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The Impact of Firm Ownership on Innovation: Evidence From China

Mi, Xiaoqi

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THE IMPACT OF FIRM OWNERSHIP ON INNOVATION: EVIDENCE FROM CHINA

by

XIAOQI MI

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Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

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THE IMPACT OF FIRM OWNERSHIP ON INNOVATION: EVIDENCE FROM CHINA

Xiaoqi Mi

Abstract

This thesis uses data from the Shanghai Stock Exchange from 2013 to 2019 to focus on the impact of five ownership structures on firm innovation. In this context, innovation refers to firm performance innovation, specialisation innovation and diversification innovation. The results show that concentrated ownership is positively related to firm innovation performance, while foreign ownership is negatively related to firm innovation performance. However, there is no significant linear relationship between firm ownership and innovation performance.

Nevertheless, the innovation performance of concentrated ownership does not differ significantly between the different levels when a threshold is used. Insider ownership positively impacts innovation performance when insider ownership is below 5% or above 20%. Particularly, insider ownership above 20% has a higher impact on innovation performance than insider ownership below 5%. State ownership is positively associated with innovation performance only when less than 5%. Moreover, the results find that only firms with more than 20% foreign ownership impaired innovation performance. There are no significant differences between different levels of institutional ownership in terms of firm innovation performance. Finally, the findings suggest that firm ownership is not related to innovation specialisation or diversification.

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Chapter 1 Introduction

1.1 Introduction

The reform and opening up in the late 1970s, known as the Chinese economic miracle, triggered noteworthy Chinese economic growth in the following decades (Ray, 2002), with an average gross domestic product (GDP) growth rate of 9.95% between 1979 and 2011 and reaching the highest GDP growth rate of 15.2% in 1984, according to National Bureau of Statistics China. The process of reform and opening up is also the process of a change in cooperate governance in China, particularly more state-owned enterprises (SOEs) towards privatisation (Xu and Uddin, 2008). Nowadays, the Chinese economy is experiencing its fifth great institutional change of SOE reform - mixed ownership reform (Lin et al., 2020). Specifically, mixed-ownership reform aims to promote market reform of SOEs and mitigate business dependence on government (Wang et al., 2021), and has undergone five stages – decentralization (1978-1984), transformation of control rights (1985-1992), separation of ownership and control of the company (1992-2002), reorganisation of the ownership of SOEs (2002-2012), mixed ownership reform (2012 – present) (Lin et al., 2020; Li et al., 2013). Since 2012, China's rapid economic growth has reached a turning point due to the exhaustion of its late-stage advantage, and economic growth has entered a slow-growing period (e.g. Lo, 2018; Wang, 2015). During this period, the Chinese government has made several efforts to accelerate economic growth. One of the most cited is innovation, which researchers believe is necessary at this stage of the economic slowdown (e.g. Chen et al., 2018; Lo et al., 2022). The concept of innovation is broad, and this thesis concentrates on innovation at the firm level. Researchers usually categorised innovation measurement into innovation input and innovation output. Innovation input is measured by R&D activities, for example R&D expenditure and R&D intensity (e.g., Cavdar and

Aydin, 2015; Kamien and Schwartz, 1982; Kurt et al., 2015). Innovation output is measured by patent data, for example the number of patents (e.g., Di Vito et al., 2010; Decker and Günther, 2017; Griliches, 1990).

Firm innovation performance plays an important role in firm profitability, because innovators are able to somehow shield themselves from market forces (Love et al., 2009). In practice, many factors can drive firm innovation performance, for example information and communication technology (He et al., 2023), corporate governance (e.g., Chi, 2023; Fan et al., 2023; Shaikh and Randhawa, 2022), gender diversity (Tonoyan and Boudreaux, 2023), investor sentiment (Lin, 2023), policies (Chen and Jin, 2023). This thesis is interested in ownership structure, which is one part of corporate governance. Different corporate governance in different countries generates various national corporate innovation and entrepreneurship systems, which, in turn, induce a difference in firm competitiveness over the world. Hoskisson et al. (2004) conclude two types of corporate governance which facilitate different types of innovation: (1) a market-based governance system promotes explorative and revolutionary innovations by taking advantage of its dynamism, flexibility and diversity; (2) a relationship-based governance system supports exploitative and incremental innovations due to its continuity, stability and commitment. Besides, internal control systems and managerial incentives determine the allocation of R&D investments so as to influence firm innovation performance significantly (Aaboen et al., 2006, Birkinshaw et al., 2008). As to narrowing down the research area from corporate governance to the ownership structure, previous research in emerging countries assesses how these firm ownership impact innovation in emerging countries (e.g. Choi et al., 2011; Chen et al., 2016; Rong et al., 2017; Liu et al., 2017; Zhou et al., 2017). Most studies, however, concentrate on the relationship between one specific ownership structure and firm innovation performance, such as the research on concentrated ownership (Nguyen et al., 2015; Clò et al., 2020), institutional ownership (Rong et al., 2017; Li and Ji, 2021), state ownership (Zhou et al., 2017; Dong et al., 2022; Lo et al., 2022), insider ownership (Chen et al., 2013; Liu et al., 2017; Cheng et al., 2021), and foreign ownership (Chen et al., 2016; Dong et al., 2022). Those five ownerships are what this essay focuses on. Only a few scholars are interested in comparatively analysing the impact of two or more ownership on firms' innovation activities in emerging economies (Choi et al., 2011; Jiang et al., 2013; Li et al., 2014). One empirical reason can be that the more ownership structures considered, the more time consuming to collect data. However, the advantage to have five ownership structures discussed in this thesis is obvious, as those five ownership structures cover all ownership in Chinese firms. Thus, we can have a comprehensive discussion about how five ownership structures affect firm innovation using the most recent data, as shifts in the political environment, foreign trade environment or business environment can change the relationship between firm ownership and innovation.

Using data from the Shanghai Stock Exchange between 2013 and 2019, this thesis focuses on the impact of five ownership structures on firm innovation. In this context, innovation refers to firm performance innovation, specialised and diversified innovation. The findings reveal that firm concentration of ownership is positively related to firm innovation performance, while foreign ownership and firm innovation performance are negatively related. Otherwise, there was no significant linear relationship between firm ownership and innovation performance. Thus, a new sample period was applied in this case.

However, the innovation performance of concentrated ownership does not differ significantly between the different levels when a threshold is used. In contrast, the study of insider ownership indicates a positive effect on innovation performance when insider ownership is below 5% or above 20%. In particular, insider ownership above 20% has a greater impact on innovation performance than insider ownership below 5%. This result is partially consistent with the work of Song et al. (2015). Furthermore, state ownership is positively associated with innovation performance only when it is less than 5%, which is partially consistent with previous findings (Choi et al., 2011). In addition, the results find that only firms with more than 20% foreign ownership damage innovation performance. There is no significant difference between different levels of institutional ownership in terms of firm innovation performance. Hence, it fills the research gap about thresholds of ownership structure and offers a guidance for current mix-ownership reform in China.

Third, the findings suggest that firm ownership is not related to innovation specialisation or diversification but more external factors impacting the firm's decision to specialise or diversify. Therefore, it fills the research gap about the determinants of firm innovation diversification and specialisation.

1.2 Research Aims

The Chinese government has launched a number of initiatives to foster innovation and find new sources of economic growth amidst a deceleration in economic growth. Since 2012, the Chinese economy has entered sluggish growth from the rapid economic growth associated with reform and opening up. In response to the notable change in the economy, the Chinese government has adopted a series of measures to stimulate economic growth, including mixed-ownership reforms and exploring opportunities for further cooperation and development with other countries. This thesis aims to examine the relationship between firm ownership and innovation, investigate the relationship between five ownership structures and innovation performance in China, find the thresholds that influence company ownership and innovation, and how different levels of company ownership affect innovation specialisation and diversification.

1.3 Research Objectives

The first purpose of this study is to investigate the relationship between five ownership structures and innovation performance in China. As the literature on innovation performance emphasises country-specific institutional factors while interpreting each country's innovation performance (e.g. Abdullah et al., 2002; Di et al., 2010), this thesis focuses on the emerging institutional setting with a large and rapidly developing market. Traditional Schumpeter-inspired economics of innovation, and recent advances in his work, seem incapable of explaining why firms sharing similar exogenous circumstances may behave very differently in terms of innovation. By contrast, the literature on corporate governance offers several helpful perspectives for understanding firms' innovative activities. Belloc (2012) suggests three main aspects of cooperate governance concerning a firm's innovation performance – ownership structures, labour and cooperate finance. In this thesis, ownership structures are the focus.

The second objective is to find the thresholds that influence company ownership and innovation. Firm ownership will be divided into different levels, and this thesis examines the relationship between different levels of firm ownership and innovation. Wright et al. (2005) suggest that the fundamental of effective corporate governance in research can be the integration of agency theory and institutional theory, as this contribution may offer a novel framework. Thus, a firm, which can implement efficient management in changing environment, relies on a suitable structure between ownership, control device and monitoring mechanism. Therefore, in this thesis, innovation will be analysed using different levels of firm ownership to identify the thresholds that affect the relationship between firm ownership and innovation. It will allow shareholders and firm managers to better understand the relationship between firm ownership and innovation, and to use the thresholds flexibly to build mixed ownership structures that allow firms to benefit from different firm ownership.

The third objective is to see how different levels of company ownership affect innovation specialisation and diversification. This thesis utilises the concept of knowledge to analyse innovation specialisation and innovation diversification. Knowledge plays an important role in the survival, growth and innovation of a company (Healey and Mintz, 2021; Yu and 2021). The varying firm performance depends on the firm's own knowledge base (Grant, 1996). The accumulation of a knowledge base adds to a firm's competitiveness, facilitates research and development (R&D), and ultimately transforms knowledge into commercial products (Cohen and Levinthal, 1990; Arora and Gambardella, 1994). The degree of knowledge accumulation can be divided into two categories, depth of knowledge and breadth of knowledge. The depth of knowledge helps to strengthen the firm's capacity to absorb new knowledge, integrate external knowledge into the firm's knowledge base, use external knowledge proficiently and effectively, and increase the firm's competitiveness (Yang et al., 2017). The breadth of knowledge facilitates the expansion of the scope of knowledge to bring new inspiration for innovation (Katila and Ahuja, 2002), and the firm's capacity in adapting to technological changes in related fields (Volberda, 1996; Srivastava and Gnyawali, 2011).

1.4 Research Questions

In order to achieve the research objectives, the following research questions need to be addressed:

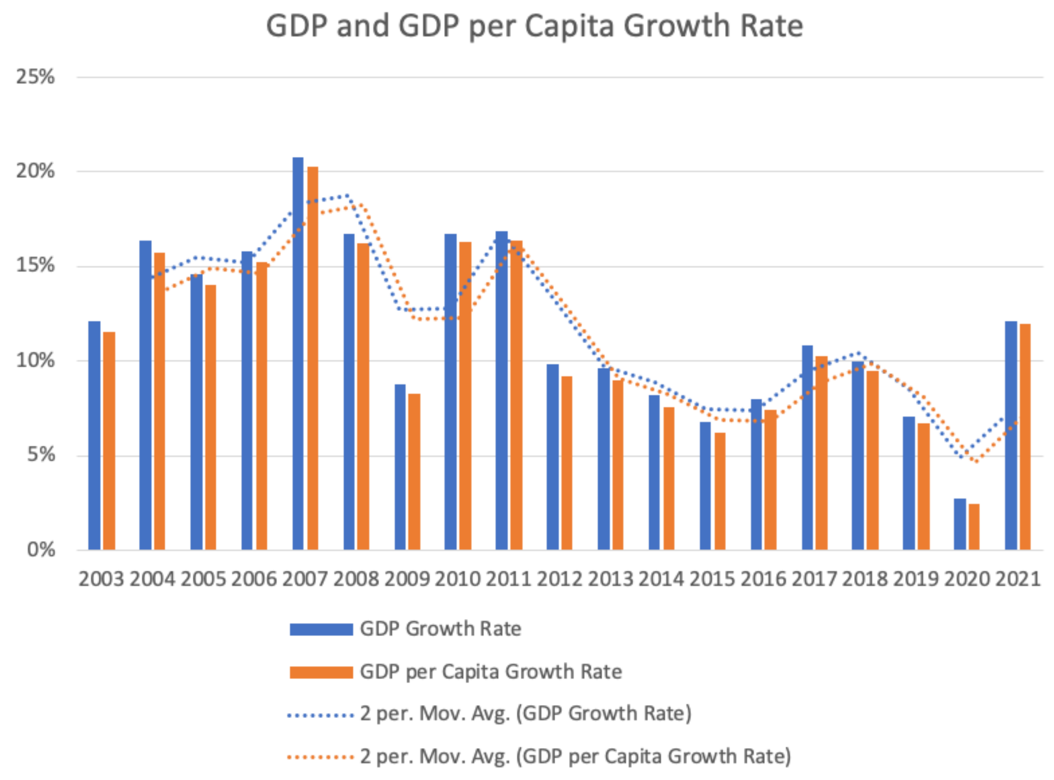
1. What is the impact of firm ownership on innovation performance?
2. What is the impact of different levels of firm ownership on innovation performance?
3. How do different levels of firm ownership affect innovation specialisation?
4. How do different levels of firm ownership affect innovation diversification?

1.5 Background

1.5.1 Chinese Economy

Since the reform and opening up, the Chinese economy has entered an era of rapid growth. From 2003 to 2013, Figure 1.1 indicates that the GDP growth rate in China remained above 10% except for 2009, followed by a decline in growth rate to below 10%. Then, the growth rate hit rock bottom (around 7%) in 2015 and climbed steadily for three years before dropping again due to China-US trade war in 2019 and COVID-19 in 2020, tumbling down from 10% to around 3%. Obviously, the Chinese economy has moved into a period of slow growth since 2013. As a result, the average GDP growth rate between 2012 and 2021 was around 8%, revealing a downshift in China's economic growth compared to the rapid economic surge of the past after the Reform and Opening Up policy.

Figure 1.1 GDP Growth Rate and GDP per capita Growth rate in China over period 2013-2021



Source: National Bureau of Statistics

It is officially called the "new normal", and the reasons for this "new normal" are manifold (Lo, 2018). For example, the slowdown mentioned in his paper is mainly due to China's "late-stage advantage" depletion. Years ago, after the reform and opening up, Chinese companies improved or innovated their products or services by absorbing and refining imported technology, increasing their competitiveness in the international market and thus leading to rapid national productivity growth. Nevertheless, the rapid economic growth that followed the reform and opening up has ended. With sluggish economic growth, encouraging local innovation has become a priority (Lo et al., 2022). The Chinese government has undertaken a number of initiatives to promote innovation and to find new sources of economic growth in the face of slowing economic growth, such as mixed ownership reforms.

1.5.1.1 Mixed-Ownership Reforms

Since the reform and opening up, a large number of SOEs have been restructured into private or mixed ownership. Five stages of SOE reform are proposed by (Lin et al., 2020):

1. 1978 to 1984, at the beginning of the reform and opening up, when decision-making rights were transferred from the government to Soviet-style socialist firms
2. 1985 to 1992, when control of the company was transferred to SOE managers by contract
3. 1992 to 2002, when the separation of ownership and control of the company
4. The reorganisation of the ownership of SOEs between 2002 and 2012
5. The reform of the mixed ownership system after 2012

At the end of 2017, that type of mixed ownership had become predominant in SOEs. Of these, 69% of SOEs with direct links to the national government had converted to mixed ownership, while provincial SOEs accounted for 56% (Shen and Yang, 2019). In addition, 25 of the 115 Chinese companies that entered the *Fortune Global 500* in 2018 had undertaken mixed-ownership reforms to varying degrees.

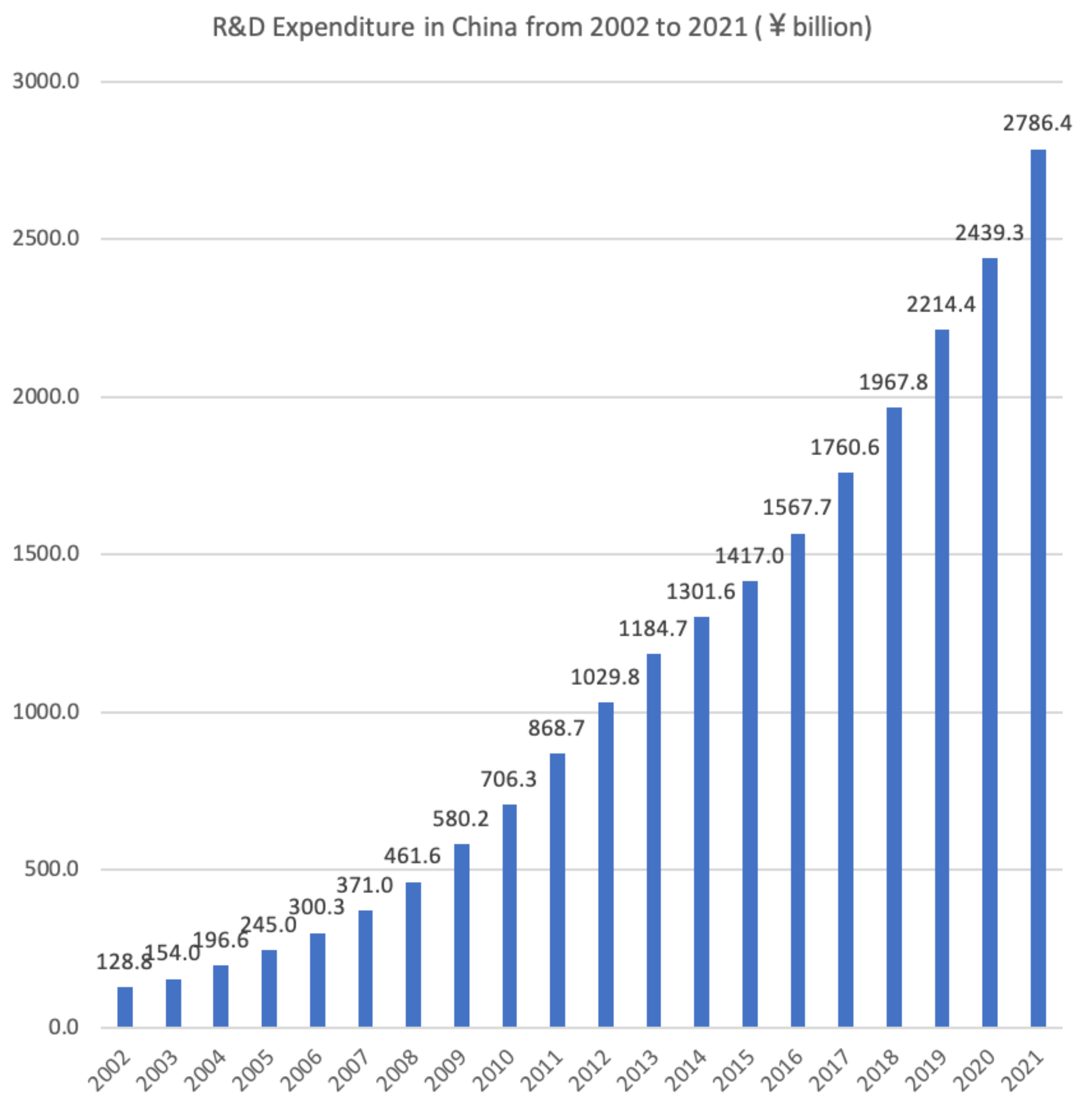
Zhang et al. (2020) point out that the mixed-ownership reforms have had a positive effect on innovation, not only in terms of increased investment in R&D but also in terms of an increased number of patents. The increased investment in R&D is due to SOEs obtaining more funds from private enterprises after being turned into mixed ownership (Chen et al., 2018).

Furthermore, the positive correlation between mixed ownership and innovation is magnified within firms in monopolistic industries compared to highly competitive industries. In addition, innovation in mixed ownership is influenced by region. The eastern part of China has a greater impact on innovation capacity than other regions (Zhang et al., 2020)

1.5.2 China's R&D Expenditure

During the downturn in economic growth, Figure 1.3 exhibits that China has continued to ramp up R&D investment, rising from 1184.7 billion yuan in 2013 to 2786.4 billion yuan in 2020. In contrast to the annual growth rate in R&D expenditure of around 20% before 2013, the annual growth rate in R&D expenditure after 2013 shrinks to around 10%.

Figure 1.2 R&D Expenditure in China from 2002 to 2021

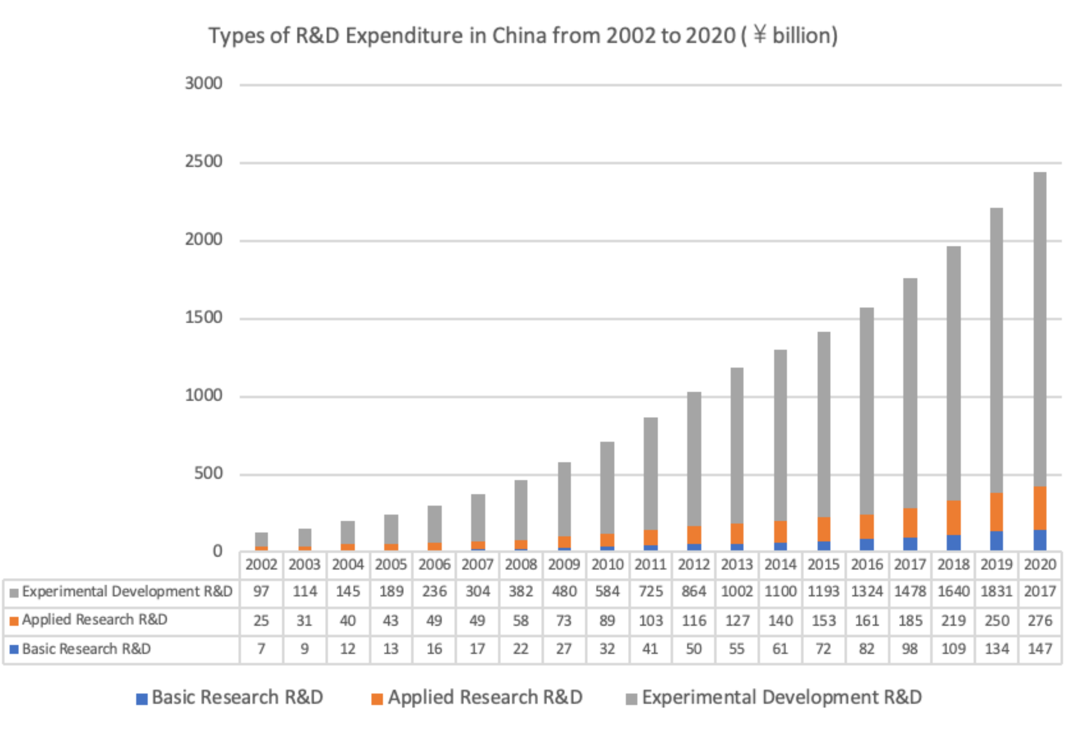


Source: National Bureau of Statistics

Generally, R&D expenditure is classified into three types - basic research, applied research and experimental development. From Figure 1.4, experimental development R&D ranks the top, applied research is second, followed by basic research. As China's high-tech technologies have been repeatedly "strangled" by Western countries in recent years, R&D expenditure in basic research in 2020 has nearly tripled compared to 2013. Even so, R&D expenditure in basic research is still far below the other two R&D categories.

Besides, R&D funding is mainly from the government and firms. Figure 1.5 demonstrates that government funding for R&D is between 60% and 70% of total R&D funding between 2002 and 2003. From 2004 to 2015, the state share hovers between 70% and 80%. After 2015, the state share of R&D funding is as high as 80%, while firm R&D funding accounted for only 20%.

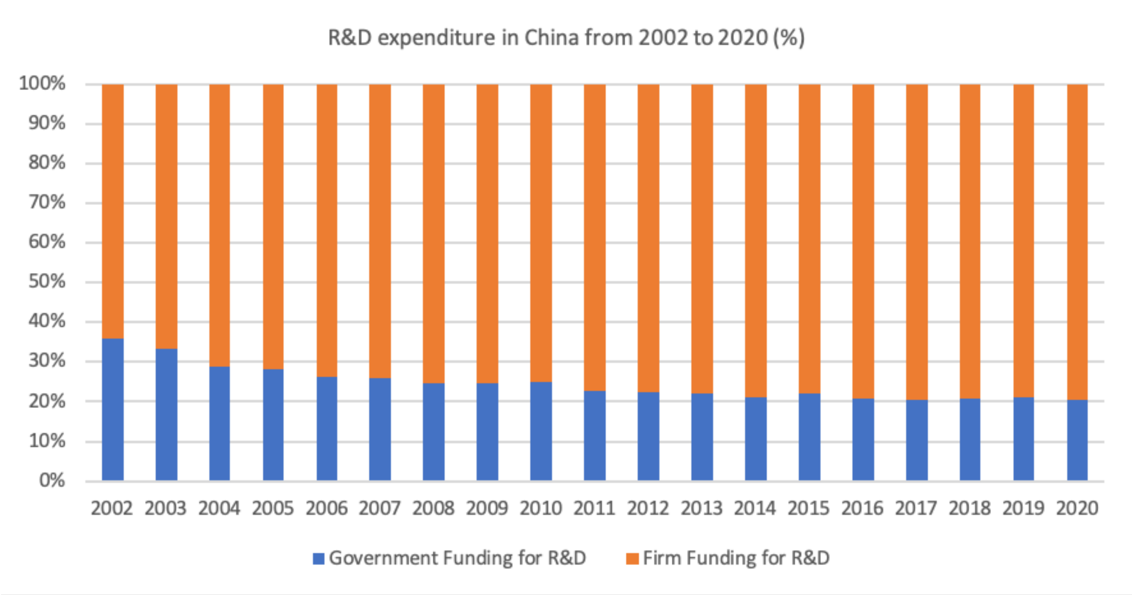
Figure 1.3 Types of R&D expenditure in China from 2002 to 2020 (￥billion)



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Experimental Development R&D	97	114	145	189	236	304	382	480	584	725	864	1002	1100	1193	1324	1478	1640	1831	2017
Applied Research R&D	25	31	40	43	49	49	58	73	89	103	116	127	140	153	161	185	219	250	276
Basic Research R&D	7	9	12	13	16	17	22	27	32	41	50	55	61	72	82	98	109	134	147

Source: National Bureau of Statistics

Figure 1.4 R&D expenditure in China from 2002 to 2020 (%)

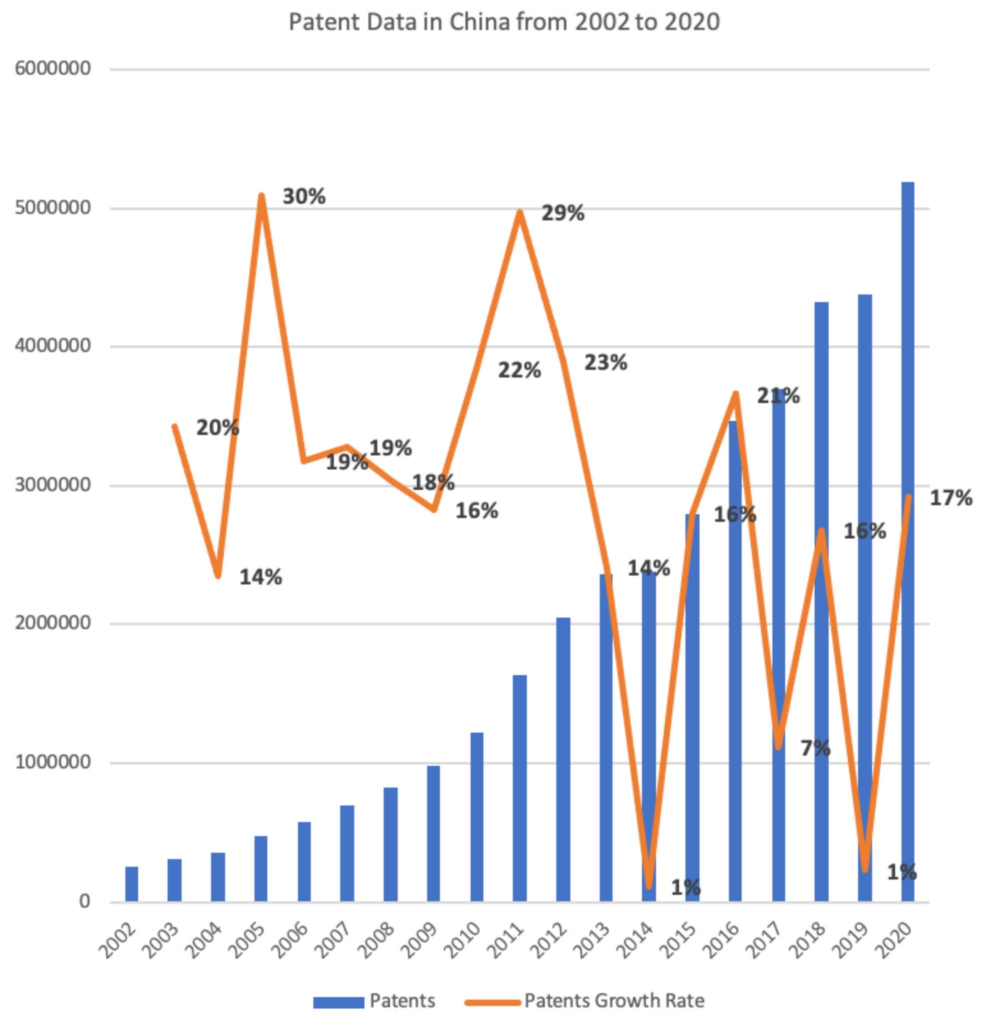


Source: National Bureau of Statistics

1.5.3 China's Patent Data

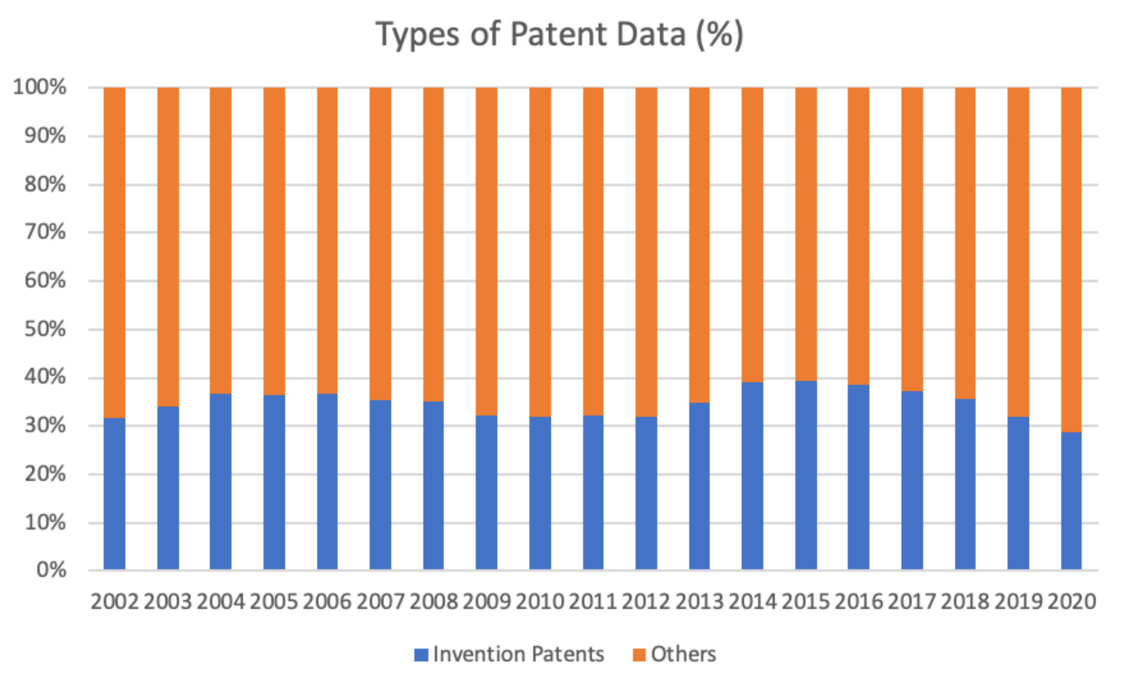
Figure 1.6 presents that the number of patent applications in 2020 has more than doubled compared to 2013, during a period of slowing economic growth in China. However, the post-2013 patent growth rate per year has decelerated markedly compared to the pre-2013 period. The total number of patents is perennially dominated by invention patents, which fluctuate between 60% and 70%, as shown in Figure 1.7.

