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The impact of innovation on the performance of Chinese listed companies

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THE IMPACT OF INNOVATION ON THE PERFORMANCE OF CHINESE LISTED COMPANIES

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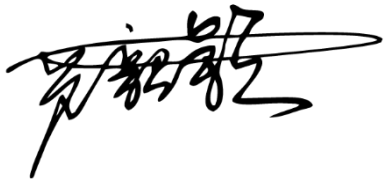
2022

I hereby declare that this PHD dissertation is my original work
and it has been written by me in its entirety.
I have duly acknowledged all the sources of information
which have been used in this dissertation.

This PHD dissertation has also not been submitted for any degree
in any university previously.



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Abstract

Company innovation has significant consequences for the macroeconomic development of the nation as well as serving as a guide for the creation of innovation strategies at the micro level of enterprises. But because the mechanism linking R&D inputs to firm success has not been completely explored, findings for various samples and sample intervals have varied greatly. Therefore, using the data of listed companies in China from 2009 to 2017 as the research sample, this paper introduces mediating and moderating variables to empirically analyze the mediating effect of innovation output in the correlation between R&D input and firm performance and the moderating effect of firm heterogeneity, including company size, nature of state-owned equity and location. The main findings of this paper are as follows. First, the impact of R&D input on the financial performance and market value performance of listed companies in China is positive, and the impact is lagged in both cases. Second, innovation output plays an important partial mediating role in the relationship between R&D input and company. Third, company size, nature of state-owned equity and location significantly have partial moderating effect on the relationship between R&D input and performance. By investigating the impact of R&D input on financial performance and market performance, and by introducing innovation output as a key mediating variable, my dissertation

overcomes the limitation of earlier studies that only looked at the impact of R&D input on company performance. This enriches the research content and broadens the research perspective.

KEYWORDS innovation input, innovation output, firm performance, firm heterogeneity

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My DBA study is nearing the end, but it is not the end. I will apply the knowledge I have learned to my work and continue to contribute to the development of society.

Chapter 1 Introduction

Innovation is the core of companies' development and the driving force of national economic growth. In the environment with slowing economic growth and international turbulence, it is all the more necessary to stress the need for innovation. Companies can only survive, prosper, and make China rich and strong via ongoing innovation. This naturally leads to a series of questions: How much impact does innovation have on a company's short-run and long-run output? What are the differences in the impact of innovation on companies of different sizes, nature of ownership, and locations?

In fact, answering this question is very important. At present, China is in a critical period of industrial transformation and development, and needs first-hand empirical evidence to help policy makers and entrepreneurs make decisions. Developing strategic emerging industries is an important state policy for China's economic transformation and a strategic base for building an innovative country. In 2021, the State Council released the outline of the 14th Five-Year Plan and the 2035 Visionary Goals, clearly stating that innovation is at the core of China's modernization, and innovation has been raised to an unprecedented level. The plan also mentions the use of fiscal and financial policies to stimulate companies to increase investment in research and development; support companies to undertake major projects, and promote the further opening of national research resources to companies. The main position of innovation of companies is strengthened. The support of emerging industries has always been the primary content of industrial policies of various countries. With the development of the economy and the increase of research and development investment, China's position in the global R&D

pattern is rising rapidly. China has surpassed Britain, France, Germany, and Japan to become the world's second most significant science and technology spender after the United States, according to the National Bureau of Statistics of the People's Republic of China. However, at the same time, the innovation ability of Chinese companies is still not as strong, and Chinese manufacturing is still in the middle and low position in the global value chain. This urgently requires us to strengthen relevant research, in order to improve the innovation ability of companies, to realize "Made in China" and to provide helpful guidance and suggestions for the "Mind in China" leap forward. Only by thoroughly understanding the impact of innovation can companies develop better and resources be better allocated.

From a micro perspective, companies are the mainstay of promoting high-quality economic development, and innovation is the magic weapon for companies to grow and develop in the market competition (Dess & Picken, 2000; Tushman & O'Reilly III, 1996). According to management scholars, innovation capability is the most important determinant of company performance (Mone et al., 1998). Beginning with Schumpeter, the theory of innovation has entered the line of view of the academic world. Since then, research on innovation has begun to receive attention and significant progress. With the progress of economic globalization, companies are increasingly connected with the world economy, and competition is becoming more and more fierce. The rapid development of technology has intensified the competition of companies, and it has also led companies to pay increasing attention to innovations. The increase in the amount of competitiveness and the short-term economic benefits and long-term benefits created thereby.

Because creative activities are essential to a company's profitability and competitive advantage, they have been recognized for a long time as a vital connection that may provide value to a business. Recently, by the rapid development of innovation, companies face fierce competition and changes in the dynamic market environment. In such a competitive market, innovation is of the utmost importance, and even the company's existence relies on its success. The exceptional research and development skills of a firm not only allow it to establish robust manufacturing processes and product innovation to dominate the market for new technologies, but also produce competitive advantages. Innovation is one of the most significant aspects in the process of scientific and technical growth, and the most important activity of businesses. Because we live in an age of fast knowledge creation, the market and technology are changing swiftly, local and international rivalry is intensifying, consumer demand is shifting, goods are becoming outdated, and new markets are forming, necessitating a quicker innovation process. Innovations may also acquire and retain market share and increase a company's profitability. The major objective of organizations in a competitive environment is to maintain efficiency and R&D productivity in order to preserve their competitive edge.

From a macro perspective, innovation is the driving force behind a country's long-term economic growth and development. A history of human social development is a history of innovation. Innovation brings about the upgrading of technology and industry, which not only profoundly changes human production and life, promotes social development and progress, but also lays the foundation for a country's comprehensive strength and international

competitiveness. From a practical point of view, it is necessary to study the impact of company innovation on company performance. Here's how innovation works in China.

(1) China's government and businesses are investing more in research and development each year.

According to the China National Bureau of Statistics Annual Reports[1], China's R&D input (including R&D capital expenditure and R&D people investment) has been expanding on an annual basis during the last several years. The average annual growth rate for R&D people is around 5 percent, whereas the average annual growth rate for R&D expenditures is approximately 13 percent. China's R&D expenditures in 2006 exceeded those of Japan, placing it second in the world. In recent years, our nation's overall R&D expenditures have stayed in second position, and the distance with the United States has been narrowing annually. China has unquestionably become one of the major innovators in the globe. The relevance of technological innovation in national macroeconomic growth and strengthening the country's position in international competitiveness is growing. In terms of R&D input as a percentage of GDP, China's R&D input has likewise climbed annually, from 1.91 percent in 2012 to 2.08 percent in 2018. Israel rated top in the world with 4.25 percent R&D input intensity in 2018, while South Korea and Japan were second and third with 4.23 percent and 3.49 percent[2], respectively, and our country still has a significant deficit compared to these inventive nations.

In addition, in the total economic innovation investment, the R&D input of enterprises has always had the leading position and has been gradually increasing, and the R&D input at

[1] Source: https://data.stats.gov.cn/
[2] Source: EU Statistics Week 2019

the company level has been the primary source of national technical advancement and economic development. In addition, according to the European Union's 2017 World Top 2500 R&D Investors, Chinese corporations have 376 of the 2,500 positions on the list, second only to American companies with 822 positions. Nevertheless, 69 of the top 100 corporations in terms of R&D intensity are American, two are Japanese, and none are Chinese. This shows that both American and Japanese companies have obvious advantages, but there is still a big gap compared with other developed countries. This shows that China's total investment in science and technology is not enough, the structure is not reasonable and other problems are still relatively prominent. This level of expenditure is still far from enough.

(2) The performance of China's companies in innovation is not satisfactory.

In light of our country's preeminent global position in terms of amount and intensity of innovation expenditure, we should turn our attention to the efficiency and effectiveness of innovation outputs. According to the 2019 Statistical Yearbook of China's High-Tech Industry, China's high-tech industry remains at the bottom and middle of the global value chain, supported primarily by a large amount of labor input, with a labor productivity that is only about one-eighth that of the United States and a net profit margin on sales of less than 5 percent, which is even lower than the profit margin of some traditional industries. According to the World Intellectual Property Organization, there were 217,200 PCT applications submitted globally in 2018, of which China accounted for 13%, 5/8 of Japan's and half of the US. Even while the numbers are still rather significant, the overall disparity has showed signs of

narrowing. In 2008, twelve years ago, the United States had over 46,800 patent applications, whereas China had just 2,502, or approximately 5 percent of the United States.

In conclusion, while Chinese businesses are at the forefront of domestic innovation and have made remarkable strides in international rankings in recent years, closing the gap with industrialized nations, there is still a disparity between R&D input intensity and innovation performance. Theoretically and practically, it is of utmost importance to investigate the link between innovation and firm success in light of this insight.

Based on the above discussion, I propose the following research questions:

(1) What is the link between R&D expenditures and the short- and long-term success of the company?

(2) Does R&D input directly affect firm performance, or does it indirectly affect firm performance through innovation outputs as mediating variables?

(3) Does the company's heterogeneity impact its R&D contribution to performance transformation? What are the good and negative factors?

In the business world, innovation has received widespread attention. However, while there has been an increasing number of practitioner-based measures, rankings, and indexes, they often remain disconnected from the academic research available.

The first intent of this dissertation in undertaking this study is to verify the impact of innovation on the output of Chinese companies and their heterogeneity. As an entrepreneur and a practitioner working on the front line of innovation management in Chinese enterprises, I have been very interested in this question in my work and study: How does the mechanism

of the effect of R&D input on the performance of enterprises work? In my studies, I found that the innovation efficiency of R&D input has an inverted U-shape, both at the macro national level and at the micro company level. Specifically, for a country, the overall innovation efficiency is very low when the country's development level is very low, and as the country's development level increases, the latecomer advantage gradually manifests and the innovation efficiency soars until the country becomes a large and powerful country, when the latecomer advantage gradually disappears and the innovation efficiency starts to decline. The same is true for an enterprise. When the scale of an enterprise is small, it is difficult to carry out high-quality innovation, and as the scale expands, the innovation ability of a dynamic enterprise is extremely strong, and when the scale of an enterprise is large enough, the focus of mature enterprises shifts, and the scale of an enterprise also limits the innovation efficiency.

Not only that, but throughout history, when a wave of technology comes, the innovation output from R&D input also increases and then decreases over time, as there is a familiarization process for exploring new technology and slowly and completely mastering that technology as awareness grows. And one of our company's main businesses - property services - has the same trend over time in terms of input usage. As I thought about these issues, I realized that the mechanism and mechanism behind these seemingly disparate issues may well actually be similar, but that this mechanism has not been fully studied. One of the important reasons is that the process of the effect of R&D input on performance is very complex and involves many elements, while the important influence of the time factor has to be considered.

Based on these important points, I focus on firm-level innovation, thus positioning the paper in a more practical way. Although higher-level models might be more comprehensive, they would necessarily include industry, national, or global levels, which are arguably beyond the individual company's control. By targeting the company level, I can provide a practical basis on which managers can build structures and systems that would enable innovation within a company.

At the same time, companies have become increasingly aware of the importance of Corporate Social Responsibility (CSR) in recent years. CSR has also become a high-profile public issue. An extensive global survey found that two-thirds of people reported that they would like companies to contribute to social goals beyond shareholder wealth. Another survey found that 52 percent of respondents seek information about companies' CSR records. Palazzo & Scherer (2008, p.2) concisely summarize the evolving public view, "Paradoxically, today, business companies are not just considered the bad guys, causing environmental disasters, financial scandals, and social ills. They are at the same time considered the solution of global regulation and public goods problems." This phenomenon puts forward higher requirements for companies because companies have to innovate not only for their interests but also for their industries and regions. In other words, not only the tax policy, the level of governance, the level of science and education of a region affect the innovation ability of companies, but also the innovation ability of companies will affect the economic environment of the region in turn. I am interested in both effects because a precise result can guide policymakers as well as provide direction for entrepreneurs.

It is worth noticing that the management and applied economics literature on innovation and related topics has a long history of struggling with the measurement of the innovative performance of companies. Both generally available measures such as R&D inputs, patent counts, patent citations, or counts of new product announcements, and more specific survey-based measurements of this particular performance by companies have been used in trying to capture this innovative performance of companies. Many studies use a single indicator (R&D, patents, or patent citations), arguing that the specific indicator that is applied has fewer shortcomings than the other indicators. However, there are often shortcomings with a single indicator. For example, R&D represents an input to the innovation process, which does not necessarily lead to technologically new or improved products and/or processes (Flor & Oltra, 2004; Kleinknecht et al., 2002). Thus, R&D data would seem to be an over-estimated measure of innovation since it includes aborted R&D efforts. As for patent, it measures inventions rather than innovations (Coombs et al., 1996; Flor & Oltra, 2004). As innovation is the translation of an invention into a marketable new or improved product or process, measuring it by using patent data risks to overestimate the innovation output by including in the measurement those inventions that have not been transformed into marketable products or processes.

To overcome these shortcomings, I adapt a variety of indicators to measure innovation, including R&D, number of patent applications, patent grants, patent application efficiency, and patent cited efficiency. These indicators not only measure the absolute advantage of a company's investment in innovation but also reflect its comparative advantage in all companies in the same industry, so that it can measure the innovation of the companies with precision.

The mutual influence between regional economic environment and companies is an important issue under the current background. China's development has reached a certain stage. At this stage, the government's supervision of companies must change from extensive direct administrative supervision to refined and reasonable supervision that takes into account multiple objectives; companies also need to put more emphasis on social responsibility and use their capabilities to contribute to their environment. My research can provide a systematic and reliable guide to how governments can encourage entrepreneurial innovation, as well as theoretical help for entrepreneurs in choosing and contributing to the environment.

The primary purpose of this paper is to establish a better understanding of the innovative performance of companies in China, considering the possible use of multiple indicators and the interactions between companies and their regions. In order to achieve this goal, I will collect companies' innovation-related data, companies' performance indicator data of Chinese listed companies as well as the regional demographic data, then combine the three data for statistical analysis and panel regression analysis.

The relevance of this work from a theoretical standpoint is as follows:

First, the traditional unidimensional indicators should be revised to enrich and strengthen the innovation performance evaluation techniques. When evaluating R&D activities, the current financial indicators of the company, especially the overall performance of R&D operations, should be taken into account. Therefore, several dimensions need to be considered when evaluating the performance of R&D activities: R&D input, patent applications, patent approvals, and the lag of R&D activities. This study integrates financial performance, which

represents short-term gains, and market value performance, which represents long-term gains, in order to create a more objective and comprehensive perspective of corporate R&D input performance.

Second, from the heterogeneous characteristics of enterprises, I unlock the "black box" in the "input-output" relationship of "R&D input-innovation output-firm performance", explore the root causes of the lack of broad consistency in traditional theoretical studies, and use relevant data of Chinese listed companies to empirically test the mechanism of heterogeneity.

The following describes the practical importance of this study.

First of all, the high risk and high reward characteristics of innovation make it not a case of "you reap what you sow". Depending on the specific internal and external environment, there is always an optimal return point beyond which resources can be misallocated and performance can decline. However, traditional research has overemphasized the contribution of innovation to firm performance. According to this theory, companies are likely to invest blindly in innovation activities, pursuing short-term returns at the expense of long-term growth.

Second, R&D inputs do not directly generate performance returns in and of themselves. A company's performance is determined by its ability to convert R&D inputs into recognized innovation outputs. Different internal conditions and external environments will have different effects on outcomes and performance conversion. In this study, I will attempt to discover the intrinsic rules of the complicated process from theoretical to empirical research that leads to the development of performance returns from R&D inputs. Corporate managers are better able

to judge innovation activities and facilitate the company's performance in innovation efforts. The value of the company is one of the most important indicators of its business performance. Capital market investors can also increase their investment returns by looking for high-quality investment targets through the effects generated by innovative outputs and the different characteristics that firms have.

The remainder of my dissertation is detailed here.

Through a study of the current research, I will present the gaps in the existing literature about the influence of R&D inputs on firm performance in Chapter 2, Literature Review.

