number of R&D staff increased from 403.4 thousand in 2017 to 724.1 thousand in 2023, while R&D expenditure increased from RMB 1,760.6 billion in 2017 to RMB 3,335.7 billion in 2023. In addition, government R&D funding expenditure has risen from RMB 348.7 billion in 2017 to RMB 569.3 billion in 2023, and enterprise R&D

capital expenditure has more than tripled from RMB 1,365 billion in 2017 to RMB 2,680 billion in 2023. However, the number of patent applications fluctuates, indicating the potential inefficiencies of translating R&D investments into innovation outputs.

Table 1.2 The development of technological innovation in China (RMB)

Year Category	2017	2018	2019	2020	2021	2022	2023
Number of R&D staff (thousand)	403.4	438.1	480.1	523.5	571.6	635.4	724.1
R&D expenditure (billion/RMB)	1760.6	1967.8	2214.4	2439.3	2795.6	3078.3	3335.7
Government R&D funding expenditure (billion/RMB)	348.7	397.9	453.7	482.6	530.0	381.4	569.3
Enterprise R&D capital expenditure (billion/RMB)	1365.0	1522.0	1692.0	1867.2	2150.0	2420.0	2680.0
Number of patent applications (ten thousand/pieces)	369.8	432.3	438.0	519.4	524.4	536.5	556.2

*Source: National Bureau of Statistics (2024)

China's position as a global innovation pioneer is becoming increasingly prominent. Businesses are increasing their investment in R&D to improve their competitiveness. As of 2023, the National Bureau of Statistics (www.stats.gov.cn/sj/ndsj) reports that China's R&D spending will increase year on year from 2017 to 2023. Specifically, government R&D spending increased from RMB 348.7 billion in 2017 to RMB 569.3 billion in 2023. In 2023, enterprise R&D spending will be RMB 2,680 billion, up from RMB 1,365 billion in 2017. R&D investment improves the competitiveness of China's technological innovation SMEs (Huang,

2023). For China's technology innovation SMEs, to maintain their firm value, they must prioritize developing their own innovation capabilities.

China cannot achieve a new development pattern without technological innovation (Cheng, 2022). Because of businesses investing substantial resources in innovation initiatives to maintain their position in a more competitive environment, R&D expenditures have increased dramatically (Huang, 2023). However, there is a paucity of research on enterprise innovation activities in developing Asian markets, and businesses in transition economies often find it challenging to undertake significant innovations due to the high capital, talent, and risk requirements for such endeavors (Na & Kang, 2019).

In innovation-related literature, technological innovation is generally categorized into innovation input and innovation output. Innovation input represents the intensity of resources invested by an enterprise to achieve innovation, with representative variables including R&D intensity and R&D expenditure ratio. Innovation output represents the innovative achievements achieved by an enterprise, with representative variables including the number of patents and the scale of intangible assets. Similarly, in innovation research, grouping firms by nature is crucial. This paper divides the sample into state-owned enterprises and non-state-owned enterprises. State-owned enterprises represent firms whose controlling shareholders are state-owned legal entities, while non-state-owned enterprises represent enterprises whose controlling shareholders are non-state-owned legal entities, defined using a dummy variable.

But for small and medium-sized enterprises, the increase in R&D and innovation may not be a good thing. Due to the high upfront costs of technological innovation, the difficulty of realizing significant returns in the short term, and the likelihood that competitors will replicate some innovations, domestic firms lack the motivation to invest in technological innovation (Qi & Wang, 2022). In China, which continues to remain behind economically developed nations in a number of respects, the intrinsic mechanisms of science and technology innovation SMEs are not properly understood or valued (Sheng, 2018). Due to the probability of business R&D failure, managers may act egotistically and shortsightedly, avoiding technological innovation initiatives in their organizations (Wang, 2022). Therefore, in the short term, R&D and innovation of small and medium-sized enterprises may have a negative impact on firm value.

This study seeks to bridge this gap by analyzing the effects of technological innovation investments on firm value, while distinguishing between SOEs and NSOEs. By integrating theoretical insights with empirical regression analysis, this research aims to provide a comprehensive understanding of how technological innovation contributes to sustainable growth and value creation in China's technology innovation SMEs.

1.4 Research Objectives

This study aims to analyse the impact of technological innovation inputs and outputs on firm value, focusing on technology-driven SMEs listed on the Science and Technology Innovation Board (STAR Market). The study specifically seeks to:

RO 1: To examine the impact of R&D intensity and the proportion of R&D proportion (input) on the firm value of technology innovation SMEs listed on the STAR Market.