Figure 1.5 Patent Data in China from 2002 to 2020



Source: National Bureau of Statistics

Figure 1.6 Types of Patent Data (%)



Source: National Bureau of Statistics

1.6 Contributions

This thesis confirms that, through economic theories and with the use of new data, firm ownership remains an important consideration in constructing firms' innovation capabilities. It clearly depicts the impact of firm ownership on innovation performance and finds that different ownership structures have different effects on innovation performance. This is the first contribution.

In particular, the use of two thresholds, 5% and 20%, further clarifies the different impacts of ownership structures on innovation performance and helps to guide firms to establish a good ownership structure and improve their innovation performance. In the fifth round of SOE reform, the 5% and 20% thresholds can also give the government a reference for SOE reform, so that SOE reform can lead to a better ownership structure and promote innovation performance. This is the second contribution and fills the research gap.

In addition, this thesis also shows that there is no relationship between firm ownership and innovation specialisation. Also, there is no relationship between firm ownership and innovation diversification. It also fills the research gap focusing on innovation diversification and specialisation. In China's unique economic environment dominated by state-owned enterprises, firms' innovation specialisation and diversification are more likely to follow policy support or the needs of the country.

Indeed, different countries have different corporate governance systems, mainly manifested in ownership structures, board independence, CEO duality, the presence of an audit committee, et cetera. The significant impacts of firm ownership on Chinese firms depend on the corporate governance system in China, which is currently an ongoing mix-ownership reform.

1.7 Structure of Thesis

Chapter 1 is introduction. Chapter 2 is literature review. Chapter 3 is research design containing hypotheses proposed. Chapter 4 is research methodology. Chapter 5 is data analysis. Chapter 6 is conclusion.

Chapter 2 Literature Review

2.1 Introduction

This chapter reviews the concepts of innovation and firm ownership in the mainstream literature and discusses the importance of knowledge for innovation. Section 2.2 is the literature review about innovation, including the measurement of innovation used in the research. Section 2.3 contains five different types of firm ownership in China and focuses on the relevance of innovation and company ownership. Section 2.4 introduces the importance of knowledge for innovation. The study treats the knowledge from two perspectives – depth of knowledge and breadth of knowledge. Finally, section 2.5 explains fresh insights from past literature.

2.2 Innovation

2.2.1 Introduction

Innovation is referred to as a new method, idea, product, et cetera. Baregheh et al. (2009) calculate the number of definitions of innovation in different scientific papers. Amazingly, there are totally about 60 definitions. Therefore, they tried to merge and summarise the definitions of innovation in multiple disciplines and made the following conclusions: "Innovation is the multi-stage process whereby organisations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace. " (Baregheh et al., 2009). As people likely confuse innovation with creativity, Amabile and Pratt (2016) distinguish creativity from innovation and give their respective definitions: (1)

creativity is a new and useful idea generated by an individual or teamwork; (2) innovation is the successful implementation of creativity within the organisation.

2.2.2 Frameworks to Determine Types of Innovation

There are various frameworks to determine the types of innovation.

The first framework, which is created by HBS professor Clayton Christensen, contains two types of innovation – sustaining innovation and disruptive innovation (Bower and Christensen, 1995). Sustaining innovation is to innovate persistently existing products or services based on the needs of current customers (Satell, 2017). For example, customers prefer faster CPUs for electronic products or higher pixel sizes for mobile phones. Disruptive innovation means new products, services, or business models disrupt the market, eventually replacing other competitors as industry leaders (Christensen, 1997). Amazon and Netflix are two examples of disruptive innovation. Disruptive innovation plays a vital role in a successful business in the long term (Christensen and Overdorf, 2000).

The second framework is that Satell (2017) further subdivides the types of innovation based on Christensen's research (Bower and Christensen, 1995; Christensen, 1997) by solving different types of problems. He believes that the core of innovation is to solve problems and summarises four types of innovation:

a) sustaining innovation: it aims to refine capabilities in existing markets. In this case, people have a clear understanding of what problems to solve and what skills to use.
b) breakthrough innovation: the problem is well-defined, but is hard to resolve within the area in which the problem arose. However, that problem may be solved quickly within adjacent areas (Kuhn, 1970).

c) disruptive innovation: if the basic logic of market competition shifts, due to technological changes or other changes in the market, firms' products or services will gradually be eliminated from the market, even if the products or services are significantly refined. Product innovation will only worsen firm development when it happens, and firms must innovate their business models instead (Christensen, 1997).

d) basic research: the definition of basic research is that it has the capability to form a basis for the growth of global technology in the long term (Iansiti and Lakhani, 2017). In pathbreaking innovations, there is no boundary. People can always find some new phenomena. Just as no one could know how the world would be shaped by Einstein's discoveries, or no one could guess that Alan Turing's universal computer would one day become a reality (Satell, 2017). From the perspective of the history of science, a large number of basic research construct a scientific knowledge system. It is not for immediate application, but will be found and applied to benefit humanity after a long time period. Therefore, various countries attach more and more importance to basic research, especially China. Facing the technological blockade of western countries, China has swollen its investment in basic research. Data from the National Bureau of Statistics in China show that the investment in basic research reached 133.6 billion yuan in 2019, accounting for 6% of the total social R&D expenditure for the first time. This proportion hovered around 5% for many years. In 2020, China's basic research funding was 146.7 billion yuan, an increase of 9.8% over the previous year. In 2021, China's basic research investment reached 169.6 billion yuan, accounting for 6.09% of the total social R&D investment.

The third framework is McKinsey's three horizons model (Baghai et al., 2000). It helps firms think about their future, sort out their business portfolio, and formulate their strategy for business coordination. Eventually, firms achieve the goal of healthy firm growth. The model discloses how innovation happens in those three-time horizons:

a) Horizon 1 is to maintain and strengthen the core business, thereby innovating continuously within existing products, services, or business models. The delivery time of Horizon 1 could be 3 to 12 months.
b) Horizon 2 is to explore and discover new expansion, extending the core business to new markets, for example. The delivery time of Horizon 2 could be 24 to 36 months.
c) Horizon 3 is to create entirely new possibilities and competencies, thereby responding to or utilising disruptive opportunities. The delivery time of Horizon 3 could be 36 to 72 months.

In modern society, Blank (2019) disagrees traditional delivery time of three horizons. In the last century, some disruptive ideas required years of research, design and delivery. Nonetheless, the delivery time of ideas for Horizon 3 can be as fast as the one for Horizon 1 today, so the delivery time of Horizon 3 products, strategies and capabilities has a devastating impact on competitors. For example, Airbnb uses existing technologies (i.e. mobile phone app and landlord) to create a new asset-light business model for tourist accommodation, unlike hotels and deployed quickly in the short term. Bizarrely, the most common user of rapid Horizon 3 disruption is not market leaders but challengers and new entrants (e.g. China) (Blank, 2019).

2.2.3 Stages of Innovation

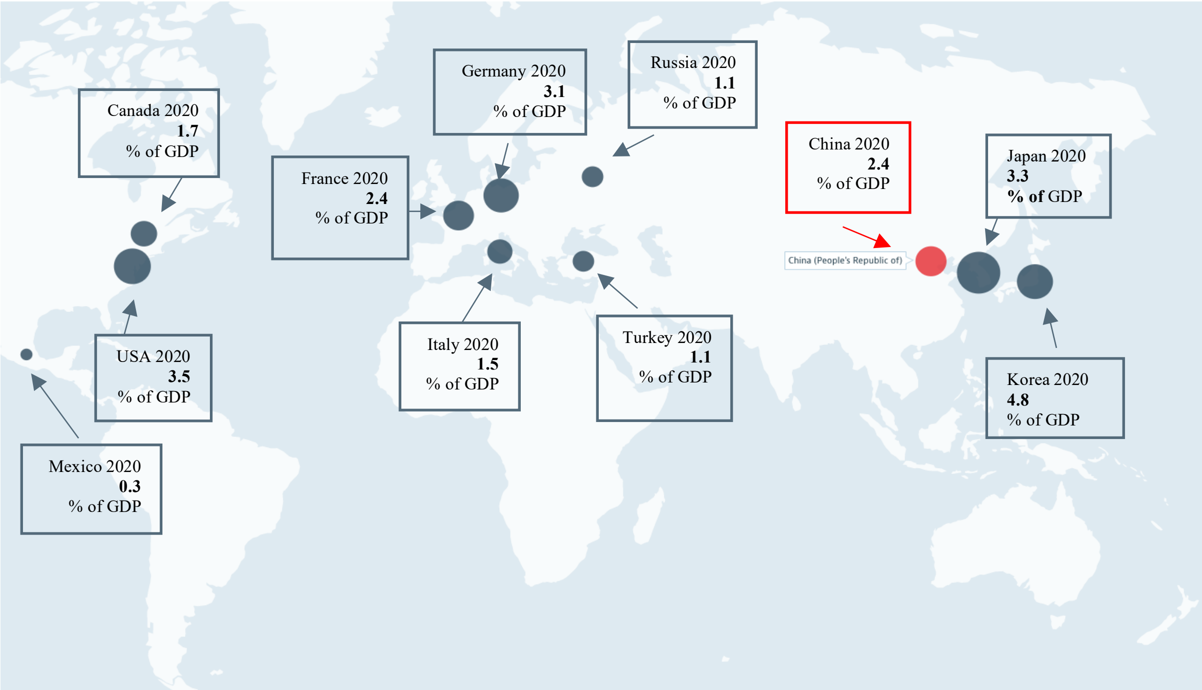
The early model comprehends three stages of innovation – idea generation, problem-solving, and idea implementation (Utterback, 1971). Nevertheless, at that time, the focus was on the manufacturing industry. Consequently, Utterback's model for stages of innovation is relatively inadequate.

Then, Mariello (2007) proposes a model with five stages of innovation. The first stage is to generate the idea through free exploration or competition and hand it over to people who can promote it. The second stage is to promote and screen the idea. The third stage is to test the idea under specific conditions. The fourth stage is to commercialise the idea, including cost and benefit evaluation. Finally, the fifth stage is to diffuse the idea in the company, so the internal staff can accept it and spend resources to implement it systematically.

2.2.4 Research and Development

Research and development (R&D) is a series of innovative activities by enterprises or governments while innovating or introducing new products or services. Hence, R&D is the first stage of developing potentially new products or services, whereas innovation is the process of transforming ideas into new products or services. To put it differently, R&D is a part of innovation in the definition, even though R&D and innovation are sometimes interchangeable. As innovation is non-quantitative, R&D is applied instead to evaluate or compare innovation. The proportion of R&D expenditure of gross domestic spending in 2020 for the G20 is displayed in Figure 2.1. Korea ranks first, with 4.8% of gross domestic product (GDP). United States has the second highest percentage of R&D expenditure over GDP (i.e. 3.5% of GDP). Japan follows it with 3.3% of GDP. R&D for Germany is 3.1% of GDP, which are fourth. The fifth is China and France, with 2.4% of GDP. Other countries are below 2% of GDP. Some G20 countries' data are not shown in Figure 2.1 due to missing data.

Figure 2.1 The proportion of R&D Expenditure of Gross Domestic Spending



2.3 Firm Ownership

2.3.1 Introduction

Institutions change among countries (Vitols et al., 2001). Freeman (1995) stresses firm's R&D activities, ownership structures, and control are overwhelmingly dependent on the domestic platform, and thus the country-specific institutional factors play a significant role in determining the national innovation system. In other words, the cross-national diversity of institutional settings can cause differences in national innovation systems (Nelson ed., 1993). As a result, countries differ in terms of which innovation strategies they apply and which innovation performance they produce. Also, the institutional divergence explains how ownership constituents affect the firm's innovation strategies (Hoskisson et al.,2002). Anguilera and Jackson (2003) agree that this diversity is due to institutional differences but also explain it through stakeholder interactions. The former matters through their capacity to support the latter, and the latter generates different demands on the national institutional configurations.

In developed countries, there are three models of corporate governance structure with respect to country-specific contexts: (1) the Anglo-American model, which is featured by outside shareholders (which means the separation of ownership and control), market-orientated corporate control, equity finance, and state laws; (2) Japanese model, which is characterised by inside shareholders, a long-term and strong relationship between companies and bank, corporation controlled usually by insiders, and legal framework designed to stimulate groups affiliated by trading relationships and cross-shareholdings; (3) German model, which highlights concentrated ownership, the long-term linkage between bank and corporation, bank representatives as a board of directors, and non-market orientated corporate control (Morck and Nakamura, 1999; Gibson 2000; Vitols et al., 2001; Aguilera and Jackson, 2003; Toms and Wright, 2005). Based on these models, scholars examine the causatives between corporate governance and firm innovation performance (e.g. Francis and Smith, 1995; Guadalupe et al., 2012; Aghion et al., 2013; Matzler et al., 2015).

However, many countries' contexts cannot simply be defined as those three models due to institutional heterogeneity (Aguilera and Jackson, 2003). Especially, these established models cannot describe corporate governance structures in developing countries. For instance, because of reform and opening-up policy, Chinese firms' ownership constituents have shifted from one dominant state ownership to five modern ownership - state ownership (Lin et al., 2010; Cullinan et al., 2012; Song et al., 2015; Dong et al., 2022; Lo et al., 2022), concentrated ownership (Ma et al., 2010; Zeng, 2010; Clò et al., 2020), insider ownership (Su, 2004; Cheung and Wei, 2006; Cheng et al., 2021), institutional ownership (Hadani, 2012; Schmidt and Fahlenbrach 2017; Lin et al., 2017; Li and Ji, 2021), and foreign ownership (Yoshikawa et al., 2010; Dachs and

Peters, 2014; Kwon and Park, 2018; Dong et al., 2022) - over last four decades. However, the diversity of Chinese corporate ownership does not entirely deny the crucial role of state-owned firms in firm performance and innovation. State ownership is still widely used in China and trusted by ordinary people. Xie et al. (2022) observed that the corporate governance structure model in China no longer converged with the Anglo-Saxon corporate governance structure model. From 2015 to 2017, Chinese SOEs applied an alternative governance model that legalises the governance authority of the CPC over the board of directors through a set of regulatory attempts. The politicised governance model disrupted investor confidence in firms and raised significant concerns about the state's power undermining other shareholders' interests (Xie et al., 2022). Indeed, the politicisation of the governance structure may be a genuine concern for foreign investors. Likewise, Cheng (2021) pointed out that the US system is geared towards allowing businesses to affect the government, while the Chinese system is geared towards aligning businesses with government objectives.

In addition to the ordinary shareholders of listed companies, there is a special category of shareholders in China known as legal persons, which is broadly similar to the status of institutional shareholders recognised in the United States. Their shares are owned by domestic institutions independent of, or partly owned by, the central or local government. In other words, SOEs consist of state-owned and legal person shares. Indeed, a review of the list of shareholders for all Chinese listed firms discloses that the majority of shareholders classified as legal person is, in fact, owners with close ties to the state.

In short, this section deals with five ownership structures – concentrated ownership, insider ownership, state ownership, institutional ownership and foreign ownership - including the link between them and innovation.

2.3.2 Agency Theory for Ownership Structure

2.3.2.1 Introduction of Agency Theory

According to Jensen (2000)'s definition, agency theory assumes that a contractual relationship exists between two conflicting parties: one party is the principal or supervisor (i.e. the principal); the other one is the subordinate (i.e. the agent).

The principal delegates decision-making powers to the agent and expect the agent performs some action in the principal's favour. In contrast, the principal's and the agent's behaviours can be motivated by their self-interest (i.e. preference, conviction and information) because they are considered a rational economic person. Then, agency theory comprises the following issues (Akerlof, 1970; Murthy and Jack, 2014):

1) Asymmetric information: principal-agent problem usually arises when the interests of the two parties are divergent and information is asymmetric (the agent has more information than the principle), so that the principal cannot directly guarantee that the agent's interests always align with the principal's best interests.
2) Moral hazard: moral hazard is likely to happen under information asymmetry. One example is that the agent may lack effort in performing the delegated task, but the principal has difficulty in evaluating the level of effort actually spent by the agent.
3) Adverse selection: this is where an agent misrepresents their skills in performing a task, and the principal is unable to thoroughly check this in advance of deciding to recruit them. To avoid this, the principal may contact the person for whom the agent previously provided services.

In the modern corporation, a firm owner or shareholder is the principal, and a firm manager is the agent. The separation of ownership and corporate control generates agency problems. Agency theory addresses this problem arising from the different objectives or desires between the principal and agent (Berle and Means, 1932; Clark et al., 1985). These differences generate agency cost such as residual loss (Jensen and Meckling,1976). However, it can be mitigated or eliminated by monitoring managers' behaviour or providing them with incentive schemes that reward them financially for maximising shareholder benefits (Boučková, 2015; Feldman and Montgomery, 2015). Typically, the schemes cover the incentive stock plan that managers obtain shares, perhaps at a lower price. Accordingly, the objective of managers is in alignment with one of the shareholders (Jensen and Meckling, 1976). The agency theory, therefore, assumes that people are egoists and suggests that conflicts of interest between principal and agent can be dissipated by providing appropriate incentives or monitoring (Berle and Means, 1932; Jensen and Meckling, 1976).The agency theory therefore assumes that people are egoists and suggests that conflicts of interest between principal and agent can be dissipated by providing appropriate incentives or monitoring (Berle and Means, 1932; Jensen and Meckling, 1976).

2.3.2.2 Problem of Agency Theory in Developing Countries

Traditional agency theory was established to build a foundation for the Anglo-American model, so previous studies of agency theory have mainly focused on developed countries (Young et al., 2008). The emphasis of corporate governance reforms has therefore been on addressing the problems caused by the separation of ownership and control of companies. Nevertheless, some argue that traditional agency models are not applicable to developing countries (Yusuf et al., 2018). It is because firms in developing countries have a relatively high level of concentrated ownership, high family control and mismanagement (Young et al., 2008; Yusuf et al., 2018). Despite such shortcomings, corporate governance reforms based on the agency theory have diffused in developing countries mainly due to the desire of these firms for investments from foreign financial institutions. Accordingly, there is a lack of widespread attention to the issue of inappropriateness arising from corporate governance reforms based on agency theory in developing countries (Yusuf et al., 2018). The inapplicability of agency theory leads to ineffective or inefficient corporate governance reforms in developing countries (Reed, 2002; Uddin and Choudhury, 2008). As an example, in Pakistan, agency theory is weakened by management's opportunism in not being able to use financial incentive schemes to reconcile the interests of the principal and the agent, and by the scarcity of independent directors (Yusuf et al., 2018). He, therefore, recommends the use of rigorous external audits and the appointment of audit firms by the regulator. The other method is to introduce legislation protecting the rights of minority shareholders.

2.3.2.3 Agency Theory and Innovation

According to agency theory, shareholders (i.e. principals) hire managers (i.e. agents) to operate the firm on behalf of the shareholders (Jensen and Meckling, 1976). The growth of firm value is related to shareholders' control power over managers' behaviours and strategies. It is because the agent shrinks his/her responsibilities to the principal whenever the agent has the opportunity because of egoism (Eisenhardt, 1989a). The most capable agent can mitigate a rise in agency risks owing to adverse selection and moral hazard (Jensen, 1993).

Radical technological innovation (RI) may compound the agency risks of adverse selection and moral hazard due to high uncertainty of the link between technology and markets and ignorance of the relationship between technology and market outcome (O'Connor and Rice, 2013). Furthermore, RI requires the pooling of multiple agents to participate in R&D (Winter, 2013), further magnifying information asymmetries and making it difficult to allocate decision-control rights, set appropriate rewards and screen out R&D failures due to management egotism (Aghion and Tirole, 1994). As a result, senior managers may be reluctant to carry out RI in their core business for the concern about disrupting the core business, while creating apprehension among bottom-level employees (Christensen, 1997). Indeed, technical management has always believed that RI should be separated from existing operations and that it should offer risk-averse and middle-level management the autonomy to explore the uncertain routes to growth. (Burgelman, 1991).

In contrast to traditional studies, some studies consider the top manager the principal and the middle manager the agent (Jones and Butler, 1992; Shaikh and O'Connor, 2020). Contrary to agency theory, innovation research usually discourages the usage of financial incentives. The reason is that it can lead to jealousy and enmity among team members, which can ruin a good atmosphere of teamwork. Lazonick (2007) presents an opposite view that most well-established R&D firms make reparation to top managers with options and equity. Those compensation packages can be even higher than those of Wall Street executives (Lazonick and Tulum, 2011). The two opposing views on which Shaikh and O'Connor (2020) are based state that the senior management's use of financial rewards can drive RI project teams to incremental innovation, although the optional non-financial external rewards used can enhance the intrinsic motivation of individual agents to engage in the pursuit of RI at the project level.

2.3.3 Resource-based Theory and Innovation

2.3.3.1 Introduction of Resource-based Theory

The idea of resource-based view was first emerged in Wernerfelt's paper (1984) and evolved into a matured theory about corporate governance in Barney et al.'s paper (2011). The main prospective of resource-based theory is to explain why firms differ and how they achieve sustainable completive advantage based on firm resources and capabilities (Barney et al., 2001). The resources that the firms can apply for implementation of business strategies can be tangible and intangible assets containing physical assets, financial capital, human capital, organizational resources (Barney and Arikan, 2005). The capabilities can be management skills and firms' organisational processes for example (Barney et al., 2011). Faced with rapid technological change, Teece et al. (1997) go further to the idea of "dynamic capabilities" and confirm that firms' specific organisational processes, tangible and intangible assets (knowledge stock) and managerial processes determine the firms' profitability because those three factors significantly affect firms' competencies based on the level of difficulty of replicability (expanding internally) and inimitability (barriers to imitation).

2.3.3.2 Resource-based Theory and Innovation

In developing counties, firms may face resource scarcities and obsolescence. A crucial challenge is to comprehend what impedes firms to acquire resources and capabilities and how they might resolve (Wright et al., 2005). Hence, resource-based theory can be applied to investigate innovation activities in a firm that require valuable and specific resources. Individual firms usually rely on external recourses for innovation as they do not have all needed resources. According to this perspective, the assumption of outside shareholders who have rich resources benefiting innovation activities and firm performance is made. Consequently, firms with state ownership can be seen as boundary spanner. Those firms in developing countries have political and financial privileges over others (Vo, 2018) and provide policy and resource benefit which is crucial for firm development (Zhou et al., 2017). Specifically, state-owned firms can obtain more tradeable or non-tradeable resources - important infrastructure resources (Chang et al., 2006; Siegel, 2007), land (Tan, 2006; Chen et al., 2014), policy support, natural link exists among SOEs, universities and research institutes, or R&D resources (Wang et al., 2017) - to invest in innovation activities.

2.3.4 Concentrated ownership

2.3.4.1 Introduction of Concentrated Ownership

Concentrated ownership means that majority of stock shares are owned by individuals, non-institutional or institutional investors, who have voting rights and/or cash flow rights. Traditionally, the only degree of equity concentration is considered an indicator of concentrated ownership. Usually, investors hold at least 5% of shares. The higher the shares owned by a few investors, the stronger the governance power. It is because larger-block shareholders have strong monitoring power over incumbent managers. As argued by agency theory, shareholders' interests are alignment with managers' interests (Ortega-Argilés et al., 2005), alleviating agency conflicts and reducing agency costs (Jensen and Meckling, 1976; Hill and Snell, 1988; Francis and Smith, 1995; Morck et al., 2005; Belloc, 2012). Consequently, concentrated firms perform better financially than separated ownership (Claessens and Djankov, 1999; Xu and Wang, 1999; Singal and Singal, 2011; Wang et al., 2012; Nguyen et al., 2015).

2.3.4.2 Concentrated Ownership and Innovation

Concentrated ownership has a positive impact on innovation as it lowers agency costs and constrains the behaviour of managers (e.g., Di Vito et al., 2010; Hill and Snell, 1988; Holmstrom,1989; Baysinger et al., 1991; Francis and Smith, 1995; Lacetera, 2001). Specifically, Baysinger et al. (1991) study 176 Fortune 500 companies by using linear regression with R&D spending per employee as a dependent variable and stock concentration levels as an independent variable, meanwhile controlling for average industry R&D intensity, diversification, and firm size. Lacetera (2001) focuses on 27 US pharmaceutical firms from 1994 to 1999 by using the cross-sectional time-series FGLS method with R&D intensity as a dependent variable and ownership concentration, insider shareholding, insider presence in the board of directors, the presence of scientists in the board of directors as independent variables, controlling firm size and financial stability. Di Vito et al. (2010) use panel regression to investigate 259 firms in Canada from 1998 to 2007 with R&D intensity as a dependent variable, concentrated ownership – the level of voting rights, the difference between voting and cash flow rights, heir-controlled, founder-controlled, and family-controlled - as independent variable, and the presence of institutional shareholding, firm age, firm size, firm growth, the long-term debt, and industry dummies. Chang et al. (2006) compare innovation performance in group-affiliated firms and independent firms by collecting the data from the top 500 Taiwanese and Korean manufacturing firms between 1991 and 1999 and performing the Poisson regression and the negative binomial regression model with the number of patents as a measurement of innovation performance. One reason is that controlled owners are more willing to take innovation strategies with high risk even if the possibility of success of an investment project is low, while managers within dispersed ownership prefer imitation strategies with low risk as they undertake the cost of failure (Hill and Snell, 1988). In transition economies, a high degree of concentration provides an efficient monitoring mechanism that is crucial to innovation activities in transition economies (Nguyen et al., 2015). Moreover, shareholders pursue a high return by virtue of greater investment in innovation even though a specific high risk is borne (Hill and Snell, 1988; Baysinger et al., 1991).

In contrast, some studies argue that stock concentration has a negative influence on innovation performance regardless of a country's level of development (Ortega-Argilés et al., 2005; Di Vito et al., 2010; Minetti et al., 2015; Shi and Xie, 2016; Steffen and Iuliia, 2016; Wan et al., 2021). In opposition to the R&D intensity as a measurement of innovation performance (dependent variable), Di Vito et al. (2010) perform the number of patents as the alternative measurement of innovation performance to get the negative impact. Ortega-Argilés et al. (2005) apply the Tobit-type model and the Passion regression model with R&D expenditure per employee and the number of patents as dependent variables respectively to explore in Spanish industries during 2001. The relevant main independent variable is the degree of separation of ownership and management functions, and control variables contain the firm size, firm age, debt, concentrated ownership, a dummy variable for a listed firm or not, technological opportunity level, region in which the firms located, and the structure of the market in which the firms operated. Steffen and Iuliia (2016) analyse 75214 firms from 24 emerging market economies (e.g., Taiwan, Israel, Hungary, South Africa, Brazil, Thailand, Poland, Chile, and Mexico) between 1998 and 2012 by using the fixed effects model with R&D expense as a dependent variable, ownership concentration and the levels of shareholder rights protection as independent variables, sensitivity of cash flow rights, inflation rate, firm size, leverage, and a complementarity effect between the levels of capital and R&D intensity as control variables. Minetti et al. (2015) investigate 20000 Italian manufacturers by using OLS, Probit, two-stage least squares (2SLS) regressions with R&D expenditure, R&D personnel, and the number of patents as main dependent variables, degrees of ownership concentration as the main independent variable, firm age, firm size, number of employees, credit rationing, credit relationship and the duration of the relationship with the main lender (banks), region in which the firms located, number of branches, provincial GDP growth, provincial Herfindahl, and local financial development. Wan et al. (2021) study Chinese firms listed on the Shanghai and Shenzhen Stock Exchanges from 2007 to 2018 by using the pooled cross-sectional regression with R&D intensity as the dependent variable, ownership concentration as the main independent variable, firm size, leverage, firm performance, Tobin's Q, CEO age, cash holdings, operating cash flow, and the nature of the controlling shareholder as control variables. The reasons include agency conflicts between large-block and minority stockholders, risk aversion caused by an absence of diversification, increased risk undertaken by owners, liquidity constraints in the market, and fewer opportunities for negotiation of firm value (Ortega-Argilés et al., 2005; Choi et al., 2011; Minetti et al., 2015). Further, Wan et al. (2021) explain that the tunnelling effect of controlling shareholders disincentives the investment in R&D. By definition, the tunnelling effect is an immoral business behaviour in which large shareholders transfer firm assets or profits to private-owned firms for their benefit at the expense of minority shareholders. Accordingly, an improvement in the regional governance environment can dampen the negative effect of concentrated ownership on innovation performance caused by the tunnelling effect (Wan et al., 2021).

Besides, concentrated ownership and innovation performance are non-linearly related (Abdullah et al., 2002; Gompers et al., 2004). Lee (2005) focuses on listed firms in the US and Japan during 1995 across seven industries - automotive, chemicals, communication, computers, electronics, pharmaceuticals, and power – by using the country-specific and pooled regressions and proposes that the concentration-innovation relationship is not only nonlinear but also nonmonotonic: in the US, ownership concentration is negatively related to innovation outcomes when R&D investment is low, but positively related to innovation when R&D investment is high; in Japan, ownership concentration is positively related to innovation when R&D investment is low, but negatively related to innovation when R&D investment is high. The relevant dependent variable is the number of patents, the independent variable is stock concentration, and control variables consist of contemporaneous R&D expenditures, firm size, market-to-book, leverage, and industry dummies. Li et al. (2010) and Chen et al. (2014) also reveal an inverse U-shape relationship between ownership concentration and innovation in emerging economies such as China by using one-factor, two-factor, and correlated uniqueness models with a seven-point differential scale for product innovation as the dependent variable, concentrated ownership as the independent variable, firm size, region, a industry dummy variable to identify a high-tech industry, sales growth and return on equity, a dummy variable to identify a state-owned firm, firm development stage, and effective production process as control variables. The relevant sample period is from 2002 to 2004. The other reason of non-linear relationship is that the effect of board independence on firm performance rises as the degree of concentration decreases (Li et al., 2015).