In Chapter 3 Methodology, I first introduce the primary research topics that this study attempts to address, followed by the development of testable hypotheses. After completing this process, I will provide the data I will use and explain the conceptual definition of innovation, innovation outputs, and firm performance. Lastly, I provide the specifications I will use to test the hypotheses.

In Chapter 4 Analysis and Results, I will first empirically investigate the total impact of innovation on firm performance. Then, I elaborate on the total impact from two vantage points: innovation output effectiveness and firm heterogeneity features.

In Chapter 5, I provide a summary of all my results, highlighting the limitations of my study and areas where I may continue my research in the future.

Chapter 2 Literature Review

Most people readily accept the idea that knowledge and economic development are intimately related, and hence that access to knowledge should be regarded as a vital factor for developing countries. However, this is not the way development used to be explained by economists. From the birth of the classical political economy more than 200 years ago, economists have focused on accumulated capital per worker when trying to explain differences in income or productivity. Similarly, differences in economic growth have been seen as reflecting different rates of capital accumulation. This perspective arguably reflects the vital role played by “mechanization” as a means for productivity advance during the first Industrial Revolution, the period during which the frame of reference for much economic reasoning was formed.

Since Schumpeter (1912) introduced his theory of innovation, R&D activities have been one of the hottest topics of study. Innovative activity is a complex process, and its entire process will roughly follow a series of processes such as beginning, trial and error, making breakthroughs, generating new technologies, acquiring patents, and launching new products; the success or failure of any one of these stages will affect the value creation outcomes of innovative activity. Academic circles have not yet established a consensus on matters such as the norms followed by R&D operations of corporations, the influence on corporate performance, and how it produces value for businesses. The mechanism of the influence of R&D input on firm value has always been a "black box," and the emphasis of scientific study is on how to unlock this "black box."

Academic study on this topic has progressed from the original association between R&D input and innovation output to the relationship between financial success and corporate value, yet there is no commonly acknowledged solution for opening this "black box." Currently, academics are attempting to explain this problem from many views of varied company features, but there is a lack of more systematic study, and there are still gaps in this research field that are awaiting discovery. The literature review section we will do is outlined in Table 1 below.

Table 1

Structure of Literature Review

Section	Content	Why Related to Research Questions
2.1	R&D Input and Company's Financial Performance	In this section I summarize and discuss the literature that examines the impact of R&D input directly on the short-term performance of companies, a literature that is relevant to the first half of my research question 1.
2.2	R&D Input and Company's Market Value Performance	In this section I summarize and discuss the literature that examines the impact of R&D input directly on the long-term performance of companies, a literature that is relevant to the second half of my research question 1.
2.3	R&D Input and Innovation Output	In this section I summarize the impact of R&D input on innovation output, and on company performance through innovation output. This strand of research is related to my research question 2.
2.4	Company Heterogeneity, R&D Input and Company Performance	In this last section, I summarize the literature on the moderating effects of company size, nature, etc. on the impact of R&D input on company performance. This is related to my research question 3.

2.1. R&D Input and Company's Financial Performance

Numerous academic research has been undertaken in this field, yielding a variety of conclusions about the present performance response, delayed effect, and non-linear connection between R&D input.

2.1.1. The Impact of R&D Input on Financial Performance

For companies, their technology-based strategies are frequently built on management-based innovation to attain competitive advantage, which is reflected via the creation and deployment of technical resources to support the company's competitive strategy (Friar & Horwitch, 1985). Cohen & Levinthal (1990) pointed out that the significance of R&D activities to corporations is not only in the production of new technologies, but also in their "absorptive capacity". The "absorptive capacity" of the firm is strengthened. "Absorptive capacity" refers to the process of finding, absorbing and digesting new external information and values, through which a corporation may apply external knowledge to its own operations. This competence is originally obtained from the company's own knowledge level, and is continually increased with the growth of R&D operations. Therefore, increasing R&D input will lead to enhanced absorptive capacity, assist enterprises to better find and capture new markets, improve the competitiveness of their goods in the market, and raise their financial performance.

According to Guth & Ginsberg (1990), technological innovation by businesses through R&D activities can result in the development or introduction of new products, as well as lower production costs and improved product competitiveness. It can also help businesses be the first

to recognize and enter new markets, create new profit growth points, and increase their profitability. a related study by Stopford & Baden-Fuller (1994) points out that companies A major way of acquiring core competence is through innovative technology, and this way can indeed determine its business performance as well.

Capon et al. (1990) concluded that R&D intensity contributes positively to both sales growth and profitability of companies, and this result is supported by many other scholarly studies. For example, Hsieh et al. (2003) found that R&D intensity and the financial performance of companies in the pharmaceutical and chemical industries.

In this issue, scholars in China have also made a lot of research work and achieved fruitful results. Using data from GEM listed companies in 2012, Zhang & Xu (2015) empirically tested the impact of R&D input on business performance of GEM listed companies. This paper found that there is positive but not significant impact of R&D input on business performance of GEM listed companies and made pertinent recommendations.

Using a database of Chinese manufacturing firms from 1998-2009, Qiu & Wei (2016) used a technique called propensity score matching (PSM) to reexamine the influence of R&D contribution on business performance. Organizational research and development techniques have shown to considerably improve organizational performance. Companies that put money into research and development outperform their peers by around 3 percentage points in terms of both factor productivity and profitability.

Ma (2017) evaluated the firm performance from the perspective of knowledge accumulation using data from Chinese pharmaceutical sector firms from 2009 to 2013, finding

that knowledge resources, as the most critical resources in an enterprise's production process, play a substantial role in fostering innovation and enhancing business competence.

2.1.2. The Lagging Effect of R&D input on Financial Performance

Some academics argue that it is not sufficient to investigate solely the present impacts of R&D input on the financial performance of organizations; this is because R&D input is characterized by enormous expenditures, significant uncertainty, and sluggish returns. However, the findings of these research are inconsistent.

R&D input and fixed-asset investment both have delayed returns, but R&D spending has a variation in future surplus creation that is around three to four times larger than that of fixed-asset investment, as stated by Kothari et al. (2002). This is due to the fact that the likelihood of a positive return on investment for R&D spending is much lower than that of investing in fixed assets. However, proponents greatly promote the growth of R&D expenditure-intensive enterprises since these investments have a larger and more long-lasting beneficial impact on a company's future surplus.

Zhao et al. (2012) use a two-way fixed effect model to empirically examine the lag effect of listed businesses' R&D input on company performance over a five-year period (2007 to 2011) using panel data of listed companies in the manufacturing industry in Shanghai and Shenzhen. The performance of listed Chinese corporations is found to be significantly affected by R&D expenditure over a two-year lag, with the effect being most pronounced.

Based on the perspective of the lag effect of R&D input on enterprise value, Wu et al. (2018) selected the data of listed pharmaceutical firms in China in 2015 and the R&D input

intensity of firms with a lag of 6 periods (including the current period), and conducted an empirical analysis using correlation analysis and regression analysis. The findings indicate that for publicly traded pharmaceutical companies, the impact of R&D expenditure on firm value is favorable and has a four-year lag.

According to Zhang & Li (2020), R&D input greatly affects a company's future profitability and has a lag effect on output. This study uses the fixed-effect model to examine the effects of R&D input intensity on firm profitability and development capacity for the period of 2014 to 2017 for the Chinese listed enterprises. The research demonstrates that while R&D input with a lag of either one or two periods has a favorable influence on return on assets, it has a negative impact on return on sales, return on assets, and sales growth rate.

2.1.3. Other Research Results on the Correlation between R&D input and Financial Performance

In addition to the above research results, domestic and foreign scholars have conducted more in-depth studies on the correlation between the two from different perspectives and obtained various research conclusions.

According to Hitt et al. (1997), as international diversity rises, firm performance initially improves before leveling off and turning negative. The association between international diversification and performance is moderated by product diversification. Performance is inversely correlated with international diversification in non-diversified enterprises, inversely correlated with substantially product-diversified firms, and curvedly correlated with moderately product-diversified firms. Markham et al. (2010) argues that even

when a technology has successfully undergone the R&D and demonstration phases, it may still have a dissemination cost that is too high and momentarily undesirable to the market. As a result, there is no relationship at all or even a negative one between R&D spending and financial returns. The "valley of death" that must be traversed in the commercialization of new technology is a phenomenon that is sometimes referred to as such.

Since the economic benefits of increased R&D activities alone are constrained if the efficacy of R&D activities in producing innovation outcomes is low, Fortune & Shelton (2012) found that innovation outcomes play a significant mediating role in the impact of R&D efforts on companies' financial performance. These results are crucial because R&D-heavy companies often make funding decisions based on the naive notion that R&D work significantly contributes to financial success.

Chinese scholars have also done a lot of related work. Based on R&D spending data of SMEs listed businesses from 2011 to 2012, Ding & Guo et al. (2013) evaluate the influence of R&D input on financial performance and market performance of companies. It has been discovered that the R&D spending of SMEs listed businesses has a considerable beneficial impact on market performance and a negative but negligible impact on current financial performance. It suggests that while the stock market might react favorably to R&D operations that raise a company's long-term investment worth and considerably boost its market valuation, same activities have a detrimental influence on the short-term financial performance of SMEs listed businesses.

Chen (2018) used component analysis and regression analysis to empirically study the relationship between R&D expenditure and corporate financial performance using data on R&D input and corporate financial performance of high-tech listed businesses from 2013 to 2015. The empirical findings reveal a negative correlation between R&D input and financial performance in the current year and a positive correlation between R&D input and financial performance with a lag of one to two years, i.e., R&D input can help improve the financial performance of enterprises with a certain lag.

Generally speaking, empirical research on the link between R&D spending and financial returns has progressed from rudimentary to rigorous, from simple to complicated, and from direct to indirect methods. The study lineage is essentially as follows: from the beginning, the direct connection between the two was studied, however researchers have received varied results from the present period effect to the lagged effect. At this time, in reality, aside the question of innovation investment, we should pay more attention to the subject of whether innovation investment can be effectively turned into innovation outcomes and whether innovation results can be successfully transformed into firm performance.

In the years since, researchers in the field have uncovered evidence suggesting that the link between R&D spending and financial returns is nuanced and subject to change depending on factors like the industry and the company's location. From this vantage point, I cannot simply examine the direct link between R&D input and corporate success without also taking into account the effect of other factors, which should be added into the model as moderating or mediating variables for testing purposes. According to the research in this field, firm size,

industry, and equity structure are the most significant moderating factors. However, it is difficult to achieve more consistent findings in this research due to the fact that the economic climate and other micro factors of the organization at home and overseas are different.

2.2. R&D Input and Company's Market Value Performance

Myers (1977) pointed out that the value of a company is composed of existing assets and future growth opportunities, and R&D activities can bring future profitability and growth opportunities to the company, so by nature, R&D is an important value-adding activity. In the early days, the influence of R&D input on company value was basically based on the direct effect, and the positive relationship between the two has been adequately studied both theoretically and empirically, and most of the conclusions reached indicate that there is indeed a significant positive influence of R&D expenditure on company value, but there are also different empirical findings. With the deepening of research and the development of management theory, especially influenced by the power-change theory, researchers began to study the mechanism of R&D input affecting company value under different circumstances, and obtained richer research results.

Research and development (R&D) are intrinsically valuable because, as Myers (1977) pointed out, a company's worth is a function of both its current assets and its potential for future growth. There has been extensive theoretical and empirical research into the positive relationship between R&D expenditure and firm value, and most of the findings indicate that there is indeed a significant positive influence of R&D expenditure on firm value, though there are also conflicting empirical findings. Research into the process by which R&D input affects

firm value has grown in depth and breadth as management theory has progressed, particularly as it has been impacted by power-change theory. This has led to more nuanced findings.

2.2.1. The Direct Effect of R&D Input on Company's Market Value Performance

Grabowski & Mueller (1978) were among the first academics to study the link between R&D spending and the value of a firm. R&D input intensity was correlated with returns across sectors, and the results showed that R&D-intensive organizations were more likely to earn surplus returns. They pioneered the use of price and earnings models to analyze the association between stock price and company value after arguing that stock market value is a more timely and accurate depiction of the intrinsic value movements of firms that are publicly traded.

Griliches (1979) found that there was a positive correlation between R&D input and company value by using a sample of manufacturing companies in the United States between 1957 and 1977. Moreover, Griliches (1981) used a time-series cross-section study of data for big U.S. corporations to discover a correlation between market value and the firm's 'intangible' capital, as measured by historical R&D expenditures and the number of patents.

Pakes (1985) investigated the dynamic relationships among the number of successful patent applications of firms, a measure of the firm's R&D expenditures, and the stock market value of the firm. This paper demonstrated that sustained R&D efforts result in a reassessment of a company's value by the stock market, suggesting that investing more in R&D might boost a business's worth. His findings corroborate Grilliches' assertion that patents provide value to businesses because they signal when technological progress has been made. However, Pakes (1985) argued that the institutional, technical, market, and industrial environment all have a

role in determining a patent's economic worth. The results of a later investigation by Levin et al. (1987) corroborated those of Griliches and Pakes.

The R&D capital of a large sample of publicly traded businesses was calculated by Lev & Sougiannis (1996), and they found their estimates to be statistically accurate and economically relevant. They then accounted for R&D capitalization in reported profits and book values of sample businesses, and found that these changes add value for investors. Moreover, they found a strong correlation between the amount of money invested in research and development by a company and its stock performance one year later, which may indicate that the shares of R&D-heavy companies are being priced too low or that investors are being compensated for an additional risk factor unrelated to the market.

Lev & Sougiannis (1999) estimated the value of R&D capital, an off-balance-sheet investment that generates anomalous profits, and used this value to demonstrate empirically: Investments in R&D are correlated with the performance of a company's stock. This 'R&D impact' encompasses the 'book-to-market effect' for R&D-heavy businesses. Furthermore, it indicates that the link between R&D and returns is not due to stock mispricing but rather to an extra-market risk component intrinsic to R&D.

To determine whether patents have an economic and statistically meaningful effect on firm-level productivity and market value, Bloom and Van Reenen (2002) evaluated the IFS-Leverhulme database on over 200 important British enterprises from 1968. While patenting has an immediate impact on market value, it tends to have a more gradual impact on productivity. Patents provide companies the exclusive right to create new ideas, allowing them

to put off making necessary expenditures until later. Due to the increased value of actual choices brought about by increased market uncertainty, the positive effect of new patents on productivity is dampened.

Value-relevant accounting information (particularly residual income, income, and net assets) of the Shanghai stock market is experimentally examined by Chen et al. (2002) based on results from overseas research. With this study, residual income is included in the field for the first time. Size and share ratio, both of which are subject to negotiation, are also considered in terms of their impact on pricing. Since then, a plethora of studies on the topic have been conducted by Chinese academics using the pricing model and the residual income model, respectively, expanding our understanding of the link between R&D spending and firm valuation.

Liang & Han (2008) considered R&D activities as the starting point and core of the value chain of high-tech enterprises. Enterprises can only optimize their value by efficiently integrating their R&D, manufacturing, and marketing operations, they said, after developing a model of the contribution of R&D activities to overall business value.

Using data from 2003-2007, Chen & Lu (2011) empirically examined the connection between R&D spending and corporate value for both state-owned and non-state-controlled listed companies. They discovered that, relative to state-controlled companies, non-state-controlled firms' R&D spending has a much stronger positive relationship with Tobin's Q, and that R&D spending makes a much bigger contribution to corporate value.

2.2.2. Long-Term Lagged Effects of R&D input on Companies' Market Value Performance

Some academics, citing the aforementioned studies on the possible long-run lagged impact of R&D input on companies' financial performance, assert that R&D activities are likely to affect company value, as the present value of companies' future earnings, in the long run; however, other academics argue that this long-run lagged impact does not exist.

Bublitz & Ettredge (1989) compared market reaction to advertising and R&D forecast errors with market reaction to forecast errors for conventional expenses, and with a theoretical benchmark for long-lived assets. Although there is some discrepancy in the findings, the weight of the data supports the view that advertising has a shorter life span than research and development.