RO 2: To identify the impact of patents and intangible assets (output) on the firm value of technology innovation SMEs listed on the STAR Market.

RO 3: To determine whether technological innovation affects the firm value of state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs) differently among technology innovation SMEs listed on the STAR Market.

1.5 Research Questions

This study investigates the impact of technological innovation on firm value, specifically among technology-driven SMEs listed on the Science and Technology Innovation Board (STAR Market). The study aims to address the following research questions:

1. Do R&D intensity and the proportion of R&D proportion impact the firm value of technology innovation SMEs listed on the STAR Market?

2. Do patents and intangible assets influence the firm value of technology innovation SMEs listed on the STAR Market?

3.Does technological innovation have a similar impact on the firm value of state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs) among technology innovation SMEs listed on the STAR Market?

1.6 Significance of the Study

1.6.1 Theoretical Significance

First, the study provides comprehensive and in-depth evidence by systematically analyzing the technological innovation activities of technologically innovative SMEs and their impact on firm value. This not only enriches existing innovation management theories, but also provides a solid foundation for further exploring the role of technological innovation SMEs. By analyzing the different dimensions of technological innovation in detail, this study reveals the specific mechanisms of how SMEs enhance firm value through technological innovation, providing new insights and references for academics and practitioners.

Second, this study is unique in that it examines the impact of technological innovation from both input and output perspectives at the same time, exploring in depth the complex relationship between input factors such as R&D input intensity and R&D spending ratio, and output factors such as the number of intangible assets and patents. This comprehensive analytical framework not only reveals the direct impact of each factor on firm value, but also explores the interactions and combined effects between them, providing a more complete theoretical model. This is important for understanding the whole picture of technological innovation and its specific

manifestations in SMEs.

In addition, this study fills the research gap in the existing literature on the impact of technological innovation on SMEs' technological innovation. Although there have been a large number of studies focusing on the impact of technological innovation on large enterprises, there are relatively few relevant studies for SMEs. Through empirical analysis, this study reveals the unique role and performance of technological innovation SMEs, especially the different impacts of different ownership structures (e.g., state-owned enterprises versus non-state-owned enterprises) on the effects of technological innovation. This not only enriches the research content in the field of technological innovation, but also provides valuable guidance for policy makers and enterprise managers.

1.6.2 Practical Significance

This research is not only of great theoretical significance, but also has practical significance in the following aspects:

First, this study deeply explores the relationship between technological innovation on technology innovation SMEs and firm value, and provides theoretical and empirical support for capital market regulatory agencies and governments at all levels to formulate economic reform policies. By revealing the key role of technological innovation in enhancing firm value, this study provides policymakers with a scientific basis to help them formulate more targeted policies to promote technological innovation and economic development of SMEs.

Secondly, this study uses theoretical analysis and empirical analysis to conduct in-depth research and verification on enterprises listed on the STAR MARKET. Through a comprehensive analysis of the technological innovation activities of these enterprises, the research results provide empirical support for the development of the STAR MARKET and help investors and regulatory agencies better understand and evaluate the market performance and value creation capabilities of the STAR MARKET enterprises.

In addition, the research results will provide scientific basis for the government to promote high-quality economic development. By revealing the key role of technological innovation in improving corporate competitiveness and market value, this study provides specific guidance for the government to formulate and implement policies to support the development of technology-based SMEs, which will help promote the optimization and upgrading of the economic structure and achieve high-quality development Target.

By studying the impact of technological innovation on firm value, this study provides important content for investor education in the capital market. Investors can better understand the importance of technological innovation to the long-term development of enterprises, thereby making more rational and scientific investment decisions, which will help improve the overall investment level and stability of the capital market.

1.7 Scope of Study

China was selected as the study region, and The Science and Technology Innovation Board (STAR MARKET) listed enterprises were chosen to concentrate on technology innovation small and medium-sized enterprises (SMEs) development from 2019 to 2023. This study uses 1622 sample data from 566 enterprises on the STAR market from 2019 to 2023 to construct a fixed-effect model to explore the impact of technological innovation inputs (such as R&D intensity and the proportion of R&D costs) and outputs (such as intangible assets and patents).

1.8 Definition of Key Terms

By delineating the content of the keywords, it lays the groundwork for future research.