2.3.4.3 Concentrated Ownership and Hypothesis

Firms with concentrated ownership have agency costs created from principal-agent objective conflict. The majority shareholders are likely to advance their interests by expropriating from minority shareholders in developing countries (Su et al., 2008). It is not feasible in developed countries where the concentration of ownership may lead to more effective monitoring mechanisms (Fama, 1980; Zajac and Westphal, 1994), but it may not be the case in developing countries. Aside from this, risk aversion due to lack of diversification, increased risk to be borne by owners, liquidity constraints in the market, and reduced opportunities to negotiate the value of the firm can all negatively affect innovation performance for ownership concentration (Ortega-Argilés et al. 2005; Choi et al. 2011; Minetti et al. 2015). In recent research, Wan et al. (2021) raise the issue of the tunnelling effect in Chinese firms, which hurts minority shareholders' interests and undercuts R&D investments. Hence, the following hypothesis is proposed:

H1. *Concentrated ownership and the firm's innovation performance will be negatively related.*

2.3.5 Insider Ownership

2.3.5.1 Introduction of Insider Ownership

Insider ownership is defined as shareholding by individuals closely related to the firm's management and/or individuals with exclusive voting rights. It includes the firm's founders and their descendants, subsidiaries, managers, executive directors and employees (Chang et al., 2006). It then can be grouped into three types of insider ownership – managerial ownership (e.g. Vijayakumaran, 2021), family ownership (e.g. Delgado-García et al., 2022), and employee ownership (e.g. Hennig et al., 2022.).

Firms with insider ownership demonstrate that managers' objectives are aligned with insiders' interests rather than those of dispersed outsider ownership shareholders. Insiders are more aware of the reality of the company than outsiders, especially individual investors (Choi et al., 2012). As a result, a higher firm performance can be achieved for firms with insider ownership (e.g. Drakos and Bekiris, 2010). In other words, insider ownership – managerial ownership (e.g. Jensen and Mecking, 1976; Florackis et al., 2009), family ownership (Chang, 2003; Morck et al., 1988), and employee ownership (e.g. Nickel, 1990; Kim and Patel, 2017) – has a positive impact on company performance owing to the lower agency costs.

Conversely, some studies propose that managerial ownership (e.g. Gomes, 2000; Acharya and Bisin, 2009) and family ownership (e.g. Thomsen and Pedersen, 2000) are negatively correlated to firm performance. Thomsen and Pedersen (2000) provide evidence of firm performance with family ownership destroyed by firm owners who are risk averse.

2.3.5.2 Insider Ownership and Innovation

Those two opposite effects of insider ownership on firm performance also result in reverse views of firm innovation performance.

On the one hand, there is a positive relationship between insider ownership and innovation performance (e.g., Chang et al., 2006; Choi et al., 2011; Chen et al., 2013; Lodh et al., 2014; Minetti, 2015). For example, Lodh et al. (2014) apply an unbalanced panel regression to investigate 395 listed Indian firms on the Bombay Stock Exchange from 2001 and 2008 with number of patents and innovation productivity as the dependent variables, family ownership as the main independent variable, firm size, firm age, knowledge stock, a dummy variable to determine whether the CEO is a member of a founding family, foreign ownership, government ownership, wage intensity, employee compensation, industry dummies, and business risk as control variables. Chen et al.

(2013) investigate Taiwanese listed firms from 1996 to 2007 by using the Tobit regression with R&D expenditure and the number of patents as the dependent variables, a continuous family ownership and a dummy variable to identify the presence of the members of the founding family as the independent variables, firm growth, operating cash flow, the volatility of cash flow, leverage, capital intensity, CEO overconfidence, past firm performance, firm size, firm age, year dummies, and industry dummies as control variables. Song et al. (2015) study 242 listed firms in China during 2009, by using the OLS and Tobit regressions with the ratio of the revenue generated by new products to the total revenue generated by all products as the dependent variable, market orientation, identity of the dominant shareholder, management ownership, and ownership concentration as the independent variable, firm size, firm age, marketing expenditure intensity, R&D expenditure intensity, and industry dummies as control variables. One reason of the positive impact is that the firm owner can have a long-term horizon that increases investment in innovation, because the firm will be passed on to descendants (Caselli and Gennaioli, 2013). Due to the greater concern about the long-term presence of the firm, family ownership has a positive effect on firm innovation (Chen et al., 2013; Lodh et al., 2014; Minetti, 2015). Regarding employee ownership, employees prefer stable jobs by maximising long-term value, thereby seeking technological innovation to increase firm value. Thus, it results in a positive firm innovation performance (Chang et al., 2006). Also, talented human resources are required for innovation activities that employees can participate. Consequently, knowledge diffusion occurs between those employees and others in the firm (Choi, 2012). Finally, managerial ownership magnifies the positive correlation between market orientation and firm innovation, as top managers can change their preferences – time and risk preferences - to be the same as the shareholders' preferences (Song et al., 2015). In this context, the managers can invest in an R&D project that may ensure future performance (Chang, 2003). Hence, managerial ownership benefits firm innovation performance. Kurt et al. (2015) concentrate on 340 large German listed firms between 2000 and 2009 by using the 2SLS regression with the forward citations of patents (innovation output) as the dependent variable, family ownership, family management, and family governance as the independent variables, firm performance, firm size, firm age, firm risk, firm leverage, firm capital intensity, firm intangible assets intensity, industry R&D intensity, and industry investment share as control variables. On the other hand, Decker and Günther (2017), Liu et al. (2017) and Chi (2023) suggest that family ownership and firm innovation are negatively correlated. In contrast to innovation output as the dependent variable used in Kurt et al. (2015)'s paper, the innovation input measured by R&D intensity generates the negative impact of family ownership on innovation input. Decker and Günther (2017) focus on German machine tool industry during 2000 and 2010 by using the Poisson regression and the negative binomial models with the number of patents as the dependent variable, family ownership, family generation, personal family ownership, institutionalised family ownership as the independent variables, firm age, firm size, knowledge stock, population density, the number of potential cooperation partners, the average number of universities and universities of applied sciences in the region where the firm located, and the number of year that firms observed in the buyer's guide as control variables. Chi (2023) investigates 1391 listed firms which are non-financial and non-state-controlled in Taiwan from 2000-2017 by using the fixed effects model with patent counts and citation counts as the dependent variables, family ownership and family control as the independent variables, firm size, investment opportunity, leverage, capital investments, R&D investments, and firm age as control variables. One interpretation of the negative impact is that a family-owned firm's limitation of management capabilities may diminish the company's R&D activities (Graves and Thomas, 2006; Bloom and

Van Reenen, 2010). The other one is that the behaviour of family managers is influenced by informal institutional mechanisms when the goal of the family owner is socio-emotional wealth (Gómez-Mejía et al., 2007; Berrone et al., 2012). As a result, it restricts R&D investment in order to lower business risk (Liu et al., 2017). Thirdly, agency costs, which causes the negative relationship between family ownership and insider ownership, rise from excess control rights, and can alleviate by external shareholders who are also large shareholders and highly expected financing costs (Chi, 2023).

2.3.5.3 Insider Ownership and Hypothesis

Agency theory suggests that insider ownership can lower managerial pressures to maximise short-term values, thereby leading to enhance R&D investment (Choi et al., 2012). In recent years, however, equity pledges have become an increasingly common source of financing for company insiders. Andersonand Puleo (2015) report that between 2006 and 2011, at least one insider pledged their shares in US firms, accounting for 26% of the total sample, with the average insider pledging 33.3% of total equity. Insiders usually pledge equity for two reasons (Dou et al., 2019): (1) insiders obtain funds through equity pledges for personal consumption or investment; and (2) insiders use the funds from equity pledges to purchase shares in their own companies, increasing their control in the firm. According to data from Wang et al. (2020)'s research, most insiders pledge equity for personal investments in China. They find that pledging of equity has made insiders more conservative towards innovative R&D and more reluctant to undertake the cost of R&D failure. Then, the following hypothesis is suggested:

H2. *Insider ownership and the firm's innovation performance will be negatively related.*

2.3.6 State Ownership

2.3.6.1 Introduction of State Ownership

The definition of state ownership is the percentage of shares in a firm held by central or regional governments and various entities connected with the government. The existence of state ownership is imperative to maintain customers' benefits with lower prices, adjust anti-inflation or expansion (Marrelli et al., 1998; Willner, 2003), and substitute for markets that lack private-owned firm capital (Marrelli et al., 1998).

Most studies reveal that state ownership is positively related to firm performance (Vernon-Wortzel and Wortzel, 1989; Xu and Wang, 1999; Sun and Tong, 2003; Jiang et al., 2008; Song et al., 2016). Hence, one interpretation is that market competitiveness is insufficient in developing countries, which can be cured by the public intervention (Willner, 2003). Further, multiple research argues for a less positive view of government-owned firms during the privatisation process because of the divergence of objectives (e.g. Dewenter and Malatesta, 2001; Cornett et al., 2010).

Boycko et al. (1996) refute that state ownership benefits firm performance. They point out that state-owned firms seek social and political goals rather than profit maximisation. Excess employment, for example, is one of the results if the managers comply with politicians' objectives. Additionally, jobs sourced from state-owned firms are given priority to candidates who have a political connection (Krueger, 1990). Thus, problems arising from the state-owned firm's inefficiency (Ikenberry, 1990) and political failure (Boycko et al., 1996) lower firm performance, which is supported by empirical studies with regard to the negative (e.g. Lin et al., 2009) or non-linear relationship (e.g. Yu, 2013; Hess et al., 2010) between state ownership and firm performance. Nonetheless, state-owned firms do not always mean inefficiency (Kay and Thompson, 1986; Vernon-Wortzel and Wortzel, 1989; Willner, 2003).

2.3.6.2 State ownership and Innovation

A critical role is played by the government in facilitating innovation capacity (Schaaper, 2009; Fan, 2011; Franco and Leoncini, 2013; Lo et al., 2022l; Wang and Jiang, 2021) and developing a firm's innovation activities (Johnson, 1982; Amsden, 1989; Haggard, 1994). Distinct institutional settings can generate different technological capabilities among countries (Mahmood and Singh, 2003) and affect firm strategy and innovation process (Hobday, 2005). For instance, a firm performs better in Korea as technology innovation is specialised, while diversified technological innovation produces a better firm performance in China (Bong Choi and Williams, 2013).

In developing countries such as China, governments develop innovation capabilities indirectly via direct intervention (i.e. direct funding and tax incentives) and by facilitating the interaction of key implementers (i.e. government research institutions, higher education and the business sector) in science and technology activities (Schaaper, 2009).

At the firm level, the government is not only portrayed as an investor but also as a resource allocation coordinator (Xu and Zhang, 2008). Some studies suggest a positive relationship between state ownership and firm innovation (e.g., Chen et al., 2022. Choi et al., 2011; Choi et al., 2012; Yi et al., 2017; Li and Xia, 2008; Lo et al., 2022; Xu and Zhang, 2008). For example, Choi et al. (2011) focus on 548 Chinese listed firms across eight industries - automotive, chemicals, communication, electronics, machinery, pharmaceuticals, textiles, and power industries – from 2001 to 2004 by using the Poisson and negative binomial models with the number of patents as the dependent variable, state ownership as the main independent variable, firm size, firm profitability, sales growth, firm age, leverage, long-term investment, knowledge stock, public A-shares, and sectoral context as control variables. Choi et al. (2012) investigate 301 Korean listed firms from 2000 to 2003 by performing the negative binomial model with patent data as the dependent variable, state ownership as the independent variable, firm size, firm profitability, sales growth, firm age, leverage, R&D intensity, business groups, and technology sector as control variables. Chen et al. (2022) take a sample of all Chinese listed firms during a period of 2009-2017 by using the chain multiple of mediating effects models with patent counts as the dependent variable, a continuous state ownership, a dummy variable for state-owned firms, and the ratio of state ownership to non-state ownership as the independent variables, government subsidies as mediating varaible, firm characteristics and external environmental factors -firm size, firm age, profitability, leverage, cash holding, tangible assets, executive shareholding ratio, board size, board independence, cultural diversity of the board social trust and environmental regulations - as control variables. Lo et al. (2022) concentrate on Chinese listed firms between 2007 and 2018 by using OLS, Tobit, PSM regression models with patent data as the dependent variable, percentage of state ownership in the top three shareholders and a dummy variable for state-owned enterprises (SOEs) as the independent variables, firm size, political connection, firm age, leverage, firm profitability, the mode of assets utilisation, the growth prospects, financing constraints, a dummy variable for the chairman of the board as well as the top manager, management ownership, concentrated ownership, institutional ownership, the intensity of research and development in the industry, and industry dummies as control variables. The first advantages of SOEs in firms' innovation activities are political, financial and resource-related privileges (Chen et al., 2023). Specifically, the government offers exclusive endorsements and treatment to SOEs in the context of weak intellectual property right (IPR) protection (Sheng et al., 2011), which means SOEs obtain better IPR protection than other types of firms (Wang et al., 2012). Secondly, SOEs are given priority over non-SOEs in allocating government R&D expenditure toward developing China's national innovation, which plays an important institutional role (Sun and Liu, 2014). Thirdly, innovation is full of uncertainty and high risks. Long-term capital is necessary because innovation has a long payback period and a high failure rate (Choi et al., 2011, 2012). SOEs can get support from government subsidies or put administrative restrictions on rivals. It then encourages SOEs to take more risks (Kornai et al., 2003; Chen et al., 2023). Fourthly, SOEs have access to important infrastructure resources if policies encourage or discourage certain types of development. SOEs then benefit from priority rights as well as being used to promote government-initiated innovation (Chang et al., 2006; Siegel, 2007). Fifthly, the limited availability of land and high real estate prices indicate significant constraints on innovation activities that require large R&D centres, but this is not a problem for state-owned enterprises (e.g. Tan, 2006). Sixthly, in China, tax incentives for product innovation (i.e. 50%) and intangible asset inventions (i.e. 150%) can be obtained through approval by the tax authorities. Due to political connections, SOEs are more likely to receive tax incentives than other enterprises, and so that the former spend less on R&D than the latter. It allows for higher profits. At the same time, the ample resources and preferential treatment that SOEs receive from the government can lessen the risk aversion of top management in their R&D investments and provide an incentive for them to invest more in creating new knowledge. Most national and provincial research projects in China are carried out by SOEs, universities or a combination of both. The government can easily supervise the process of these research projects and assess innovation outputs and economic benefits, which helps SOEs achieve higher performance (Ruiqi et al., 2017). Seventhly, a majority of Chinese universities and research institutions are state-controlled and governed, and so they have some natural links with SOEs. Motohashi and Yun (2007) 's research indicate that over 30% of surveyed SOEs actively outsource science and technology activities to universities and public research institutions. SOEs can benefit from university-industry collaboration to obtain complementary capabilities that can diminish R&D risks, thereby enhancing innovation performance and firm performance (Eom and Lee, 2010; George, Zahra and Wood, 2002). Eighthly, SOEs rely on their close ties with the government to gain access to advanced technology and management experience, as well as the scientific talent they need, as a way to increase the efficiency of the use of R&D resources performance (Wang et al., 2015; Ruiqi et al., 2017). Ninthly, SOEs are also more likely to receive purchase orders from the government, which greatly assists in the commercialisation of R&D product performance (Ruiqi et al., 2017).

Conversely, some researchers find state ownership is negatively related to firm innovation (e.g., Ayyagari et al., 2011; Vo, 2018). Vo (2018) study Vietnam-listed and non-financial firms from 2007 to 2015 by using the linear regression with risk taking behaviour as the dependent variable, sate ownership as the independent variable, firm size, firm fixed assets, firm cash holdings, and firm age as control variables. Ayyagari et al. (2011) investigate 19,000 firms across 47 developing economies between 2002 and 2004 by applying the logit probability model with the aggregate Innovation Index, Core Innovation, or eight individual indicators of firm innovation as the dependent variable, state ownership as the main independent variable, firm size dummies, firm age, legal status, number of establishments, industry dummies, country dummies, and capacity utilization as control variables. One reason is that while government subsidies enhance firms' innovation, excessive government subsidies diminish the positive or even negative impact on firms' R&D, implying a waste of resources (Yi et al., 2021). This is mainly due to the fact that, in the interest of continued government resource support, firms with large government subsidies prioritize their R&D strategies and resource allocation, including specific technological and production goals, to meet governmental concerns rather than to build up and improve their own innovative capabilities (Rhee and Leonardi, 2018).

2.3.6.3 State ownership and Hypothesis

In the latest research on SOEs, Lo et al. (2022) reaffirm the importance of state ownership for firm innovation. At the firm level, the advantages of state ownership contain political, financial and resource-related privileges (Zhou et al., 2017). Drawn on the literature review in chapter 2, the following hypothesis is recommended:

H3. *State ownership and the firm's innovation performance will be positively related.*

2.3.7 Institutional Ownership

2.3.7.1 Introduction of Institutional Ownership

Institutional ownership is defined as the proportion of ownership owned by financial institutions. There are various types of institutional owners -mutual funds, hedge funds, pension funds, investment advisers, bank trusts, insurance companies and venture capital (Chen et al., 2007).

In general, institutional investors are mainly sophisticated professional investors whose primary purpose is to earn long-term profits for their clients (Connelly et al., 2018). Institutional owners often work directly or indirectly with their companies due to the size of their holdings, their investment strategies, their influence on financial markets, and their failure to sell underperforming firms (Edmans and Holderness, 2017). Direct engagement refers to the direct involvement of the institution in the discussion of the firm's direction and strategy by the firm's senior management, and such direct engagement serves as a core competitive advantage for institutional investment services (Healey and Mintz, 2021). Indirect engagement means that the ability of institutions to motivate firms and enforce discipline is critical to stimulating and promoting strategic actions and processes that they believe are beneficial to the company (Brav et al., 2008). Healey and Mintz (2021, p.840) list five ways in which institutions are typically utilised to indirectly influence firms: “the appointment of board members, (ii) risk oversight, (iii) adjustment of executive compensation, (iv) implementation of corporate governance structures, and (v) public criticism of the firm either via announcements in the media or support of shareholder proposals”. In sum, institutional investors are enabled to leverage decision-making in the business. Furthermore, institutional investors (as majority shareholders) can monitor effectively at a lower agency cost than minority shareholders, thus positively impacting firm performance (Pound, 1988; McConnell and Servaes, 1990; Lin and Fu, 2017). As argued by the active monitoring view, managers have greater pressure from institutional investors to maximise shareholder value (Shleifer and Vishny, 1986). Financial institutions have an incentive of large equity stakes to monitor for the sake of remitting agency problems and lowering information asymmetries that hinder innovation (Minetti et al., 2015). Accordingly, empirical studies demonstrate that institutional ownership is positively correlated to firm value (McConnell and Servaes, 1990; Lin and Fu, 2017; Healey and Mintz, 2021).

2.3.7.2 Institutional Ownership and Innovation

Likewise, the positive impact of institutional ownership on firm performance, institutional ownership is also positively correlated to innovation performance (Berger et al., 2014; Choi et al., 2011; Eng and Shackell, 2001; Fan et al., 2023; Miller et al., 2022; Mishra, 2022; Opler and Sokobin, 1997; Rong et al., 2017). For example, Choi et al. (2011) focus on 548 Chinese listed firms during 2001 and 2004 by using the Poisson and negative binomial models with the number of patents as the dependent variable, institutional ownership as the main independent variable, firm size, firm profitability, sales growth, firm age, leverage, long-term investment, knowledge stock, public A-shares, and sectoral context as control variables. Rong et al. (2017) study Chinese listed firms from 2002 to 2011 by using the OLS, fixed effects, 2SLS, and Gaussian mixture models with patent and citation counts as the dependent variables, institutional ownership as the independent variable, Tobin's Q, return on asset, leverage, year dummies, industry dummies, and firm dummies as control variables. Miller et al. (2022) study the listed firms in the US from 1991 to 2008 by applying the linear regression with patent counts and citation counts as the dependent variables, monitoring institutional ownership as the independent variables, firm size, firm age, capacity intensity, labour productivity and quality, profitability, stock performance, growth opportunities, cash holdings, capital structure (leverage), stock volatility, institutional block ownership, four-digit SIC Herfindahl Index and its squared term as control variables.

Chi et al. (2019) find that only mutual funds as one type of institutional investors positively affect firm innovation, other types of institutional investors consisting of insurance company, pension fund and Qualified Foreign Institutional Investor have less positive or no impact on firm innovation. This paper contains a sample of non-financial listed firms in China during a period of 2001-2004. It uses fixed effects models with patent data as the dependent variables, a categorical variable for three types of institutional ownership (i.e., mutual funds, insurance company and pension fund, and foreign institutions) as the independent variables, ownership concentration, state control, a dummy variable for the CEO position holding by the board of chair, board dependence, the number of board meetings, profitability, sales growth rate, cash holding, leverage, firm size, a dummy variable for a firm listed on the ChiNext board, and region as control variables.

Mishra (2022) concludes a positive impact of institutional ownership on firm innovation if the institutional ownership is below the threshold and turns into a negative impact if the institutional ownership is above the threshold. The research scope is the number of firms to the non-financial and non-utility firms listed in the Standard & Poor's (S&P)

1500 in 2005, and the sample period is from 2000 to 2018. It applies Tobit and cross-lagged structural models with R&D intensity and knowledge capital as the dependent variables, institutional ownership as the independent variable, firm size, financial slack, financial leverage, firm-specific risk, Tobin's q, CEO tenure, firm diversification, and market concentration as control variables.

That kind of a positive effect of institutional ownership on firm innovation can be attributed both to effective agency oversight (by agency theory) and to the role of the agency in protecting managers from the risk of dismissal (by management career considerations) (Bushee, 1998; Minetti et al., 2015; Miller et al., 2022). In addition to measures such as monitoring mechanism, institutional investors in emerging markets can even threaten invested firms to exit the firms to further minimise agency conflicts compared to developed markets (Chi et al., 2019). In this case, managers are unlikely to reduce R&D so as to turn around declining earnings, when the level of institutional ownership is high (Bushee, 1998). Furthermore, institutional investor networks contribute firm innovation and gain more patents compared to their counterparts (Fan et al., 2023).

Mishra (2022) disagrees with this view, arguing that managers scale back R&D investment when institutions retain a high level of ownership. This behaviour of a reduction in R&D investment depends on the proportion of institutional ownership. When institutional ownership is below the threshold, R&D investment and institutional ownership are positively correlated, but the opposite is true when it is above the threshold. To elaborate, when institutional shareholding exceeds a certain threshold, managers will succumb to pressure from institutions, resulting in management short-sightedness. Short-sightedness refers to maximising the short-term value for managers rather than the long-term value (Bushee, 1998). The cause may be that institutional investors only hold shares for a short period, resulting in a short-term horizon (Minetti et al., 2015). In contrast, long-term institutional ownership signals a shift from financial investment to an investment in the firm's future, helping reassure managers. Directly, there is a positive influence of the stability of institutional investors' shareholdings on the relationship between institutional ownership and innovation (Sakaki and Jory, 2019). Moreover, active or passive monitoring depends on the types of institutional investors, the shareholdings of institutional investors, stress sensitivity and institutional investors from national or international firms (Lin and Fu, 2017; Sakaki and Jory, 2019; Mishra, 2022).

2.3.7.3 Institutional Ownership and Hypothesis

Institutional investors monitor the behaviour of managers either explicitly or implicitly through governance activities or by gathering information on the quality of R&D investments respectively (Bushee, 1998). Active monitors may help managers get rid of concerns about R&D failure, motivate innovation and pursue long-term value (Monks and Minow 1995). That kind of a monitoring role becomes even more critical as the incumbent management is weakened (Fung, 2012). Even though financial institutions are under-developed in emerging countries compared to those well-developed and dispersed institutional ownership in US listed firms, Rong et al. (2017) state that institutional investors have a positive impact on innovation performance, which comes mainly from mutual funds. Thus, the following hypothesis is proposed:

H4. *Institutional ownership and the firm's innovation performance will be positively related.*

2.3.8 Foreign Ownership

2.3.8.1 Introduction of Foreign Ownership

Foreign ownership is defined as a firm owned or controlled by an individual who is not a citizen of that country or by a firm not headquartered in that country. There are six types of foreign investments in China: (1) Chinese-Foreign Equity Joint Ventures; (2)

Chinese-Foreign Contractual Joint Ventures; (3) Wholly Foreign-Owned Enterprise; (4) Share Company With Foreign Investment; (5) Foreign Invested Holding Company; (6) Joint Exploitation.

Most studies note that foreign ownership is positively correlated to firm performance and productivity(e.g. Srholec, 2009; Yang and Tsou, 2020; Xu et al., 2022). It is primarily due to foreign firms having larger equity stakes, higher commitment, and long-term engagement (Douma et al., 2006). Furthermore, foreign direct investment (FDI) contributes to domestic firms' productivity and indirectly affects local firms' productivity in vertically related industries. It is facilitated by technological knowledge, management practices and governance influences being transferred among foreign and domestic firms, thereby creating new business linkages. This phenomenon is so-called the spillover effects of FDI (Singhania et al., 2015).

2.3.8.2 Foreign Ownership and Innovation

Most papers discover a positive relationship between foreign ownership and innovation performance (Srholec, M., 2009; Choi et al., 2012; Gu et al., 2020). For example, Choi et al. (2012) investigate 301 Korean listed firms between 2000 and 2003 by using the negative binomial model with patent data as the dependent variable, foreign ownership as the independent variable, firm size, firm profitability, sales growth, firm age, leverage, R&D intensity, business groups, and technology sector as control variables. Srholec (2009) focuses on 46000 firms in industry and market services from 12 European Union members – Belgium, Bulgaria, Czech Republic, Estonia, Germany, Latvia, Lithuania, Norway, Portugal, Romania, Slovakia and Spain – between 1998 and 2000 by using the probit regression model with a dummy variable for whether the firm has innovation activity (e.g., new product innovation, process innovation) and dummy variables for the firm cooperated with national, foreign partners or both as the dependent variables, foreign ownership as the independent variable, firm size, a dummy variable for whether a firm exports to the foreign market, a dummy variable for whether a firm was established during the sample period, and industry dummies as control variables. The main reason of the positive impact is the spillover effects of FDI. As previously discussed, domestic firms can enhance their R&D capabilities by acquiring advanced foreign knowledge through foreign investment (Singhania et al., 2015). In emerging economies, knowledge transfer from multinational companies is a vital strategic resource for domestic firms to improve their performance in technological innovation (Choi et al., 2012). Even if foreign firms prevent the diffusion of knowledge in order to maintain their competitive advantage (Jiang et al., 2013), it does not help (Srholec, M., 2009). Moreover, global resources are another benefit of foreign investment. Many multinational companies often attempt to strengthen their competitiveness in the global market by finding low-cost or technologically complementary resources in foreign markets. Resources in markets are equally important to local firms (Choi et al., 2012). Furthermore, Gu et al. (2020) argue that foreign banks can enhance information environments and diminish agency problems for firms, thereby stimulating firm innovation (e.g. increased quantity and quality of patent applications) within an economy where government intervention is intense, and investor protection is insufficient.

Dong et al. (2022) show that foreign ownership negative affects the relationship between innovation and export by considering the sample of Chinese manufacturing firms with a sample period of 2000-2007. They employ the linear regression with export performance as the dependent variable, patent counts, patents adjusted by firm size, and the share of new product sales in total sales as the independent variables, state ownership and foreign ownership as moderators, firm size, firm age, total factor productivity, leverage, marketing capability, tangible resources, international openness, marketization, regional dummies, industry dummies, and time dummies as control variables. This negative moderating effect is mainly because innovation in multinational companies strongly rely on parent companies or research centres located in other country. In other words, those foreign investments from multinational companies to the domestic country are principally for production not innovation (Dong et al., 2022).

2.3.8.3 Foreign Ownership and Hypothesis

Spillover effects contribute to domestic firms improving R&D capabilities through foreign investment (Singhania et al., 2015). Knowledge transfer from multinational companies is a vital strategic resource for domestic enterprises to improve their technological innovation performance in emerging economies (Choi et al., 2012). The diffusion of that kind of knowledge is difficult to restrict, even if foreign companies are intent on obstructing it (Srholec, M., 2009). In particular, foreign investors can mitigate agency problems for firms in markets where government intervention is intense and investor protection is insufficient (Gu et al., 2020). Consequently, the following hypothesis is proposed:

H5. *Foreign ownership and the firm's innovation performance will be positively related.*

2.4 Depth and Breadth of Knowledge

2.4.1 Introduction

Knowledge is crucial to the survival, growth and innovation of a business (Healey and Mintz, 2021; Yu and 2021). On the basis of knowledge being scarce, non-tradable and non-imitable, with no equivalent substitutes, a firm's knowledge base becomes the foundation for maintaining its competitive advantage (Grant, 1996). Firm performance differences depend primarily on their knowledge base (Grant, 1996). In order to maintain a competitive advantage in a knowledge-rich industry, firms must constantly increase their knowledge base through substantial investments (Xu and Cavusgil, 2019). The accumulation of a knowledge base depends on the evaluation of new alternative knowledge and the assimilation of new knowledge with known knowledge, which ultimately facilitates the successful creation of new products (Cohen and Levinthal, 1990; Arora and Gambardella, 1994). So the quality of innovation depends on a firm's absorptive capacity (that is, its ability to assess, absorb and use new knowledge) (Abecassis-Moedas and Mahmoud-Jouini 2008; Tortoriello 2015). Hence, a firm's knowledge base is the most valuable asset.

To build up the knowledge base, a firm can accumulate knowledge by exploring new areas of knowledge (i.e. breadth of knowledge) or deepen understanding and enrich knowledge by intensifying knowledge in known fields (i.e. depth of knowledge). By definition, breadth is the wider range of innovation knowledge, and depth is the more specialised innovation knowledge. The breadth of knowledge is related to innovation diversity, while the depth of knowledge is related to innovation quality (Lodh and Battaggion, 2015). Apart from internal R&D, firms can obtain knowledge from strategic alliances and acquisitions. (Lin and Wu, 2010).

Research on innovation in recent years has placed an in-depth emphasis on the importance of developing the technical breadth and depth of knowledge (e.g. Lin and Wu, 2010; Lodh and Battaggion, 2015; Yu and Yan, 2021).

2.4.2 Depth of Knowledge

Conceptually, depth of knowledge encompasses two meanings that possess complementary characteristics. One is the knowledge base owned by the firm itself, and the other is the relative competitiveness of the firm's knowledge base against that of its competitors (Lin and Wu, 2010). With regard to the three ways of acquiring knowledge, Lin and Wu's (2010) research suggest a focus on internal R&D to build up knowledge in the company's core areas when the depth of knowledge is low. Conversely, knowledge acquisition should be shifted to cross-firm alliances and acquisitions when the firm's depth of knowledge is high.