Separating the mispricing and risk explanations for R&D-related excess returns is facilitated by the evidence presented by Chambers et al. (2002). The results indicated that mispricing was less likely to account for the correlation between R&D expenditures and excess returns than was a failure to adequately account for risk. However, the findings did not rule out the possibility of a second source of excess returns due to mispricing and related to shifts in R&D expenditures. And this finding is actually a support to the findings of Chan et al. (1990).

Luo et al. (2009) firstly investigated the value relevance of R＆D expenditure of Chinese public companies. It has been discovered that investments in R&D have increased over the previous several years, which has helped businesses financially. Furthermore, industrial firms show the strongest correlation between R&D spending and financial success.

The findings provide evidence that the sample corporations acted rationally when allocating resources to R&D.

2.2.3. Other Research Results on the Impact of R&D Input to the Market Value Performance

While the vast majority of academics have theoretically examined, and found much empirical evidence from empirical studies to support, the idea that R&D input plays a catalytic role in the enhancement of company value, there is no shortage of academics who have found different or even opposite conclusions.

According to research conducted by Amir & Lev (1996), who looked at the value-relevance to investors of financial and nonfinancial information of independent cellular firms, financial information are essentially useless for security valuation when considered in isolation. Value may be inferred from non-monetary variables. Earnings alone don't fully explain pricing, but when coupled with other factors, they do help. In this research, we focus on how complementary financial and non-financial data might be.

Von Braun (1990) proposed the concept of "acceleration trap" for R&D input, which means that if R&D input is continuously increased, the relationship between it and Rouse& Boff (1998) found that the return on R&D input in the U.S. computer industry was unusually low, and investors tended to be more interested in the products that had the potential to be of interest to them.

Chen et al. (2012) used an ANN to investigate what factors impact the success of research and development programs. The findings point to a reverse U-shaped relationship

between the quality of the project environment and the success of R&D endeavors. Furthermore, this study employs an in-depth interview of qualitative research to discover the primary reason why the quality of the project environment has an inverse U-shaped influence on the success of R&D projects. This research has two important consequences for managers. Firstly, in today's complex and unpredictable world, correlations between R&D project success and its drivers are not usually linear. Secondly, businesses should consider the U-shaped influence that a high-quality project environment has on R&D project success.

It has also been discovered that R&D input might have an adverse effect on the value of a firm by harming the interests of various stakeholders. For instance, the effect of R&D expenditures on the wealth of shareholders and creditors is not the same. Investment in R&D may have a detrimental effect on a company's bond market performance since increasing shareholder wealth often comes at the cost of creditors. Using a sample of listed companies in the Chinese stock market between 2003 and 2005, Xie et al. (2009) found no significant positive correlation between R&D input and market value over the same period and market value changes in the coming year.

From the aforementioned literature, it can be seen that the academic study on the association between R&D input and firm financial performance and company value has not achieved a consensus. The variety of firms leads to the variation in resource endowment and capacity to employ varied resources to produce value, and so the different features of each company play distinct roles in the impact of R&D input. If the role of firm heterogeneity is disregarded, it may lead to quite different findings from various samples.

2.3. R&D Input and Innovation Output

Academics have done several studies on the relationship between R&D expenditures and the creation of new innovations, and they have all come to the same general conclusion: R&D expenditures drive innovation production.

Griliches is the pioneered researcher in this field. Griliches (1964) was the first to include R&D inputs into the Cobb-Douglas production function model and to draw the crucial conclusion that R&D input is favorable to productivity development. In the time since, he has focused on research and development inputs and outputs, yielding successful outcomes. R&D flows (Griliches, 1979) and R&D stocks (Griliches, 1986) are used as indicators of R&D inputs, and their effects on the growth rate and value added of partial factor production, as well as product sales revenue as a proxy for total factor productivity, have been studied. It was established that R&D input may produce competitive advantage for organizations due to the positive association between R&D input and productivity.

For instance, Hall & Mairesse (1995) analyzed data on R&D spending by French manufacturers in the 1980s to conclude that, similar to the 1970s, the 1980s saw a good return on investment in R&D capital for French manufacturers. Wakelin (2001) estimated a Cobb–Douglas function including R&D intensity for 170 UK firms, finding that a positive and significant role is found for the firm's own R&D expenditure in influencing productivity growth.

As researchers looked further into the link between R&D expenditures and new product development, they started using patent numbers as a proxy for business innovation success. In

fact, Scherer (1967) was the first to employ patent counts to quantitatively examine the connection between R&D inputs and outputs. Because of patent data's limitations—first, not all innovations are patentable; second, patent applications vary by time period, company type, industry, and even country; and third, not all patentable innovations are valuable—researchers weren't initially in agreement that using patent data to measure innovation outcomes was the most appropriate. However, patent data have become reliable indicators of R&D and innovation activities, and have increasingly shown their importance in innovation analysis, thanks to the close relationship between patents and R&D activities, the ease with which data can be accessed, and the characteristics of objective criteria, low randomness, and less dramatic changes. By correlating the patent measure with the R&D expenditures of a sample of 121 enterprises over a period of 8 years, Pakes & Griliches (1980) investigated the extent to which patents serve as a "good" indication of innovative activity.

Scholars have paid a lot of attention to the correlation between R&D spending and patent production ever since the 1980s, and the SPC is now one of the most widely used metrics for this kind of empirical patent study. There has been a shift in the focus of R&D toward the efficiency, quantity, quality, and structure of patent production, and many organizations have begun using patents as a key metric in their R&D employees' performance reviews in an effort to boost morale. Most of the relevant academic studies that emerged during this period concluded that there was a positive relationship between R&D input and patent output (J. Acs & Audretsch, 1989; Pavitt, 1988).

Scholarly interest in this topic has evolved over the years from an initial focus on the direct relationship between R&D inputs and innovation output to a more nuanced examination of the impact of R&D cost input structure on innovation output, the correlation between R&D personnel inputs and innovation output, and the moderating effect of the correlation between the two across a variety of company sizes, industries, and equity structures. Tsai (2005) showed that R&D productivity roughly follows a 'U-shape' relationship with company size, suggesting that both big and small enterprises have more R&D productivity competitive advantage than medium-sized firms. Czarnitzki et al. (2009) found that mainly ‘Research’ but not ‘Development’ leads to patents. Disaggregating ‘Research’ and ‘Development’ shows a significant premium of ‘Research’ towards patenting by studying 122 companies in Belgium. Seru (2014) investigated corporate R&D activities and found that companies acquired in diversification mergers create both a reduced number of inventions and also less-novel discoveries.

Scholars have looked at the connection between R&D spending and innovation outcomes like productivity, patents, and product sales income, and their conclusions have been quite consistent: spending time and money on R&D does contribute to innovation outcomes. From the standpoint of the effect of R&D input on innovation output, the study of R&D input and the efficiency of R&D activities is a necessary precondition for R&D activities. Most international studies utilize company-level micro data, but in China, before 2010, most domestic researchers could only use industry-level or national macro data owing to the difficulty of obtaining data on R&D input due to the irregularity of accounting information

disclosure in the early years. Additionally, the association between R&D input and innovation output is no longer a hot area of study, since research into the influence of R&D input on short- and long-term company success has taken its place.

2.4. Company Heterogeneity, R&D Input and Company Performance

Even as far back as 1950, economist and management theorist Hal R. Alchian believes that firms' varying strategies for acquiring and using information and emulating successful practices may have a wide range of consequences on the development of competitive capacities. Companies are diverse from the standpoint of endogenous development because of variances in the fundamental knowledge and capacities gathered through time inside the company's structure (Alchian, 1950).

Some studies suggest that a variety of company characteristics may affect the size of the market valuation of R&D inputs. For example, Doukas & Switzer (1992) provide evidence that for firms in industries characterized by high (low) seller concentration, announcements of increases in planned R&D expenditures are associated with significant positive (negative) excess stock returns. Also applying data from the U.S., Connolly & Hirschey (2005) find evidence that valuation effects of R&D remain somewhat greater for larger as opposed to smaller firm, consistent with findings reported by Chauvin & Hirschey (1993).

Although some academics have begun to consider the role that company heterogeneity plays in the correlation between R&D expenditures and market cap, this branch of study is still in its formative stages, and the vast majority of relevant scholars have not conducted a systematic theoretical analysis of the issue in terms of heterogeneity.

2.4.1. The Effect of Company Size on the Correlation between R&D Input and Company Performance

Previous studies have focused on the positive effect that firm size has on the level of R&D expenditure; that is, the company's propensity to invest in R&D is positively associated with its size (Acs & Audretsch, 1988; Audretsch & Acs, 1991; Dosi, 1988; Fisher & Temin, 1973). It is widely believed that a major proportion of industrial R&D is undertaken by large companies. Therefore, it was assumed that economies of scale exist in expenditures on R&D. The relationship between firm size and R&D activities is particularly interesting in view of the fact that in recent years, we have witnessed a large number of small firms that engage in innovative activity. This is particularly true of companies belonging to the high-tech industrial branch (Acs & Audretsch, 1988, 1993; Kleinknecht, 1989). The current study will investigate the degree of association between size of companies and rate of investment in R&D activities.

According to the Schumpeter hypothesis, which dominates the early research, larger firms invest more in research and development. One school of thought holds that larger companies have more resources available for flexible deployment, and so company size facilitates R&D activities, while another school of thought holds that larger organizations are less likely to invest in R&D because of their inflexible organizational structures and high levels of behavioral inertia when it comes to making changes in resource allocation choices.

Fisher & Temin (1973) argued that the literature's test of the relationship between firm size and R&D input is inappropriate in order to test Schumpeter's hypothesis. A more reasonable test would be the relationship between firm size and innovation output. Researchers

have thus focused more and more on determining whether or not there is a connection between the magnitude of a firm's R&D input and the performance or market value of that company.

Connolly & Hirschey (2005) found evidence that valuation effects of R&D remain somewhat greater for larger as opposed to smaller firm, consistent with findings reported by Chauvin & Hirschey (1993). After classifying the sample into groups for easier analysis, they discovered that the impact of R&D input on firm value was greatest for the largest companies.

Khoshnevis & Teirlinck (2018) used the input oriented constant and variable returns to scale data efficiency analysis models to evaluate the efficiency of firms. They found that small-sized firms suffer from scale and technical inefficiency; medium-sized firms endure scale inefficiency rather than technical inefficiency; large firms present a higher average scale efficiency and technical efficiency.

With A-share listed firms as their study sample, Chi et al. (2020) investigated the influence of company size on innovation performance and the mediating effect of R&D expenditure from the vantage points of the credit environment and the knowledge stock. The study concludes that: larger firms are more likely to invest in R&D, which in turn improves their innovation performance; the stronger the credit environment of the region in which the firms are located, the stronger the promotion effect of enterprise size on R&D input; the more knowledge stock the firms accumulate, the more efficiently R&D input is converted into innovation performance; and, finally, compared with the eastern region, the western region has a higher rate of R&D input yielding positive innovation results. With a more favorable lending

climate, businesses in the area are better able to leverage R&D spending into tangible innovation results.

2.4.2. The Effect of The Nature of Ownership on the Correlation between R&D input and Company Performance

From the standpoint of corporate heterogeneity, there has been an uptick in recent years in the number of published studies examining the link between R&D input and stock price. Studies on the impact of state-owned and non-state-owned equity type on the connection between R&D input and firm performance, using the listed companies in China as a sample, are still relatively uncommon, and the findings produced are not consistent.

Numerous research has underlined the moderating effect of ownership type. Researchers have argued that the operating characteristic of SOEs is that they are subject to interventions and constraints from different levels of government, regardless of whether control is state-owned or not. On the one hand, SOEs have a close relationship with the government and receive more favorable resource support from the government (Lioukas et al., 1993).

As Clarke (2003) points out in his research on corporate governance in China, the ownership structure of Chinese listed businesses is a distinguishing characteristic of the Chinese capital market. State owned enterprises (SOEs) are saddled with a plethora of social obligations that for-profit businesses aren't required to shoulder. This means that SOEs in the manufacturing sector, for instance, can't implement widespread use of automated production lines to generate more employment opportunities. Its goods' ability to compete in the market.

Since the market economy is expanding, rivalry among SOEs has increased. Inefficient technological innovation output occurs because SOEs are unable to make the most of the resources to which they have access due to a lack of ownership and high political responsibilities.

Wang et al. (2017) examined the relationship between R&D expenditures and future performance, as well as the moderating effects of ultimate ownership on the relationship. R&D expenditures are shown to be positively associated to businesses' future performance, and R&D expenditures by state-owned enterprises (SOEs) lead to greater future performance than those of non-SOEs, using data from a sample of 772 Chinese listed firms between 2007 and 2012. Finally, the data showed that the R&D-performance link is moderated in a favorable way by the voting rights of ultimate owners.

Li & Tao (2013) analyzed 974 listed companies of China’s A-share market, finding that the government subsidies being regarded as the "guiding hand", have significantly positive effects on the independent innovation in private enterprises, but the independent innovation and innovation performance is not affected significantly by the government subsidies which play the negative role of "indulging hand" in the process of independent innovation in state-owned enterprises.

To investigate the moderating effects of these three aspects of equity structure on R&D input and enterprise performance, Yuan (2016) used the small and medium-sized board listed companies on the Shenzhen Stock Exchange between 2010 and 2014 as the research object, introducing the nature of ownership, equity concentration, and equity checks and balances in

the equity structure as moderating variables. Empirical analysis shows that the equity structure moderates the connection between R&D spending and profits in three different ways: the degree of equity checks and balances has a negative effect, while the concentration of equity has a positive one, and the nature of ownership has a negative effect.

2.5. Summary

Scholars from all over the world have studied the link between R&D spending and corporate success since Griliches' seminal work in the 1960s. They've come to a wide range of findings, which may be applied to a wide range of businesses. Academic research on this topic has always been highly enthusiastic, which has greatly enriched academic research results and provided theoretical guidance for the formulation of corporate innovation investment strategies, both of which have served as important research basis for this paper as the contribution of corporate innovation to the development of various economies has become increasingly apparent in recent years.

However, existing literature still has a number of flaws. I have summarized them as follows and organized them into Table 2.

Table 2

The Gaps between The Existing Research and This Paper

Gaps	Related Research Questions
Existing studies usually only use the correlation between a single dimension of R&D input and a single dimension of company performance. However, it is not accurate and comprehensive to evaluate R&D performance from a single perspective. I offer a more integrated perspective on the correlation between input and company performance.	**Research question 1**: What is the link between R&D expenditures and the short- and long-term success of the company?
Most of the studies take it for granted that R&D input will bring performance improvement, but there is a lack of in-depth and systematic analysis on the mechanism of the effect. I explore how R&D input affects company performance in China from the perspective of mediating and moderating effects.	**Research question 2**: Does R&D input directly affect firm performance, or does it indirectly affect firm performance through innovation outputs as mediating variables? **Research question 3**: Does the company's heterogeneity impact its R&D contribution to performance transformation? What are the good and negative factors?
Most studies ignore the impact of firm heterogeneity (size, nature of the firm, location, etc.) on the innovation efficiency of firms, especially in studies targeting Chinese firms. My study complements this gap.	**Research question 3**: Does the company's heterogeneity impact its R&D contribution to performance transformation? What are the good and negative factors?

First, most studies that look at the correlation between R&D spending and financial performance focus on just one aspect of the topic. Assessing the success of R&D from a single perspective is neither accurate nor thorough since the process from R&D input to firm performance response is long, there are several contributing variables, and there are significant degrees of uncertainty.

Second, although there are many studies that have shown a correlation between R&D spending and increased profits, these studies are limited by the "black box" problem; that is, they all presume that spending more on R&D would lead to better results, but they don't look into why this is the case. While this approach simplifies the research process overall, it sacrifices objectivity and reduces the usefulness of study findings by ignoring a large number of mediating and moderating variables.

Third, organizations with low levels of innovation activities and low R&D input intensity may be consistent in wanting to enhance their R&D input levels due to the long-term trend of favorable study results on the importance of R&D input to company success. Findings acquired from various samples and time periods are inconsistent and sometimes contradictory because of the absence of systematic theoretical analysis and empirical testing on the elements impacting R&D input and output and the mechanism of performance creation in the whole research. There has to be more study done on this issue.