Table 1.3 Definitions of Key Terms

Key Term	Definition
Technological Innovation	Technological innovation refers to technological innovation at the enterprise level, which refers to the innovative activities of product development and production carried out by technological innovation that enhances the markup of the enterprise, improves the productivity of the enterprise, and strengthens the competitiveness of the enterprise. The measurement of technological innovation focuses primarily on two aspects: first, technological innovation input, for which R&D intensity and the proportion are the primary indicators (Feng et al., 2023). The second is the technological innovation output, with the number of patents and intangible assets as the primary indicators (Zang et al., 2023). The overwhelming majority of recent research confirms the significance of R&D expenditures in technological innovation activities. R&D costs are the aggregate of all costs incurred during the research and development of products, technologies, materials, processes,

	and standards, as well as during the development process. R&D expenses are also known as R&D costs (Wen, 2020). Technological innovation output, More academics in domestic and international literature have selected the number of patents as a measure of a enterprise's technological innovation capability.
Technology Innovation Small and Medium-sized Enterprises (SMEs)	China's technological innovation is driven primarily by technological innovation small and medium-sized enterprises (SMEs). Technology innovation SMEs are typically knowledge-intensive, technology-intensive, and capital-intensive, they are frequently characterized by small scale, high risk, extended cycle time, and high uncertainty (Xue, 2020). The primary international criterion for identifying technology innovation SMEs is the quantity of R&D expenditures invested, Total R&D expenditure, the ratio of direct R&D expenditure to total output value, and the ratio of direct R&D expenditure to value added are the indicators used to measure R&D intensity. They differ from traditional enterprises in that they have more novel characteristics and growth and creation patterns that are unique. Technology innovation SMEs are characterized by their technological innovation, rapid expansion, small size, and high risk. Their ability to compete in the market relies heavily on the development of their own innovation model and the enhancement of their technological innovation capability, with technological innovation serving as a crucial development factor (Xiong, 2017).
Firm value	There are two types of indicators for gauging firm value: financial and market. Commonly used financial indicators, such as total asset margin, net profit from operating income, net asset margin, and operating income growth rate, are primarily evaluated from the perspective of the enterprise's debt repayment capability, operational capability, and profitability. Tobin Q value, stock price, market net ratio, etc., which are derived from the figures in the financial statements of enterprises and market risk to determine the value of firms. The TobinQ value (Market capitalization/net asset) is chosen as the evaluation indicator of firm value in this study because it is more comprehensive and superior to financial indicators, and better reflects the investment value and development potential of firms.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, this study provides a comprehensive review of the literature on the impact of technological innovation on the firm value of the technology innovation SMEs in China, with particular attention to three theoretical perspectives, there are technical innovation theory, signaling theory and firm heterogeneity theory. The theoretical and empirical reviews are presented to conclude the influence of the dependent variable on the independent variable.

2.2 Theoretical Review

Through the following three theoretical analyses, it can be concluded that R&D activity is an act with high capital requirement, high risk and high uncertainty. Technology innovation SMEs enhances their core competitiveness by investing high amounts in R&D to develop product technology and enhance their innovation capability. When the market capitalization of an enterprise is high and its R&D output is high, the financial statements can convey information to investors about the good development of the enterprise, enhance investors' confidence in the success of the enterprise's R&D, and further influence the firm value of the enterprise. Among them, firm heterogeneity theory as the uncommon theory in the study, its meaning is that there are differences between enterprises in China enterprises, usually in China enterprises are divided into state-owned enterprises (SOEs) and non-state-owned

enterprises (NSOEs), different nature of the enterprise will have different regression results.

Table 2.1 Correlation theory and corresponding variables

Theory	Variable
Technology innovation theory	Intangible assets and the number of patent applications
Signaling theory	R&D Intensity and proportion of R&D
Firm Heterogeneity theory	Nature of the enterprise

2.2.1 Technology Innovation Theory

Economist Joseph Schumpeter first devised the theory of technological innovation. In his Theory of Economic Development, Schumpeter explains the relationship between innovation and invention, contending that invention is a precondition for innovation and that innovation is the combination of never-before-existing elements to form a new system that increases productivity. Innovation is not only a technological but also an economic breakthrough, and innovation is the source of economic development. Creating a new product that has never existed before, introducing a completely new method of generation, discovering a new market that has never been explored before, utilizing a new combination of resource allocation, and employing a new model of enterprise governance are the five primary components of innovation. As can be seen, innovation includes conventional product and process innovation, as well as institutional innovation, market expansion, and governance concept innovation, among other aspects, whereas the R&D investment discussed in this study is limited to product, equipment, process, and other technological innovation.