2.4.2.1 Advantages of Depth of Knowledge

Firstly, the exploration of the depth of knowledge helps firms to effectively identify the value of new knowledge and improve their absorptive capacity (Yang et al., 2017). As a result, it is easier to find paths to new product success (Caner and Tyler 2015; Ferreras-Méndez et al. 2015) to identify gaps between its own technology and the latest technology in the industry (Zahra and George, 2002), and to be more aware of current market trends (Roberts and Adams 2010; Tsai et al. 2013) than a firm with a weak knowledge base, for example.

Secondly, if a company focuses on exploring the depth of knowledge, it can assimilate and integrate external knowledge with a deep knowledge base (Yang et al., 2017). It is because knowledge from external sources can be substantially different from the firm's own knowledge, making it difficult to understand and assimilate external knowledge (Jimenez-Castillo and Sanchez-Perez, 2013).

Thirdly, only those with a deep understanding and know-how can effectively use newly acquired knowledge, as knowledge is intangible and difficult to document explicitly. A deep knowledge base contributes to the commercialisation and exploitation of knowledge (Zhou et al., 2009) and lays the foundation for product and process optimisation and improvements (Healey and Mintz, 2021).

Fourthly, the depth of knowledge base can be a sustainable competitive advantage for the firm because of the moat created by asset mass efficiency and time compression diseconomies (Dierickx and Cool, 1989). Lin and Wu (2010, p.583) define asset mass efficiency and time compression diseconomies: "Asset mass efficiencies come from the effect that the more assets a firm has, the lower the marginal cost of producing further additions to the asset stock. Time compression diseconomies come from the effect that asset accumulation cannot be rushed." Although a company's knowledge base is an intangible asset that is not documented on the balance sheet, it is known as a strategic asset for successful companies.

2.4.2.2 Disadvantages of Depth of Knowledge

Firstly, the marginal benefit of exploring the depth of knowledge is diminishing (Katila and Ahuja, 2002). If improvements along the technology trajectory reach their limits, the benefits gained from subsequent product development will increase at a diminishing rate. Further development based on the same knowledge gets more expensive, and the solution becomes more complex, finally resulting in the costs of exploring the depth of knowledge outweighing the benefits.

Secondly, too much focus on the depth of knowledge exploration may not only enable a firm to be an unbeatable industry leader but also irreparably damage it (Katila and Ahuja, 2002). Knowledge gained from over-exploration of existing knowledge can become obsolete when disruptive or radical technological breakthroughs emerge in the industry. Technologies or strategies that once gave a company a competitive lead can become problems that need to be solved (Leonard, 1995). Argyris and Schon (1978) point out that companies may try to hide or hinder disruptive or radical innovation in order to maintain the status quo.

2.4.3 Breadth of Knowledge

The exploration of the breadth of knowledge allows firms to acquire and assimilate technical information from a variety of sources. In detail, a firm with a wide knowledge domain is more aware of a diverse customer base and multiple market segments than a firm with a narrow knowledge domain (De Luca and Atuahene-Gima 2007). In a highly competitive industry, companies are used to learning and imitating the knowledge of other companies for their R&D activities. The more complex the knowledge domain becomes, the more product innovation relies on acquiring external knowledge (Carayannopoulos and Auster, 2010).

2.4.3.1 Advantages of Breadth of Knowledge

Firstly, the exploration of the breadth of knowledge adds new elements to the firm's knowledge domain, and thus brings new inspiration for innovation (Katila and Ahuja, 2002) and enabling the firm to integrate relevant technologies in a more sophisticated way (Bierly and Chakrabarti, 2009; Srivastava and Gnyawali, 2011).

Secondly, an increase in the knowledge domain increases a firm's ability to adapt to technological changes in relevant areas and enhances its flexibility to change its strategy (Volberda, 1996; Srivastava and Gnyawali, 2011). It addresses the core rigidity problem posed by knowledge over-exploration (i.e. the second disadvantage of knowledge exploration discussed in sub-section 2.4.2.2).

2.4.3.2 Disadvantages of Breadth of Knowledge

Firstly, the limited resources of a firm constrain the exploration of the breadth of knowledge. Excessive pursuit of knowledge breadth may suppress a firm's knowledge accumulation and development in specific areas (Lausen and Salter, 2006; Zhou and Li, 2012). An increase in knowledge breadth may divert too many firm resources to different areas, with only a tiny piece of resources allocated to each area. It results in inferior innovation outcomes (Xu, 2015). Yang et al. (2017) suggest that the impact of the breadth of knowledge on new product performance depends on the depth of knowledge. If the depth of knowledge is high, the breadth of knowledge will have a positive impact on the new product and vice versa.

Secondly, the cost and complexity of integrating new knowledge become higher as the breadth of knowledge expands (Grant， 1996).

2.4.4 Hypotheses for Innovation Specialisation and Innovation Diversification

2.4.4.1 Concentrated Ownership

If the level of concentrated ownership is high, the majority shareholder pursues a diversification strategy to reduce the risk taken and to achieve personal goals rather than value maximisation. When shareholder rights are not adequately protected, concentrated ownership and diversification exhibit a quadratic U-shape, unlike the linear correlation observed in legally sound markets (Del Brio et al., 2011). However, Parigi and Pelizzon (2008) argue that when large shareholders are able to transfer profits, they will not be interested in diversifying their investments and instead focus back on repurchasing firm shares, and the firm's ownership structure becomes concentrated. However, a less diversified investment also means less potential for innovative diversification. In China, listed firms are characterised by a concentration of shareholdings, insufficient protection of minority shareholders' rights, and tunnelling accordingly (Wang et al., 2020). Therefore, the following hypothesis is proposed:

H6a: *The higher the level of concentrated ownership, the higher the level of innovation specialisation.*

H6b: *The higher the level of concentrated ownership, the lower the level of innovation diversification.*

2.4.4.2 Insider Ownership

Chen and Ho (2000) point out that a low level of insider ownership gives rise to agency problems, which means that the interests of managers are not aligned with those of insiders. It causes significant value loss due to diversity, whereas it is not found at a high level of insider ownership.

Nonetheless, insider ownership contributes to diversification due to 1) agents seeking to increase their reputation and value in the company (Shleifer and Vishny, 1989) and 2) the second generation of family-owned firms having more resources to diversify than the founders of the first generation of firms (Weng and Chi, 2019).

H7a: *The higher the level of insider ownership, the lower the level of innovation specialisation.*

H7b: *The higher the level of insider ownership, the higher the level of diversity of innovation diversification.*

2.4.4.3 State Ownership

In general, SOEs are more likely to favour diversification than non-SOEs (Guthrie, 1997; Li et al., 1998). The first reason is that SOEs are more likely to have access to political resources and financial support, which can contribute to the successful implementation of a diversification strategy (Lu and Yao, 2006). The second point is that diversification weakens the negative impact of the external market environment on the company (Lee and Hooy, 2018) or helps the firm establish the resources and capabilities that are the firm's core competencies (Keister, 1998). The third point is that the government generally appoints the managers of SOEs with a high level of state ownership, and the political connections of the managers also positively influence diversification to a large extent (Li et al., 2012). Fourthly, managers appointed by the government do not have enough incentives and professional knowledge to effectively supervise firm development or pursue profit maximisation. In this situation, the diversification strategy allows that kind of manager to pursue personal interests or other non-profit objectives (such as seeking a large firm size) (Delios et al., 2008). Thus, the following hypothesis is proposed:

H8a: *The higher the level of state ownership, the lower the level of innovation specialisation.*

H8b: *The higher the level of state ownership, the higher the level of innovation diversification.*

2.4.4.4 Institutional Ownership

Institutional ownership has a positive impact on diversification for the following reasons: 1) long-term stable institutional investors (Jafarinejad et al., 2015); and 2) effective monitoring mechanisms, especially active monitors, can mitigate diversification discounts (Singh et al., 2004; Hartzell et al., 2014). Moreover, the lower the diversification discount, the more willing institutional investors are to have extensive research, increase profits, and remain competitive in an increasingly globalised market. Thus, the following hypothesis is proposed:

H9a: *The higher the level of institutional ownership, the lower the level of innovation specialisation.*

H9b: *The higher the level of institutional ownership, the higher the level of innovation diversification.*

2.4.4.5 Foreign Ownership

On the one hand, foreign ownership plays a positive role in innovation specialisation. In particular, the foreign parent company, through the rational deployment of resources, allows different subsidiaries to innovate and specialise in a particular area, and ultimately the subsidiary takes a firm foothold in the industry's value chain (Collinson and Wang, 2012).

One the other hand, firms face localisation issues when growing their business in other countries (Hitt et al., 2000). Foreign firms are at a disadvantage compared to local firms in terms of local resources, suppliers and end sellers (Gaur and Kumar, 2009). Especially in the service sector, business operations rely heavily on social networks Yang et al. (2017). As an example, they point out that foreign hotels in China are not as familiar with Chinese business practices and their social networks are not as strong as local hotels, resulting in higher transaction or operational costs associated with diversification. As a result, firms are reluctant to undertake diversification when the level of foreign ownership is high. The lower the level of foreign ownership, the more willing the company is to diversify (Yang et al., 2017). This is primarily due to the local advantage. Hence, the following hypothesis is suggested:

H10a: *The higher the level of foreign ownership, the higher the level of innovation specialisation.*

H10b: *The higher the level of foreign ownership, the lower the level of innovation diversification.*

2.5 Fresh Insights from Previous Literature

The previous sub-sectors have reviewed relevant theories and empirical literature about the impact of firm ownership on innovation performance. First, this thesis examines the relationship between firm ownership and innovation performance based on previous literature (e.g., Chi, 2023), but with an updated sample period of 2013 – 2019. This sample period is mainly because the year 2013 is the beginning of the fifth round of SOE reform (Lin et al., 2020). Second, Mishra (2022) focuses on the threshold of institutional ownership and concludes that intuitional ownership below or above the threshold is positively or negatively related to firm innovation, respectively. This thesis then extends the idea of threshold to all five ownerships. Compared to many previous literature measures ownership structures (independent variable) as a continuous variable or a binary variable for whether the firm belongs to a particular firm ownership (e.g., Chen et al., 2013; Lo et al., 2022), firm ownership is a categorical variable with different levels of percentage of firm ownership. Thus, it will show the different impacts of firm ownership on innovation performance based on different levels of firm ownership. Third, Bong Choi and Williams (2013) propose that a firm performs better in Korea as technology innovation is specialised, while diversified technological innovation produces better firm performance in China. Based on the concepts of innovation specialisation and innovation diversification, this thesis concentrates on how firm ownership affects firm innovation specialisation or innovation diversification.

2.6 Summary

This chapter reviews the literature with regard to the concepts of innovation and firm ownership and considers the importance of knowledge for innovation. The impact of firm ownership on innovation performance varies with political contexts, market environments, corporate environments, internal and external resources, et cetera. The role of knowledge in the innovative growth of firms comes from two aspects – depth of knowledge and breadth of knowledge. Also, this section presents hypotheses related to the relationship between firm ownership and innovation performance, firm ownership and innovation specialisation, and firm ownership and innovation diversification, based primarily on the literature review.

In sum, hypotheses on firm ownership and innovation performance will be tested first with continuous and categorical ownership structures (i.e., first and the second contribution) as follows:

(1) **H1.** *Concentrated ownership and the firm's innovation performance will be negatively related.*

(2) **H2.** *Insider ownership and the firm's innovation performance will be negatively related.*

(3) **H3.** *State ownership and the firm's innovation performance will be positively related.*

(4) **H4.** *Institutional ownership and the firm's innovation performance will be positively related.*

(5) **H5.** *Foreign ownership and the firm's innovation performance will be positively related.*

Then, five ownership structures will be tested against the depth of innovation and diversity of innovation (i.e., the third contribution), respectively, as follows:

H6a: *The higher the level of concentrated ownership, the higher the level of innovation specialisation.*

H6b: *The higher the level of concentrated ownership, the lower the level of innovation diversification.*

H7a: *The higher the level of insider ownership, the lower the level of innovation specialisation.*

H7b: *The higher the level of insider ownership, the higher the level of diversity of innovation diversification.*

H8a: *The higher the level of state ownership, the lower the level of innovation specialisation.*

H8b: *The higher the level of state ownership, the higher the level of innovation diversification.*

H9a: *The higher the level of institutional ownership, the lower the level of innovation specialisation.*

H9b: *The higher the level of institutional ownership, the higher the level of innovation diversification.*

H10a: *The higher the level of foreign ownership, the higher the level of innovation specialisation.*

H10b: *The higher the level of foreign ownership, the lower the level of innovation diversification.*

Chapter 3 Data and Methodology

3.1 Introduction

Section 3.2 is about the sample and data. Sector 3.3 discusses all variables used in the models. Section 3.4 contains the research models, methods for mitigating endogeneity, and robustness tests.

3.2 Sample and Data

To practically evaluate the relationship between firm ownership and innovation performance in China, this thesis collects data from all Chinese firms listed on the Shanghai Stock Exchange between 2013 and 2019. This sample period is mainly because the year 2013 is the beginning of the mixed ownership reform. Financial data and the data on ownership structures are collected from firm annual reports and China Securities Market. Patent data are obtained from China's State Intellectual Property Office. However, some firms which do not have R&D expenditures or patent data are removed. Besides, this thesis is interested in the non-financial firms only. Hence, it leaves 1409 firms and 8518 firm-year observations.

3.3 Variables

3.3.1 Dependent Variables

Dependent variable is innovation performance, which is difficult to quantify and compare, yet it is crucial to choose appropriate measurement since reliable information about innovation activities and outcomes is required for data analysis (Michie, 1998).

The conclusion might not be the same if different measures of innovation had been used. Unfortunately, there are no widely accepted measures because of the various dimensionality of innovation (Kline and Rosenberg, 1986; Smith, 2005). Kuznets (1962) classifies the measurement of innovation into two groups: (1) measures of input; (2) measures of output.

3.3.1.1 Measures of Input

For the investigation of the relationship between firm ownership and innovation, R&D intensity is a widely acceptable indicator of innovation input (e.g., Abbas et al., 2022; Di Vito et al., 2010; Kurt et al., 2015; Lacetera, 2001), as input measurement measures the amount of innovation drive business invests in. In this thesis, R&D intensity is defined as the ratio of R&D expenditure to the firm's total sales. Since R&D investment is crucial for firms to pile up greater technological and market capabilities and subsequently increase innovation performance, R&D expenditure is a reasonable indicator of innovation investment (Matzler et al., 2015). Moreover, R&D intensity is not only able to control size effects and heteroscedasticity, but also easy to compare different firms' innovation performance (Barker and Mueller, 2002; Chen and Hsu, 2009). Other popular R&D measurements contain R&D expenditure (Chen et al., 2013; Minetti et al., 2015; Steffen and Iuliia, 2016), R&D expenditure per employee (Baysinger et al., 1991), and R&D personnel (Minetti et al., 2015).

3.3.1.1.1 Advantages of R&D measurement

R&D data is publicly available and is regularly collected by the State. In addition to sector-specific data, time series are also available. National researchers usually use the data for cross-national, cross-sector and cross-firm comparisons (Kleinknecht et al., 2002).

3.3.1.1.2 Disadvantages of R&D measurement

Aghion and Tirole (1994) argue that assessment of R&D activities may give a too limited view of innovation, since the R&D has been represented as different actors with conflict purposes in existing economic literature. Secondly, R&D is an innovation input that may not be an essential factor for producing innovative products or processes, thereby overestimating innovation intensity (Flor and Oltra, 2004; Becheikh et al., 2006). Thirdly, not all innovations are generated from research laboratories, which means they can be solutions to a specific challenge or ideas innovators suddenly got. As a result, R&D data underestimates innovation activities, which excludes those that emerged from non-R&D investments (Michie, 1998; Kleinknecht et al., 2002; Edquist and Zabala, 2015). Fourthly, large firms have an advantage over small and medium enterprises (SMEs), because SMEs tend to have informal and occasional R&D efforts compared to large companies, thereby underestimating innovation intensity (Kleinknecht, 1987; Kleinknecht et al., 2002).

3.3.1.2 Measures of Output

For the investigation of the relationship between firm ownership and innovation, patent data measured by $\ln(1 + the\ number\ of\ patents)$, due to the possibility of highly skewed patent counts (e.g., Chen et al., 2022; Chi et al., 2019; Wan et al., 2021). Output measurement measures the effectiveness of innovative investments in achieving the desired results. Patent is a document issued by a sovereign state and granted to an inventor if the invented product or process is a novelty and has potential utility. It excludes rights for others except the inventor to use this product or process for a limited period (Comanor, 1964). Patent data is usually applied to measure innovation output (Griliches, 1990) since it is a proper proxy for innovation outcomes (Kamien and Schwartz, 1982).

For the investigation of the relationship between firm ownership and innovation specialisation, the depth of innovation (*Depth*) is measured by Herfindahl-Hirschman Index (HHI). HHI is usually to measure the market concentration. The higher the HHI, the higher the market concentration (Kvålseth, 2018). In this thesis, the depth of innovation measured by HHI is to find out the concentration rate of patent in one category for a firm. In this case, State Intellectual Property Office (SIPO) in China typically classifies patents into eight groups (i.e. A – H), as shown in the following table.

Table 3.1 International Patent Classification (IPC)

Section	Classification
A	Human necessities
B	Performing operations; Transportation
C	Chemistry; Metallurgy
D	Textiles; Papers
E	Fixed constructions
F	Mechanical engineering
G	Physics
H	Electricity

As a result, the depth of innovation is calculated by HHI based on patent data:

$$Depth\ (HHI) = \sum_{i=1}^{8} \left(\frac{n_i}{N}\right)^2 \qquad (3.1)$$

where

n_i is the number of patents in the i^{th} section of IPC for a firm;

N is the total number of patents for a firm.

The higher the HHI, the more concentrated the types of patents.

For the investigation of the relationship between firm ownership and innovation diversification, the diversity of innovation (*Diversity*) is measured by the entropy. The lower the entropy coefficient, the greater the diversified innovation. As we can see, entropy is the other measurement of concentration. The reason for not using 1 minus HHI to measure the diversity of innovation is that HHI has already been applied to measure the depth of innovation, and hence, the statistical inferences of the diversity of innovation are converse to the ones of the depth of innovation.

The Shannon entropy coefficient as an alternative measurement of concentration is (Shannon, 1948):

$$ED = \sum_{j=1}^{N} p_j Ln\left(\frac{1}{p_j}\right) = -\sum_{j=1}^{N} p_j Ln(p_j) \qquad (3.2)$$

where p_j is the percentage of type j.

The properties of entropy coefficient are as follows (Hart, 1971; Bandt, 2020):

- $ED \geq 0$: ED is 0 when $p_j = 1$ (i.e., all products are concentrated in one type), because $1 \times \log(1) = 0$. It means entropy coefficient is 0 when there is high concentration. Also, ED is 0 when $p_j = 0$, becuase $0 \times \log(0) = 0$. Consequently, ED is non-negative.
- $ED \leq \ln(J)$: ED is $\ln(J)$ when $p_j = \frac{1}{N}$ for all j, which means the number of products is equal in all types.

In order to avoid the ED of 0 if all products are in one type and use it for measuring diversification, the entropy coefficient based on patent data is modified by exponential function (Jost, 2006):

$$Diversity = MED = \exp\left[\sum_{j=1}^{8} \frac{n_j}{N} Ln\left(\frac{N}{n_j}\right)\right] \qquad (3.3)$$

where

n_j is the number of patents in the j^{th} section of IPC in Table 3.1 for a firm;

N is the total number of patents for a firm.

The higher the value of MED, the higher the diversification.

3.3.1.2.1 Advantages of Patent Data

Firstly, the patent database is rich in data and time-honoured. Secondly, the patent database is open to the public and electronically categorised by field of technology, allowing easy access to detailed information on patents and citation analysis to assess their relative importance (Kleinknecht et al., 2002).

3.3.1.2.2 Disadvantages of Patent Data

The first shortcoming is that the patent system is not the same across countries. Second, some innovations may not be patentable, especially for software (Griliches, 1990; Michie, 1998). Third, the tendency to patent differs among sectors (Griliches, 1990; Archibugi and Sirilli, 2001). The reasons can be high patenting expenses, complicated patenting procedures, or the quick diffusion process of new technology (Mansfield, 1985; Michie, 1998). Hence, some enterprises apply other proper approaches to protect their innovation outcomes, for example, industrial secrecy (Archibugi and Pianta, 1996; Michie, 1998; Kleinknecht et al., 2002). Fourth, patent quality varies significantly (Kamien and Schwartz, 1982; Griliches, 1990; Griffith et al., 2006). Fifth, patent data is more like a measure of invention instead of innovation (Coombs et al., 1996; OECD, 1997; Flor and Oltra, 2004). Becheikh et al. (2006) explain that innovation is the transformation of an invention into a merchantable new or improved product or process. Hence, measuring the number of patents granted may lead to an overestimation of innovation outcome, if invented products or processes which have not been marketable are included in patent data.

3.3.1.3 R&D Intensity vs Patent Data

Both R&D intensity and patent data are used as the dependent variable in the models. It is because innovation covers, but is not limited to, research and development. R&D is only the first step in the innovation process. Since innovation is hard to quantify, R&D and patent data are used to measure and compare the innovation, giving investors and researchers an intuitive sense of innovation performance. In other words, R&D intensity is innovation input and patent data is innovation output. Nevertheless, Acharya and Xu (2017) argue that the patent data can be more effectively reflect the actual innovation output for a firm than R&D measurements. One reason is that the patents are listed on China's State Intellectual Property Office when the firms have applied for them, and thus, the number of patents for a firm each year is calculated based on the patent application year. It is because the year of application is closer to when the innovation was made (Griliches, 1990). Furthermore, innovation input has a higher likelihood of endogenous problem than innovation output (Leten et al., 2007; Van de Vrande et al., 2011). Additionally, innovation inputs (e.g., R&D intensity) do not always generate innovation outputs (e.g., patents) (Dong et al., 2022; Tavassoli, 2018).

3.3.2 Independent Variables

To test Hypotheses 1 - 10, this thesis portrays the specific features of the firm's ownership structure. The shares of Chinese listed firms are differentiated into A-shares, B-shares, H-shares, N-shares and S-shares, due to where the shares are listed and the investors they are exposed to. A-shares are issued by companies registered in China for subscription and trading in RMB by domestic institutions, organizations or individuals (excluding Taiwan, Hong Kong and Macau investors). B-shares are also issued in China by companies registered in China, but unlike A-shares, they are issued with a nominal value in RMB but subscribed and traded in foreign currencies, and listed and traded on Chinese stock exchanges. H-shares, N-shares and S-shares refer to foreign stocks registered in mainland China, but listed in Hong Kong, New York and Singapore respectively (Li et al., 2006; Arslan-Ayaydin et al., 2022.).

By the specific characteristics of the firm's ownership structure in China, ownership structures are measured in the following table. The reason to contain all types of shares (i.e., A-shares, B-shares, H-shares, N-shares and S-shares) is to take individual investors and organisations from foreign countries (Choi et al., 2011).

Table 3.2 Independent Variables

Independent Variables	Description	Literature	Hypothesis
Concentrated Ownership	Sum of squared of firm shares owned by top 5 large shareholders	Kvålseth (2018)	H1, H6a and H6b
State Ownership	Proportion of firm shares owned by all levels of government, its related agencies and solely state-owned enterprise in top 10 largest shareholders	Chen et al. (2022); Chi et al. (2019)	H3, H8a and H8b
Insider Ownership	Proportion of firm shares owned by managers, directors, supervisory board members and workers in top 10 largest shareholders	Chang et al. (2006); Choi et al. (2011)	H2, H7a and H7b
Institutional Ownership	Proportion of firm shares owned by financial institutions in top 10 largest shareholders	Choi et al. (2011); David et al. (2006)	H4, H9a and H9b
Foreign Ownership	Proportion of firm shares owned by foreign corporation and institutional investors (from different types of shares except A Share) in top 10 largest shareholders	Choi et al. (2011)	H5, H10a and H10b

3.3.3 Control Variables

There are several variables controlled in the thesis. Firm size is measured by total assets of the firm to proxy for how firm size affects its innovation (e.g., Miller et al., 2022; Minetti et al., 2015; Wan et al., 2021). Firm *age* is measured by the number of years that a firm was established to account for the effect of a firm's life cycle on firm innovation (e.g., Chen et al., 2023; Miller et al., 2022; Decker and Günther, 2017). Knowledge stock is measured by the total number of accumulated patents during the period from the year of establishment to year 1 to capture how the number of patents accumulated affects innovation ability for a firm (e.g., Choi et al., 2011; Decker and Günther, 2017; Lodh et al., 2014). *Leverage* is estimated by the ratio of total debt to total assets (debt ratio) to take the impact of capital structure on innovation into account (e.g., Steffen and Iuliia, 2016; Wan et al., 2021). *Profitability* is measured by the ratio of net income and total assets (named as return on assets) to account for operating profitability (e.g., Choi et al., 2011; Lo et al., 2022). *R&D intensity* is measured by ratio of R&D expenditure to the firm's total sales to take innovation input into account for innovation output (e.g., Steffen and Iuliia, 2016), and hence, this control variable is only available for the patent data as the dependent variable. *Industry* dummy variables in the following table distinguish different sectors that firms belong to (e.g., Di Vito et al., 2010; Lee, 2005; Lodh et al., 2014; Wan et al., 2021).

Table 3.3 Dummy Variables

Dummy Variable Code	Dummy Variable Description	Number of Firms
1	Agriculture, forestry, animal husbandry and fishery	14
2	Mining industry	53
3	Manufacturing industry	1440
4	Electricity, heat, gas and water production and supply industry	83
5	construction industry	55
6	Wholesale and retail trade	103
7	Transportation, warehousing and postal industry	80
8	Accommodation and catering industry	5
9	Information transmission, software and information technology services	148
10	Real estate	61
11	Leasing and business services	21

Continued

12	Scientific research and technical service industry	40
13	Water conservancy, environment and public facilities management industry	35
14	Education industry	5
15	Health and social work	2
16	Culture, sports and entertainment industry	31
17	Comprehensive industry	7

3.4 Research Model

3.4.1 Firm ownership and Innovation performance

If Y_{it} is the R&D intensity of firm i at time t and X_{kit} is the kth explanatory variable of firm i at time t, the model can be described as the following equation to test Hypotheses H1-H5:

$$R\&D\ intensity_{it} = \alpha + \beta_1 ownership_{i,t-1} + \beta_2 \ln(size)_{i,t-1} + \beta_3 age_{i,t-1} + \beta_4 knowledge_{i,t-1} + \beta_5 leverage_{i,t-1} + \beta_6 industry_{i,t-1} + \beta_7 Profitability_{i,t-1} + \beta_8 ln(invest)_{i,t-1} + \varepsilon_{it} \qquad (3.4)$$

$$Patent_{it} = \alpha + \beta_1 ownership_{i,t-1} + \beta_2 \ln(size)_{i,t-1} + \beta_3 age_{i,t-1} + \beta_4 knowledge_{i,t-1} + \beta_5 leverage_{i,t-1} + \beta_6 industry_{i,t-1} + \beta_7 Profitability_{i,t-1} + \beta_8 ln(invest)_{i,t-1} + R\&D\ intensity_{i,t-1} + \varepsilon_{it} \qquad (3.5)$$

where

- $ownership_{it}$ is firm ownership for firm i at time t.
- $\ln(size)_{it}$ is log of firm size for firm i at time t. Since the value of firm size is too large compared to other values of variables. For example, firm size of Dongfeng Motor Corporation in 2013 was too big (i.e. ¥20191845033.17), but

the relatively concentrated ownership was too small (i.e. 61% in 2013). Then, the estimated parameters α and β from the model looks inharmonious. The estimated parameters for firm size can be too small compared to others. Consequently, the logarithm is used, that is ln $(Size)$.

- age_{it} is firm age for firm i at time t.
- $knowledge_{it}$ is knowledge stock for firm i at time t.
- $leverage_{it}$ is the total debt and firm size ratio for firm i at time t.
- $industry_{it}$ is dummy variables for firm i at time t.
- $Profitability_{it}$ is profitability for firm i at time t.
- $ln(invest)_{it}$ is log of long-term investment. The reason of taking natural logarithm is discussed above in ln $(size)_{it}$.

Since innovation input (i.e., R&D intensity) and innovation output (i.e., patent) are applied in this thesis to examine the relationship between firm ownership and innovation, equations (3.4) and (3.5) are both for the research question (1) in Chapter 1. For research questions 1 and 2 in Chapter 1, both continuous and categorical variables for firm ownership are used in equations (3.4) and (3.5). Most studies employ continuous variable for firm ownership (e.g., Chen et al., 2022), but it may generate a problem if the relationship between firm ownership and innovation is actually non-linear or only has a significant influence when the percentage of firm ownership is above or below the threshold (e.g., Mishra, 2022). Hence, for the second contribution in this thesis, a categorical variable of firm ownership is used to find out the threshold. Firm ownership is grouped by:

- Zero Level: the percentage of firm ownership = 0%
- Low Level: 0% < the percentage of firm ownership < 5%
- Medium Level: 5% < the percentage of firm ownership < 20%
- High Level: 20% < the percentage of firm ownership < 100%

Two reasons for choosing 5% and 20% to be thresholds are as follows:

1) Appendix A displays histograms of five ownership structures. All five histograms indicate a positive skewness, because the data is more often piled up below 20%. Hence, 20% is taken as a threshold.
2) Listed Company Takeover Measures announced by the China Securities Regulatory Commission (CSRC) mention that once an investor's shares reach 5% of the issued shares of a listed company, each increase or decrease in shareholding needs to be reported and announced to the CSRC. Therefore, 5% is taken as a threshold.

In particular, concentrated ownership is measured by HHI, so that it is a non-zero variable. Hence, only three levels of concentrated ownership exist – low level, medium level, and high level. As opposed to other ownership structures, there are only three levels of concentrated ownership.

3.4.2 Firm Ownership and Innovation Specialisation

The third research question is to investigate the relationship between the depth of innovation and firm ownership at time t. The regression model is as follows to test Hypotheses H6a – H6a:

$$Depth_{it} = \alpha + \beta_1 ownership_{i,t-1} + \beta_2 R\&D\ intensity_{i,t-1} + \beta_3 \ln\ (size)_{i,t-1} + \beta_4 age_{i,t-1} + \beta_5 knowledge_{i,t-1} + \beta_6 leverage_{i,t-1} + \beta_7 Profitability_{i,t-1} + \beta_8 \ln\ (invest)_{i,t-1} + R\&D\ intensity_{i,t-1} + \varepsilon_{it} \qquad (3.6)$$

One thing that needs to be confirmed is that firm ownership (*ownership*) is a categorical variable in this case, and the levels of firm ownership for this categorical variable are shown in sub-sector 3.4.1. Apart from the concentrated ownership, there are four levels of firm ownership – zero level, low level, medium level, and high level. The categorical variable of concentrated ownership only has three levels – low, medium, and high. Also, HHI measures the depth of innovation as discussed in sub-sector 3.3.1.2. Innovation is more specialised as the level of firm ownership is higher than the baseline.