To sum up, previous research has looked at how to quantify innovation inside a firm and how various external influences might affect the bottom line. Nevertheless, studies have demonstrated that the effects of innovation vary experimentally from country to country. Research conducted in China has been mentioned very seldom. Therefore, I investigate the diversity in size, location, and ownership of Chinese businesses and how innovation affects their success.

Chapter 3 Methodology

3.1. Research Questions

My research questions are as follow:

(1) What is the link between R&D expenditures and the short- and long-term success of the company?

(2) Does R&D input directly affect firm performance, or does it indirectly affect firm performance through innovation outputs as mediating variables?

(3) Does the company's heterogeneity impact its R&D contribution to performance transformation? What are the good and negative factors?

What is innovation and what determines its development within companies? This question has sparked the interest of researchers, managers and policy makers for decades. For much of the twentieth century, economists largely disregarded technological change. The work of Joseph Schumpeter in the first half of 20th century pushed economists to appreciate the fundamental role of technological progress in affecting economic growth and social welfare. In his two famous books, The Theory of Economic Development and Capitalism, Socialism, and Democracy, this eminent economist claims that innovation represents the driving force of economic development (Schumpeter, 1912). Since that time, economists have increasingly appreciated the economic significance of technological progress, and it is now common to hear that a company's, an industry's, or even a nation's capacity to progress technologically underpins its long-run economic performance.

Today, the economic landscape has changed considerably in comparison to Schumpeter's time. However, his work remains topical. According to several specialists, innovation is now unavoidable for companies which want to develop and maintain a competitive advantage and/or gain entry into new markets (Brown & Eisenhardt, 1995; Stock et al., 2002). It also represents one of the main factors underlying countries' international competitiveness and their productivity, output and employment performance (Asheim & Isaksen, 1997; Michie, 1998).

The undeniable importance of innovation for contemporary companies justifies the increasing interest that researchers are taking in it. However, if the number of papers on the topic has evolved exponentially during the last decades, there is still no precise prescription for successful innovation (Rothwell, 1992). Several researchers have tested the effect of some innovation-related variables. However, even though they tested similar variables, they discovered differing degrees of association with the rate of innovation (Souitaris, 1999, 2002; Wolfe, 1994). The innovation process is thus still poorly understood (Coombs et al., 1996) and the current state of the literature contributes little to improving my understanding of the phenomenon. Also, due to the limitations of the availability of innovation data, there is very little research on Chinese situation.

Therefore, it is a natural question to ask, what is the relationship between innovation and company performance indicators in the Chinese context?

A company which has developed a superior product, superior technology, or superior organizational skills with respect to its competitors, will be able to conquer market shares, at

the expense of other companies, and possibly obtain extra profits. Furthermore, if there is more than one technological trajectory, relative to various products, the company will be able to choose, thanks to the R&D results, among the various technological trajectories those that correspond to the sub-markets that grow faster. Also, in this way the company will be able to grow more than companies that do little or no research at all. If there is substitutability among the technological trajectories, the companies that operate on more advanced technological trajectories will be able to conquer larger market shares than companies that operate on more traditional trajectories.

These facts imply that, especially in the sectors with greater potential opportunities of innovation, companies that do less research grow less than those that do more research. All in all, this highlights the fact that, on average, the companies which do research grow faster than those that do not do research or do it with a much lower intensity. However, a higher rate of growth of more research-intensive companies does not mean that such companies will always obtain larger profits.

In traditional sectors, where there are fewer technological opportunities, the intensity of innovations does not constitute in general a major barrier to entry. This implies that the larger profits arising from innovation are rapidly reduced by the entry of new imitating companies on the technological trajectory chosen by the same company. This tends to reduce profits and the competitive advantage is also reduced unless there is a continuous introduction of innovation on the part of the company. Therefore, I do not expect, on average, major differences in profit between companies that do research and those that do not.

The case of sectors with high technological opportunities is different. In fact, R&D expenditures create considerable barriers to entry. If there is Bertrand competition in R&D and in prices, and if the goods obtained by companies have a sufficiently high degree of substitution (PC, video recorder, etc.), prices will approach marginal costs and profit rates will be null. The case will be different if Cournot competition or forms of collusion prevail. Thus, even in the case of sectors with high technological opportunities, it is not certain that the companies which have the capacity to introduce new technologies, deliver new products and introduce organizational innovations at the pace required by the new technology will obtain a competitive advantage which allows a growth of profits (Audretsch, 1995). The length of time over which such advantage may be retained has decreased over the years, especially in the sectors with the main opportunities for innovation. Thus, for a company to be a leader, it is necessary to have continuous introduction of further innovative elements. These aspects contribute and explain why it is not always possible to find a clear relationship between innovation intensity and indexes of company profitability, because innovations behave very different among different sectors. This phenomenon can also be observed in companies with different life cycles, different sizes, and different ownership forms. It is necessary to observe this heterogeneity and try to explain it.

A literal reading of Schumpeter (1912) classic discussion suggests that he was primarily impressed by the qualitative differences between the innovative activities of small, entrepreneurial companies and those of large, modern corporations with formal R&D laboratories. Studying the impact of different company sizes on innovation effectiveness is also

a topic of great interest to us, as China has made rapid progress in the past 40 years of reform and opening up, and companies of all sizes have made outstanding contributions to this leap. Thus, I want to study the difference in innovation effectiveness between companies of different sizes. In addition, different locations of the company and different ownership types are also topics I care about.

Regional heterogeneity is another interesting topic. Because different regions have different tax policies, science and education environment, it is exciting to study which region characteristics can promote the innovation performance of companies. In the meanwhile, the innovative performance of companies will also affect the development of the region, which is also of great concern.

The environment of a region has a great influence on the innovation of a business. For example, encouraging innovation policies that provide financial support for company innovation is likely to result in improved innovation performance of local companies. At the same time, a well-functioning business will, in turn, affect the local business environment. The mechanism of this interaction is very interesting and it is very relevant to the hotspots of institutional economics research. Institutions are the rules of the game in a society, the disciplines that are artificially designed to shape the way people interact. The system determines the transaction and production costs, as well as the feasibility and profit level of carrying out a given economic activity. Institutional theory defines a system as a multifaceted social structure of symbolic elements, social activities and material resources that can provide guidance and resources for companies to choose, prohibit and regulate actions. The system

encompasses three dimensions: the regulatory environment focuses on the laws, regulations and procedures that can have an impact on corporate behavior, legitimacy is based on legal sanctions; the regulatory environment is derived from social norms, values and belief norms of human behavior and is socially embedded and diffuse, legitimacy is based on social customs and beliefs; the cognitive environment refers to the knowledge and skills widely shared by people in society to explain a particular phenomenon or activity, legitimacy is based on cultural legitimacy.

3.2. Hypotheses

There is no clear conclusion on the relationship between R&D input and firm performance based on the preceding debate. The fundamental reason for this situation is that the vast majority of studies on the correlation between the two are focused on the direct effect and lack a deeper investigation; consequently, it is highly likely that the sample selected in different countries, different industries, and different years has some characteristics that are just caught, resulting in biased empirical results that are not representative of the entire population.

From the standpoint of financial performance and market value performance, the effect of R&D input on both is similar: Financial performance often represents the short-term past performance of a business; hence, the change in R&D input profit may be more readily reflected in the financial index. The market value performance of the firm reflects the company's long-term performance and the capital market's anticipation of the company's future

cash flow income; it also has an effect on the company's future long-term earnings and cash flows, and therefore on the business's market value. As a result, I offer **Hypothesis 1**.

Hypothesis 1: There is a positive relationship between R&D input and financial performance and market value performance.

The contribution of R&D has a statistically significant beneficial direct effect on the company's short- and long-term development and growth. As mentioned earlier, in the early literature, scholars often explored the direct correlation between R&D input and firm performance, and made conflicting findings due to different underlying conditions. In fact, the external and internal environments of firms, in addition to having a direct impact on firm performance, can also indirectly influence the short- and long-term success of firms through the path of R&D input, a relationship that has been overlooked by academics for a long time and has led to differences between the conclusions obtained using different data. Therefore, R&D input is one of the most important factors affecting firm performance, and it plays an increasing role as an indirect mechanism of action in the firm. On the one hand, it has a direct impact on the firm's financial performance and market value performance; on the other hand, the annual growth rate of innovation output, as well as the retention of innovation output, are influenced by R&D input, which further affects firm performance. Consequently, I propose **Hypothesis 2**.

Hypothesis 2: There is a positive correlation between the R&D input and innovation output, with certain delays.

In fact, in addition to the direct effect of R&D input on firm performance, R&D input also indirectly affects the short- and long-term performance of firms through other factors, which, if ignored, may lead to inconsistent or even contradictory findings among studies with different samples and time horizons, which may be able to explain why scholars' attitudes toward the role of innovation have not been consistent in the previous literature.

Griliches (1990) suggests that since patents represent successful innovation activities, it has a stronger impact on performance, while R&D inputs face greater uncertainty and therefore it has a weaker impact on performance. In contrast, to examine a firm's innovation process as a whole, the whole chain of R&D activities, i.e., R&D inputs and innovation outputs, needs to be included in the same study, otherwise it will lead to less than comprehensive or even contradictory conclusions. In fact, if the innovation process of an enterprise is considered as a class of functions, its inputs are inputs (capital, manpower, time, etc.), while the outputs are knowledge, technology, products, etc. It is a dynamic process that changes from moment to moment, is full of uncertainties, and increases with the required level of technology. Due to the existence of uncertainty, the benefits of innovation are more difficult to estimate than the inputs of other factors of production such as labor and capital, and it is also more difficult to get a fixed input-output ratio. Since technological innovation activities are inherently risky, the various risk factors involved in R&D activities should be fully considered when making R&D input. In this case, R&D expenditures may bring additional risky benefits, but in case of failure, the company will face a huge sunk cost, and the input can neither be converted into knowledge and technology nor contribute to the development of the company. Therefore, there should be

an internal mechanism between R&D input and firm performance that is not yet clear, rather than a simple direct correlation. Of course, R&D inputs may directly affect financial performance and market value performance through the mechanism described above; in addition, R&D inputs may first affect innovation output and further affect firm performance through changes in the stock and increment of innovation output. Accordingly, **Hypothesis 3** is proposed.

Hypothesis 3: Innovation output has a positive impact on company performance and it plays a partially mediating role in the correlation between R&D input and company performance.

The larger the company, the more resources it has access to and uses, and therefore, the more access to financing and to a wider range of information, which enhances the efficiency and performance of innovation (Khoshnevis & Teirlinck, 2018). From this perspective, firm size may enhance the impact of R&D contribution on firm performance.

However, when the intensity of R&D input is excessive, the innovation efficiency would decline as R&D input increases. Currently, the bigger the corporation, the more rigid the structure, the greater the inertia, and the more difficult it is to respond in a timely manner to the worsening of the status quo. At this point, the size of the corporation becomes the trigger for the negative effect of R&D input on company performance, accelerating the deterioration in corporate performance even further. In this work, I argue the **fourth hypothesis**.

Hypothesis 4: The effect of company size on R&D input and company performance is inverted U-shaped. When company size is small, the positive effect of R&D input on company

performance increases with size; when a certain point is exceeded, the positive effect of R&D input on company performance decreases with size.

The correlation between the nature of equity ownership on R&D input and firm performance is also two-sided. When a firm is state-owned, the firm has access to a large number of resources. And in important areas of national importance, state-owned enterprises can gain monopoly rights over rare resources and create barriers to entry. And by RBV's view, the most essential factor for a firm's performance improvement is the resources it obtains. Therefore, from this viewpoint, if a firm has the nature of state-owned equity, this nature can help the firm to improve the efficiency of its R&D activities.

However, managers of SOEs are the decision makers of various types of decisions, and the government, as the actual owner of SOEs, tends to manage the specific decisions of the enterprises less. Therefore, the principal-agent relationship is more complex in SOEs than in non-SOEs. In addition, SOEs have more social responsibilities than private enterprises, such as maintaining social stability and solving local employment problems. Combining these factors, it can be seen that managers of SOEs may be more concerned about their responsibility to society as a whole and being accountable to the top, and therefore more risk-averse, seeking stability, and leading to a rejection of innovations with high risks. In addition, the greater abundance of resources is also a double-edged sword that may lead SOEs to survive without high-intensity innovation activities, thus reducing the positive impact of R&D input on firm performance from another perspective. Thus, **Hypothesis 5** is put forward.

Hypothesis 5: State ownership will weaken the relationship between R&D input and company performance.

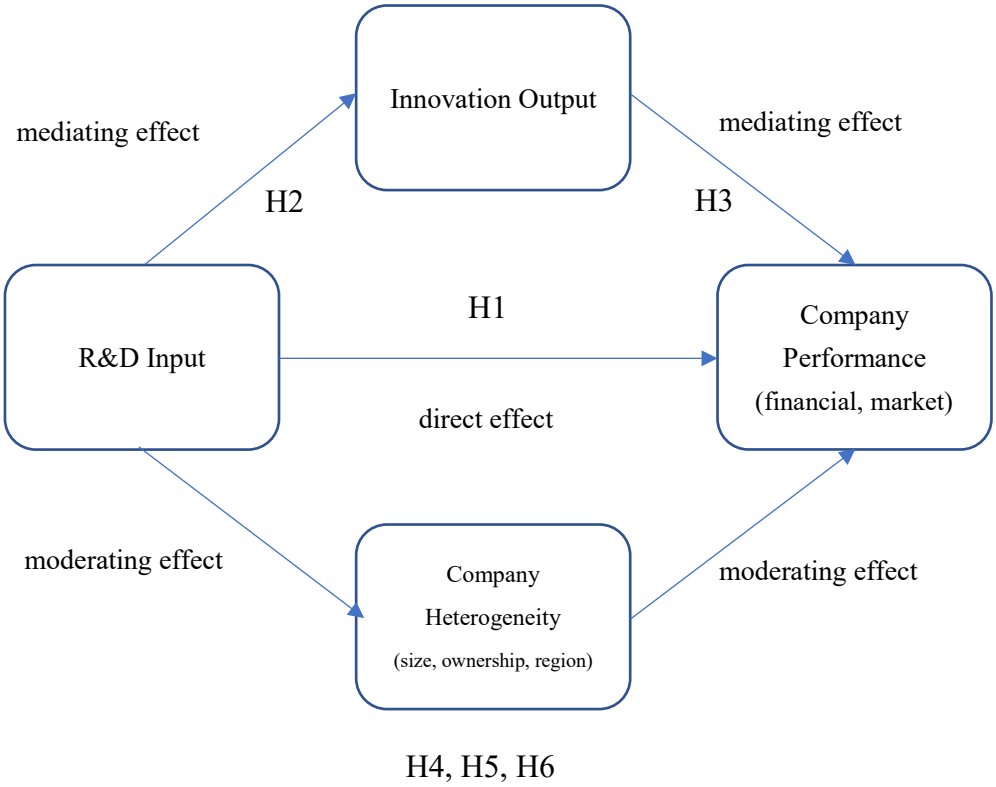
There is also heterogeneity in the influence of the environment of the company's location on the company's R&D input and company performance. Where the institutional environment is good, the property rights and operations of companies are more protected; where the educational environment is good, the sources of talent for companies are better; where the business environment is good, it's easier for companies to partner with other companies to get better innovation output.

Despite the exceptions, the Eastern Region as a whole will be better off because of earlier economic development, followed by the middle region and finally the western region. For this reason, I propose the **Hypothesis 6**.

Hypothesis 6: The location of the company has a different impact on the relationship between R&D input and company performance. The relationship between R&D input and company performance is strongest in eastern region, second in middle region and weakest in western region.

To summarize, the effect of R&D inputs on company output is threefold. First, R&D inputs have a direct effect on company output. Second, R&D inputs have an indirect effect on company output through the mediating effect of innovation output. Finally, R&D inputs have an indirect effect on company output through the moderating effects of factors such as company size, nature of ownership, etc. I have organized the effect relationships into the following figure.