Transformation of R&D resources into considerable outputs and the creation of firm value through patented products is the most important aspect of technological innovation. However, costly R&D expenditures are not correlated with the efficacy of innovation outputs, and enterprises with outstanding innovation capabilities and various intangible assets (such as patents and trademark rights) do not necessarily maximize the economic benefits of these assets (Lin et al., 2017). R&D increases the level of the entire production line by, on the one hand, expanding the number of products, on the other hand, improving the quality of products, thereby enhancing the competitiveness of businesses and boosting their value.

Therefore, based on the technology innovation theory, this study uses patent variables and intangible assets as proxy variables for technological innovation output. The increase in patent variables and intangible assets will send positive signals to investors, making them feel that the enterprise is fully committed to research and development for higher profits and has achieved fruitful results, making investors more optimistic about the enterprise's development, thereby improving the enterprise's operating conditions.

2.2.2 Signaling Theory

The signaling theory relies on effective enterprise information disclosure, which refers to the actions of market participants who disclose their operational and financial information in conformance with the law. Not only does information disclosure reflect the public's right to know, but it also reflects the market regulatory

information published annually by publicly traded enterprises. According to this theory, managers are able to understand the future development of the product market based on market information, and by obtaining future profits from market information, investors are also able to obtain more accurate and truthful information in order to select projects that are more in line with investment expectations and have a more reasonable profit-to-risk ratio. When managers reveal more favorable information, they are able to attract additional external capital. This theory is utilized primarily in markets with asymmetric signals, in which information is transmitted from the signal sender to the signal receiver.

As an essential factor in an enterprise's growth, R&D expenditures have a significant impact on the investment decisions of external investors. If an enterprise does not disclose sufficient information to the outside world, investors will lose confidence in the enterprise's development if they do not comprehend the enterprise's future direction. When enterprises disclose their R&D activities to market investors in a timely manner, the negative impact of information asymmetry can be eliminated, allowing investors to obtain accurate information about the enterprise, learn about its future plans and R&D direction, and increase their confidence.

Intellectual property and technology patents are essential to the development of technology innovation SMEs in particular. Even though the research process is time-consuming and uncertain, and there is always the risk of R&D failure, the majority of investors concur that R&D represents the importance that technology innovation SMEs place on their innovation capabilities and long-term development plans. In

addition, enterprise managers can conceal the fact that the R&D activities of an enterprise are advantageous to its development by actively communicating information about the R&D process, the amount of R&D investment, and the effectiveness of R&D investment to the outside world when disclosing information. In short, R&D investment can improve the enterprise's innovation capability and core competitiveness, which can communicate to external investors that the enterprise has a high growth potential, attracting external investors and boosting investor confidence, which can then increase the firm value. Technological innovation is the foundation of technology innovation SMEs, and the development of fundamental technologies necessitates extensive R&D efforts.

Therefore, based on signaling theory, this study uses R&D intensity and R&D expenditure ratio as proxy variables for technological innovation input. The increase in R&D intensity and the increase in R&D investment represent the increase in technological innovation investment.

2.2.3 Firm Heterogeneity Theory

Firm heterogeneity refers to differences in firm value in terms of enterprise size, year of establishment, capital intensity, ownership, human capital, organizational practices, and technology selection. Through product innovation, enterprises can implement product differentiation strategies, reduce manufacturing costs, and abbreviate production cycles (Xu et al., 2019). In China, technology innovation SMEs constitutes the preponderance of businesses. The fierce competition necessitates that

technology innovation SMEs be more innovative to obtain a competitive edge over their domestic and international rivals. As a new type of enterprise in modern society, the primary professional work focuses of technology innovation SMEs is the development and sale of technology innovation products, and this type of enterprise has a brief operating history but an astounding growth rate (Li, 2021). They have contributed significantly to the advancement of the national economy (Li et al., 2021).

Due to China's unique circumstances, enterprises are divided into state-owned and non-state-owned enterprises. The enterprise is a state-owned enterprise when the proportion of state-owned capital contribution exceeds fifty percent. When the proportion of non-state-owned capital contribution exceeds fifty percent, the enterprise is considered private. National policy has the greatest impact on the business strategy of a state-owned enterprise, and the enterprise's business strategy and orientation should align with the country's overall direction and demonstrate greater social responsibility. Private enterprises, on the other hand, are profit-driven and determine their business direction based on market fluctuations.