3.4.3 Firm ownership and Innovation Diversity

The fourth research question in Chapter 1 is to investigate the relationship between the diversity of innovation and firm ownership at time t. The regression model is as follows to test Hypotheses H6b - H10b:

$$Diversity_{it} = \alpha + \beta_1 ownership_{i,t-1} + \beta_2 R\&D\ intensity_{i,t-1} + \beta_3 \ln{(size)}_{i,t-1} + \beta_4 age_{i,t-1} + \beta_5 knowledge_{i,t-1} + \beta_6 leverage_{i,t-1} + \beta_7 Profitability_{i,t-1} + \beta_8 \ln{(invest)}_{i,t-1} + R\&D\ intensity_{i,t-1} + \varepsilon_{it} \qquad (3.7)$$

Again, ownership is a categorical variable as discussed in sub-sector 3.4.1.

The diversity of innovation is calculated by entropy coefficient as discussed in sub-sector 3.3.1.2. Based on the equation 3.4, the higher the value of *diversity* is, the higher degree of diversification is.

3.4.4 Controlling for Endogeneity

Since panel regression is used in this thesis, Hausman Specification (HS) test is applied to determine fixed effects model or random effects model is preferred (Hausman, 1978). In practice, endogeneity is a common problem for researchers (e.g., De Silva, 2023, Gao et al., 2019; Tang et al., 2022), and may be caused by omitted variables, such as government policies that facilitate firm innovation, R&D investment persistence and reverse causality (Chi et al., 2019; Kang et al., 2017; Gao et al., 2019; Mishra, 2022). Lack of recognition and treatment of endogeneity can lead to inconsistent and biased estimated coefficients, incorrect interpretations, or even erroneous findings (Bascle, 2008). To eliminate endogeneity in the regression models, this thesis lags firm ownership and control variable by one period, referring to Chen et al. (2022), Gao and Zheng (2020), Li et al. (2021) and Mishra (2022).

3.4.5 Robustness Tests

Robustness tests are performed to confirm the stability of the estimated coefficients in the regression models, which would have changed if this had not been done. There are four regression models (i.e., equations (3.4) – (3.7)) to test all hypotheses, and hence, there are four robustness tests. First, the change in R&D intensity, using the difference in R&D intensity between the current year and last year divided by R&D intensity in the last year as the dependent variable, can be employed to test the relationship between firm ownership and innovation performance (equation (3.4)). Second, the change in the number of patents for a firm, which is estimated by the ratio of the difference in patent counts between the current and last year to patent counts in the last year as the dependent variable, can be used to test the relationship between firm ownership and innovation performance (equation (3.5)) (Chi et al., 2019). Third, Shannon entropy shown in sub-sector 3.3.1.2 is one of the measurements for concentration (Shannon, 1948), and hence, can proxy for HHI to measure innovation specialisation so as to check the robustness of the estimated coefficients in the equation (3.6). Fourth, $^{1}/_{HHI}$ can be an alternative measurement for the innovation diversification (Jost, 2006), as HHI is a measurement for innovation specialisation as discussed in sub-sector 3.3.1.2.

3.5 Summary of Research Methodology

This chapter discusses sample and data, all variables, and research models. Endogeneity may arise from empirical work and can be solved by lagged ownership and lagged control variables. Besides, robustness tests make sure the robustly estimated coefficients in the regression models.

Chapter 4 Empirical Investigation into Ownership - Innovation Relationships

4.1 Introduction

This chapter performs empirical inquiries into the relationships between ownership structure and innovation performance. It reports the empirical results from modelling the relationships by testing the hypotheses developed in chapter 3. Specifically, it investigates the effects of firm ownership on innovation performance. It goes further to examine the impacts of firm performance on the depth of innovation and the diversification of innovation. Empirical findings are summarised and discussed with implications for management and research. In the following, section 4.2 reports descriptive statistics, offering a general outlook of the sample companies in ownership structure and innovation activities. Whereas section 4.3 present, analyse and discuss the modelling results.

4.2 Descriptive Statistics and Summary Data

4.2.1 Introduction of Descriptive Statistics and Summary Data

This thesis analyses data from firms listed on the Shanghai Stock Exchange between 2013 and 2019. The data were obtained from firm annual reports and Patent Search and Analysis of State Intellectual Property Office. There are totally 1409 firms.

4.2.2 Descriptive Statistics and Summary Data of Variables

Table 4.1 expresses Descriptive Statistics and Summary Data for independent variables and dependent variables. Independent variables contain five ownership structures.

The mean of state ownership is 24.58%, and the median is 16.28%. 75% of total observations is about 47%, which is a substantially high percentage compared to other firm ownership. It is almost twice as high as the second-highest third quartile (i.e. concentrated ownership). Besides, state ownership has the highest mean and median among the five ownership structures, which discloses the ongoing dominance of SOEs in China.

The mean of insider ownership is 7.38%, and the median is 0.01%. The third quartile is 2.12%, which reveals a large number of firms in China without insider ownership or only with a small piece of insider ownership.

The mean of foreign ownership is 4.70%, and the median is 0%. The upper quartile of foreign ownership (1.06%) is even less than insider ownership. The fewest firms with foreign ownership as opposed to other corporate ownership.

The mean of institutional ownership is 13.53%, and the median is 6.87%. 75% of data points have a level less than 20%.

The mean of concentrated ownership is 18.10%, and the median is 15.26%. The upper quartile is 25.29%, which exhibits that Chinese firms are highly concentrated to some extent.

There are three dependent variables - R&D intensity, depth of innovation and diversity of innovation.

The mean of R&D intensity is just 2.55%, and the median is 1.31%. The third quartile is as small as 3.71%. The third quartile is as small as 3.71%, which signifies a low degree of investment in R&D by listed companies.

The mean of the depth of innovation is 0.61, and the median is 0.54. The degree of innovation specialisation ranges from 0 to 1, with the third quartile at 0.81 - a considerable proportion of firms focus on a single area of R&D.

The mean of the diversity of innovation is 1.79, and the median is 1.69. The upper quartile is 2.05.

Table 4.1 Descriptive Statistics and Summary Data for Independent and Dependent Variables

	Mean	Standard Deviation	Minimum	Maximum	25%	50%	75%
State Ownership	24.58%	25.72%	0%	95.26%	0%	16.28%	47.42%
Insider Ownership	7.38%	16.48%	0%	89.99%	0%	0.01%	2.12%
Foreign Ownership	4.70%	12.05%	0%	88.55%	0%	0%	1.06%
Institutional Ownership	13.53%	16.89%	0%	90.99%	2.05%	6.87%	17.76%
Concentrated Ownership	18.10%	12.93%	0.002%	79.42%	8.24%	15.26%	25.29%
R&D Intensity	2.55%	4.37%	0	169.43%	0.0004%	1.31%	3.71%
Depth of Innovation	0.61	0.24	0.19	1	0.41	0.54	0.81
Diversity of Innovation	1.70	0.46	1	2.76	1.37	1.69	2.05

4.2.3 Comparison of Means

As explained in sub-section 4.4.8, the firm ownership is assigned to four levels:

- Zero Level: the percentage of firm ownership = 0%
- Low Level: 0% < the percentage of firm ownership ≤ 5%
- Medium Level: 5% < the percentage of firm ownership ≤ 20%
- High Level: 20% < the percentage of firm ownership ≤ 100%

Table 4.2 indicates the means of R&D intensity, depth of innovation, and diversity of innovation for each level of firm ownership.

Table 4.2 Means of Independent and Dependent Variables with Different Levels of Ownerships Structure

		R&D Intensity	Depth of Innovation	Diversity of Innovation
State Ownership	Zero (0%)	0.0344	0.6472	1.6202
	Low (0% < Ownership ≤5%))	0.0317	0.6191	1.6724
	Medium (5% < Ownership ≤20%)	0.0254	0.6294	1.6517
	High (≥20%)	0.0180	0.5643	1.7890
Insider Ownership	Zero (0%)	0.0170	0.6081	1.6972
	Low (0% < Ownership ≤5%))	0.0224	0.5830	1.7544
	Medium (5% < Ownership ≤20%)	0.0418	0.6269	1.6571
	High (≥20%)	0.0468	0.6437	1.6224
Foreign Ownership	Zero (0%)	0.0257	0.6168	1.6785
	Low (0% < Ownership ≤5%))	0.0266	0.5771	1.7662
	Medium (5% < Ownership ≤20%)	0.0241	0.5965	1.7334
	High (≥20%)	0.0236	0.5964	1.7257
Institutional Ownership	Zero (0%)	0.0304	0.6204	1.6672
	Low (0% < Ownership ≤5%))	0.0246	0.5822	1.7545
	Medium (5% < Ownership ≤20%)	0.0272	0.6111	1.6907
	High (≥20%)	0.0222	0.6341	1.6494

Continued

Concentrated Ownership	Zero (0%)	-	-	-
	Low (0% < Ownership ≤5%))	0.0292	0.6432	1.6249
	Medium (5% < Ownership ≤20%)	0.0276	0.6203	1.6727
	High (≥20%)	0.0213	0.5784	1.7626

a) Comparison of Means for State Ownership

The mean of R&D intensity in Table 4.2 decreases as the level of state ownership increases.

Non-state ownership has the highest value of innovation specialisation (i.e. 0.6472). The medium level comes next (i.e. 0.6294), followed by the low level (i.e. 0.6191). The high level produces the least value for innovation specialisation (i.e. 0.5643)

Conversely, the high level ranks first in innovation diversification (i.e. 1.7890). The low level has the second largest value of innovation diversification (i.e. 1.6724), followed by the medium level (i.e. 1.6517). The lowest value of innovation diversification is zero level (i.e. 1.6202). In terms of the mean value of innovation diversification alone, SOEs are more diversely innovative than non-SOEs.

b) Comparison of Means for Insider Ownership

Regarding insider ownership, the mean of R&D intensity increases as the level of insider ownership increases in Table 4.2.

Apart from the zero-level, the higher the insider ownership, the more specialisation in innovation. However, insiders at a low level are reluctant to specialise in innovation, as opposed to non-insider ownership.

In turn, except for the zero level, the higher the insider ownership, the less innovative diversification.

c) Comparison of Means for Foreign Ownership

The highest mean value of R&D intensity in Table 4.2 is the low-level foreign ownership (i.e. 0.0266), followed by the zero-level (i.e. 0.0257). The third is the medium-level (i.e. 0.0241), and the fourth is the high-level (i.e. 0.0236).

At low levels, foreign ownership recorded the highest mean in terms of innovation diversification (i.e. 1.7662). The next highest is the medium level (i.e. 1.7334), followed by the high level (i.e. 1.7257). Finally, the fourth is the zero level (i.e. 1.6785).

It suggests that firms prefer innovation diversification with foreign ownership rather than those without foreign ownership.

d) Comparison of Means for Institutional Ownership

Non-institutional ownership ranks first in R&D intensity (i.e. 0.0304) in Table 4.2. The medium level of institutional ownership has the second highest R&D intensity (i.e. 0.0272). The next is the low level (i.e. 0.0246). The last one is the high-level (i.e. 0.0222). Interestingly, non-institutional investors are more willing to innovate than institutional investors.

Excluding the zero-level, the higher the institutional ownership, the more the innovation specialisation is preferred. Unless institutional ownership is above 20%, non-institutional investors are more active in innovation than institutional investors.

Except for the zero-level, the higher the institutional ownership is, the lower the innovation diversification is. A high-level institutional ownership is less devoted to innovative diversity than non-institutional ownership

e) Comparison of Means for Concentrated Ownership

Since the HHI index measures concentrated ownership, it is a non-zero measurement. Therefore, there is no value for R&D intensity, innovation specialisation, and innovation diversification at zero level of concentrated ownership in Table 4.2. Only three levels of concentrated ownership are available, unlike other firm ownership.

The higher the level of concentrated ownership, the lower the R&D intensity, on average.

The depth of innovation increases as the level of concentrated ownership decreases.

In contrast, the greater the concentration of ownership, the greater the willingness of firms to diversify in innovation.

4.2.4 Comparison of Means by ANOVA

Table 4.3 shows that all p-values from the ANOVA tests are less than 5%, thus rejecting the null hypothesis at the 5% level. Hence, the means for all four levels of R&D intensity, depth of innovation and diversity of innovation are significantly different, excluding concentrated ownership. Moreover, three levels of concentrated ownership have also significantly different means for R&D intensity, depth of innovation and diversity of innovation.

Table 4.3 P-values from ANOVA

	R&D Intensity	Depth of Innovation	Diversity of Innovation
State Ownership	0.0000	0.0000	0.0000
Insider Ownership	0.0000	0.0000	0.0000
Foreign Ownership	0.0000	0.0015	0.0001
Institutional Ownership	0.0000	0.0000	0.0000
Concentrated Ownership	0.0000	0.0000	0.0000

4.2.5 Comparison of Means by Post-Hoc Analysis

In order to know how three/four levels of ownership structures differ in means of three variables (i.e. R&D intensity, the depth of innovation, and the diversity of innovation), Post-Hoc analysis was applied with Tukey-Kramer because sample sizes for each level of five ownership structures are wildly different as shown in Appendix B. In addition to concentrated ownership, there are six pairwise comparisons for the other four firm ownership (i.e. Low vs Zero, Medium vs Zero, High vs Zero, Medium vs Low, High vs Low and High vs Medium). However, due to non-zero values of concentrated ownership, it only has three pairwise comparisons (i.e. Medium vs Low, High vs Low and High vs Medium).

The p-values of pairwise comparisons are indicated in Appendix C. Table 4.4 exposes which pairwise comparison has significantly different means of three variables at the 5% level. 'Yes' indicates a significant difference, whereas 'No' is the opposite.

Table 4.4 Pairwise Comparisons (Significantly Different Means or Not)

		R&D Intensity	Depth of Innovation	Diversity of Innovation
State Ownership	Low - Zero	No	No	No
	Medium - Zero	Yes	No	No
	High - Zero	Yes	Yes	Yes
	Medium – Low	No	No	No
	High – Low	Yes	Yes	Yes
	High - Medium	Yes	Yes	Yes
Insider Ownership	Low - Zero	Yes	Yes	Yes
	Medium - Zero	Yes	No	No
	High - Zero	Yes	Yes	Yes
	Medium – Low	Yes	Yes	Yes
	High – Low	Yes	Yes	Yes
	High - Medium	No	No	No
Foreign Ownership	Low - Zero	No	Yes	Yes
	Medium - Zero	No	No	No
	High - Zero	No	No	No
	Medium – Low	No	No	No
	High – Low	No	No	No
	High - Medium	No	No	No
Institutional Ownership	Low - Zero	Yes	No	Yes
	Medium - Zero	No	No	No
	High - Zero	Yes	No	No

Continued

	Medium – Low	No	Yes	Yes
	High – Low	No	Yes	Yes
	High - Medium	Yes	No	No
Concentrated Ownership	Medium - Low	No	No	No
	High - Low	No	Yes	Yes
	High - Medium	No	Yes	Yes

a) Post-Hoc Analysis for State Ownership

Table 4.4 demonstrates a significant difference in the mean R&D intensity of those four pairwise comparisons: medium and zero, high and zero, high and low, and high and medium. In addition, other variables have significantly different means in those three pairwise comparisons: high and zero, high and low, and high and medium. It discloses that the means of all variables for the high-level state ownership are significantly different from the other levels.

The pairwise comparisons ' Low vs Zero' and 'Medium vs Low' do not exhibit any significant difference in R&D intensity, innovation specialisation and diversification.

b) Post-Hoc Analysis for Insider Ownership

For R&D intensity, only the comparison between the high-level and the medium-level insider ownership says 'No' in Table 4.4, while all other pairwise comparisons say 'Yes'. Accordingly, the means of R&D intensity for insider ownership are significantly different from non-insider ownership, regardless of the level of insider ownership.

The other two variables - the depth of innovation and the diversity of innovation - have significantly different means in the following comparisons: (1) 'Low and Zero'; (2) 'High and Zero'; and (3) 'Medium and Low'.

c) Post-Hoc Analysis for Foreign Ownership

None of the pairwise comparisons in Table 4.4 displays any difference in the mean of R&D intensity for foreign ownership. Of the six pairwise comparisons, only the low-level and the zero-level differed significantly in the mean values of innovation specialisation and diversification.

d) Post-Hoc Analysis for Institutional Ownership

For institutional ownership, there is a significant difference in the mean R&D intensity of those three pairwise comparisons in Table 4.4: low and zero, high and zero, and high and medium. Moreover, both innovation specialisation and diversification significantly differ in the means between medium and low levels as well as high and low levels.

e) Post-Hoc Analysis for Concentrated Ownership

A significant difference in the means of all variables, except R&D intensity, was found in comparing the high level of concentrated ownership to the other two levels. On the other hand, R&D intensity does not differ significantly for the three levels of concentrated ownership in Table 4.4.

4.2.6 Summary of Descriptive Statistics and Summary Data

This section compares the various levels of firm ownership across the three variables involving R&D intensity, innovation specialisation and innovation diversification.

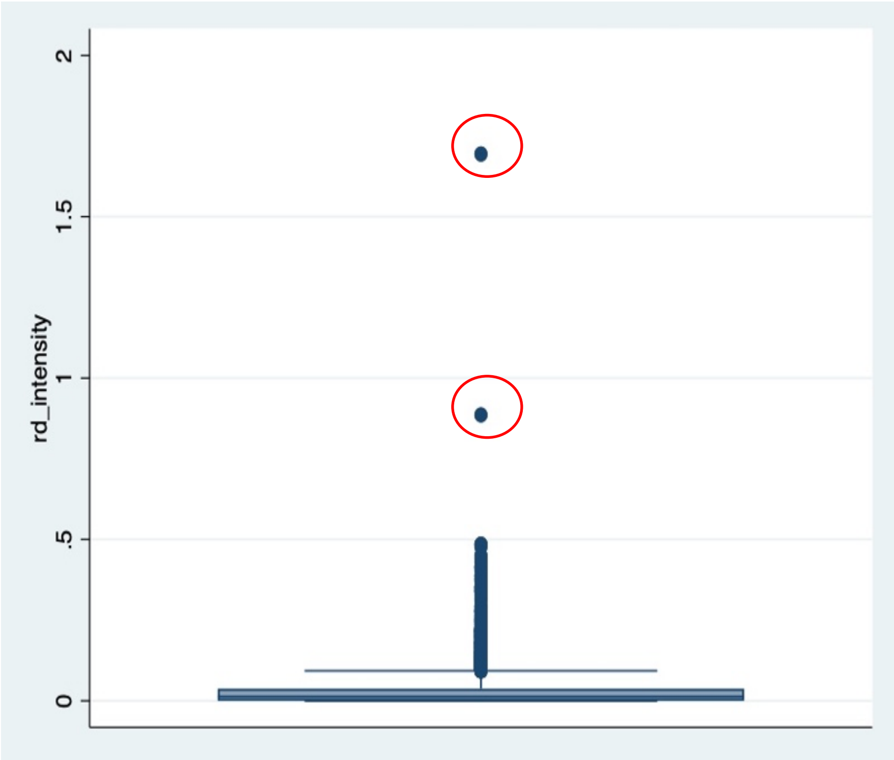
4.3 Empirical Results and Analysis

4.3.1 Introduction

This section focuses on testing the hypothesis tests presented in Chapter 4.

Before proceeding with the regression analysis, a boxplot for R&D intensity is drawn. Figure 4.1 illustrates two influential outliers of interest in particular, which have been circled in red. Upon searching the data, both outliers are from a firm called Caihong Display Devices (hereinafter referred to as *Caihong*), caused by a spike in R&D intensity between 2014 and 2015. So as not to let two outliers affect the regression model, the data from *Caihong* will be first wiped out.

Figure 4.1 Boxplot for R&D Intensity



4.3.2 R&D Intensity

4.3.2.1 Concentrated Ownership

4.3.2.1.1 Model 1: Continuous Concentrated Ownership

i. Tests for Assumptions of Panel Data Regression

The LM test was applied to determine which type of regression to use. As the p-value for the LM test was p <0.01, the null hypothesis of no panel effect was rejected by it at the 5% level. Accordingly, the panel data regression was better than the pooled regression. Given that the p-value for the HS test was p <0.01, it rejected the null hypothesis of a random effect at the 5% level. A panel data regression with fixed effects was, therefore, an appropriate model.

Then, tests of the regression assumptions were then carried out to ensure that the coefficients were inconsistent or biased.

First, the mean of residuals was 0, which meant that the assumption of linearity did not violate (*Assumption 1*). Second, the assumption of homoscedasticity violated as the modified Wald test had a p-value of $p < 0.01$ (*Assumption 2*). Third, the p-value for the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). In other words, residuals were autocorrelated. Fourth, the p-value of the Ramsey RESET Test was $p < 0.01$, which rejected the null hypothesis (*Assumption 4*). Accordingly, misspecification was not a concern in this case. Fifth, the total sample size was large enough to suggest that residual distribution was asymptotically normal (*Assumption 5*). Sixth, the pairwise correlation matrix in Appendix D reveals that multicollinearity is not a problem as the correlation is still low. Hence, the assumption of no perfect multicollinearity held (*Assumption 6*).

In order to correct the violations of the assumptions, the fixed effects model was re-regressed by the robust standard error.

ii. Results

Table 4.5 Regression with Continuous Concentrated Ownership

VARIABLES	(1) H1 Fixed Effects Robust	t-statistics	p-values
Concentrated	0.0127* (0.0072)	1.7700	0.0770
Firm Size	-0.0024** (0.0010)	-2.3700	0.0180
Firm Age	0.0016*** (0.0002)	7.6600	0.0000
Knowledge Stock	0.0000 (0.0000)	1.1400	0.2530
Leverage	0.0005 (0.0009)	0.5100	0.6070

Continued

Public A-shares	-0.0069	0.2620	-0.0190
	(0.0062)		
Long-term Investment	0.0006**	0.0200	0.0001
	(0.0003)		
Industry 2	0.0059	0.6490	-0.0194
	(0.0129)		
Industry 3	0.0168**	0.0410	0.0007
	(0.0082)		
Industry 4	0.0021	0.8080	-0.0147
	(0.0085)		
Industry 5	-0.0016	0.9110	-0.0294
	(0.0142)		
Industry 6	-0.0047***	0.0000	-0.0057
	(0.0005)		
Industry 7	0.0112	0.2810	-0.0092
	(0.0104)		
Industry 8	0.0119	0.3130	-0.0113
	(0.0118)		
Industry 9	0.0442**	0.0240	0.0059
	(0.0196)		
Industry 10	0.0126	0.1140	-0.0030
	(0.0080)		
Industry 11	0.0041	0.6390	-0.0131
	(0.0088)		
Industry 12	0.0112	0.3370	-0.0117
	(0.0117)		
3	0.0332*	0.0550	-0.0007
	(0.0173)		
Industry 14	0.0009	0.9400	-0.0214
	(0.0113)		
Industry 15	0.1320***	0.0000	0.1179
	(0.0072)		
Industry 16	0.0588***	0.0000	0.0394
	(0.0099)		
Industry 17	0.0082	0.5690	-0.0200
	(0.0144)		
Industry 18	0.0179	0.1560	-0.0069
	(0.0126)		
Constant	0.0249	0.2390	-0.0166
	(0.0212)		
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0806		
FIRM FE	YES		
Log-likelihood	23946		
INDUSTRY FE	YES		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table above signifies the panel data regression outputs.

For the independent variables, the p-value of concentrated ownership is $p < 0.1$, which rejects the null hypothesis at the 10% level. Concentrated ownership and R&D intensity are significantly and positively related at the 10% level. In other words, R&D intensity is expected to increase by 0.0127 as the level of concentrated ownership increases by one unit, while holding other things equal. It then is at odds with the hypothesis (i.e. H1).

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related at the 5% level. If firm size increases by 1%, the mean of R&D intensity decreases by $2.4e^{-5}$, ceteris paribus. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age is significantly and positively related to R&D intensity. The expected change in R&D intensity is 0.0016 for an additional one year increase in firm age, while holding other variables constant. The p-value of ln(long-term investment) is $p < 0.05$, rejecting the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean of R&D intensity increases by $6.322e^{-6}$, ceteris paribus.

The baseline for industry dummy is ‘agriculture, forestry, animal husbandry and fishery’, which is denoted as industry code 1. The category of all dummy variables’ codes and descriptions are in Table 4.5. The p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0168 higher than the baseline, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis at the 1% level. The mean R&D intensity of wholesale and retail trade is 0.0047 lower than the baseline, ceteris paribus. The p-value of industry code 9 is $p < 0.05$, rejecting the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0442 higher than the baseline, ceteris paribus. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0332 higher than the baseline, ceteris paribus. Both industry codes 15 and 16 have p-values of $p < 0.01$, which rejects the null hypothesis. On average, the education industry and health and social work have an R&D intensity of 0.1320 and 0.0588 higher than the baseline, respectively, ceteris paribus.

In addition, the log-likelihood value is 23946.

4.3.2.1.2 Model 2: Categorical Concentrated Ownership

i. Tests for Assumptions of Panel Data Regression

Applying the LM test was to determine which type of regression to use. Due to the p-value of $p < 0.01$ for the LM test, it rejected the null hypothesis of no panel effect at the 5% level. Panel data regression was, therefore, better than pooled regression. Due to the p-value of the HS test being $p < 0.01$, the null hypothesis of a random effect was rejected at the 5% level. Consequently, a panel data regression with fixed effects was an appropriate model.

The regression assumptions were then tested to ensure that the coefficients were not inconsistent or biased.

First, the mean of residuals was 0, implying the parameters' linearity (*Assumption 1*). Second, the assumption of homoscedasticity violated by the modified Wald test as the p-value was $p < 0.01$ (*Assumption 2*). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). It meant that there was a serial correlation. Fourth, the p-value of the Ramsey RESET Test was $p < 0.01$, which rejected the null hypothesis of no omitted variable at the 1% level (*Assumption 4*). As a consequence, there was no misspecification error. Fifth, residual distribution was asymptotically normal because of a large sample size (*Assumption 5*). Sixth, Appendix

D indicates the pairwise correlation matrix, showing that correlations keep low. Then, the assumption of no perfect multicollinearity held.

To sum up, the fixed effects model with the robust standard error was applied thereafter because of the violations of assumptions.

ii. Results

Table 4.6 Regression with Categorical Concentrated Ownership

VARIABLES	(2) H1 Fixed Effects Robust	t-statistics	p-values
Medium	-0.0015 (0.0019)	-0.7700	0.4400
High	-0.0004 (0.0021)	-0.2000	0.8430
Firm Size	-0.0025** (0.0010)	-2.5100	0.0120
Firm Age	0.0015*** (0.0002)	7.7400	0.0000
Knowledge Stock	0.0000 (0.0000)	1.0600	0.2900
Leverage	0.0005 (0.0009)	0.5200	0.6000
Public A-shares	-0.0024 (0.0053)	-0.4500	0.6560
Long-term Investment	0.0006** (0.0003)	2.3200	0.0210
Industry 2	0.0066 (0.0131)	0.5100	0.6130
Industry 3	0.0173** (0.0082)	2.1200	0.0340
Industry 4	0.0030 (0.0085)	0.3600	0.7220
Industry 5	-0.0007 (0.0141)	-0.0500	0.9600
Industry 6	-0.0045*** (0.0005)	-8.4600	0.0000
Industry 7	0.0114 (0.0105)	1.0900	0.2760
Industry 8	0.0113 (0.0118)	0.9600	0.3390
Industry 9	0.0448** (0.0196)	2.2900	0.0220
Industry 10	0.0124 (0.0081)	1.5200	0.1280
Industry 11	0.0045 (0.0088)	0.5100	0.6080

Continued

Industry 12	0.0115	0.9800	0.3270
	(0.0118)		
Industry 13	0.0325*	1.8200	0.0690
	(0.0179)		
Industry 14	0.0018	0.1600	0.8720
	(0.0113)		
Industry 15	0.1320***	17.7200	0.0000
	(0.0074)		
Industry 16	0.0593***	5.9400	0.0000
	(0.0100)		
Industry 17	0.0084	0.5900	0.5570
	(0.0143)		
Industry 18	0.0185	1.4700	0.1420
	(0.0126)		
Constant	0.0281	1.3200	0.1860
	(0.0212)		
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0802		
FIRM FE	YES		
INDUSTRY FE	YES		
Log-likelihood	23944		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is the firm with low level of concentrated ownership.

From the table above, the p-values of medium and high levels are both greater than 0.1, respectively, so null hypotheses cannot be rejected. R&D intensity is not significantly different among the three levels of concentrated ownership on average while holding other variables constant.

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related. The mean of R&D intensity decreases by 2.5e-5 if firm size increases by 1%, ceteris paribus. The p-value of firm age is $p < 0.01$ which rejects the null hypothesis at the 1% level. Firm age and R&D intensity are positively and significantly related. The expected change in R&D intensity is $p < 0.01$ for an additional one year increase in firm age, ceteris paribus. The p-value of ln(long-term investment) is $p < 0.05$, which rejects the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean of R&D intensity increases by 6e-6, ceteris paribus.

For industry dummies, the p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0173 higher than the one of agriculture, forestry, animal husbandry and fishery, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis. The mean R&D intensity of wholesale and retail trade is 0.0045 lower than the baseline, ceteris paribus. The p-value of industry code 9 is $p < 0.05$, which rejects the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0448 higher than the baseline, ceteris paribus. The p-value of industry code 13 is less than 0.1, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0325 higher than the baseline, ceteris paribus. The p-values of industry codes 15 and 16 are both $p < 0.01$, so those two null hypotheses can be rejected. The means of R&D intensity in the education industry and health and social work are 0.1320 and 0.0593 higher than the base level, respectively, ceteris paribus.

Except variables mentioned above, all other variables' p-values are greater than 0.1, which cannot reject the null hypotheses.

The log-likelihood value is 23944.

4.3.2.1.3 Discussions for Concentrated Ownership with R&D Intensity

i. Likelihood Ratio Test

Log-likelihood in model (1) with continuous concentred ownership (i.e. 23946) is marginally higher than the one in model (2) with categorical concentred ownership (i.e. 23944). The p-value of the likelihood ratio test is greater than 0.1, which fails to reject the null hypothesis. Accordingly, model (2) is not better than model (1).

ii. Continuous Concentrated Ownership

In Table 4.5, concentrated ownership has a significantly positive impact on R&D intensity. As a consequence, concentrated ownership and a firm's innovation performance are positively related, yet it is not consistent with the hypothesis in Chapter 3 suggesting the negative correlation (H1).

The reason for that kind of positive impact could be that a high degree of concentration generates an efficient monitoring mechanism that lowers agency costs and disciplines managers' behaviour (Baysinger et al., 1991; Cho, 1992; Francis and Smith, 1995; Holmstrom, 1989; Nguyen et al., 2015). Specifically, large shareholders may prefer innovation strategies with high risk, even if the probability of success is low. Conversely, managers from firms with a low degree of concentration may be more willing to take imitation strategies with low risk, because they do not want to undertake the cost of failure (Hill and Snell, 1988).

Another advantage of concentrated ownership is that large shareholders can optimise and integrate all resources internally or externally to increase the probability of a successful R&D project (Lacetera, 2001). In other words, larger shareholders enhance R&D investment.