Figure 1 The Effect Relationships of Hypotheses



3.3. Data

In this paper, I select all A-share listed companies in Shanghai and Shenzhen as the research sample from 2009 to 2017. The start time is set to 2009 because the stock market crash occurred in 2007 and 2008, and the stock value hardly reflected the intrinsic quality of the company, and the stock market stabilized after 2009. The ending time is set to 2017 because the available patent data are only available until 2017. Observations with missing data in the sample period are all excluded.

A part of raw innovation variables, including patent application, patent grant and patent citations, are collected from CNRDS Database.

Company performance variables, including market value, earnings per share, dividend per share, price-earnings ratio, net assets per share, operating income, , total return on assets, return on earnings, and Tobin’s Q, etc., and control variables, including company's size, locations, industries and ownership types of A-share listed companies are collected from CSMAR Database. R&D input is also collected from CSMAR Database.

Continuous variables are winsorized at the 1 percent and 99 percent levels to limit the influence of outliers on parameter estimation.

The regional demographic variables are collected from National Bureau of Statistics of China. The corresponding regional data are consolidated according to the location of the headquarters of the listed companies.

3.4. Variable Definitions

3.4.1. Explanatory Variables: R&D Input

Research and Development (R&D) is a systematic and creative activity in the field of science and technology to increase the total amount of knowledge (including the total amount of human cultural and social knowledge) and to use this knowledge to create new applications, including three types of activities: basic research, applied research, and experimental development.

When viewed at the micro level, the objective of R&D activities is to create and manufacture goods for the purpose of strengthening the firms' core competitiveness. Due to the hazardous and unpredictable character of R&D inputs, it is more challenging to quantify and assess R&D inputs than other forms of expenditures. As for the specific practice in China, the

current accounting standards define the accounts to which R&D expenses are to be recorded, such as salaries and benefits of personnel engaged in technology development, raw material costs, depreciation of fixed assets, amortization of intangible assets, and other expenses.

3.4.2. Mediating Variables: Innovation Output

We often see the term innovation output appear when assessing the innovation capacity of countries and firms, but there is not yet a uniform definition of this term. The current more authoritative definition in China comes from the National Bureau of Statistics' Research Group on China Innovation Index. This group is led by the Department of Social Science and Culture of the NBS, and has proposed the concept of China Innovation Index. Among them, the innovation output indicators mainly include the number of scientific and technical papers, the number of patents granted, the ratio of invention patents to patents granted, the number of trademarks owned, and the technical market turnover of scientific and technical papers. The innovation effectiveness indicators mainly include the proportion of new product sales revenue to main business revenue, the proportion of high-tech product exports, energy consumption per unit of GDP, labor productivity, and the contribution rate of scientific and technological progress, reflecting the impact of innovation on economic and social development. As can be seen, this indicator system is mainly designed for the macro economy and is not fully relevant to the micro-level company data used in this paper, however it does serve as a useful reference.

Generally speaking, the input-output relationship always corresponds to one another, so the output corresponding to the R&D input is the R&D output, which is the innovation output. The understanding of the company's innovation output should be limited to the direct

or indirect output achieved by the company's R&D activities, which can bring short-term or long-term economic benefits to the company, thus giving the company an incentive to continue its R&D activities.

Therefore, this paper defines innovation output as the intermediate products that help companies improve their market share and performance, such as new technologies, new products or new services, or enhanced productivity, etc., as well as the experience, knowledge, and capability that aid future innovation development and company value enhancement, etc., which are obtained by investing innovation resources in innovation activities and making innovations i. New resources that contribute to the future innovation and increase of value. The majority of innovation results are contingent on the financial and human resources invested in R&D operations.

There is an input-output link between R&D inputs and the number of patents, which is one of the most direct incremental innovation results of R&D. In past research on the link between R&D inputs and innovation output, the number of patents has been the most often used proxy for innovation output. This is because R&D activities typically have a high level of information asymmetry, and the number of patents provides measurable and unbiased indicators for evaluating R&D outcomes (Griliches, 1990; Seru, 2014). Although the number of patents is not the most ideal indicator of innovation output, it is a generally dependable indicator, hence it is selected to represent the innovation output of organizations.

In contrast to studies that use the overall number of patents as a proxy variable for the incremental innovation output of organizations, this research will also use the number of new

patents added annually. Among the three categories of patents now awarded certification in China, invention patents are the most creative and demanding to create, while utility model and design patents are generally less inventive and complex. Therefore, these three categories of patents may indicate the quality and innovation level of organizations' intellectual output, with invention patents having a greater innovation level than utility and design patents.

In recent years, a growing number of studies have used citation-weighted patents as an indicator of innovation output3. The benefit of this variable is that it accounts for the fact that various patents have varying relevance, and patents that are referenced more often are more significant and, hence, have a higher innovation output value. This is in fact a superior metric, but owing to a lack of data, I am unable to use it in this study4.

There is relatively little academic research on the stock and incremental outputs of innovation. The measure used by Chen et al. (2016) is the total number of patents, which captures the cumulative efficacy of technology. Whereas Fortune & Shelton (2012) used intangible assets, which they consider as a stock variable indicating the level of R&D effort, the validity of this innovation output will affect the association between R&D effort as a flow variable and firm performance. This paper argues that since the total number of patents is cumulative in nature, it does not fully reflect the firm's ability to accumulate and absorb knowledge and technology over time (Agovino et al., 2018), and that incremental increases in the number of patents should also be taken into account.

[3] The following link provides a thorough summary of citation-weighted patents: https://www.oecd.org/science/inno/33835392.pdf

[4] I am very grateful to Professor Shantanu Bhattacharya for providing the information of this measure.

3.4.3. Explanatory Variables: Company's Performance

In basic words, corporate performance refers to the operational efficiency of a company over a certain time of operation, which may be assessed by a variety of indicators such as profitability, solvency, asset operation, and the firm's potential to expand in the future. The first three of these competencies may be measured using a variety of financial measures and are thus considered "financial performance." The last question relates to the company's long-term development forecast, which cannot be judged using simply the existing financial data.

In previous studies, most studies usually use only financial performance indicators to assess firm performance. However, financial performance is an indicator of the short-term performance of a firm's development and does not accurately represent the long-term impact of R&D input on firm performance. Therefore, I include the indicator of market value of the firm, which is a comprehensive indicator of the overall market of investors' assessment of the long-term development of the firm and can compensate for this limitation to some extent. In view of this, this paper will investigate the impact of R&D input on firm performance from two perspectives, namely financial performance and market value performance, in a comprehensive manner.

Defining corporate value at multiple levels might result in divergent perspectives, even from an economics and finance viewpoint alone. For instance, accountants highlight the book value of the company, which is the entire amount of capital used to construct the firm and can be determined by valuing all assets and putting them together. From a corporate finance standpoint, the value of a firm is the present value of the predicted free cash flows, where the

discount rate is the weighted average cost of capital, which incorporates the time value of capital, its sustainability, and the risks connected with it. In addition, from the standpoint of the theory of valuation, the value of a firm is decided by its usefulness for investors, i.e., its future profitability. This indicator relates to a firm's capacity to generate profits from its production and operation operations. A company with stable profitability is able to get steady cash flow for a significant period of time in the future, and may thus enhance its market value continually.

In this paper, the market value performance of a firm is defined as the market value performance, which is the profitability of the firm's future growth and all the value it provides to investors. In this context, the internal components of the enterprise should be considered as a unified entity and all components should be examined. The expression and assessment of a firm's market value performance can generally be divided into two categories: financial value, which is based on the firm's financial data, and market value, which incorporates the firm's future growth and profitability. Currently, the most popular market value assessment methods in academia are discounted cash flow models, residual income valuation models and Tobin's Q-value estimation models.

Financial indicators such as return on assets (ROA) is the ratio of a company's realized earnings in a certain period to the company's total assets in that period, and is used to measure how much net profit is generated per unit of assets. ROA is one of the most widely used indicators in the industry to measure the profitability of a company and can reflect the short-term performance of the company in a more comprehensive manner, but the return on assets

as an accounting profit indicator is less predictive of future profitability. The company's market capitalization performance can play a good complementary role in this regard, and can reflect the information of the company's long-term operating multi-color and future cash flow earnings, so this paper uses both financial performance and market capitalization performance to measure the performance of listed companies. In this paper, two indicators, ROA and Tobin's Q, which indicate the financial performance and market value performance of the company respectively, are selected as the explanatory variables of the model for empirical study.

The use of Tobin's Q has the following advantages. First, Tobin's Q can be used as one of the important indicators to measure a company's business performance; the higher the Tobin's Q, the higher the company's return on investment, and vice versa. Second, Tobin's Q can be used for long-term valuation of a company. Tobin's Q is very forward-looking and can predict the development of a company in a certain period of time in the future, and at the financial level, it can better reflect the level of risk represented by Tobin's Q than traditional financial or market indicators, and its calculation process is simple, easy to grasp, easy to operate, and easy to form a unified evaluation standard. In addition, it is also an innovation in the field of company market value; the ratio indicator has its unique theoretical foundation and rich practical experience, and can better reflect the relationship between the real economy and the virtual economy. Thus, it can be widely used in the research of various industries.

Based on Tobin's Q theory, Griliches (1981) constructed a theoretical model of the value of the firm. The firm can be considered as a combination of tangible and intangible assets, so the share price of the firm should be equal to the discounted value of the net income that

could be generated by all the assets. It can be said that Griliches' theoretical model provides the basis for subsequent research, on which this model has been greatly extended and supplemented, especially in the study of the link between R&D input and firm value, which has been widely used. In this paper, we will use Tobin's Q as a measure of a firm's market value performance, based on Griliches' theoretical model.

3.4.4. Control Variables and Moderating Variables

The performance of firms varies greatly by size, nature of equity, and location. Firms of different sizes and types differ significantly in their ability to innovate. As firm heterogeneity, we pick size, type, and location. Large organizations have a solid resource basis and economies of scale, but tiny businesses are more adaptable. Additionally, the capital structure of a corporation has an impact on corporate success. Consequently, this study adopts the natural logarithm of total assets as a proxy variable for business size and the gearing ratio derived as year-end total liabilities/year-end total assets as a control variable, based on the majority of empirical research on firm performance. To control the influence of various corporate governance arrangements on firm performance, control variables are chosen based on the type of control. State-owned control is assigned a value of 1 and non-state-owned control a value of 0 when calculating the type of control. A company’s location is also important in corporate governance, because the natural environment, business environment, and related policies vary greatly from region to region in the vast size of China, and these factors can significantly affect the innovation motivation and efficiency of companies.

3.5. Empirical Research Design

Referring to Fortune & Shelton (2012), this paper's specifications are constructed based on Griliches' theoretical model. The fixed-effect panel regression model will be used to examine all hypotheses, i.e., the degree of correlation between a company's investment in innovation and the performance of companies, and heterogeneity. Because fixed-effect panel regression model can control individual fixed effect and time fixed effect, enhancing the robustness of results.

The basic regression specification (1) for Hypothesis 1 is as follow:

$$Performance_{i,t} = \beta_0 + \beta_1 Input_{i,t-n} + \sum \beta_j Control_{i,t} + \lambda_i + \gamma_t + \varepsilon_{i,t} \qquad (1)$$

Where $performance_{i,t}$ is company i's performance at year t. The explanatory variable $Input_{i,t-n}$ on the right side of the equation reflects the intensity of company R&D input in innovation activities. i, t represent the index of company i in year t, and n=0,1,2 represent the R&D input of that year, one year ago and two years ago, respectively, in order to test the lag of R&D input. The definitions of i, t and n are the same in the following models. The control variables are total assets (in logarithm), location, and the nature of the company. λ_i is industry fixed effect, and γ_t is time fixed effect. I expect that β_2 is significantly negative.

In order to test the **Hypothesis 2: There is a positive correlation between the R&D input and innovation output, with certain delays**, I use innovation output $Patent_{i,t}$ (including the stock of patents and the increment of patents) as the explanatory variable, and R&D input intensity as the explanatory variable, the effects of the current period and the lag

period are also considered. I expect that both β_1 and β_2 should be significantly positive. The Specification (2) is as follow.

$$Patent_{i,t} = \beta_0 + \beta_1 Input_{i,t-n} + \sum \beta_j Control_{i,t} + \lambda_i + \gamma_t + \varepsilon_{i,t} \qquad (2)$$

Specification (3) is used to verify the **Hypothesis 3: Innovation output has a positive impact on company performance and it plays a partially mediating role in the correlation between R&D input and company performance.**

$$Performance_{i,t} = \beta_0 + \beta_1 Input_{i,t-n} + \beta_3 Patent\_i_{i,t-n} + \beta_4 Patent\_s_{i,t-n} + \sum \beta_j Control_{i,t} + \lambda_i + \gamma_t + \varepsilon_{i,t} \qquad (3)$$

The left side of the equation is company performance, and the right side contains the R&D input and innovation output, where $Patent\_i_{i,t}$ indicates the increment of patents, and $Patent\_s_{i,t}$ indicates the stock of patents. If the former part of **Hypothesis 3** is assumed to be true, I expect β_3 to be significantly positive.

Furthermore, in order to test the latter part of **Hypothesis 3** that innovation output has a partial mediating effect in the correlation between R&D input and company performance, models (1), (2) and (3) have been used to construct a stepwise regression model to test the mediating effect. The existence of mediating effect can be verified by observing the significance of correlation coefficient in these three models, and $\beta_3 < \beta_4$.

In order to test the **Hypothesis 4, 5 and 6**, the heterogeneity variables are introduced into the model as moderate variables, including the size of the company, the nature of ownership, and the location of the company.

Based on the partly mediating effect of innovation output between R&D input and the inverted u-shape of company performance, the following tests were conducted to determine the mediating influence of company heterogeneity on the link between R&D input and company performance.

First, I run the regression of company performance on the variables of R&D input, company heterogeneity, and the interaction term between R&D input and company heterogeneity. If the coefficient of the interaction term in the estimate results is significant, the moderating effect of company heterogeneity on the relationship between R&D input and company performance is significant. The Specification (4) is as follow.

$$Performance_{i,t} = \beta_0 + \beta_1 Input_{i,t-n} + \beta_2 Heterogeneity_{i,t} + \beta_3 Input_{i,t-n} \times Heterogeneity_{i,t} + \sum \beta_j Control_{i,t} + \lambda_i + \gamma_t + \varepsilon_{i,t} \quad (4)$$

Then, I run the regression of innovation output on variables of R&D inputs, company heterogeneity, and the interaction term between R&D inputs and company heterogeneity, and if the coefficient of the interaction term in the results is significant, it indicates that the moderating effect of company heterogeneity on the relationship between R&D inputs and innovation output is significant. The specification (5) is as follow.

$$Patent_{i,t} = \beta_0 + \beta_1 Input_{i,t-n} + \beta_2 Heterogeneity_{i,t} + \beta_3 Input_{i,t-n} \times Heterogeneity_{i,t} + \sum \beta_j Control_{i,t} + \lambda_i + \gamma_t + \varepsilon_{i,t} \quad (5)$$

Specification (4) is designed to test whether company heterogeneity moderates the relationship between R&D input and company performance, and then test Hypotheses 4, 5, and 6. If the interaction term coefficient β_2 is significantly positive and β_3 is significantly negative, it indicates that company heterogeneity enhances the relationship; on the contrary, if the interaction term coefficient β_2 is significantly negative and β_3 is significantly positive, it indicates that company heterogeneity has a weakening effect on the relationship. On the contrary, if the interaction term coefficient β_2 is significantly negative and β_3 is significantly positive, it means that company heterogeneity has a weakening effect on the relationship. According to the hypothesis, the heterogeneity that is expected to have an enhancing effect on this inverted U-shaped relationship is company size, ownership nature, and location. I expect to see the following results. Firstly, for the region, the impact of innovation on business growth decreases in order of East, Middle and West, and this can be explained by factors such as policy support, business environment, and scientific research strength. Second, for company size, the impact of innovation on company growth changes in an inverted U-shaped curve as company size increases, which can be explained by the scale effect of innovation and life cycle theory. Finally, for the nature of companies, I would expect to see greater innovation efficiency in private companies, which may be the result of more efficient use of investment in R&D.