2.3 Empirical Review

2.3.1 Technology Innovation Input and Firm Value

The technological innovation input includes investment intensity of R&D and proportion of R&D. The investment intensity of R&D expenditure is the ratio of R&D expenditure to total sales revenue. The proportion of R&D is the ratio of research and development expenses to total assets.

In a study by Wen (2020), 786 technology innovation SMEs that disclosed R&D investment from 2010 to 2019 were selected as the sample data for empirical analysis. The empirical investigation determined that R&D expenditure and R&D intensity were positively associated with firm value. Nie (2016) collected research data from these 95 enterprises in 2014 and 59 of them in 2007 and 2014 and established an index system of technological innovation energy of listed enterprises in the pharmaceutical manufacturing industry based on the theoretical foundation of R&D intensity of technological innovation and intrinsic value of firms. The results of the empirical study showed that the R&D intensity of the pharmaceutical manufacturing industry for science and technology innovation has been increasing over time, and the overall science and technology innovation energy of listed companies in the pharmaceutical manufacturing industry has a significant positive relationship with firm value. Chatterjee and Bhattacharjee (2020) examined the effect of ownership and R&D intensity on the market performance of 264 Indian technology innovation SMEs. The interaction between promoter ownership concentration and R&D intensity had a positive effect on the performance of Indian technology innovation SMEs, according to the study. According to Zhu and Huang (2012), technological innovation is central to a enterprise's business strategy to compete in a competitive market, and enterprises that adopt an intensive investment strategy in terms of R&D intensity will have a significantly higher financial performance in the second year. According to Bennett et al. (2021), the intensity of enterprise innovation investment as a driver of economic sustainability is the subject of study. Enterprise governance and financial performance

influence the intensity of enterprise innovation investment in the context of economic sustainability, as indicated by empirical calculations based on empirical evidence. Empirical studies show that technology innovation SMEs with higher investment intensity in R&D tend to have higher levels of innovation and superior firm performance. This is because R&D activities create new products, processes and services that improve an enterprise's competitiveness and profitability.

Ma and Ju (2022) uses data on innovation investment from Chinese A-share listed companies with non-zero risk from 2007 to 2017 to link the value relevance of innovation investment with internal control, from the perspectives of operating performance and market capitalization. Empirical tests reveal that internal control significantly enhances the value relevance of innovation investment: the better the internal control, the greater the contribution of innovation investment to a enterprise's operating performance and market capitalization. Further investigation, based on potential mechanisms of mitigating agency problems and strengthening risk management, reveals that the moderating effect of internal control on the value relevance of innovation investment is more pronounced in enterprises with relatively severe agency problems and in expensing R&D expenditures.

Kong and Yang (2023) examines the impact of innovation efficiency on firm market capitalization using a sample of Chinese listed enterprises. The study finds that innovation efficiency significantly contributes to increasing firm market capitalization. This study also examine the important role of securities analysts and institutional investors in conveying information about innovation efficiency, thereby enhancing

firm value. Empirical results indicate that high-tech industries and intellectual property protection have a positive moderating effect, while financing constraints have a negative moderating effect. Furthermore, this study finds that the returns of portfolios with different levels of innovation efficiency are reasonably priced by the market.

Cheng et al. (2024) analyzes the patterns of industrial development from the perspective of their interactive mechanisms, providing theoretical reference for formulating corresponding development strategies and plans. First, a NSBM model is constructed to evaluate multi-stage technological innovation efficiency and deconstruct the evolution of the technological innovation value chain in high-tech industries. Second, a GML model is used to evaluate green total factor productivity and clarify the status of green and high-quality development in high-tech industries. Finally, a truncated regression model is constructed to analyze the factors influencing the external environment of green transformation and development. The results show that upgrading the technological innovation value chain is conducive to promoting green transformation and development.

Khalil and Khuram (2024) break down innovation into traditional and environmental innovation. The results show that traditional innovation only benefits an enterprise's market value, while its environmental impact is significantly diminished—it significantly increases carbon emissions and causes considerable environmental damage. In contrast, investing in environmental innovation clearly has a significant impact on both an enterprise's financial performance and the environment.

Li and He (2021) reported that a multiple linear regression model was