Furthermore, firms with concentrated ownership may be more interested in long-term development in a business field rather than short-term profit maximisation (Mayer, 1997; Miozzo and Dewick, 2002). On the one hand, those firms are willing to occupy a leading position or even monopolise the market. Apart from political reasons, innovative technologies beyond the times may help those firms to achieve their goals. Accordingly, R&D investment plays a crucial role in this case. On the other hand, a few large shareholders are more willing to invest in a long-term R&D project than to maximise the firm profit in the short term, because they believe innovation's success may improve the firm's survival in the market (Chang et al., 2006; Chang and Hong, 2000; Mahmood and Mitchell, 2004; Rowley and Bae, 2004; Shleifer and Vishny, 1996). In the manager's view, those few large shareholders' aims may relieve their managerial pressures to maximise short-term profits, thereby boosting R&D investment (Baysinger et al., 1991).

iii. Categorical Concentrated Ownership

R&D intensity in concentrated ownership does not vary across the three levels, in line with the findings in Table 4.4. Thus, it also does not agree with hypothesis H1.

iv. Control Variables

It is not surprisingly that firm age has a significantly positive effect on innovation performance, even if that impact is trivial. In view of the fact that old firms can benefit from their business experience and foresight (Arrow, 1962; Sorensen and Stuart, 2000; Chang et al., 2002), and enhancing R&D investment to improve the degree of firm growth persistence and let firms survive in an increasingly competitive market.

In addition, the negative impact of firm size on innovation performance is too small to be negligible. However, firms with concentrated ownership may be satisfied with firm scale and are not willing to undertake the cost of R&D failure, if firm size upswings dramatically.

Similarly, the positive impact of long-term investment on innovation performance is also negligibly small. The performance of firm with concentrated ownership to increase their R&D intensity is more evident if there is substantial long-term investment.

Regarding industry dummies, the baseline is agriculture, forestry, animal husbandry and fishery. On average, firms with concentrated ownership within those five industries – (1) manufacturing industry; (2) information transmission, software and information technology services; (3) scientific research and technical service industry; (4) education industry; and (5) health and social work - have a significantly higher R&D intensity than the baseline. It may be that technological innovation in each of these sectors requires considerable time, effort, capital, etc.

4.3.2.2 Insider Concentration

4.3.2.2.1 Model 1: Continuous Insider Ownership

i. Tests for Assumptions of Panel Data Regression

To begin with, the LM test was applied to define the type of regression to be utilised. The LM test had a p-value of $p < 0.01$, given that it rejected the null hypothesis of no panel effects at the 1% level. Panel data regression was, therefore, superior to pooled regression. The HS test had a p-value of $p < 0.01$ as it rejected the null hypothesis of random effects at the 1% level. Therefore, the panel data regression with fixed effects was an appropriate model.

The regression assumptions were tested afterwards for consistent and unbiased coefficients.

First, the mean of residuals was 0, which indicated that the assumption of linearity in parameters holds (*Assumption 1*). Second, the assumption of homoscedasticity violated due to the p-value of $p < 0.01$ by the modified Wald test (*Assumption 2*). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). To put it differently, there was autocorrelation. Fourth, the p-value of the Ramsey RESET Test was $p < 0.01$, which rejected the null hypothesis of no omitted variable (*Assumption 4*). As a consequence, there was a misspecification error. Fifth, residual distribution was asymptotically normal because of a large sample size (*Assumption 5*). Sixth, the pairwise correlation matrix in Appendix D reveals that multicollinearity is not a problem as the correlation is still low. Hence, the assumption of no perfect multicollinearity held (*Assumption 6*).

To sum up, the fixed effects model with the robust standard error was applied thereafter to fix the problems of violations of assumptions.

ii. Results

Table 4.7 Regression with Continuous Insider Ownership

VARIABLES	(3) H2 Fixed Effects Robust	t-statistics	p-values
insider	0.0133 (0.0138)	0.9600	0.3380
Firm Size	-0.0025** (0.0011)	-2.3900	0.0170
Firm Age	0.0015*** (0.0002)	7.6800	0.0000
Knowledge Stock	0.0000 (0.0000)	1.0200	0.3070
Leverage	0.0007 (0.0012)	0.5700	0.5670
Public A-shares	-0.0037 (0.0057)	-0.6400	0.5220
Long-term Investment	0.0006** (0.0003)	2.0800	0.0370
Industry 2	0.0071 (0.0129)	0.5500	0.5840
Industry 3	0.0169** (0.0080)	2.1200	0.0340
Industry 4	0.0028 (0.0083)	0.3400	0.7310
Industry 5	-0.0011 (0.0141)	-0.0700	0.9410
Industry 6	-0.0044*** (0.0005)	-8.1300	0.0000
Industry 7	0.0109 (0.0101)	1.0800	0.2790
Industry 8	0.0105 (0.0116)	0.9100	0.3630
Industry 9	0.0441** (0.0189)	2.3300	0.0200
Industry 10	0.0127 (0.0078)	1.6200	0.1040
Industry 11	0.0044 (0.0085)	0.5200	0.6060
Industry 12	0.0113 (0.0115)	0.9900	0.3220
Industry 13	0.0302* (0.0166)	1.8200	0.0690
Industry 14	0.0013 (0.0110)	0.1200	0.9070
Industry 15	0.1322*** (0.0069)	19.1700	0.0000
Industry 16	0.0586*** (0.0097)	6.0400	0.0000

Continued

Industry 17	0.0080 (0.0143)	0.5600	0.5770
Industry 18	0.0182 (0.0123)	1.4800	0.1380
Constant	0.0287 (0.0224)	1.2800	0.1990
Observations	8,284		
Number of Firms	1,409		
Adjusted R-squared	0.0823		
FIRM FE	YES		
Log-likelihood	23959		
INDUSTRY FE	YES		

For the independent variables, the p-value of insider ownership in Table 4.9 is greater than 0.1, which fails to reject the null hypothesis at the 10% level. Insider ownership and R&D intensity are insignificantly and positively related. It is in disagreement with the hypothesis (i.e. H2).

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related at the 5% level. If firm size increases by 1%, the mean of R&D intensity decreases by 2.5e-5, ceteris paribus. It is a really minor impact. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age is significantly and positively related to R&D intensity. The expected change in R&D intensity is 0.0015 for an additional one unit increased in firm age, while holding other variables constant. The p-value of ln(long-term investment) is $p < 0.05$, which rejects the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean of R&D intensity increases by 6e-6, ceteris paribus.

For industry dummies, the p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0169 higher than the one of agriculture, forestry, animal husbandry and fishery, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis. The mean R&D intensity of wholesale and retail trade is 0.0044 lower than the baseline, ceteris paribus. The p-value of industry code 9 is 0.020, which rejects the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0441 higher than the baseline, ceteris paribus. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0302 higher than the baseline, ceteris paribus. The p-values of industry codes 15 and 16 are both $p < 0.01$, so those two null hypotheses can be rejected. The means of R&D intensity in the education industry and health and social work are 0.1322 and 0.0586 higher than the base level, respectively, ceteris paribus. Except variables mentioned above, all other variables' p-values are greater than 0.1, which cannot reject the null hypotheses.

The log-likelihood value is 23959.

4.3.2.2.2 Model 2: Categorical Insider Ownership

i. Tests for Assumptions of Panel Data Regression

The LM test was applied to see the type of regression to be used. As the p-value for the LM test is $p < 0.01$, it rejected the null hypothesis of no panel effect at the 1% level. Panel data regression was, therefore, better than pooled regression. Given that the p-value for the HS test is $p < 0.01$, it rejected the null hypothesis of a random effect at the 1% level. Consequently, a panel data regression with fixed effects was a suitable model. Regression assumptions were tested afterwards to ensure coefficients were consistent and not biased.

First, the mean of residuals is 0, which implied the linearity in parameters (*Assumption 1*). Second, the assumption of homoscedasticity violated by modified Wald test as the p-value was $p < 0.01$ (*Assumption 2*). Third, the p-value of run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). It meant that there was serial correlation. Fourth, the p-value of Ramsey RESET Test was $p < 0.01$, which rejected the null hypothesis of no omit variable at the 5% level (*Assumption 4*). As a consequence, there was a misspecification error. Fifth, residual distribution was asymptotically normal because of large sample size (*Assumption 5*). Sixth, the correlation matrix is display in Appendix E, which suggests that there is no violation of the assumption of no perfect multicollinearity, due to low correlations (*Assumption 6*).

To sum up, the fixed effects with robust standard error was applied thereafter, because of the violations of assumptions.

ii. Results

Table 4.8 Regression with Categorical Insider Ownership

VARIABLES	(4) H2 Fixed Effects Robust	t-statistics	p-values
Low	0.0025*** (0.0009)	2.8200	0.0050
Medium	0.0017 (0.0022)	0.6900	0.4900
High	0.0103* (0.0053)	1.8100	0.0710
Firm Size	-0.0025** (0.0010)	-2.4500	0.0140
Firm Age	0.0015*** (0.0002)	7.5400	0.0000
Knowledge Stock	0.0000 (0.0000)	1.0600	0.2880
Leverage	0.0005 (0.0010)	0.5700	0.5670
Public A-shares	-0.0030 (0.0056)	-0.5000	0.6170
Long-term Investment	0.0006** (0.0003)	1.9800	0.0480
Industry 2	0.0081 (0.0126)	0.6500	0.5140
Industry 3	0.0187** (0.0080)	2.3400	0.0200
Industry 4	0.0048 (0.0082)	0.6000	0.5490
Industry 5	0.0012 (0.0139)	0.0800	0.9380
Industry 6	-0.0021* (0.0011)	-2.0700	0.0380
Industry 7	0.0129	1.2500	0.2100

Continued

	(0.0102)		
Industry 8	0.0108	0.9500	0.3400
	(0.0114)		
Industry 9	0.0456**	2.4400	0.0150
	(0.0186)		
Industry 10	0.0147*	1.8500	0.0650
	(0.0079)		
Industry 11	0.0065	0.7500	0.4540
	(0.0086)		
Industry 12	0.0135	1.1700	0.2420
	(0.0115)		
Industry 13	0.0335*	1.8500	0.0640
	(0.0180)		
Industry 14	0.0028	0.2600	0.7940
	(0.0108)		
Industry 15	0.1328***	19.4900	0.0000
	(0.0068)		
Industry 16	0.0605***	6.1500	0.0000
	(0.0098)		
Industry 17	0.0096	0.6900	0.4880
	(0.0141)		
Industry 18	0.0200	1.6200	0.1060
	(0.0124)		
Constant	0.0253	1.2500	0.2110
	(0.0213)		
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0846		
FIRM FE	YES		
INDUSTRY FE	YES		
Log-likelihood	23965		

The baseline for the independent variable is the firm without any insider ownership (i.e. zero-level).

From the table above, the p-value of the low level is $p < 0.01$, which rejects the null hypothesis at the 1% level. On average, R&D intensity is 0.0025 higher for lower levels of insider ownership than for non-insider ownership, ceteris paribus. The p-value of the medium level is greater than 0.1, which fails to reject the null hypothesis. The expected R&D intensity between the medium-level and the zero-level is indifferent. The p-value of the high level is $p < 0.1$, which rejects the null hypothesis at the 10% level. High-level insider ownership benefits 0.0103 more on R&D intensity than non-insider ownership, ceteris paribus.

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related. The mean of R&D intensity decreases by 2.5e-5 if firm size increases by 1%, ceteris paribus. The p-value of firm age is 0 $p < 0.01$, which rejects the null hypothesis. Firm age and R&D intensity are positively and significantly related. The expected change in R&D intensity is 0.0015 for an additional one year increase in firm age, ceteris paribus. The p-value for long-term investment is $p < 0.05$, rejecting the null hypothesis. Long-term investment and R&D intensity are positively and significantly correlated. Other things being equal, a one-unit increase in long-term investment results in an expected change in R&D intensity of 6e-5.

For industry dummies, the p-value for industry code 3 is $p < 0.05$, rejecting the null hypothesis at the 5% level. On average, R&D intensity in manufacturing is 0.0187 higher than that in agriculture, forestry, animal husbandry and fishing, ceteris paribus. A p-value of $p < 0.05$ for industry code 6 rejects the null hypothesis. While holding other variables constant, the average R&D intensity in wholesale and retail trade is 0.0021 below the baseline. Industry code 9 has a p-value of $p < 0.05$, rejecting the null hypothesis at the 5% level. The average R&D intensity for information transmission, software and information technology services is 0.0456 above the baseline, ceteris paribus. The p-value for industry code 13 is $p < 0.1$, rejecting the null hypothesis at the 10% level. Scientific research and technology services have an average R&D intensity of 0.0335 above the baseline, ceteris paribus. Industry 15 and 16 have a p-value of $p < 0.01$, so the null hypothesis is rejected for these two. The mean values for R&D intensity regarding the education sector and health and social work are 0.1328 and 0.0605 above the baseline level, respectively, ceteris paribus. The null hypothesis cannot be rejected with p-values greater than 0.1 for all variables except those mentioned above.

The log-likelihood value was 23975.

4.3.2.2.3 Discussions for Insider Ownership with R&D Intensity

i. Likelihood Ratio Test

The log-likelihood value in Table 4.7 is 23959, which is smaller than the one in Table 4.8 (i.e. 23975). The p-value of the likelihood ratio test is close to 0, which rejects the null hypothesis. Accordingly, the model with categorical insider ownership is better than the model with continuous insider ownership.

ii. Continuous Insider Ownership

Table 4.9 demonstrates no relationship between insider ownership and R&D intensity, and this finding does not agree with the previous hypothesis (H2).

The non-relationship between R&D intensity and insider ownership may be because that insider ownership usually accounts for a small part of the total share capital in China. Approximately 33% of firms have no insider ownership, 45% have less than 5%, and 7.5% have insider ownership between 5% and 20% (i.e. Appendix B). The mean insider ownership in Table 4.1 is as small as 7.38%. In short, insider ownership is less developed in China.

Secondly, in order to ensure that future position is secure, managers are more likely to put more effort into improving public relations than enhancing the firm performance (Bisot and Child, 1996; Xin and Pearce, 1996; Peng, 2000).

Thirdly, equity compensation for managers and boards of directors is less common in China (Choi et al., 2011).

Table 4.10 indicate that insider ownership is more beneficial to R&D intensity than non-insider ownership at all levels except the medium level. Insider ownership is more beneficial to innovation performance when it is greater than 20% or less than 5%, compared to firms without insider ownership. Further, firms with more than 20% insider ownership have an advantage over firms with a proportion of less than 5% when it comes to R&D intensity. Again, it disagrees the hypothesis H2.

The results partly agree with the agency theory that a rise in insider ownership causes managers' interests to align with the shareholders' interests, owing to the efficient monitoring scheme. It then favours innovation, as effective monitoring mechanisms allow managers to mitigate concerns about the consequences of R&D failure on their careers.

Insiders with small shareholdings may be employees who have been rewarded with shares. So, equity incentives also have a positive effect on corporate innovation in China. Moreover, employees are more willing to innovate in order to achieve self-worth and have stable employment (Chang et al., 2006).

Another reason is that the firm owner may focus on innovation in order to find long-term competitiveness of products or services for a successful continuation of the firm in the hands of future generations (Caselli and Gennaioli, 2013).

The fourth reason is that agency theory is not appropriate, as it advocates that insider ownership can lower managerial pressures to maximise short-term values, thereby enhancing R&D investment (Choi et al., 2012). Alternatively, the transaction cost of economy (TCE) examines the relationship between insider ownership and innovation performance more precisely than agency theory (Suk et al., 2012). TCE offers an explanation of why companies exist, scale up or farm out activities to an external environment. Firms aim to optimise the unnecessary transition costs incurred in the exchange of resources within the business environment. A variety of factors -

opportunism, limited rationality, environmental uncertainty, limited information and asset specificity - are noted by the theory as affecting the extent of transaction costs (Williamson, 1965). These factors are all expected to worsen the firms' innovation performance potentially. Compared to developed countries, emerging countries can be seen as underdeveloped markets with uncertain business environments and a lack of or expensive resources for innovation (Suk et al., 2012). In an uncertain business environment, firms can safeguard themselves through political connections. It also brings more policy-related information to firms, lowering transaction costs and promoting technological innovation. In a family business, insider ownership may be beneficial for communication between top management as a way of consolidating decision-making power and thus saving transaction costs. Such situations allow firms to be sensitive to changes in the external business environment and to allocate firm resources efficiently to achieve innovative performance (Poza et al.,1997; Tagiuri and Davis, 1996).

In short, even though agency theory suggests that insider ownership contributes to firms' innovation performance, the fact is that only 14.1% of observations have insider ownership over 20%. A side reflection of the high-level insider ownership in Chinese listed firms is relatively rare.

iii. Categorical Insider Ownership

Table 4.10 indicate that insider ownership is more beneficial to R&D intensity than non-insider ownership at all levels except the medium level. Insider ownership is more beneficial to innovation performance when it is greater than 20% or less than 5%, compared to firms without insider ownership. Further, firms with more than 20% insider ownership have an advantage over firms with a proportion of less than 5% when it comes to R&D intensity. Again, it disagrees the hypothesis H2.

The results partly agree with the agency theory that a rise in insider ownership causes managers' interests to align with the shareholders' interests, owing to the efficient monitoring scheme. It then favours innovation, as effective monitoring mechanisms allow managers to mitigate concerns about the consequences of R&D failure on their careers.

Insiders with small shareholdings may be employees who have been rewarded with shares. So, equity incentives also have a positive effect on corporate innovation in China. Moreover, employees are more willing to innovate in order to achieve self-worth and have stable employment (Chang et al., 2006).

Another reason is that the firm owner may focus on innovation in order to find long-term competitiveness of products or services for a successful continuation of the firm in the hands of future generations (Caselli and Gennaioli, 2013).

iv. Control Variables

Firm age has a statistically and significantly positive impact on R&D intensity for firms with insider ownership in Table 4.10, yet the impact is minimal. The learning-by-doing model tells that the older the firm, the more business experience and foresight it has (Arrow, 1962; Sorensen and Stuart, 2000; Chang et al., 2002). Accordingly, older firms with insider ownership may encourage R&D activities to survive in an increasingly competitive market.

Firm size significantly and negatively affect R&D intensity for firms with insider ownership, but this impact is trivial in Table 4.10. If firm size upswings dramatically, firms with insider ownership may be satisfied with firm scale and unwilling to undertake the cost of R&D failure.

Regarding industry dummies, the baseline is agriculture, forestry, animal husbandry and fishery. On average, firms with insider ownership within those six industries – (1)

manufacturing industry; (2) information transmission, software and information technology services; (3) scientific research and technical service industry; (4) education industry; and (5) health and social work - have a significantly higher R&D intensity than the baseline as shown in Table 4.10. One interpretation is that an equity-compensation scheme is prevalent in those industries to promote innovative performance. As with concentrated ownership, insider ownership has a lower innovation performance in the wholesale and retail trade than the baseline.

4.3.2.3 State Ownership

4.3.2.3.1 Model 1: Continuous State Ownership

i. Tests for Assumptions of Panel Data Regression

First, the LM test was employed to identify the type of regression to be used. Given that the LM test has a p-value of $p < 0.01$, it rejects the null hypothesis of no panel effect at the 5% level. Hence, the panel data regression is superior to the pooled regression. The p-value of the HS test is $p < 0.01$ as it rejects the null hypothesis of random effects at the 1% level. As a result, the panel data regression with fixed effects is an appropriate model.

Then, the tests were applied for defining whether the regression assumptions violated. First, the mean of residuals is 0, which indicates that the assumption of linearity in parameters holds (*Assumption 1*). Second, the assumption of homoscedasticity violates by modified Wald test, because the p-value of the test is $p < 0.01$ (*Assumption 2*). Third, the p-value of run test of randomness is $p < 0.01$, which rejects the null hypothesis (*Assumption 3*). To rephrase it, residuals are serially correlated. Fourth, the p-value of Ramsey RESET Test is $p < 0.01$, which rejects the null hypothesis of no omit variable (*Assumption 4*). As a result, there is a problem of model misspecification. Fifth, the total sample size is large enough to say that residual distribution is asymptotically normal (*Assumption 5*). Sixth, the pairwise correlation in Appendix D displays that assumption of no perfect multicollinearity holds (*Assumption 6*), because correlations are pretty low.

In order to correct the violations of the assumptions, the fixed effects model was re-regressed by robust standard error.

ii. Results

Table 4.9 Regression with Continues State Ownership

VARIABLES	(5) H3 Fixed Effects Robust	t-statistics	p-value
state	0.0012	0.3700	0.7100
	(0.0033)		
Firm Size	-0.0025**	-2.4200	0.0160
	(0.0010)		
Firm Age	0.0015***	7.6500	0.0000
	(0.0002)		
Knowledge Stock	0.0000	1.0700	0.2850
	(0.0000)		
Leverage	0.0005	0.5200	0.6010
	(0.0009)		
Public A-shares	-0.0028	-0.5000	0.6170
	(0.0057)		
Long-term Investment	0.0006**	2.3300	0.0200
	(0.0003)		
Industry 2	0.0068	0.5300	0.5990
	(0.0129)		
Industry 3	0.0171**	2.0800	0.0370
	(0.0082)		
Industry 4	0.0029	0.3400	0.7360
	(0.0085)		
Industry 5	-0.0011	-0.0800	0.9390
	(0.0142)		
Industry 6	-0.0046***	-8.0100	0.0000
	(0.0006)		
Industry 7	0.0115	1.1100	0.2690
	(0.0104)		
Industry 8	0.0110	0.9300	0.3540
	(0.0118)		
Industry 9	0.0447**	2.2900	0.0220
	(0.0195)		
Industry 10	0.0127	1.5900	0.1120
	(0.0080)		
Industry 11	0.0046	0.5200	0.6010
	(0.0088)		
Industry 12	0.0115	0.9800	0.3250
	(0.0117)		
Industry 13	0.0322*	1.8100	0.0700

Continued

	(0.0178)		
Industry 14	0.0014	0.1300	0.9000
	(0.0113)		
Industry 15	0.1326***	18.5000	0.0000
	(0.0072)		
Industry 16	0.0593***	5.9600	0.0000
	(0.0099)		
Industry 17	0.0084	0.5900	0.5560
	(0.0143)		
Industry 18	0.0183	1.4500	0.1470
	(0.0126)		
Constant	0.0271	1.2600	0.2070
	(0.0215)		
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0799		
FIRM FE	YES		
Log-likelihood	23942		
INDUSTRY FE	YES		

Table 4.9 signifies the panel data regression outputs for state ownership. The p-value of state ownership is greater than 0.1, which fails to reject the null hypothesis. Hence, state ownership is insignificantly and negatively related to R&D intensity. The result is different from the previous hypothesis (i.e. H3).

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related at the 5% level. If firm size increases by 1%, the mean of R&D intensity decreases by 2.5e-5, ceteris paribus. It is a really minor impact. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age is significantly and positively related to R&D intensity. The expected change in R&D intensity is 0.0015 for an additional one year increase in firm age, while holding other variables constant. The p-value of ln(long-term investment) is $p < 0.05$, which rejects the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean of R&D intensity increases by 6e-6, ceteris paribus.

For industry dummies, the p-value for industry code 3 is $p < 0.05$, rejecting the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0171 higher than the one of agriculture, forestry, animal husbandry and fishery, ceteris paribus. Industry code 6 has a p-value of $p < 0.01$, rejecting the null hypothesis. The average R&D intensity in wholesale and retail trade is 0.0046 lower than the baseline, all else equal. Industry code 9 has a p-value of $p < 0.05$, rejecting the null hypothesis at the 5% level. The average R&D intensity for information transmission, software and information technology services is 0.0447 above the baseline, all else equal. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0322 higher than the baseline, ceteris paribus. The p-values of industry codes 15 and 16 are $p < 0.01$, so those two null hypotheses are rejected. The mean R&D intensity regarding the education industry and health and social work is 0.1326 and 0.0593 above the baseline level, respectively, all else equal. The p-values for all variables except those mentioned above are greater than 0.1, and the null hypothesis cannot be rejected.

The log-likelihood value is 23942.

4.3.2.3.2 Model 2: Categorical State Ownership

i. Tests for Assumptions of Panel Data Regression

First, an LM test was applied to observe the type of regression to be used. As the LM test has a p-value of $p < 0.01$, it rejects the null hypothesis of no panel effect at the 1% level. Thus, the panel data regression is better than the pooled regression. Since the p-value of the HS test is $p < 0.01$, it rejects the null hypothesis of a random effect at the 1% level. The panel data regression with fixed effects is, therefore, an appropriate model.

Afterwards, regression assumptions were tested to ensure the coefficients were unbiased and consistent.

First, the mean of residuals is 0, which means that the assumption of linearity does not violate (*Assumption 1*). Second, the assumption of homoscedasticity violates as the modified Wald test has a p-value of $p < 0.01$ (*Assumption 2*). Third, the p-value of the run test of randomness is $p < 0.01$, which rejects the null hypothesis (*Assumption 3*). In other words, residuals are autocorrelated. Fourth, the p-value of the Ramsey RESET Test is greater than 0.1, which fails to reject the null hypothesis (*Assumption 4*). Accordingly, misspecification is not a concern in this case. Fifth, the total sample size is large enough to suggest that residual distribution is asymptotically normal (*Assumption 5*). Sixth, the pairwise correlation matrix in Appendix D suggests no perfect multicollinearity because of low correlations (*Assumption 6*).

In order to correct the violations of the assumptions, the fixed effects model was re-regressed by the robust standard error.

ii. Results

Table 4.10 Regression with Categorical State Ownership

VARIABLES	(6) H3 Fixed Effects Robust	t-statistics	p-values
Low	0.0031* (0.0017)	1.8300	0.0670
Medium	-0.0018 (0.0028)	-0.6500	0.5150
High	-0.0008 (0.0021)	-0.3800	0.7040
Firm Size	-0.0025** (0.0010)	-2.4200	0.0160
Firm Age	0.0015*** (0.0002)	7.8400	0.0000
Knowledge Stock	0.0000 (0.0000)	1.0800	0.2790
Leverage	0.0005 (0.0009)	0.5200	0.6020
Public A-shares	-0.0021 (0.0057)	-0.3600	0.7170

Continued

Long-term Investment	0.0006** (0.0003)	2.2900	0.0220
Industry 2	0.0069 (0.0128)	0.5300	0.5930
Industry 3	0.0173** (0.0081)	2.1200	0.0340
Industry 4	0.0024 (0.0084)	0.2900	0.7720
Industry 5	-0.0005 (0.0142)	-0.0400	0.9700
Industry 6	-0.0047*** (0.0005)	-9.1200	0.0000
Industry 7	0.0105 (0.0105)	1.0000	0.3160
Industry 8	0.0105 (0.0118)	0.8900	0.3760
Industry 9	0.0448** (0.0195)	2.2900	0.0220
Industry 10	0.0124 (0.0079)	1.5600	0.1200
Industry 11	0.0040 (0.0087)	0.4600	0.6440
Industry 12	0.0114 (0.0117)	0.9700	0.3310
Industry 13	0.0323* (0.0177)	1.8300	0.0680
Industry 14	0.0012 (0.0113)	0.1100	0.9140
Industry 15	0.1322*** (0.0071)	18.5200	0.0000
Industry 16	0.0586*** (0.0100)	5.8500	0.0000
Industry 17	0.0084 (0.0142)	0.5900	0.5570
Industry 18	0.0177 (0.0124)	1.4200	0.1540
Constant	0.0281 (0.0216)	1.3000	0.1930
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0820		
FIRM FE	YES		
INDUSTRY FE	YES		
Log-likelihood	23953		

The baseline is the zero level of state ownership.

The low level has a p-value of $p < 0.1$ in Table 4.10, rejecting the null hypothesis at the 10% level. On average, R&D intensity for the low-level is 0.0031 higher than the zero-level. The other two levels of state ownership do not differ significantly from non-state ownership in R&D intensity since they have p-values greater than 0.1.

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related. The mean of R&D intensity decreases by 2.5e-5 if firm size increases by 1%, ceteris paribus. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age and R&D intensity are positively and significantly related. The expected change in R&D intensity is 0.0015 for an additional one year increase in firm age, ceteris paribus. The p-value of ln(long-term investment) is $p < 0.05$, which rejects the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean of R&D intensity increases by 6e-6, ceteris paribus.

The baseline for industry dummy is 'agriculture, forestry, animal husbandry and fishery', which is denoted as industry code 1. The p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0173 higher than the one of the baseline, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis. The mean R&D intensity of wholesale and retail trade is 0.0047 lower than the baseline, ceteris paribus. The p-value of industry code 9 is $p < 0.05$, which rejects the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0448 higher than the baseline, ceteris paribus. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0323 higher than the baseline, ceteris paribus. Both industry codes 15 and 16 have p-values of $p < 0.01$, and both hypotheses can be rejected. On average, the education industry and health and social work have an R&D intensity of 0.1320 and 0.0586 higher than the baseline, respectively, ceteris paribus. Other control variables' p-values are relatively large, which fail to reject the null hypotheses at the 10% level.

The log-likelihood value is 23953.

4.3.2.3.3 Discussions for State Ownership with R&D Intensity

i. Likelihood Ratio Test

The log-likelihood value in Table 4.11 is 23942, which is lower than the one in Table 4.12 (i.e. 23953). Nonetheless, the p-value of the likelihood ratio test is $p < 0.01$, rejecting the null hypothesis at the 1% level. The model with categorical state ownership (i.e. model 6) performs better than the model with continuous categorical state ownership (i.e. model 5).

ii. Continuous State Ownership

There is no relationship between state ownership and innovation performance found in Table 4.13, which rejects the hypothesis made in Chapter 3 (i.e. H3).

Though firms with state ownership have resource benefits, the importance of resource allocation from the government drops when firms are listed in the exchange. Except for financial support from the government, listed firms are more likely to raise funds in the market (Zhou et al., 2017).

Another reason may be that highly sophisticated SOEs that have invested heavily in innovation are not listed for technical confidentiality as well as political and commercial reasons.

iii. Categorical State Ownership

Results such as those in Table 4.10 refute the conclusion that state ownership and innovation performance are non-correlated, concluding that low-level state ownership has a greater impact on R&D intensity than the zero-level. Innovation is facilitated when state ownership is below 5% rather than for non-state ownership. The result is consistent with hypothesis H3 only when state ownership is low.

One reason could be that the low-level state ownership takes advantage of state resources without the fear of the state seizing the firm's control rights. In 2015, the CPC promulgated regulations on the work of the party committees in the firm with the clear intention of the firm's control rights (Xie et al., 2022). It may cause other investors concerns about the firm's future and increase great pressure on managers. Accordingly, Managers in a firm with a high level of state ownership may abate R&D investment, as they are reluctant to bear the cost of R&D failure for the sake of their future careers.

iv. Control Variables

In spite of the fact that firm age positively affects R&D intensity in Table 4.14, such influence is minor. Due to the learning-by-doing model, older firms take advantage of business experience and foresight (Arrow, 1962; Sorensen and Stuart, 2000; Chang et al., 2002). As a result, firms with state ownership favour R&D investment to let firms be alive in an increasingly competitive market.