The purpose of Specification (5) is to determine whether the moderating effect of company heterogeneity on the link between R&D input and firm performance occurs via

moderating the mediating effect. Then, according to the hypothesis, it should be β_2 significantly positive, while β_3 significantly negative.

Chapter 4 Analysis and Findings

4.1. Descriptive Statistics

The findings of descriptive statistics for primary variables are shown in Table 3. From the descriptive statistics of the R&D input ratio (R&D input as a percentage of operating revenue) of each A-share listed company, it can be found that there is a huge difference across companies, which indicates that even for listed companies with a substantial scale, there is considerable heterogeneity in the input in innovation activities. And this is also reflected in the

R&D output. As can be seen in Table 3, the number of patent applications and grants per year range from 0 to several thousand, with a large standard error. Such a large difference in R&D input and R&D output is very likely to lead to very different short-term and long-term financial and market performance of companies. This inspires me to take the next step in my analysis.

Table 3

Descriptive Statistics

Variables	Description	(1) N	(2) mean	(3) sd	(4) min	(5) max
roa	Return on assets	4,951	0.0291	0.225	-14.59	2.933
tobinq	Tobin's Q	4,769	2.236	2.944	0.153	118.3
log_rdinput	R&D expenditure (in logarithm)	4,951	17.29	2.084	6.908	23.68
rdinputratio	R&D expenditure/operating income	4,951	2.420	4.985	2.49e-05	169.4
log_asset	Total assets (in logarithm)	4,951	22.51	1.367	17.28	28.51
patent_gr	Number of total patents granted	4,951	14.93	156.6	0	4,873
patent_igr	Number of invention patents granted	4,951	5.839	73.03	0	2,644
patent_ugr	Number of utility patents granted	4,951	7.751	90.16	0	3,445
patent_dgr	Number of design patents granted	4,951	1.335	22.32	0	846
patent_va	Number of total patents still valid as of the year	4,951	304.2	1,473	0	43,619
patent_iva	Number of invention patents still valid as of the year	4,951	98.17	736.6	0	19,340

patent_uva	Number of utility patents still valid as of the year	4,951	168.2	863.9	0	31,416
patent_dva	Number of design patents still valid as of the year	4,951	37.78	185.5	0	5,808
patent_quote_gr_ns	Number of citations of patents granted (remove self-citations)	4,951	108.4	819.5	0	18,400
patent_quote_va_ns	Number of citations of patents still valid (remove self-citations)	4,951	226.4	2846.9	0	128,829
location						
1	Eastern region		0.55			
2	Middle region		0.18			
3	Western region		0.19			
4	Northeastern region		0.08			
industry						
1	Agriculture, forestry and fishery		0.011			
2	Mining industry		0.028			
3	Light manufacturing industry		0.207			
4	Equipment manufacturing industry		0.321			
5	Energy supply industry		0.034			
6	Other heavy manufacturing industries		0.230			
7	Merchandising and logistics		0.060			

8	Information technology industry	0.033
9	Real estate, leasing, business services, general and other	0.076

Besides, coinciding with China's economic trends, listed companies are concentrated in the eastern region, with 55% of the companies in the east. While the listed companies in the middle and western regions account for 18% and 19% respectively, the least listed companies are in the northeast region, accounting for only 8% in the sample. As for the industry distribution, light industrial companies account for 21% of the sample, while heavy industrial companies account for about 60%, indicating that industrial companies dominate the listed companies. The industrial companies are the main body that in extreme need of innovation, and technological development can guarantee the long-term development of the company, so this study is also very important for guiding the development of companies.

4.2. Analysis of the Impact of R&D Input on Company Performance

4.2.1. Results of the Empirical Model's Estimation

First, I investigate the direct relationship between R&D expenditure and firm performance. and estimate Equation (1) using the data to examine the impact of R&D input on company financial performance (short-term performance) and market value performance (long-term performance) under the full sample, respectively, and observed the current, one-year lagged and two-year impact, and the results are shown in Table 4.

Table 4:

Fixed-Effect Estimates of R&D input on Company Performance

Variables	(1) roa	(2) roa	(3) roa	(4) tobinq	(5) tobinq	(6) tobinq
rdinputratio	0.1277***			0.0682***		
	(0.0429)			(0.0091)		
L.rdinputratio		0.1954***			0.0625***	
		(0.0474)			(0.0103)	
L2.rdinputratio			0.2449***			0.0509***
			(0.0521)			(0.0115)
log_asset	0.9095***	0.9920***	0.9231***	-0.6190***	-0.6542***	-0.6753***
	(0.0712)	(0.0753)	(0.0792)	(0.0151)	(0.0163)	(0.0175)
region fixed effect	∨	∨	∨	∨	∨	∨
company nature fixed effect	∨	∨	∨	∨	∨	∨
industry fixed effect	∨	∨	∨	∨	∨	∨
time fixed effect	∨	∨	∨	∨	∨	∨
Observations	4,858	4,405	3,920	4,680	4,237	3,759
R2-Adjusted	0.0954	0.0973	0.0955	0.370	0.373	0.381

Table 4 demonstrates the linear relationship between R&D input intensity and the company's performance, controlling for other variables to be constant. Columns (1) - (3) show the results where the dependent variable is the company's financial performance (return on total assets) and the independent variables are the R&D input intensity for the current year, the first lagged year, and the second lagged year, respectively.

From the regression coefficients, significant and positive correlations between R&D input intensity and business financial performance indicate that R&D input intensity has a positive driving influence on firm financial performance, which is strengthening with time.

Specifically, a 1% increase in R&D input intensity in the current year increases return on total assets by about 0.13%, while a 1% increase in R&D input intensity in the previous year and two years increases return on total assets by about 0.20% and 0.24%, respectively.

Columns (4) - (6) show the results where the dependent variable is the company's market value performance (Tobin's Q). Unlike financial performance indicators, the impact of R&D input intensity on a company's market value, although also positive, diminishes over time. One possible explanation is that the impact of R&D input on business operations is lagged, as it takes time after an R&D project is funded before it is converted into innovative output, which in turn drives the firm's operating performance. However, the market is more interested in what the firm is doing in the moment, and if the company increases its innovation investment intensity, investors will boost their confidence in the company, and this effect will gradually diminish over time.

The above regression results confirm Hypothesis 1, i.e., there is a positive relationship between R&D input and financial performance and market value performance. In addition to this, I find that the impact of R&D inputs on financial performance and market value performance is different. Is this difference true for different companies? This motivated me to look at the heterogeneity of impacts.

4.2.2. Heterogeneity

4.2.2.1. Size

First, I use the average assets of the firms during the sample period as the basis for dividing the firms into two groups, small and large. Then I separately estimate Equation (1)

using subsamples of small sizes and large sizes.[5] The results are shown in Columns (1)-(4) of Table 5. Comparing the coefficients, it is easy to find that R&D input intensity has a higher impact on the financial performance and market value performance of small companies than large companies. T-tests also show that the differences are both significantly larger than zero. This result is consistent with the company's life cycle theory. Small companies are more likely to belong to the growth period in the life cycle, and are expanding, so increasing R&D input and encouraging innovation can help companies to develop markets and achieve faster growth in the short term; while large companies are more likely to belong to the maturity period in the life cycle, and the market they face has become stable, so it is difficult to see the effect of increasing R&D input in the short term.

Table 5:

Heterogeneity of Impact of R&D input on Company Performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	roa		tobinq		Roa		tobinq	
	Small Size	Large Size	Small Size	Large Size	Non-State	State-Own	Non-State	State-Own
L.rdinputratio	0.2153***	0.1350**	0.0636***	0.0476***	0.1679**	0.2117***	0.1071***	0.0346***
	(0.0663)	(0.0686)	(0.0150)	(0.0094)	(0.0755)	(0.0618)	(0.0198)	(0.0109)
log_asset	2.3766***	0.2971**	-1.7194***	-0.2618***	1.5661***	0.7214***	-0.9638***	-0.5175***
	(0.2000)	(0.1194)	(0.0449)	(0.0166)	(0.1397)	(0.0890)	(0.0368)	(0.0156)
region fixed effect	√	√	√	√	√	√	√	√
firm nature fixed effect	√	√	√	√				
industry fixed effect	√	√	√	√	√	√	√	√
time fixed effect	√	√	√	√	√	√	√	√

[5] For neatness of the table, the independent variable R&D input intensity is elected with only one year of lagged. The results in the same year and two lagged years are the same.

Observations	2,081	2,324	1,971	2,266	1,465	2,940	1,376	2,861
R2-Adjusted	0.100	0.127	0.501	0.251	0.119	0.0831	0.403	0.351

4.2.2.2. Nature of the Company

Then, I divide listed firms into state-owned and non-state-owned companies to investigate whether the nature of the firm's equity affects the effect of innovation. The estimated results are presented in columns (5)-(8) of Table 5. There are differences in the direction of whether being a state-owned enterprise affects the effect of R&D intensity on firm performance. The positive effect of R&D input on financial performance is stronger for state-owned companies than for non-state-owned companies, while the opposite effect is observed for market value performance.

4.2.3. Robustness Check

Since R&D input intensity is a proportional number of R&D input to operating income, some may worry that it is the amount of R&D input that plays a role in the R&D process rather than the ratio to operating income. Therefore, I replace $Input_{i,t-n}$ in Equation (1) with the logarithm of R&D input and re-estimate Equation (1), and the results are shown in Table 6.

Table 6

Robustness Check of Impact of R&D input on Company Performance

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	roa	roa	roa	tobinq	tobinq	tobinq
log_rdinput	0.3119***			0.0464***		
	(0.0653)			(0.0126)		
L.log_rdinput		0.4914***			0.0364***	
		(0.0625)			(0.0137)	

L2.log_rdinput			0.6477***			0.0376***
			(0.0588)			(0.0144)
log_asset	0.2624***	0.5102***	0.6212***	-0.6662***	-0.6890***	-0.7083***
	(0.0889)	(0.0935)	(0.0976)	(0.0191)	(0.0204)	(0.0216)
region fixed effect	√	√	√	√	√	√
firm nature fixed effect	√	√	√	√	√	√
industry fixed effect	√	√	√	√	√	√
time fixed effect	√	√	√	√	√	√
Observations	4,874	4,417	3,929	4,696	4,249	3,768
R2-Adjusted	0.115	0.106	0.0951	0.364	0.368	0.378

Comparing the estimation results in Table 6 with those in Table 4, the estimation results in both tables are consistent. Past R&D input is significantly positively correlated with company's financial performance and market value performance, and the impact is increasing in financial performance, decreasing in market value performance. The results of this robustness test strengthen the confidence of the estimation results and reconfirm Hypothesis 1.

4.3. Analysis of the Mediating Effect of Innovation Output in the Impact of R&D input on Company Performance

4.3.1. Estimation Results of Impact of R&D input on Innovation Output

Now we have verified that R&D inputs and company performance are positively correlated. But what elements motivate R&D contributions to favorably impact the success of a company? Resource-based theory suggests that not all resources have equal impacts on a company's competitive advantage (Barney, 1991; Hoopes et al., 2003). Resources are heterogeneous, and resources are not equal in generating competitive advantage. All resources

are not equally capable of generating competitive advantage because knowledge (Cepeda-Carrión, 2011) and capabilities (Richardson, 1972) are heterogeneous in each company. Based on these literatures, I will try to arrive at an answer to the above question in this subsection.

A direct result of R&D input is innovation output, which, as mentioned earlier, can be measured using the number of patents. There are three types of patents: invention patents, design patents, and utility model patents. Among these, invention patents are generally the most difficult to develop and have the highest value. First, I will estimate Equation (2) to explore the effect of R&D input on the stock of innovation output and to test Hypothesis 2.

Table 7 demonstrates the effect of R&D input intensity on the stock of innovation output. Columns (1)-(3) in the table show the impact of R&D input intensity in the current year, the previous year and two years ago on the new patents granted in the current year, and columns (4)-(6), (7)-(9) and (10)-(12) correspond to invention patents, utility model patents and design patents, respectively.

From the overall regression results of columns (1)-(3) in Table 7, the correlation coefficients of R&D input intensity on the stock patent output are positively significant from both the current period and lagged perspectives, and Hypothesis 2 is verified, i.e., the R&D input is positively correlated with innovation output and has some lags. From the standpoint of lagged impact, R&D input intensity in the current year, one year delayed, and two years lagged all have a substantial positive effect on patent production, demonstrating that R&D expenditure has a long-term lagged effect on patent output. The coefficient of R&D input intensity increases

year by year from 70.66 in the current period, to 78.90 with one period lag, and then to 88.84 with two periods lag, with significance at the 1% level in all three periods. This demonstrates that the influence of R&D input on patent production is the greatest across the whole two-year lag, confirming that corporations must undergo a more complex approval procedure when filing for patents, resulting in a time lag effect.

Columns (4)-(6), (7)-(9) and (10)-(12) of Table 7 use invention patents, utility model patents and design patents, respectively, as explanatory variables to compare the contribution of R&D input intensity to the three in the current period, lagged period and both periods. Looking at each category of patents, R&D input intensity has a positive and significant contribution to invention patents, with the same trend as the summed patents, and again both have a two-years lagged effect. The effect of R&D input intensity on utility model patents is also positive but its trend is not obvious. As for design patents, on the other hand, the coefficients have the same trend as total patents, while not statistically significant. Comparing the correlation coefficients and significance of these three eras reveals that the influence of R&D input intensity on invention patents is stronger and more significant than its impact on utility and design patents. The reason for this result may be due to the fact that the higher the level of innovation, the stronger the dependence on R&D input for the incremental innovation output. This result provides evidential support and a more detailed direction of analysis for the conjecture proposed in Hypothesis 2.

Having explored the effect of R&D input intensity on the stock of innovation output, I further want to explore the effect of R&D input intensity on new innovation output each year.

Would boosting R&D inputs accelerate the rate of innovation output formation? To do so, I replace the dependent variable with the number of patents granted per year and re-estimate Equation (2). The estimation results are shown in Table 8. The results in Table 8 are very similar to those in Table 7. Increasing R&D input intensity significantly increases the number of patents granted each year and the number of invention patents granted among them, while the coefficient of the utility model changes from significant to insignificant. This indicates that increasing the intensity of R&D input not only significantly increases the number of patents, but also significantly increases the rate of patent increase.

Table 7

Fixed-Effect Estimates of Impact of R&D input on the Stock of Innovation Output

Variables	(1) patent_va	(2) patent_va	(3) patent_va	(4) patent_iva	(5) patent_iva	(6) patent_iva	(7) patent_uva	(8) patent_uva	(9) patent_uva	(10) patent_dva	(11) patent_dva	(12) patent_dva
rdinputratio	70.6588***			54.6747***			15.0495***			0.9345		
										(1.2501)		
	(9.6616)			(4.9942)			(5.7662)					
L.rdinputratio		78.8950***			61.5334***			16.0324**			1.3293	
		(10.9660)			(5.9375)			(6.3904)			(1.3469)	
L2.rdinputratio			88.8350***			71.3781***			15.6142**			1.8427
			(12.5682)			(6.8616)			(7.2881)			(1.5238)
log_asset	405.5874***	416.2696***	430.0099***	146.9419***	157.6366***	166.6159***	217.8311***	218.6013***	222.4292***	40.8144***	40.0316***	40.9648***
	(16.0357)	(17.3942)	(19.1026)	(8.2889)	(9.4180)	(10.4291)	(9.5704)	(10.1364)	(11.0773)	(2.0748)	(2.1364)	(2.3160)
region fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
firm nature fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
industry fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
time fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
Observations	4,858	4,405	3,920	4,858	4,405	3,920	4,858	4,405	3,920	4,858	4,405	3,920
R2-Adjusted	0.160	0.160	0.160	0.102	0.106	0.112	0.130	0.128	0.124	0.112	0.111	0.109

Table 8

Fixed-Effect Estimates of Impact of R&D input on the Flow of Innovation Output

Variables	(1) patent_gr	(2) patent_gr	(3) patent_gr	(4) patent_igr	(5) patent_igr	(6) patent_igr	(7) patent_ugr	(8) patent_ugr	(9) patent_ugr	(10) patent_dgr	(11) patent_dgr	(12) patent_dgr
rdinputratio	11.3341***			9.3246***			1.7158			0.2938		
	(2.7838)			(1.1670)			(1.8248)			(0.3776)		
L.rdinputratio		10.5606***			9.6513***			0.7944			0.1148	
		(3.1148)			(1.3174)			(2.0478)			(0.4164)	
L2.rdinputratio			12.9576***			12.6617***			0.1670			0.1290
			(3.5253)			(1.5179)			(2.2850)			(0.4681)
log_asset	88.7292***	88.7517***	88.0126***	34.3452***	35.9344***	37.5743***	47.8762***	46.6641***	44.4641***	6.5078***	6.1531***	5.9742***
	(4.6204)	(4.9406)	(5.3581)	(1.9369)	(2.0896)	(2.3070)	(3.0287)	(3.2483)	(3.4730)	(0.6268)	(0.6604)	(0.7115)
region fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
firm nature fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
industry fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
time fixed effect	√	√	√	√	√	√	√	√	√	√	√	√
Observations	4,858	4,405	3,920	4,858	4,405	3,920	4,858	4,405	3,920	4,858	4,405	3,920
R2-Adjusted	0.0920	0.0891	0.0851	0.0920	0.0969	0.103	0.0604	0.0551	0.0490	0.0291	0.0248	0.0224

4.3.2. Estimation Results of Impact of Innovation Output on Company Performance and Analysis of the Mediating Effect

In the first portion of this subsection, I will analyze the impact of innovation stock and increment on firm financial performance and market value, respectively. Observe the significance of the correlation coefficients to confirm the presence of the mediating influence. Therefore, I estimate Equation (3) and the regression results are shown in Table 9.