The negative impact of firm size on R&D intensity is paltry in Table 4.14. Nevertheless, firms with state ownership may no longer be interested in R&D investment if the firm size becomes extremely large.

The positive and slight effect of long-term investment on R&D intensity in Table 4.14 shows that state-owned firms' interests in R&D rise as there is a surge in long-term investment.

Regarding industry dummies, the baseline is agriculture, forestry, animal husbandry and fishery. On average, firms with insider ownership within those five industries – (1) manufacturing industry; (2) information transmission, software and information technology services; (3) scientific research and technical service industry; (4) education industry; and (5) health and social work - have a significantly higher R&D intensity than the baseline. It includes highly sophisticated industries, such as manufacturing, where the government invests enormously in scientific research in order to break through the technological blockade from western countries as soon as possible. So, in contrast to agriculture, forestry, animal husbandry and fishery, it is understandable for the government to have a relatively high R&D intensity in these sectors.

4.3.2.4 Institutional Ownership

4.3.2.4.1 Model 1: Continuous Institutional Ownership

i. Tests for Assumptions of Panel Data Regression

Initially, the LM test was employed to decide the type of regression to be applied. As the LM test had a p-value of $p < 0.01$, it rejected the null hypothesis of no panel effect at the 1% level. Consequently, the panel data regression was better than the pooled regression. Since the p-value of the HS test was $p < 0.01$, it rejected the null hypothesis of a random effect at the 1% level. A panel data regression with fixed effects was, therefore, an appropriate model.

After choosing an appropriate model, assumptions should be tested to confirm the regression estimates were meaningful (i.e. consistent and unbiased).

First, the mean of residuals was 0, which suggested that the assumption of linearity in parameters held (Assumption 1). Second, the p-value of the modified Wald test was $p < 0.01$, rejecting the null hypothesis of homoscedastic errors (Assumption 2). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (Assumption 3). To put it in another way, residuals were serially correlated. Fourth, the p-value of the Ramsey RESET Test was $p < 0.01$, which rejected the null hypothesis of no omitted variable (Assumption 4). As a result, there was a problem with model misspecification. Fifth, residuals were asymptotically normal due to a large sample size (Assumption 5). Sixth, the assumption of no perfect multicollinearity held due to correlations in Appendix D being pretty low (Assumption 6).

Then, the robust standard error was applied to correct the violations of the assumptions.

ii. Results

Table 4.11 Regression with Continuous Institutional Ownership

VARIABLES	(7) H4 Fixed Effects Robust	t-statistics	p-values
institutional	0.0001 (0.0042)	0.0200	0.9840
Firm Size	-0.0025** (0.0010)	-2.4200	0.0160
Firm Age	0.0015*** (0.0002)	7.6400	0.0000
Knowledge Stock	0.0000 (0.0000)	1.0600	0.2890
Leverage	0.0005 (0.0009)	0.5200	0.6000
Public A-shares	-0.0026 (0.0065)	-0.4000	0.6860
Long-term Investment	0.0006** (0.0003)	2.3300	0.0200
Industry 2	0.0069 (0.0129)	0.5300	0.5930
Industry 3	0.0171** (0.0081)	2.1100	0.0350
Industry 4	0.0029 (0.0084)	0.3500	0.7270
Industry 5	-0.0010 (0.0141)	-0.0700	0.9440
Industry 6	-0.0045*** (0.0005)	-8.5400	0.0000
Industry 7	0.0115 (0.0105)	1.0900	0.2770
Industry 8	0.0107 (0.0118)	0.9100	0.3660
Industry 9	0.0447** (0.0195)	2.2900	0.0220
Industry 10	0.0127 (0.0079)	1.6100	0.1080
Industry 11	0.0046 (0.0087)	0.5300	0.5960
Industry 12	0.0116 (0.0117)	0.9900	0.3220
Industry 13	0.0319* (0.0177)	1.8000	0.0720
Industry 14	0.0014 (0.0111)	0.1300	0.8960
Industry 15	0.1326*** (0.0072)	18.5400	0.0000
Industry 16	0.0590*** (0.0104)	5.6900	0.0000
Industry 17	0.0085 (0.0143)	0.5900	0.5530

Continued

Industry 18	0.0183 (0.0125)	1.4600	0.1440
Constant	0.0270 (0.0217)	1.2400	0.2140
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0798		
FIRM FE	YES		
Log-likelihood	23942		
INDUSTRY FE	YES		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The p-value of institutional ownership in the Table 4.11 is greater than 0.1, which fails to reject the null hypothesis. Hence, institutional ownership is insignificantly and positively related to R&D intensity.

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related at the 5% level. If firm size increases by 1%, the mean of R&D intensity decreases by 2.5e-5, ceteris paribus. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age is significantly and positively related to R&D intensity. The expected change in R&D intensity is 0.0015 for an additional one year increase in firm age, while holding other variables constant. The p-value of ln(long-term investment) is $p < 0.01$, which rejects the null hypothesis at the 1% level. If long-term investment increases by 1%, the mean of R&D intensity increases by 6e-6, ceteris paribus.

The baseline for industry dummy is ‘agriculture, forestry, animal husbandry and fishery’. The p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0171 higher than the one of the baseline, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis. The mean R&D intensity of wholesale and retail trade is 0.0045 lower than the baseline, ceteris paribus. The p-value of industry code 9 is $p < 0.05$, which rejects the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0447 higher than the baseline, ceteris paribus. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0319 higher than the baseline, ceteris paribus. Both industry codes 15 and 16 have p-values of $p < 0.01$, so null hypotheses are rejected. On average, the education industry and health and social work have an R&D intensity of 0.1326 and 0.0590 higher than the baseline, respectively, ceteris paribus. Other control variables and dummy variables' p-values are relatively large, which fail to reject the null hypotheses at the 10% level.

In addition, the log-likelihood value is 23942.

4.3.2.4.2 Model 2: Categorical Institutional Ownership

i. Tests for Assumptions of Panel Data Regression

To start with, the LM test was employed to determine the type of regression to be used. Due to the fact that the LM test had a p-value of $p < 0.01$, it rejected the null hypothesis of no panel effect at the 1% level. Panel data regression was, therefore, better than pooled regression. As the p-value of the HS test was $p < 0.01$, it rejected the null hypothesis of random effects at the 1% level. Consequently, the panel data regression with fixed effects was an appropriate model.

After that, regression assumptions should be tested due to consistent and unbiased coefficients needed.

First, the mean of residuals was 0, which means that the assumption of linearity did not violate (*Assumption 1*). Second, the assumption of homoscedasticity violated by the modified Wald test with the p-value of $p < 0.01$ (*Assumption 2*). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). In other words, residuals were autocorrelated. Fourth, the p-value of the Ramsey

RESET Test was $p < 0.01$, which rejected the null hypothesis at the 1% level (*Assumption 4*). Accordingly, misspecification was a concern in this case. Fifth, the total sample size was large enough to suggest that residual distribution was asymptotically normal (*Assumption 5*). Sixth, the pairwise correlation was displayed in Appendix D and suggested that there is no perfect multicollinearity due to relatively low values of correlations (*Assumption 6*).

The fixed effects model with robust standard error was then utilised to correct the violations of the assumptions.

ii. Results

Table 4.12 Regression with Categorical Institutional Ownership

VARIABLES	(8) H4 Fixed Effects Robust	t-statistics	p-values
Low	0.0005 (0.0012)	0.3700	0.7140
Medium	0.0008 (0.0014)	0.5400	0.5880
High	0.0007 (0.0019)	0.3900	0.6940
Firm Size	-0.0025** (0.0010)	-2.4500	0.0140
Firm Age	0.0015*** (0.0002)	7.6900	0.0000
Knowledge Stock	0.0000 (0.0000)	1.0500	0.2950
Leverage	0.0005 (0.0009)	0.5200	0.6010
Public A-shares	-0.0031 (0.0065)	-0.4800	0.6310
Long-term Investment	0.0006** (0.0003)	2.3100	0.0210
Industry 2	0.0068 (0.0130)	0.5200	0.6020
Industry 3	0.0171** (0.0082)	2.1000	0.0360
Industry 4	0.0030 (0.0084)	0.3600	0.7180
Industry 5	-0.0009 (0.0141)	-0.0700	0.9480
Industry 6	-0.0046*** (0.0005)	-8.6300	0.0000

Continued

Industry 7	0.0116 (0.0104)	1.1200	0.2640
Industry 8	0.0107 (0.0118)	0.9100	0.3650
Industry 9	0.0447** (0.0195)	2.2900	0.0220
Industry 10	0.0128 (0.0079)	1.6100	0.1070
Industry 11	0.0046 (0.0087)	0.5300	0.5950
Industry 12	0.0117 (0.0116)	1.0100	0.3130
Industry 13	0.0318* (0.0178)	1.7800	0.0750
Industry 14	0.0015 (0.0112)	0.1400	0.8920
Industry 15	0.1328*** (0.0070)	19.1100	0.0000
Industry 16	0.0590*** (0.0101)	5.8200	0.0000
Industry 17	0.0084 (0.0144)	0.5800	0.5610
Industry 18	0.0184 (0.0125)	1.4700	0.1430
Constant	0.0270 (0.0216)	1.2500	0.2110
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0797		
FIRM FE	YES		
INDUSTRY FE	YES		
Log-likelihood	23942		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is zero-level institutional ownership.

All p-values for three levels of institutional ownership are greater than 0.1 in the table above. No significant difference in institutional ownership compared to non-institutional ownership for all three levels of R&D intensity, on average, ceteris paribus. For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related. The mean of R&D intensity decreases by 2.5e-5 if firm size increases by 1%, ceteris paribus. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age and R&D intensity are positively and significantly related. The expected change in R&D intensity is 0.0015 for an additional one year increase in firm age, ceteris paribus. The p-value of ln(long-term investment) is $p < 0.05$, which rejects the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean of R&D intensity increases by 6e-6, ceteris paribus.

The baseline for industry dummy is 'agriculture, forestry, animal husbandry and fishery'. The p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0171 higher than the one of the baseline, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis. The mean R&D intensity of wholesale and retail trade is 0.0046 lower than the baseline, ceteris paribus. The p-value of industry code 9 is $p < 0.05$, which rejects the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0447 higher than the baseline, ceteris paribus. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0318 higher than the baseline, ceteris paribus. Both industry codes 15 and 16 have p-values of $p < 0.01$, which rejects the null hypothesis. On average, the education industry and health and social work have an R&D intensity of 0.1328 and 0.0590 higher than the baseline, respectively, ceteris paribus. Other control variables' p-values are relatively large, which fail to reject the null hypotheses at the 10% level.

In addition, the log-likelihood value is 23942.

4.3.2.4.3 Discussions for Institutional Ownership with R&D Intensity

i. Likelihood Ratio Test

The log-likelihood value in Table 4.11 is 23942, which is same as the log-likelihood value in Table 4.12 (i.e. 23942). Likelihood ratio test generates the p-value above 0.1, which fails to reject the null hypothesis. The model with continuous institutional ownership is better than the model with the categorical institutional ownership.

ii. Continuous Institutional Ownership

Table 4.17 reveals no relationship between institutional ownership and R&D intensity, whereas this conclusion is inconsistent with the hypothesis made in Chapter 3 (i.e. H4). Despite firms with institutional ownership favour efficient monitoring mechanisms, particularly with weak incumbent management (Fung, 2012), it is underdeveloped in developing countries compared to developed countries. Of the data, approximately 8% of the sample have no institutional ownership, 34% have less than 5% (but higher than 0%), and 36% have levels between 5% and 20%. Institutional investors usually regulate and monitor managers via governance activities or gathering information about the quality of R&D investments (Bushee, 1998). If the level of institutional ownership is low, active monitoring by institutional ownership cannot eliminate managers' concerns about R&D failure and cannot relieve managers' pressure to maximise short-term profits. Additionally, the holding period of institutional investors may be too short for gaining long-term benefits of R&D investment.

iii. Categorical Institutional Ownership

On average, institutional ownership is not significantly different across all three levels of R&D intensity compared to non-institutional ownership. It is then in disagreement with hypothesis H4.

iv. Control Variables

Firm age has a statistically and significantly positive impact on R&D intensity for firms with institutional ownership in Table 4.17, yet the impact is paltry. A rise in firm age accumulates business experience and business foresight, owing to the learning-by-doing model foresight (Arrow, 1962; Sorensen and Stuart, 2000; Chang et al., 2002). Firms with institutional ownership boost R&D investment to survive in an increasingly competitive market.

Firm size significantly and negatively affect R&D intensity for firms with institutional ownership, yet this impact is trivial. If firm size upswings dramatically, firms' interest in R&D investment reduces as they are unwilling to undertake the cost of R&D failure.

The little and positive impact of long-term investment on R&D intensity discloses that R&D intensity grows extensively only if there is a bulk investment in long-term assets. With regard to industry data, the baseline is agriculture, forestry, animal husbandry and fisheries. For those firms with concentrated ownership in those five sectors - (1) manufacturing; (2) information transmission, software and information technology; (3) scientific research and technical services; (4) education; and (5) health and social work - the R&D intensity is, on average, significantly higher than the baseline. In contrast, the R&D intensity of the wholesale and retail sector in institutional ownership is below the baseline.

4.3.2.5 Foreign Ownership

4.3.2.5.1 Model 1: Continuous Foreign Ownership

i. Tests for Assumptions of Panel Data Regression

First of all, the LM test was applied to see which type of regression to be used. Since the p-value of the LM test was $p < 0.01$, it rejected the null hypothesis of no panel effect at the 1% level. Hence, panel data regression was better than pooled regression. As the p-value of the HS test was $p < 0.01$, it rejected the null hypothesis of random effect at the 1% level. Therefore, panel data regression with fixed effects model was a proper model.

Then, regression assumptions should be tested to confirm coefficients that were consistent and unbiased.

First, the mean of residuals was 0, which meant the parameters are linear (*Assumption 1*). Second, the variance of error terms was heteroscedastic because the p-value of the modified Wald test was $p < 0.01$. The null hypothesis was then rejected (*Assumption 2*). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). To put it in another way, residuals were serially correlated. Fourth, the p-value of the Ramsey RESET Test was $p < 0.01$, which rejected the null hypothesis of no omitted variable (*Assumption 3*). As a result, there was a problem with model misspecification. Fifth, residuals were asymptotically normal due to a large sample size (*Assumption 5*). Sixth, Appendix D indicates multicollinearity is not an issue as the correlation is quite low (*Assumption 6*).

In order to correct the violations of the assumptions, the model was re-regressed by the robust standard error.

ii. Results

Table 4.13 Regression with Continuous Foreign Ownership

VARIABLES	(9) H5 Fixed Effects Robust	t-statistics	p-values
foreign	-0.0246** (0.0098)	-2.5000	0.0120
Firm Size	-0.0024** (0.0010)	-2.3800	0.0170
Firm Age	0.0015*** (0.0002)	7.6800	0.0000
Knowledge Stock	0.0000 (0.0000)	1.0900	0.2740
Leverage	0.0005 (0.0009)	0.5300	0.5940
Public A-shares	-0.0007 (0.0057)	-0.1300	0.8960
Long-term Investment	0.0006** (0.0003)	2.3700	0.0180
Industry 2	0.0065 (0.0129)	0.5000	0.6170
Industry 3	0.0172** (0.0082)	2.1000	0.0360
Industry 4	0.0028 (0.0084)	0.3400	0.7360
Industry 5	-0.0007	-0.0500	0.9590

Continued

	(0.0141)		
Industry 6	-0.0045***	-8.4100	0.0000
	(0.0005)		
Industry 7	0.0115	1.1000	0.2710
	(0.0104)		
Industry 8	0.0122	1.0300	0.3040
	(0.0119)		
Industry 9	0.0447**	2.3000	0.0220
	(0.0195)		
Industry 10	0.0120	1.5100	0.1300
	(0.0079)		
Industry 11	0.0046	0.5200	0.6010
	(0.0087)		
Industry 12	0.0116	0.9900	0.3200
	(0.0117)		
Industry 13	0.0321*	1.8000	0.0720
	(0.0178)		
Industry 14	0.0015	0.1300	0.8960
	(0.0113)		
Industry 15	0.1327***	18.5600	0.0000
	(0.0071)		
Industry 16	0.0587***	5.9200	0.0000
	(0.0099)		
Industry 17	0.0082	0.5700	0.5670
	(0.0142)		
Industry 18	0.0183	1.4500	0.1460
	(0.0126)		
Constant	0.0256	1.2000	0.2320
	(0.0214)		
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0815		
FIRM FE	YES		
Log-likelihood	23949		
INDUSTRY FE	YES		

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The p-value of foreign ownership in the table above is $p < 0.05$, rejecting the null hypothesis at the 5% level. R&D intensity is expected to decrease by 0.0246 for an additional one unit increase in foreign ownership, all other things being equal.

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related at the 5% level. If firm size increases by 1%, the mean of R&D

intensity decreases by 2.4e-5, ceteris paribus. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age is significantly and positively related to R&D intensity. The expected change in R&D intensity is 0.0015 for an additional one year increase in firm age, while holding other variables constant. The p-value of ln(long-term investment) is $p < 0.05$, which rejects the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean value of R&D intensity increases by 6e-6, ceteris paribus.

The baseline for industry dummy is 'agriculture, forestry, animal husbandry and fishery'. The p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0172 higher than the one of the baseline, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis. The mean R&D intensity of wholesale and retail trade is 0.0045 lower than the baseline, ceteris paribus. The p-value of industry code 9 is $p < 0.05$, which rejects the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0447 higher than the baseline, ceteris paribus. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0321 higher than the baseline, ceteris paribus. Both industry codes 15 and 16 have p-values of $p < 0.01$, which rejects the null hypothesis. On average, the education industry and health and social work have an R&D intensity of 0.1327 and 0.0587 higher than the baseline, respectively, ceteris paribus. Other variables' p-values are relatively large, which fail to reject the null hypotheses at the 10% level.

In addition, the log-likelihood value is 23949.

4.3.2.5.2 Model 2: Categorical Foreign Ownership

i. Tests for Assumptions of Panel Data Regression

An LM test was first applied to identify the type of regression to be used. Since the p-value of the LM test was $p < 0.01$, it rejected the null hypothesis of no panel effect at the 1% level. The panel data regression was, therefore, better than the pooled regression. Since the HS test had a p-value of $p < 0.01$, it rejected the null hypothesis of a random effect at the 1% level. Then, A panel data regression with fixed effects was a suitable model.

Then, all regression assumptions should be tested to get consistent and unbiased estimators.

First, the mean of residuals was 0, which meant that the assumption of linearity did not violate (*Assumption 1*). Second, the assumption of homoscedasticity violated due to the p-value of $p < 0.01$ in the Wald test (*Assumption 2*). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). It meant that residuals were serially correlated. Fourth, the p-value of the Ramsey RESET Test was $p < 0.01$, which rejected the null hypothesis at the 1% level (*Assumption 4*). Accordingly, misspecification was a concern. Fifth, the total sample size was large enough to suggest that residual distribution was asymptotically normal (*Assumption 5*). Sixth, Appendix D demonstrates relatively low correlations, which means multicollinearity is not a problem (*Assumption 6*).

The fixed effects model was then applied to correct the violations of the assumptions.

ii. Results

Table 4.14 Regression with Categorical Foreign Ownership

iii. VARIABLES	(10) H5 Fixed Effects Robust	t-statistics	p-values
Low	-0.0006 (0.0007)	-0.8300	0.4090
Medium	-0.0026 (0.0020)	-1.3100	0.1900
High	-0.0080*** (0.0028)	-2.8700	0.0040

Continued

Firm Size	-0.0024**	-2.3900	0.0170
	(0.0010)		
Firm Age	0.0015***	7.6000	0.0000
	(0.0002)		
Knowledge Stock	0.0000	1.0400	0.2970
	(0.0000)		
Leverage	0.0005	0.5300	0.5950
	(0.0009)		
Public A-shares	-0.0012	-0.2100	0.8320
	(0.0056)		
Long-term Investment	0.0007**	2.4000	0.0170
	(0.0003)		
Industry 2	0.0066	0.5100	0.6120
	(0.0129)		
Industry 3	0.0172**	2.1100	0.0350
	(0.0082)		
Industry 4	0.0029	0.3400	0.7310
	(0.0085)		
Industry 5	-0.0007	-0.0500	0.9620
	(0.0141)		
Industry 6	-0.0044***	-7.9700	0.0000
	(0.0006)		
Industry 7	0.0116	1.1100	0.2670
	(0.0104)		
Industry 8	0.0123	1.0300	0.3050
	(0.0120)		
Industry 9	0.0448**	2.3000	0.0220
	(0.0195)		
Industry 10	0.0121	1.5300	0.1260
	(0.0079)		
Industry 11	0.0047	0.5300	0.5940
	(0.0087)		
Industry 12	0.0117	1.0000	0.3180
	(0.0117)		
Industry 13	0.0321*	1.8000	0.0720
	(0.0178)		
Industry 14	0.0015	0.1400	0.8910
	(0.0113)		
Industry 15	0.1327***	18.5400	0.0000
	(0.0072)		
Industry 16	0.0588***	5.9300	0.0000
	(0.0099)		
Industry 17	0.0081	0.5700	0.5670
	(0.0142)		
Industry 18	0.0183	1.4600	0.1450
	(0.0126)		
Constant	0.0252	1.1800	0.2390
	(0.0214)		
Observations	8,286		
Number of Firms	1,409		
Adjusted R-squared	0.0815		

Continued

FIRM FE	YES
INDUSTRY FE	YES
Log-likelihood	23950

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is non-foreign ownership.

From the table above, the p-value of the high-level foreign ownership is $p < 0.01$, rejecting the null hypothesis at the 1% level. On average, R&D intensity for the high-level is 0.0080 lower than the zero-level while holding other variables constant. The other two levels of R&D intensity are not significantly different compared to non-foreign ownership, as their p-values are greater than 0.1.

For control variables, the p-value of ln(firm size) is $p < 0.05$, which rejects the null hypothesis at the 5% level. Ln(firm size) and R&D intensity are significantly and negatively related. The mean of R&D intensity decreases by 2.4e-5 if firm size increases by 1%, ceteris paribus. The p-value of firm age is $p < 0.01$, which rejects the null hypothesis. Firm age and R&D intensity are positively and significantly related. The expected change in R&D intensity is 0.0015 for an additional one year increase in firm age, ceteris paribus. The p-value of ln(long-term investment) is $p < 0.05$, which rejects the null hypothesis at the 5% level. If long-term investment increases by 1%, the mean of R&D intensity increases by 7e-6, ceteris paribus.

The baseline for industry dummy is ‘agriculture, forestry, animal husbandry and fishery’. The p-value of industry code 3 is $p < 0.05$, which rejects the null hypothesis at the 5% level. On average, the R&D intensity of the manufacturing industry is 0.0172 higher than the one of the baseline, ceteris paribus. The p-value of industry code 6 is $p < 0.01$, which rejects the null hypothesis. The mean R&D intensity of wholesale and retail trade is 0.0044 lower than the baseline, ceteris paribus. The p-value of industry code 9 is $p < 0.05$, which rejects the null hypothesis at the 5% level. The mean R&D intensity of information transmission, software and information technology services is 0.0448 higher than the baseline, ceteris paribus. The p-value of industry code 13 is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean R&D intensity of scientific research and technical service industry is 0.0321 higher than the baseline, ceteris paribus. Both industry codes 15 and 16 have p-values of $p < 0.01$, which rejects the null hypothesis. On average, the education industry and health and social work have an R&D intensity of 0.1327 and 0.0588 higher than the baseline, respectively, ceteris paribus. Other variables' p-values are relatively large, which fail to reject the null hypotheses at the 10% level.

In addition, the log-likelihood value is 23950.

4.3.2.5.3 Discussions for Foreign Ownership with R&D Intensity

i. Likelihood Ratio Test

The log-likelihood value in Table 4.13 is 23949, and the log-likelihood value in Table 4.14 is 23950. Then, the likelihood ratio test generates a p-value above 0.1, which fails to reject the null hypothesis. Then, the model with continuous foreign ownership is better than the model with categorical foreign ownership.

ii. Continuous Foreign Ownership

Table 4.13 discloses that foreign ownership and R&D intensity are negatively related, which is not in line with the previous hypothesis (i.e. H5).

One interpretation is that many foreign firms have set up subsidiaries in China. In such cases, foreign firms prefer to import R&D from the parent firms than to innovate locally in the subsidiaries. It has the advantage of being more cost-effective for foreign firms by cutting down on using a range of resources, including money, required for R&D (Globerman and Meredith, 1984). High foreign ownership inhibits the incentive and the ability to innovate in subsidiaries to some extent. However, indigenous innovation is essential to China's new source of inclusive growth.

Furthermore, approximately 67% of the data does not contain foreign ownership. Moreover, within the remaining 33%, financial investments in Chinese firms through the Hong Kong Securities Clearing Company (HKSC) are also included. HKSC is the sole subsidiary of the Hong Kong stock exchange. It is an authorised clearing institution that operates the central clearing and settlement system in Hong Kong. Some Chinese firms may be listed not only in Shanghai Stock Exchange, but also in Hong Kong stock exchange. If firms are registered in mainland China, firm shares listed in Hong Kong are called H shares. Foreign investors cannot directly buy shares in the stock exchange located in mainland China, but they can indirectly buy H shares of Chinese listed firms on the Hong Kong Stock Exchange. The firm's annual report does not show each investor's name, but only HKSC and hence many foreign investors via H shares are interested in a financial investment rather than supervision. Hence, it may result in a negative impact of foreign ownership on innovation performance, as foreign investors pursue short-term maximisation rather than long-term value.

iii. Categorical Foreign Ownership

Table 4.14 confirms the negative relationship between foreign ownership and R&D intensity for the proportion of foreign ownership over 20%. Again, the result is not in line with hypothesis H5.

High foreign ownership adds to the fact that the company is a subsidiary of a foreign company. Due to the cost of innovation, foreign firms are more willing to take advanced technology from the parent company to China, leaving the Chinese subsidiary to become an original equipment manufacturer (OEM) and inhibiting its willingness to develop its R&D capabilities (Globerman and Meredith, 1984). The parent company prefers the subsidiary to exploit its advantages - a large pool of trained workers, relatively low resource costs, and a vast Chinese market - to extract more benefits for the parent company.

iv. Control Variables

The effect of firm age on R&D intensity is statistically positive but minor, as shown in Table 4.13. Older firms benefit from business experience and foresight, according to the learning-by-doing model (Arrow, 1962; Sorensen and Stuart, 2000; Chang et al., 2002). I

The small and negative effect of firm size on R&D intensity exposes that the willingness of firms with foreign ownership to invest in R&D reduces as firm size upswings dramatically.

The long-term investment has a slight and positive influence on R&D intensity. It shows that a growth of R&D intensity is obvious only when a huge sum of investment in long-term assets.

Regarding industry dummies, the baseline is agriculture, forestry, animal husbandry and fishery. On average, firms with foreign ownership within those five industries – (1) manufacturing industry; (2) information transmission, software and information technology services; (3) scientific research and technical service industry; (4) education industry; and (5) health and social work - have a significantly higher R&D intensity than the baseline.

4.3.3 Depth of Innovation and Diversity of Innovation

4.3.3.1 Concentrated Ownership

4.3.3.1.1 Depth of Innovation and Concentrated Ownerships

i. Tests for Assumptions of Panel Data Regression

The first step still is to define which model to be used. LM test was applied, resulting in a p-value of $p < 0.01$ which rejected the null hypothesis of no panel effect at the 1%

level. Hence, panel data regression was better than pooled regression. As the p-value of the HS test was $p < 0.01$, it rejected the null hypothesis of random effect at the 1% level. Therefore, panel data regression with a fixed effects was a proper model.

Then, regression assumptions should be tested to obtain consistent and unbiased estimators.

First, the zero mean residual implied that the assumption of linearity holds (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which illustrated the heteroscedastic residuals. *Assumption 2* did not hold. Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). To rephrase it, there was a serial correlation in residuals. Fourth, the p-value of the Ramsey RESET Test was greater than 0.1, which failed to reject the null hypothesis (*Assumption 4*). It meant that there is no misspecification error. Fifth, the total sample size was large enough to say that residual distribution is asymptotically normal (*Assumption 5*). Sixth, the pairwise correlation matrix is in Appendix E. It exhibits low correlations except for the correlation between depth and diversity. It was understandable that depth and diversity are highly correlated, as they were two-sided of a mirror. It was good news that we could know the other side's story if we know one side. Hence, the high correlation would not bother the regression analysis since those two variables would not be used in one regression. In other words, multicollinearity was not an issue in this situation, and *Assumption 6 held.*

Due to heteroscedastic and non-independent residuals, the robust standard error was applied to fix those problems.

ii. Results

Table 4.15 Depth of Innovation for Concentrated Ownership

VARIABLES	(11) H6a Depth of Innovation Robust	t-statistics	p-values

Continued

Medium	-0.0048 (0.0270)	-0.1800	0.8580
High	-0.0117 (0.0348)	-0.3400	0.7360
R&D Intensity	0.1254 (0.2075)	0.6000	0.5460
Firm Size	-0.0008 (0.0164)	-0.0500	0.9630
Firm Age	-0.0106*** (0.0026)	-4.1500	0.0000
Knowledge Stock	-0.0001* (0.0000)	-1.8600	0.0630
Leverage	-0.0071 (0.0106)	-0.6700	0.5020
Public A-shares	-0.0930 (0.0771)	-1.2100	0.2280
Long-term Investment	-0.0154*** (0.0052)	-2.9800	0.0030
Constant	1.1882*** (0.3153)	3.7700	0.0000
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0192		
FIRM FE	YES		
Log-likelihood	1977		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is low-level concentrated ownership. The p-value of the medium-level is greater than 0.1, which fails to reject the null hypothesis. It has the same situation for the high level, which contains a p-value above 0.1. The experimental results disagree with the previous hypothesis (i.e. H6a).

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly negative relationship between firm age and the depth of innovation. The depth of innovation is expected to decrease by 0.0106 for one additional year increased in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.1$, which rejects the null hypothesis at the 10% level. The depth of innovation is expected to decrease by 0.0001 as the total number of patents increases by 1 unit while holding other variables constant.

The p-value of long-term investment is $p < 0.01$, which rejects the null hypothesis at the 1% level—long-term investment and the depth of innovation in significantly and negatively related. Expected change in depth of innovation is -0.000154, if long-term investment increases by 1%, ceteris paribus. The p-values of other variables are all greater than 0.1, which fails to reject the null hypothesis.

The log-likelihood value, in this case, is 1977.

4.3.3.1.2 Diversity of Innovation and Concentrated Ownerships

i. Tests for Assumptions of Panel Data Regression

The p-value from the LM test is $p < 0.01$, which rejects the null hypothesis of pooled regression. The HS test was applied afterwards and showed a p-value of $p < 0.01$, rejecting the null hypothesis of random effects. Consequently, the fixed effects model was applied.