Table 9

Estimates of Impact of Innovation Output on Company Performance

Variables	(1) roa	(2) roa	(3) roa	(4) tobinq	(5) tobinq	(6) tobinq
rdinputratio	0.1317***			0.0618***		
	(0.0431)			(0.0091)		
patent_gr	0.0028***			0.0055***		
	(0.0007)			(0.0012)		
patent_va	0.0002*			0.0000***		
	(0.0001)			(0.0000)		
L.rdinputratio		0.2052***			0.0550***	
		(0.0478)			(0.0103)	
L.patent_gr		0.0038***			0.0059***	
		(0.0013)			(0.0013)	
L.patent_va		0.0002*			0.0001***	
		(0.0001)			(0.0000)	
L2.rdinputratio			0.2557***			0.0422***
			(0.0525)			(0.0115)
L2.patent_gr			0.0051***			0.0057***
			(0.0019)			(0.0015)
L2.patent_va			0.0002*			0.0001***
			(0.0001)			(0.0000)
log_asset	0.9235***	1.0270***	0.9523***	-0.6717***	-0.7076***	-0.7285***
	(0.0784)	(0.0823)	(0.0861)	(0.0166)	(0.0177)	(0.0189)
region fixed effect	√	√	√	√	√	√
firm nature fixed effect	√	√	√	√	√	√

industry fixed effect	√	√	√	√	√	√
time fixed effect	√	√	√	√	√	√
Observations	4,858	4,405	3,920	4,680	4,237	3,759
R2-Adjusted	0.0953	0.0975	0.0957	0.377	0.381	0.389

Looking first at columns (1)-(3) of Table 9, here the impact of R&D inputs, increment of innovation output and stock of innovation output on financial performance for the current period, one period lagged and two periods lagged are shown. It can be found that the regression coefficients of incremental patent $patent\_gr$ and incremental innovation stock output $patent\_va$ on roa are statistically significant in each period, although, increment of innovation output is more significant. This result indicates that both increment of innovation output and stock of innovation output have a positive effect on the financial performance of companies. In addition, the regression coefficients of $rdinputratio$ on roa for each period are also significant at the 1% level, and in addition to the previous findings that the regression results between R&D input and firm performance (Table 3) and R&D input and innovation (Table 7) output are significant, all the correlation coefficients in the stepwise regression specifications (1), (2), and (3) used to verify the mediating effect are also significant, indicating that both from the increment of innovation and the firm's performance are positively influenced. It can be shown that innovation output mediates the relationship between R&D input and firm financial success, both from incremental and stock perspectives. On the one hand, R&D input may have a direct impact on the financial performance of a company, and on the other, innovation output might have an indirect impact on financial performance.

The above regression results also show that the regression coefficient of $patent\_gr$ is significantly higher than that of $patent\_va$, which suggests that incremental innovation is more influential than the stock of innovation output in determining a company's financial performance; however, they also suggest that, while R&D input does have a direct effect on a company's financial performance, the impact on financial performance is less pronounced when considering only the stock of innovation output.

The dependent variable in columns (4)-(6) of Table 9 is switched from roa to $tobinq$ to investigate the effect of innovation output on the market value performance of companies. In terms of regression coefficients, first, similar to the effect of innovation output on companies' financial performance, the effect of both $patent\_gr$ and $patent\_va$ on $tobinq$ is significantly positive. Second, all the correlation coefficients of the explanatory variables in the mediating effect model are consisting of stepwise regression specifications (1), (2) and (3) are significant, proving that innovation output plays the role of a partial mediating variable in the relationship between R&D input and market value performance. This result, combined with the results in columns (1)-(3), jointly verifies Hypothesis 3. Finally, the coefficient of $patent\_va$ remains significantly higher than the coefficient of $patent\_gr$, which also suggests that R&D spending affects company performance in terms of market value thanks to the intermediate variable of innovation output growth.

4.3.3. Robustness Check

In analyzing the partial mediating effect of innovation output, my analysis is divided into two steps: first, I test whether there is a positive effect of R&D input on

innovation output; after that, I test whether there is a positive effect of innovation output on firm performance.

In the first step, I choose the stock and increment of the number of patents to measure innovation output. Some may be concerned that the quality of patents varies and that analyzing the number of patents alone may overstate the role of poorer quality patents, making the estimation results unreliable. To alleviate this concern, I chose a dependent variable that captures patent quality, patent citations (after removing self-citations). Patents with high citation counts are generally of higher quality, so this variable better captures the effect of R&D inputs on the quality of innovation outputs. The estimation results of replacing the dependent variable in Table 7 with the number of patent citations are shown in Table 10.

Table 10

Robustness Check of R&D input on Innovation Output

Variables	(1) patent_quote_va_ns	(2) patent_quote_va_ns	(3) patent_quote_va_ns	(4) patent_quote_gr_ns	(5) patent_quote_gr_ns	(6) patent_quote_gr_ns
rdinputratio	36.5233***			9.2201***		
	(2.8413)			(0.7668)		
L.rdinputratio		40.1138***			9.8413***	
		(3.1541)			(0.8467)	
L2.rdinputratio			42.2978***			10.3417***
			(3.5421)			(0.9451)
log_asset	152.2010***	155.4836***	159.2084***	43.8901***	44.2007***	44.8290***
	(4.7157)	(5.0030)	(5.3836)	(1.2726)	(1.3431)	(1.4364)
region fixed effect	√	√	√	√	√	√
firm nature fixed effect	√	√	√	√	√	√

industry fixed effect	√	√	√	√	√	√
time fixed effect	√	√	√	√	√	√
Observations	4,858	4,405	3,920	4,858	4,405	3,920
R2-Adjusted	0.275	0.277	0.279	0.276	0.276	0.277

Columns (1)-(3) of Table 10 show the results of estimation of citations of patent stock, and columns (4)-(6) show the results of year-by-year estimation of citations of patents granted in the current year. Comparing Table 7, Table 8 and Table 9, it can be seen that the dependent variable, whether it is the number of patents or the number of citations of patents, is positively correlated with R&D input, which indicates that the higher the intensity of R&D input, the higher the quantity and quality of innovation output. In addition to this, as the number of lags increases, the effect of R&D input becomes stronger, which is consistent for both the quantity and quality of innovation output. This result suggests that there is indeed a lag in R&D inputs and that it takes several years to bring out the best effect.

In the second step, the same concern, that is, number of patents may not be a valid measure of innovation output, also applies. Therefore, we replace the patent stock with the citation of the patent stock and the patent increment with the citation of the patent increment and re-estimate Table 9, and the results are shown in Table 11.

Table 11

Robustness Check of Impact of Innovation Output on Company Performance

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	roa	roa	roa	tobinq	tobinq	tobinq

rdinputratio	0.1292***			0.0546***		
	(0.0436)			(0.0092)		
patent_quote_gr_ns	0.0057**			0.0012**		
	(0.0024)			(0.0005)		
patent_quote_va_ns	0.0015**			0.0001		
	(0.0006)			(0.0001)		
L.rdinputratio		0.2088***			0.0477***	
		(0.0483)			(0.0104)	
L.patent_quote_gr_ns		0.0061**			0.0016***	
		(0.0030)			(0.0006)	
L.patent_quote_va_ns		0.0020**			0.0000	
		(0.0008)			(0.0002)	
L2.rdinputratio			0.2595***			0.0344***
			(0.0529)			(0.0116)
L2.patent_quote_gr_ns			0.0058*			0.0012**
			(0.0035)			(0.0005)
L2.patent_quote_va_ns			0.0020**			0.0002
			(0.0010)			(0.0002)
log_asset	0.8844***	1.0074***	0.9455***	-0.6819***	-0.7171***	-0.7365***
	(0.0794)	(0.0833)	(0.0870)	(0.0168)	(0.0179)	(0.0191)
region fixed effect	√	√	√	√	√	√
firm nature fixed effect	√	√	√	√	√	√
industry fixed effect	√	√	√	√	√	√
time fixed effect	√	√	√	√	√	√
Observations	4,858	4,405	3,920	4,680	4,237	3,759
R2-Adjusted	0.0961	0.0981	0.0962	0.379	0.382	0.390

Consistent with Table 9, the coefficients in Table 11 of R&D inputs and citations of granted patents in the current period, with one period lag, and with two periods lag are still significantly positive. However, unlike the results for the number of patents, the effect of citations of the patent stock on the firm's market value performance, although still positive, is no longer statistically significant. This indicates that the quality of new patents is more important than the quality of old patents for the market value performance of a

firm. Firms should continuously strengthen their innovation in order to gain better competitive opportunities.

4.4. Analysis of the Moderating Effect of Company Heterogeneity in the Impact of R&D Input on Company Performance

4.4.1. Summary Statistics

The results of my research show that R&D helps businesses convert their existing resources into novel products, which in turn boosts their efficiency and profitability. Companies vary in terms of their resource endowments as well as other internal and external features such as their stage of growth, organizational structure, the location in which they operate, and the type of the industry they are a part of. I will first divide the firms into groups according to these characteristics to see whether heterogeneity exists among companies from descriptive statistics, and later verify it through more rigorous regression analysis.

Table 12

Descriptive Statistics of Main Variables between Groups

Variables		rdinputratio	patent_va	patent_gr	roa	tobinq
size						
	small	2.6766	51.3350	9.2892	2.3066	2.9481
		(2.6524)	(168.4747)	(66.7439)	(7.7337)	(2.3195)
	large	1.8078	347.8144	73.4692	3.7620	1.5994
		(2.0524)	(1662.5030)	(452.5292)	(5.5103)	(0.9703)
state-own company						
	yes	1.9335	179.0283	38.9653	2.7773	1.9367
		(2.1444)	(930.6801)	(237.1249)	(6.4770)	(1.3773)
	no	2.5484	152.9657	36.5337	3.4956	2.6965
		(2.7182)	(1307.2650)	(405.8996)	(7.9339)	(2.3414)
location						
	eastern region	2.3306	237.3874	54.8811	3.4418	2.1673
		(2.4803)	(1419.2210)	(406.4301)	(6.5996)	(1.7667)

middle region	1.9884	99.8487	22.1735	2.9115	2.3700
	(2.0874)	(356.7087)	(104.4545)	(7.3556)	(1.9573)
western region	1.8702	87.4404	16.3450	2.2775	2.3258
	(2.3195)	(370.2688)	(79.5472)	(7.8248)	(1.9205)
northeastern region	1.7940	59.2476	11.1241	2.4326	2.0604
	(2.1677)	(250.5094)	(110.6194)	(7.0487)	(1.4810)

Table 12 shows the descriptive statistics after grouping by company size, whether it is a state-owned enterprise, location, and industry, respectively. Within each group, the first row is the mean of the corresponding variable and the second row is the standard deviation of the variable.

Looking first at the grouping according to size, I select the median of total assets, with those below the median defined as small size and those above the median defined as large size. On average, it appears that large-scale companies spend less on R&D as a percentage of operating income, while the number of patents is much higher than that of small-scale companies. In addition, large companies have better financial performance, while small companies have better market value performance, and these statistics are consistent with enterprise life cycle theory.

Then, I make a comparison by classifying the companies according to whether they are SOEs or not. As can be seen in Table 12, the R&D input intensity and company performance of SOEs are lower than those of private companies, which may be due to the fact that SOEs aim not only to make profits but also to protect people's livelihood, thus reducing their market performance. As for the innovation output, the patent ownership of SOEs is slightly higher than that of non-SOEs.

As for the comparison between regions, it can be seen that companies in the eastern region have higher R&D input, innovation output, and financial performance than other

regions, which is in line with the general perception. In addition to this, companies in the middle region have higher R&D input and R&D output than those in the western region, and thus higher than those in the northeastern region. This descriptive statistic shows that the heterogeneity of innovation effects in terms of performance across the country is also huge.

Since the differences between the level of R&D input, the level of innovation output, and company performance are very different among groups, it can be expected that factors such as size and location are likely to have a moderating effect on the effect of R&D input on company performance.

4.4.2. Estimation Results of Company Size

In the previous subsection, we find that company size has a very strong effect on variables such as R&D inputs, but the limited precision of the grouping makes it difficult to be able to accurately reflect the effect of company size on the correlation between R&D inputs and company performance. Therefore, using total assets as a proxy variable for company size, I estimate specifications (4) and (5) by making interaction terms between company size and the square of company size and the intensity of R&D input intensity, respectively. To demonstrate the brevity of the table, we keep only the independent variables with one lag, and the results are similar for the current period and two lags. The same applies for subsequent tables. The estimation results are shown in Table 13.

Table 13

Estimates of Effect of Company Size on Impact of R&D input on Company Performance

	(1)	(2)	(3)
Variables	patent_va	roa	tobinq
L.rdinputratio	35,682.5564***	-30.8822***	-6.2900***

	(1,647.4889)	(8.5174)	(1.6986)
log_asset	3,792.6711***	12.5159***	10.1051***
	(415.6521)	(2.1489)	(0.4285)
log_asset2	-86.1277***	-0.2531***	-0.2090***
	(9.1397)	(0.0473)	(0.0094)
c.log_asset#cL.rdinputratio	3,289.4561***	2.7559***	0.5192***
	(145.5652)	(0.7526)	(0.1498)
c.log_asset2#cL.rdinputratio	-75.6581***	-0.0609***	-0.0107***
	(3.2078)	(0.0166)	(0.0033)
region fixed effect	√	√	√
firm nature fixed effect	√	√	√
industry fixed effect	√	√	√
time fixed effect	√	√	√
Observations	4,405	4,405	4,237
R2-Adjusted	0.425	0.118	0.495

In column (2) of the regression results made by estimating Specification (4) with roa as the explanatory variable, the coefficient of the interaction term between the linear term of company size and R&D input is 2.7559, while the coefficient of the interaction term between the square term of company size and R&D input is -0.0609, both significant at the 1% level. In column (3) of the regression results with Tobin'q as the explanatory variable, the coefficient of the interaction term between the linear term of company size and R&D input is 0.5192, while the coefficient of the interaction term between the square term of company size and R&D input is -0.0107, both of which are also significant at the 1% level. This indicates that company size plays a statistically significant moderating role in the relationship between R&D input intensity and both financial performance and market value performance, and the effect is inverted U-shaped: that is, when the company size is small, the larger the size is, the more it contributes to the positive impact of innovation

input to company financial performance and market value performance, and as the size increases, the effect of this positive impact becomes lower and lower until after a certain point , the further expansion of company size is detrimental to the positive effect of increased R&D input on company performance. For financial performance, this inflection point is RMB 6.7 billion and for market value performance, this inflection point is RMB 34.4 billion. In other words, while a firm is extremely small, the beneficial effect of R&D input on financial and market value performance grows in proportion to the company's size, but as the company grows in size, the short-term advantages of rising size reduce while the long-term benefits grow. However, after the company becomes excessively large, further expansion of size only weakens the positive impact of innovation investment. In summary, Hypothesis 4 is verified.

Further, combining with Specification (5), by manipulating the moderating variable of innovation output, we may examine the efficacy of company size as a moderator. Column (1) shows the estimation results. In the regression results with innovation stock as the explanatory variable, the coefficient of the interaction term between the linear term of firm size and R&D input is 3289, while the coefficient of the interaction term between the square term of company size and R&D input is -76, both significant at the 1% level, which suggests that company size moderates the correlation between R&D input and the mediating variable innovation output, and maintains an inverted U-shaped relationship, i.e., the positive impact of the increase in R&D input to the innovation stock output is amplified by an increase in company size at first, but is then attenuated as the company grows larger.

4.4.3. Estimation Results of Nature of the Company

Table 14 reports the regression results that ownership nature as state or non-state has a mediating moderating effect in the correlation between R&D input and company performance. The estimation results in columns (2) and (3) show that the nature of ownership moderates the relationship between innovation investment and financial performance and market value performance, with a regression coefficient of -0.1464 for the former and -0.0947 for the latter being statistically significant at the 10% and 1% levels, respectively, revealing that there is a nuanced link between innovation investment and financial and market value performance depending on the kind of ownership structure in place at the company. The nature of state ownership will reduce the positive impact of R&D input to the financial performance and market value performance of the company. This result verifies Hypothesis 5.

In the regression results of column (1) with innovation stock $patent\_va$ as the explanatory variable, the coefficient of the interaction term between if_state and R&D input is -93.5931, which is significant at the 1% level, indicating that the nature of ownership moderates the correlation between R&D input and the mediating variable innovation output, and the nature of state ownership also reduces the positive impact of R&D input to innovation output.

Table 14

Estimates of Effect of Nature of the Company on Impact of R&D input on Company Performance

Variables	(1) patent_va	(2) roa	(3) tobinq
L.rdinputratio	129.2765***	0.1167*	0.1137***
	(15.0804)	(0.0654)	(0.0142)
if_state	17.4908	-1.7579***	-0.0772

	(64.4620)	(0.2795)	(0.0603)
if_state × L.rdinputratio	-93.5931***	-0.1464*	-0.0947***
	(19.2859)	(0.0836)	(0.0181)
log_asset	410.7456***	1.0007***	-0.6601***
	(17.3869)	(0.0754)	(0.0163)
region fixed effect	√	√	√
firm nature fixed effect			
industry fixed effect	√	√	√
time fixed effect	√	√	√
Observations	4,405	4,405	4,237
R2-Adjusted	0.164	0.098	0.377

4.4.4. Estimation Results of Location

Table 15 displays the estimate findings with business location as the moderating variable, which was used to test Hypothesis 6. This hypothesis states that the location of the firm has a distinct influence on the link between R&D input and firm performance. First, by observing column (2) and column (3), we can find that the coefficient of the interaction term is negative in both middle and western regions with the eastern region as omitted group and the absolute value is higher for the western region. This indicates that the positive effect of R&D inputs on company performance is weaker in the middle and western regions compared to the eastern region. It is worth noting that although the coefficients in column (2) are not statistically significant, the direction and magnitude relationships are consistent with column (3). As for the northeastern region compared with the eastern region, it is difficult to assert whether the impact of R&D inputs is stronger or weaker compared with the eastern region because the coefficients are not statistically significant and the direction of the coefficients in columns (2) and (3) is opposite. The above results illustrate that company location plays a moderating role when comparing

East, Middle and West, which verifies Hypothesis 6. Further, when replacing the dependent variable with patent stock $patent\_va$, the sign, significance and magnitude relationship of the coefficients of the interaction term in column (1) are all similar to column (3), which proves that company location directly affects the positive relationship between R&D input and company performance on the one hand, and the positive relationship between R&D input and company performance on the other hand. Contrarily, it affects the positive link between R&D input and innovation output, which in turn effects firm performance.

Table 15

Estimates of Effect of Location on Impact of R&D input on Company Performance

Variables	(1) patent_va	(2) roa	(3) tobinq
L.rdinputratio	113.2532***	0.2237***	0.0843***
	(13.3424)	(0.0578)	(0.0125)
middle region	-29.7826	-0.1828	0.0824
	(81.0424)	(0.3514)	(0.0761)
western region	23.2727	-0.8820***	0.1887***
	(76.4915)	(0.3316)	(0.0715)
northeastern region	-33.0747	-0.6324	-0.1191
	(112.3903)	(0.4873)	(0.1045)
middle × L.rdinputratio	-82.1734***	-0.0957	-0.0527**
	(27.2510)	(0.1181)	(0.0259)
western × L.rdinputratio	-87.9930***	-0.1077	-0.0760***
	(25.6109)	(0.1110)	(0.0241)
northeastern × L.rdinputratio	-95.8531**	0.0792	-0.0098
	(38.2104)	(0.1657)	(0.0353)
log_asset	415.6485***	0.9901***	-0.6551***
	(17.3706)	(0.0753)	(0.0163)
region fixed effect			
firm nature fixed effect	√	√	√
industry fixed effect	√	√	√
time fixed effect	√	√	√
Observations	4,405	4,405	4,237
R2-Adjusted	0.163	0.0970	0.374

Chapter 5 Discussion and Conclusion

5.1. Summary of Findings

This paper applies the data of Chinese listed companies from 2009-2017 as a sample to empirically test the impact of R&D input on company performance of listed companies, and the main findings of the study are as follows.

(1) The impact of R&D input on the financial performance and market value performance of listed companies in China is positive, and the impact is lagged in both cases. Small companies have higher impact than large companies, and for SOEs, R&D input has a greater impact on financial performance and a smaller impact on market value performance.

The above findings suggest that R&D input improves firm performance in general, and that this positive effect takes time to strengthen. Moreover, since the effect of R&D input is heterogeneous across companies, managers should focus on both short-term financial performance and long-term market value performance of companies.

My findings complement those of the literature. Past studies have considered the direct relationship between R&D inputs and innovation output, but have not considered inter-firm heterogeneity. And studies that have considered firm heterogeneity have not explored the lagged effect of R&D input.

This finding also has important practical implications for companies. This paper further confirms the necessity and importance of innovation, while showing that the results of innovation are lagging. This tells managers of enterprises that they need to be more forward-looking in their management practices, plan ahead, lay out precisely, and plan ahead when the business is doing well in order to get a head start and achieve better

development when the market is competitive. This finding can also help local governments to make better decisions: enterprise innovation is not a one-time thing, but a long-term accompaniment and a long-term effort. The government should provide a long-term supporting plan for enterprise innovation in order to achieve the desired results.

(2) The output of innovation is a crucial mediator between R&D input and financial returns for businesses. The stock of innovation and the rate of innovation growth are both positively affected by R&D input, but with a lag. Company performance benefits greatly from both incremental innovation and the stock of innovation. Company performance may be positively or negatively impacted depending on the quality of the innovation output, with invention patents having the most positive impact. The innovation increment is more crucial to the success of a company's finances and market value than the innovation stock.

These results demonstrate that R&D expenditures are only the beginning of the innovation process, and that the road from initial investment to ultimate performance payoff is long, winding, and fraught with peril. Only efficient innovation activities can provide efficient innovation outputs, which in turn may reduce R&D risk, boost bottom lines, and increase enterprise value. The current situation calls for companies to maximize the output of invention patents while also ensuring that the overall level of innovation output stock represented by intangible assets of intellectual property rights is low. This is because the degree of patent innovation of listed companies in China is not high, the patent structure is unevenly developed, the number of invention patents is obviously less than the number of non-invention patents, and the overall level of innovation output stock is low. In addition, businesses need to focus on learning and growing their skills rather than resting on their laurels, so that they can boost their own performance and get the most financial

rewards from their investments in research and development. For local governments, this finding suggests that the quality of innovation by companies is also critical, and that a portion of the results of R&D investment is reflected in the number of patents and, in turn, affects enterprise performance. Therefore, enterprises should be promoted and encouraged to file patents to convert R&D investment into innovation output as soon as possible, and to facilitate the filing of patent applications.

This finding complements the findings of literatures. They find that the stock of innovation output plays an important mediating role in the financial performance of companies, while I further find that both the stock and increment of innovation output play a mediating effect on the impact of R&D input on company performance.

(3) Heterogeneous characteristics, such as company size, nature of state-owned equity, and location, significantly affect the relationship between R&D input and performance, i.e., with the increase of R&D input, the trend of rising company per capita profits continues. The details are as follows.

First, the effect of firm size on the efficiency of R&D input is nonlinear. When the size of a company is small, although small companies invest more intensely in R&D and carry out more dynamic innovation activities, they are less efficient than large companies in terms of patent output and therefore less efficient than large companies in terms of innovation. However, although large companies are indeed able to improve their performance more effectively by increasing R&D input through their scale advantage, accumulation advantage and smooth patent application channels, the efficiency of R&D input will be reduced after the scale reaches a certain level and continues to increase, which is more difficult for large companies to quickly adjust their innovation strategies due to

their large scale and slower transition compared to the flexibility of small companies. This will cause the misuse of resources and therefore the decline of innovation efficiency. My finding that innovation efficiency and company size are non-linear is consistent with Khoshnevis & Teirlinck (2018), for whom I provide evidence based on Chinese companies. In addition to this, I fill the gap of Chi et al. (2020) and, like their findings, I also find a positive effect of company size on the correlation between R&D input and company value overall, in addition to the non-linearity of size.

This finding can help enterprises of different sizes and different growth stages to better position their innovation goals. Companies in the earliest stage are not eager to innovate, but focus on gaining a firm foothold in the market; companies in the growth stage should vigorously promote corporate innovation and make it the essence of corporate life in order to achieve better development; companies in the maturity stage should be prepared for danger and consider spinning off business lines or entering new industries to make corporate innovation rejuvenate.

Second, the equity structure plays a very critical role in converting R&D input into financial and market value performance. As a whole, the innovation investment intensity of SOEs is lower than that of private enterprises because of variables including the lack of the owner and the complexity of the principal-agent relationship. SOEs are more powerful than private corporations in terms of patent production because of their access to more resources, but private companies are more effective at turning R&D input into intellectual property assets. Most privately held businesses would rather invest in learning new skills and buying new technologies in order to boost their future success. My findings complement the findings of Wang et al. (2017). They find that firms with state-owned

ultimate control have better R&D input performance than non-state-owned firms, while I find that in the short run this effect holds, in the long run it does not.

I hope this finding will help private entrepreneurs regain their confidence. Business operation is a long-term process, and innovation is likewise a long and uncertain process. However, historical data shows that, on average, private enterprises that persist in innovation achieve better innovation efficiency compared to state-owned enterprises, and therefore need to persist in corporate innovation. In addition, it is also hoped that this finding will help local governments to make better decisions to encourage and support private enterprises to innovate in the long run.

Finally, location also has a significant impact on the efficiency of R&D input. Although in recent years, the middle and western regions have been providing more and more support for business operations and independent innovation, it can be seen that when it comes to the accumulation of innovation output, the eastern region is much higher than the middle and western regions. This difference in the accumulation of innovation output is also reflected in the efficiency of R&D inputs, with the positive impact of R&D inputs on innovation output and the positive impact of R&D inputs on firm performance being higher in the eastern region than in the middle and western regions. This indicates that, at the current stage of development, it is still the business environment in the eastern region that is more suitable for firms to innovate. This result adds to the findings of literature that find that location is an important determinant of accumulation of innovation input, but they did not study for specific locational effects in China. This dissertation finds that the eastern region has a higher accumulation of innovation input as compared to the other regions.

This finding can help entrepreneurs find a more suitable location for their own business development positioning, and at the same time help local governments establish a sense of alignment and strive to improve their own business environment to attract enterprises to move in.

I summarize all the findings and the extent to which it validates the hypothesis in the following table.

Table 16

Summary of Findings

Hypothesis Supported	Not	Partially	Full
Hypothesis 1: All other things being equal, there is a positive relationship between R&D input and financial performance and market value performance.			√
Hypothesis 2: There is a positive correlation between the R&D input and innovation output, with certain delays.			√
Hypothesis 3: Innovation output has a positive impact on company performance and it plays a partially mediating role in the correlation between innovation input and company performance.			√
Hypothesis 4: The effect of company size on R&D input and company performance is inversely u-shaped. In other words, when the scale of the firm is small, the effect of R&D input on company performance will be enhanced; the			√

negative impact of R&D input on company performance will be exacerbated by the company's size.			
Hypothesis 5: State ownership will weaken the relationship between R&D input and company performance. That is, the R&D input of state-owned companies has a weaker effect on the performance of companies.		√	
Hypothesis 6: The location of the company has a different impact on the relationship between R&D input and company performance. The relationship between R&D input and company performance is strongest in eastern region, second in middle region and weakest in western region.		√	

5.2. Limitations and Perspectives

Although I have made some new attempts in different dimensions of the input-output relationship, and some realistic research findings have been obtained, the following limitations still exist in this paper.

(1) More precise metrics are required for gauging businesses' ability to generate new ideas. Current conventional wisdom often uses patents as a surrogate for innovation output, however this approach confuses the stock with the flow of new ideas. Since not all R&D outputs are patented and the implicit stock of innovation, like the knowledge, technology, and ability owned by technicians of companies, cannot be quantified thanks to

the limitations of financial statements, this paper uses the annual increase in patents granted as a proxy for the increasement of innovation. In addition, citation-weighted patent counts have been used in place of raw patent numbers to measure innovation output in several recent research. Although I could have included this variable in my work, I choose not to owing to the access of data on patent citations; should I ever get the chance to gather this information, I will revise my analysis accordingly.

(2) Ignoring the inefficiency of the stock market and the irrationality of investors. The paper's findings depend on the assumptions of market efficiency and managerial rationalism. However, the position in China is more difficult than it would be in a country with a sophisticated market system, like the United States or Western Europe. Our financial market is increasingly characterized by illogical conduct and a heightened speculative climate. There is a paucity of long-term innovation strategy among Chinese businesses, which instead focus on immediate gains. Investors in the market seem to approve of the irrational conduct of small and medium-sized shareholders, and there is also a "herd effect" in firms, many of which do not grow their own sector but go after hot places instead. Managers and capital market investors' irrationality may have a significant impact on the outcomes and success of R&D as an investment activity. For this reason, it is important to account for irrational conduct in study designs to avoid introducing bias.

(3) In the discussion of company heterogeneity, there is a lack of factors of company heterogeneity. For example, it has been found that the intensity of competition in a company’s industry also has an impact on the company’s performance as well as innovation efficiency (Gupta et al., 2017). For the discussion of the nature of ownership, this paper finds that although the nature of ownership moderates the effect of R&D input

on company performance, the effect of the nature of ownership itself on innovation efficiency is not significant, and more in-depth research is needed. In addition, there are other heterogeneities that can be included in the discussion, which are not included in the design of this study for the time being due to data availability, and I will consider them accordingly in future studies.

This is how I see future studies panning out. The mechanism between R&D expenditures and financial returns to businesses should remain be the primary focus of future studies. Possible directions for further study of this topic include.

(1) The purpose of this study is to delve further into the role that innovation output effectiveness plays as a mediator between R&D input and bottom-line results for businesses. It is possible that in the future researchers may look to the efficiency viewpoint of "input and output" in economics in order to build a multi-dimensional assessment index for the efficacy of businesses' innovation output and to evaluate the efficacy of their R&D input. Although it is now impossible to acquire an adequate assessment of the implicit innovation output using existing financial measures, this information may be gathered via the use of questionnaires and other means in the future.

(2) Further research can be conducted on industry segments, unique growth companies, and non-listed companies to consider more heterogeneous characteristics of companies, conduct comparative studies from a more nuanced perspective, dig deeper into the diversity of companies, and derive more practical reference results from them.

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