After that, regression assumptions should be tested for consistent and unbiased estimators.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which showed the heteroscedastic residuals. *Assumption 2* was violated. Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). To rephrase it, there was a serial correlation in residuals. Fourth, the p-value of the Ramsey RESET Test was $p < 0.05$, which failed to reject the null hypothesis at the 5% level (*Assumption 4*). It meant there was not a problem of misspecification. Fifth, residuals were asymptotically normal due to a large sample size (*Assumption 5*). Finally, *Assumption 6* does not violate because most correlations matrix in Appendix E remains at a low level apart from the correlation between diversity and depth. However, it did not raise a concern for multicollinearity, as those two were dependent variables.

Since residuals were heteroscedastic and serially correlated, the robust standard error was applied.

ii. Results

Table 4.16 Diversity of Innovation for Concentrated Ownership

VARIABLES	(12) H6b Diversity of Innovation Robust	t-statistics	p-values
Medium	-0.0006	-0.0100	0.9900
	(0.0480)		
High	0.0075	0.1200	0.9040
	(0.0617)		
R&D Intensity	-0.1640	-0.4700	0.6380
	(0.3483)		
Firm Size	0.0274	0.9000	0.3670
	(0.0304)		
Firm Age	0.0197***	4.1700	0.0000
	(0.0047)		
Knowledge Stock	0.0002**	2.4500	0.0150
	(0.0001)		
Leverage	0.0039	0.2100	0.8330
	(0.0183)		
Public A-shares	0.1794	1.3200	0.1870
	(0.1359)		
Long-term Investment	0.0266***	2.9200	0.0040
	(0.0091)		
Constant	0.0719	0.1200	0.9030
	(0.5896)		
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0286		
FIRM FE	YES		
Log-likelihood	-328.6		

The p-values of the medium-level and the high-level are both greater than 0.1. Both hypotheses cannot be rejected. There is not a significant difference in the diversity of R&D for the three levels of concentrated ownership, on average, when other variables are held constant. The experimental results are inconsistent with the previous hypothesis (i.e. H6b).

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly positive relationship between firm age and the diversity of innovation. The expected change in the diversity of innovation is 0.0197 for one additional year increase in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.05$, which rejects the null hypothesis at the 5% level. Knowledge stock and the diversity of innovation are positively related. Excepted change in the diversity of innovation is 0.0002 for an additional one unit increased in knowledge stock while holding other variables constant. The p-value of ln(long-term investment) is $p < 0.01$, which rejects the null hypothesis at the 5% level. Ln(long-term investment) and the diversity of innovation are significantly and positively related. If long-term investment increases by 1%, the diversity of innovation is expected to increase by 0.000266, ceteris paribus.

The log-likelihood value is -328.5954.

4.3.3.2 Insider Ownership

4.3.3.2.1 Depth of Innovation and Insider Ownerships

i. Tests for Assumptions of Panel Data Regression

A p-value of $p < 0.01$ for the LM test rejects the null hypothesis of pooled regression. The HS test was then applied, showing a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Therefore, the fixed effects model was applied.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which suggested heteroscedastic residuals. *Assumption 2* violated due to non-constant variance. Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). In other words, residuals were autocorrelated. Fourth, the p-value of the Ramsey RESET Test was greater than 0.1, which failed to reject the null hypothesis (*Assumption 4*). It meant that there is no misspecification error. Fifth, the total sample size was large enough to say that residual distribution was asymptotically normal (*Assumption 5*). *Finally, Assumption 6* holds due to a low level of correlations in Appendix E.

Due to the violations of assumptions, the robust standard error was applied to fix these problems.

ii. Results

Table 4.17 Depth of Innovation for Insider Ownership

VARIABLES	(13) H7a Depth of Innovation Robust	t-statistics	p-values
Low	0.0118	0.7500	0.4510
	(0.0155)		
Medium	-0.0239	-0.8300	0.4070
	(0.0299)		
High	0.0159	0.3700	0.7100
	(0.0394)		
R&D Intensity	0.1169	0.3600	0.7190
	(0.2066)		
Firm Size	0.0008	0.2800	0.7760
	(0.0166)		
Firm Age	-0.0107***	-4.4700	0.0000
	(0.0026)		
Knowledge Stock	-0.0001*	-1.8000	0.0720
	(0.0000)		
Leverage	-0.0061	0.0300	0.9750
	(0.0111)		
Public A-shares	-0.1019	-1.2400	0.2150
	(0.0727)		
Long-term Investment	-0.0156***	-3.2100	0.0010
	(0.0052)		
Constant	1.1506***	3.6700	0.0000
	(0.3172)		
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0200		
FIRM FE	YES		
Log-likelihood	1980		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is zero-level insider ownership.

The p-values for all three levels in the table above are greater than 0.1, indicating that there is no significant difference between the R&D intensity of insider ownership and non-insider ownership for the three levels, on average, all else being equal. The conclusions show inconsistency with hypothesis H7a.

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly negative relationship between firm age and the depth of innovation. The depth of innovation is expected to decrease by 0.0107 for one additional year increased in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean depth of innovation decreases by 0.0001, as knowledge increases by one unit, ceteris paribus. The p-value of long-term investment is $p < 0.01$, which rejects the null hypothesis at the 1% level—long-term investment and the depth of innovation in significantly and negatively related. Expected change in depth of innovation is -0.000156, if long-term investment increases by 1%, ceteris paribus. The p-values of other variables are all greater than 0.1, which fails to reject the null hypothesis.

The log-likelihood value is 1980.

4.3.3.2.2 Diversity of Innovation and Insider Ownerships

i. Tests for Assumptions of Panel Data Regression

The LM test showed a p-value of $p < 0.01$, rejecting the null hypothesis of pooled regression. The HS test was then applied, showing a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Therefore, a fixed effects model was applied.

The regression assumptions were tested, and the results were as follows.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which showed the heteroscedastic residuals. It then violated *Assumption 2.* Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). To put it differently, residuals were serially correlated. Fourth, the p-value of the Ramsey RESET Test was greater than 0.05, which failed to reject the null hypothesis at the 5% level (*Assumption 4*). It meant there was not a problem of misspecification. Fifth, residuals were asymptotically normal due to a large sample size (*Assumption 5*). There was no perfect multicollinearity due to pretty low correlations in Appendix E (*Assumption 6*).

Then, the robust standard error was utilised for the fixed effects model.

ii. Results

Table 4.18 Diversity of Innovation for Insider Ownership

VARIABLES	(14) H7b Diversity of Innovation Robust	t-statistics	p-values
Low	-0.0206	-0.7200	0.4690
	(0.0281)		
Medium	0.0517	1.0300	0.3050
	(0.0522)		
High	-0.0145	-0.1800	0.8550
	(0.0668)		
R&D Intensity	-0.1400	-0.1800	0.8540
	(0.3484)		
Firm Size	0.0245	0.6400	0.5220
	(0.0307)		
Firm Age	0.0199***	4.5300	0.0000
	(0.0047)		
Knowledge Stock	0.0002**	2.4100	0.0160
	(0.0001)		
Leverage	0.0028	-0.3700	0.7090
	(0.0192)		
Public A-shares	0.1831	1.2700	0.2040
	(0.1284)		
Long-term Investment	0.0270***	3.1500	0.0020
	(0.0092)	-0.7200	0.4690
Constant	0.1346		
	(0.5930)		
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0296		
FIRM FE	YES		
Log-likelihood	-326.0		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is zero level of insider ownership.

The p-values for all three levels in the table above are all greater than 0.1, denoting that the R&D intensity between insider ownership and non-insider ownership is not significantly different at the three levels, on average, ceteris paribus. The conclusions are not in agreement with hypothesis H7b.

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly positive relationship between firm age and the diversity of innovation. The expected change in the diversity of innovation is 0.0199 for one additional year increase in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.05$, which rejects the null hypothesis at the 5% level. Knowledge stock and the diversity of innovation are positively related. Excepted change in the diversity of innovation is 0.0002 for an additional one unit increased in knowledge stock. The p-value of ln(long-term investment) is $p < 0.01$, which rejects the null hypothesis at the 1% level. Ln(long-term investment) and the diversity of innovation are significantly and positively related. If long-term investment increases by 1%, the diversity of innovation is expected to increase by 0.000270, ceteris paribus.

The log-likelihood value is -326.

4.3.3.3 State Ownership

4.3.3.3.1 Depth of Innovation and State Ownerships

i. Tests for Assumptions of Panel Data Regression

The p-value of the LM test is $p < 0.01$, rejecting the null hypothesis of pooled regression. The HS test is then applied, showing a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Therefore, a fixed effects model is applied.

After that, the tests of regression assumptions were applied.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which suggested heteroscedastic residuals. It then violates *Assumption 2*. Third, the p-value of the run test of randomness was $p < 0.01$, rejecting the null hypothesis (*Assumption 3*). To rephrase it, there was no serial correlation in residuals. Fourth, the p-value of the Ramsey RESET Test was greater than 0.1, which failed to reject the null hypothesis (*Assumption 4*). It meant that there was no misspecification error. Fifth, the total sample size was large enough to say that residual distribution was asymptotically normal (*Assumption 5*). Consequently, the assumption of normality held. Sixth, Appendix E indicates no multicollinearity due to low correlations (*Assumption 6*).

Due to heteroscedastic and serially correlated residuals, the fixed effects model was modified by robust standard error.

ii. Results

Table 4.19 Depth of Innovation for State Ownership

VARIABLES	(15) H8a Depth of Innovation Robust	t-statistics	p-values
Low	-0.0135 (0.0173)	-0.7800	0.4340
Medium	-0.0081 (0.0281)	-0.2900	0.7740
High	-0.0242 (0.0235)	-1.0300	0.3040
R&D Intensity	0.1256 (0.2100)	0.6000	0.5500
Firm Size	0.0009 (0.0166)	0.0500	0.9560
Firm Age	-0.0106*** (0.0025)	-4.1800	0.0000
Knowledge Stock	-0.0001* (0.0000)	-1.8700	0.0620
Leverage	-0.0059 (0.0105)	-0.5600	0.5750
Public A-shares	-0.1043 (0.0728)	-1.4300	0.1530
Long-term Investment	-0.0155*** (0.0052)	-2.9900	0.0030

Continued

Constant	1.1625*** (0.3153)	3.6900	0.0000
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0193		
FIRM FE	YES		
Log-likelihood	1978		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is zero-level state ownership.

All p-values for three levels of state ownership are greater than 0.1 in the table above.

No significant difference in state ownership compared to non-state ownership for all three levels of innovation specialisation, on average, all else being equal. Thus, the findings are not consistent with hypothesis H8a.

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly negative relationship between firm age and the depth of innovation. The depth of innovation is expected to decrease by 0.0106 for one additional year increased in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean depth of innovation decreases by 0.0001 as knowledge increases by one unit, ceteris paribus. The p-value of long-term investment is $p < 0.01$, which rejects the null hypothesis at the 1% level. Long-term investment and the depth of innovation in significantly and negatively related. Expected change in depth of innovation is -0.000155 if long-term investment increases by 1%, ceteris paribus. The p-values of other variables are all greater than 0.1, which fails to reject the null hypothesis.

The log-likelihood value is 1978.

4.3.3.3.2 Diversity of Innovation and State Ownerships

i. Tests for Assumptions of Panel Data Regression

The p-value for the LM test was $p < 0.01$, rejecting the null hypothesis of pooled regression. The HS test was then applied, showing a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Therefore, a fixed effects model was applied. Following this, a test of the regression hypothesis was applied.

First, the zero mean residual implied that the assumption of linearity holed (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which suggested heteroscedastic residuals. It violated *Assumption 2*. Third, the p-value of the run test of randomness was $p < 0.01$, rejecting the null hypothesis (*Assumption 3*). There was a serial correlation in residuals. Fourth, the p-value of the Ramsey RESET Test was greater than 0.01, which failed to reject the null hypothesis at the 1% level (*Assumption 4*). It meant there is not a problem of misspecification. Fifth, residuals were asymptotically normal due to a large sample size (*Assumption 5*). Sixth, *Assumption 6 holds due to low correlations in Appendix E.*

Because of heteroscedastic residuals, the fixed effects model was re-regressed by the robust standard error.

ii. Results

Table 4.20 Diversity of Innovation for State Ownership

VARIABLES	(16) H8b Diversity of Innovation Robust	t-statistics	p-values
Low	0.0224 (0.0309)	0.7200	0.4700
Medium	0.0316 (0.0506)	0.6200	0.5320
High	0.0466 (0.0403)	1.1600	0.2480
R&D Intensity	-0.1480 (0.3531)	-0.4200	0.6750
Firm Size	0.0249 (0.0307)	0.8100	0.4160
Firm Age	0.0196*** (0.0047)	4.2000	0.0000
Knowledge Stock	0.0002** (0.0001)	2.4500	0.0150

Continued

Leverage	0.0012	0.0700	0.9460
	(0.0183)		
Public A-shares	0.1866	1.4500	0.1480
	(0.1287)		
Long-term Investment	0.0268***	2.9100	0.0040
	(0.0092)		
Constant	0.1014	0.1700	0.8630
	(0.5894)		
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0288		
FIRM FE	YES		
Log-likelihood	-327.7		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is zero level of state ownership.

The p-values for three levels of state ownership are greater than 0.1, so null hypotheses cannot be rejected. All three levels of state ownership show no significant difference in R&D intensity from non-state ownership when comparing state and non-state ownership, on average, ceteris paribus. The results are not in line with hypothesis H8b. For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly positive relationship between firm age and the diversity of innovation. The expected change in the diversity of innovation is 0.0196 for one additional year increase in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.05$, which rejects the null hypothesis at the 5% level. Knowledge stock and the diversity of innovation are positively related. Excepted change in the diversity of innovation is 0.0002 for an additional one unit increased in knowledge stock. The p-value of ln(long-term investment) is $p < 0.01$, which rejects the null hypothesis at the 1% level. Ln(long-term investment) and the diversity of innovation are significantly and positively related. If long-term investment increases by 1%, the diversity of innovation is expected to increase by 0.000268, ceteris paribus.

The log-likelihood value is -327.7.

4.3.3.4 Institutional Ownership

4.3.3.4.1 Depth of Innovation and Institutional Ownerships

i. Tests for Assumptions of Panel Data Regression

A p-value of $p < 0.01$ for the LM test rejected the null hypothesis of pooled regression. The HS test was then applied, showing a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Therefore, a fixed effects model was applied. Afterwards, a test of the regression hypothesis was applied.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which meant heteroscedastic residuals(*Assumption 2).* Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). To rephrase it, there was autocorrelation in residuals. Fourth, the p-value of the Ramsey RESET Test was greater than 0.1, which failed to reject the null hypothesis (*Assumption 4*). Hence, there was no misspecification error. Fifth, the total sample size was large enough to say that residual distribution was asymptotically normal (*Assumption 5*). Finally, multicollinearity was not a concern due to relatively low correlations in Appendix E.

Since some assumptions of panel data regression were violated, the robust standard error modified the fixed effects model.

ii. Results

Table 4.21 Depth of Innovation for Institutional Ownership

VARIABLES	(17) H9a Depth of Innovation Robust	t-statistics	p-values
Low	0.0083 (0.0154)	0.5400	0.5920
Medium	0.0012 (0.0172)	0.0700	0.9450
High	-0.0098 (0.0242)	-0.4000	0.6860

Continued

R&D Intensity	0.1211	0.5800	0.5590
	(0.2073)		
Firm Size	-0.0010	-0.0600	0.9540
	(0.0166)		
Firm Age	-0.0104***	-4.0700	0.0000
	(0.0026)		
Knowledge Stock	-0.0001*	-1.8500	0.0650
	(0.0000)		
Leverage	-0.0073	-0.7100	0.4790
	(0.0103)		
Public A-shares	-0.0849	-1.1800	0.2360
	(0.0716)		
Long-term Investment	-0.0154***	-2.9800	0.0030
	(0.0052)		
Constant	1.1750***	3.7400	0.0000
	(0.3145)		
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0193		
FIRM FE	YES		
Log-likelihood	1978		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is zero-level institutional ownership.

The p-values for all three levels in the table above are greater than 0.1, indicating no significant difference between the R&D intensity of institutional ownership and non-institutional ownership for the three levels, on average, all else equal. The conclusions show inconsistency with hypothesis H9a.

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly negative relationship between firm age and the depth of innovation. The depth of innovation is expected to decrease by 0.0104 for one additional year increased in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean depth of innovation decreases by 0.0001 as knowledge increases by one unit, ceteris paribus. The p-value of long-term investment is $p < 0.01$, which rejects the null hypothesis at the 1% level—long-term investment and the depth of innovation in significantly and negatively related. Expected change in depth of innovation -0.000154, if long-term investment increases by 1%, ceteris paribus. The p-values of other variables are all greater than 0.1, which fails to reject the null hypothesis.

The log-likelihood value is 1978.1874.

4.3.3.4.2 Diversity of Innovation and Institutional Ownerships

i. Tests for Assumptions of Panel Data Regression

LM tests showed a p-value of $p < 0.01$, rejecting the null hypothesis of pooled regression. Then an HS test was applied, showing a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Thus, a fixed effects model was applied. Subsequently, a test of the regression hypothesis was applied.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, which showed the heteroscedastic residuals (*Assumption 2).* Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). There was a serial correlation in residuals. Fourth, the p-value of the Ramsey RESET Test was greater than 0.01, which failed to reject the null hypothesis at the 1% level (*Assumption 4*). It meant there was not a problem of misspecification. Fifth, residuals were asymptotically normal due to the large sample size (*Assumption 5*). Sixth, Appendix E displayed correlations at a low level, and hence there was no concern about perfect multicollinearity (*Assumption 6*).

The fixed effects model was then modified by the robust standard error.

ii. Results

Table 4.22 Diversity of Innovation for Institutional Ownership

VARIABLES	(18) H9b Diversity of Innovation Robust	t-statistics	p-values

Continued

Low	-0.0161 (0.0267)	-0.6000	0.5470
Medium	-0.0054 (0.0302)	-0.1800	0.8590
High	0.0164 (0.0430)	0.3800	0.7030
R&D Intensity	-0.1527 (0.3478)	-0.4400	0.6610
Firm Size	0.0279 (0.0306)	0.9100	0.3620
Firm Age	0.0194*** (0.0047)	4.1100	0.0000
Knowledge Stock	0.0002** (0.0001)	2.4500	0.0140
Leverage	0.0038 (0.0180)	0.2100	0.8320
Public A-shares	0.1559 (0.1273)	1.2300	0.2210
Long-term Investment	0.0267*** (0.0091)	2.9200	0.0040
Constant	0.0868 (0.5851)	0.1500	0.8820
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0287		
FIRM FE	YES		
Log-likelihood	-327.8		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is the zero level of institutional ownership.

All three levels in the table above have p-values greater than 0.1, indicating that, other things being equal, there is no significant difference between the R&D intensity of institutional and non-institutional ownership at the three levels, on average. The conclusions are shown to be inconsistent with Hypothesis H9b.

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly positive relationship between firm age and the diversity of innovation. The expected change in the diversity of innovation is 0.0194 for one additional year increase in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.05$, which rejects the null hypothesis at the 5% level. Knowledge stock and the diversity of innovation are positively related. Excepted change in the diversity of innovation is 0.0004 for an additional one unit increased in knowledge stock. The p-value of ln(long-term investment) is $p < 0.01$, which rejects the null hypothesis at the 1% level. Ln(long-term investment) and the diversity of innovation are significantly and positively related. If long-term investment increases by 1%, the diversity of innovation is expected to increase by 0.000267, ceteris paribus.

The log-likelihood value is -327.78.

4.3.3.5 Foreign Ownership

4.3.3.5.1 Depth of Innovation and Foreign Ownerships

i. Tests for Assumptions of Panel Data Regression

The p-value for the LM test was $p < 0.01$, rejecting the null hypothesis of pooled regression. This was followed by the application of the HS test, which showed a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Thus, a fixed effects model was applied.

After that, a test of the regression hypothesis was applied.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, rejecting the null hypothesis of homoscedasticity (*Assumption 2*). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). To rephrase it, there was a serial correlation in residuals. Fourth, the p-value of the Ramsey RESET Test was greater than 0.1, which failed to reject the null hypothesis (*Assumption 4*). It meant that there was no misspecification error. Fifth, the total sample size was large enough to say that residual distribution was asymptotically normal (*Assumption 5*). Sixth, the assumption of no perfect multicollinearity holds since correlations in Appendix E remain low (*Assumption 6*).

Due to the violation of assumptions, the robust standard error was applied to fix these problems.

ii. Results

Table 4.23 Depth of Innovation for Foreign Ownership

VARIABLES	(1) H10a Depth of Innovation Robust	t-statistics	p-values
Low	-0.0145	-1.3500	0.1770
	(0.0107)		
Medium	0.0139	0.5500	0.5800
	(0.0251)		
High	-0.0179	-0.3600	0.7210
	(0.0500)		
R&D Intensity	0.1077	0.5100	0.6100
	(0.2109)		
Firm Size	-0.0015	-0.0900	0.9270
	(0.0164)		
Firm Age	-0.0101***	-3.9200	0.0000
	(0.0026)		
Knowledge Stock	-0.0001*	-1.8800	0.0610
	(0.0000)		
Leverage	-0.0077	-0.7300	0.4630
	(0.0104)		
Public A-shares	-0.1097	-1.4500	0.1470
	(0.0755)		
Long-term Investment	-0.0152***	-2.9600	0.0030
	(0.0051)		
Constant	1.1986***	3.8400	0.0000
	(0.3122)		
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0200		
FIRM FE	YES		
Log-likelihood	1980		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is zero-level foreign ownership. All p-values for three levels of foreign ownership are greater than 0.1 in the table above. On average, there is no significant difference in foreign ownership compared to non-foreign ownership for all three innovation specialisation levels. Thus, the findings are not consistent with hypothesis H10a.

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly negative relationship between firm age and the depth of innovation. The depth of innovation is expected to decrease by 0.0101 for one additional year increased in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.1$, which rejects the null hypothesis at the 10% level. The mean depth of innovation decreases by 0.0001, as knowledge increases by one unit, ceteris paribus. The p-value of long-term investment is $p < 0.01$, which rejects the null hypothesis at the 1% level—long-term investment and the depth of innovation in significantly and negatively related. The expected change in depth of innovation is -0.000152, if long-term investment increases by 1%, ceteris paribus. The p-values of other variables are all greater than 0.1, which fails to reject the null hypothesis.

The log-likelihood value is 1980.

4.3.3.5.2 Diversity of Innovation and Foreign Ownerships

i. Tests for Assumptions of Panel Data Regression

The LM test showed a p-value of $p < 0.01$, and the null hypothesis of pooled regression was rejected. The HS test was then applied, showing a p-value of $p < 0.01$, rejecting the null hypothesis of a random effect. Hence, a fixed effects model was applied.

This was followed by the application of a test of the regression hypothesis.

First, the zero mean residual implied that the assumption of linearity held (*Assumption 1*). Second, the p-value of the modified Wald test was $p < 0.01$, rejecting the null hypothesis. In other words, residuals were not constant (*Assumption 2*). Third, the p-value of the run test of randomness was $p < 0.01$, which rejected the null hypothesis (*Assumption 3*). There was a serial correlation in residuals. Fourth, the p-value of the

Ramsey RESET Test was greater than 0.1, which failed to reject the null hypothesis at the 1% level (*Assumption 4*). It meant there was not a problem of misspecification. Fifth, residuals were asymptotically normal due to the large sample size (*Assumption 5*). Sixth, the pairwise correlation matrix in Appendix E indicates no perfect multicollinearity (*Assumption 6*).

Since some assumptions of panel data regression were violated, the fixed effects model was modified by the robust standard error.

ii. Results

Table 4.24 Diversity of Innovation for Foreign Ownership

VARIABLES	(2) H10b Diversity of Innovation Robust	t-statistics	p-values
Low	0.0287 (0.0194)	1.4800	0.1400
Medium	-0.0272 (0.0441)	-0.6200	0.5380
High	0.0024 (0.0889)	0.0300	0.9780
R&D Intensity	-0.1425 (0.3539)	-0.4000	0.6870
Firm Size	0.0279 (0.0301)	0.9300	0.3540
Firm Age	0.0187*** (0.0047)	3.9600	0.0000
Knowledge Stock	0.0002** (0.0001)	2.4600	0.0140
Leverage	0.0048 (0.0180)	0.2700	0.7890
Public A-shares	0.2066 (0.1325)	1.5600	0.1190
Long-term Investment	0.0265*** (0.0091)	2.9200	0.0040
Constant	0.0627 (0.5789)	0.1100	0.9140
Observations	4,074		
Number of Firms	958		
Adjusted R-squared	0.0295		
FIRM FE	YES		
Log-likelihood	-326.2		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The baseline is non-foreign ownership.

The p-values for three levels of foreign ownership are higher than 0.1, so null hypotheses cannot be rejected. All three levels of foreign ownership show no significant difference in R&D intensity from non-foreign ownership when comparing foreign and non-foreign ownership, on average, all other variables are equal. The results are not in line with hypothesis H10b.

For control variables, the p-value of firm age is $p < 0.01$, which rejects the null hypothesis. There is a significantly positive relationship between firm age and the diversity of innovation. The expected change in the diversity of innovation is 0.0187 for one additional year increased in firm age, ceteris paribus. The p-value of knowledge stock is $p < 0.05$, which rejects the null hypothesis at the 5% level. Knowledge stock and the diversity of innovation are positively related. Excepted change in the diversity of innovation is 0.0002 for an additional one unit increased in knowledge stock. The p-value of ln(long-term investment) is $p < 0.01$, which rejects the null hypothesis at the 1% level. Ln(long-term investment) and the diversity of innovation are significantly and positively related. If long-term investment increases by 1%, the diversity of innovation is expected to increase by 0.000265, ceteris paribus.

The log-likelihood value is -326.33393

4.3.3.6 Discussion of Depth of Innovation and Diversity of Innovation

None of the firm ownership shows a significant effect on innovation specialisation or diversification. The findings are inconsistent with Hypotheses H6a – H10b. It reveals that innovative specialisation or diversification is not determined by firm ownership but other factors.

One interpretation is a national demand. SOEs, as state-controlled enterprises, undertake to accept the tasks assigned to them by the state. State-owned enterprises operate in a wide range of markets, including those with profound barriers to private companies

(Marrelli et al., 1998). These include knowledge barriers, trade barriers, political barriers, et cetera. Because of those barriers, SOEs' task is to promote commercial or technological developments in those areas, such as the nuclear power industry or outer space exploration. The decision to specify or diversify innovation in SOEs is, therefore, likely to be determined by the government, rather than by individuals or firm management.

Second, innovation specialisation or diversification depends on the inventor. Boh et al. (2014) divide inventors into three categories - generalists, specialists and polymaths - and point out that different types of inventors contribute differently to organisations. Specialists have a depth of knowledge that allows them to specialise in innovation and obtain technological innovations that have a high impact. On the other hand, the breadth of knowledge of the generalists and polymaths allows them to have many ideas and to explore and innovate in different fields, obtaining patents in several areas.

Third, the direction of innovation may also be influenced by national policy. For example, companies may prefer to conduct R&D in industries that are strongly supported by the state as a way to access better resources.

Fourth, the thresholds used for classifying different levels of firm ownership may not provide a good explanation of the impact of different levels of ownership on innovation specialisation or diversification. The results might be improved by other thresholds.

Fifth, the measurement of a firm's innovation specialisation and innovation diversity is based on the total number of patents, whereas some firms may choose not to patent their advanced technologies in order to safeguard them, with industrial secrecy as an example (Archibugi and Pianta, 1996; Michie, 1998; Kleinknecht et al., 2002). So using the number of patents to measure innovation and the firm's knowledge base may be biased.

4.4 Summary of Data Analysis

The relationship between concentrated ownership and R&D intensity is positive. The higher the level of concentrated ownership, the higher the R&D intensity. It disagrees with the hypothesis suggested in Chapter 3 (i.e. H1). Moreover, different levels of concentrated ownership do not behave differently in terms of innovation specialisation and innovation diversification. Hence, the results are inconsistent with hypotheses H6a and H6b.

Regressions from continuous and categorical insider ownership generate results inconsistent with H2. Despite the fact that insider ownership is less developed in China, insider ownership is more conducive to innovation performance than in firms without insider ownership, when insider ownership is greater than 20% or less than 5%. In terms of R&D intensity, firms with insider ownership over 20% are more advantageous than those with a proportion below 5%.

All three levels of insider ownership are indistinguishable from non-insider ownership in specialised or diversified innovation. That is not following the previous hypotheses H7a and H7b.

The result with continuous state ownership is not in line with hypothesis. Nevertheless, the result with categorical state ownership partly agrees with hypothesis H3. It reveals that there is a positive impact of state ownership on innovation performance when the level of state ownership is below 5%. In terms of R&D intensity, none of the other three levels of ownership differs significantly from non-state ownership. Hence, that is at odds with the previous hypotheses H8a and H8b.

Institutional ownership and R&D intensity are not related. Therefore, both regression results, including continuous or categorical institutional ownership, are not in accordance with hypothesis H4. Furthermore, The other three levels of ownership are not significantly different from non-institutional ownership in terms of R&D intensity. This is at odds with the previous hypotheses H9a and H9b.

Regressions with continuous and categorical foreign ownership show that foreign ownership and R&D intensity are negatively related, which is inconsistent with hypothesis H5.

Moreover, there is no significant difference between foreign and non-foreign ownership in innovation specialisation or diversification. Neither of those conclusions is compatible with the hypothesis (H10a and H10b).

Chapter 5 Conclusion

5.1 Introduction

This chapter concludes main findings (i.e. Section 6.2), and provide contributions (i.e. Section 6.3), limitations (i.e. Section 6.4) and recommendations (i.e. Section 6.5).

5.2 Main Findings

5.2.1 Introduction of Main Findings

This sub-section comprehensively summarises how firm ownership affects firm innovation based on the data from the Shanghai Stock Exchange between 2013 and 2019. The sub-section 6.2.2 focuses on the R&D intensity of a firm. The sub-section 6.2.3 deals with specialised and diversified innovation for a firm.

5.2.2 Innovation Performance

5.2.2.1 Concentrated Ownership

Concentrated ownership has a significant positive effect on R&D intensity. The more concentrated ownership, the higher the R&D intensity. It follows agency theory when high concentrations of ownership favour innovative performance. Such positive effect benefits from efficient monitoring or incentive schemes by diminishing the conflict between agents' and principals' interests and regulating agents' (managers') behaviour (e.g. Berle and Means, 1932; Jensen and Meckling, 1976; Boučková, 2015; Feldman and Montgomery, 2015).

While Yusuf et al. (2018) point out that the prevalence of high concentrated ownership, strong family control and mismanagement in developing country firms weakens the foundation of agency theory, the data from the study (Appendix B) indicates that only about one-third of the sample size contains concentrated ownership above 20% and only less than one-fifth of the sample size contains insider ownership (including family ownership) above 20%. Indeed, highly concentrated ownership does exist in Chinese listed firms, but in terms of data, they only account for approximately one-third of firms. Moreover, the proportion of family ownership involved in insider ownership is even smaller. Thus, the high concentration of ownership and strong family control proposed by Yusuf et al. (2018) is less common in Chinese listed firms and does not affect the conclusions of agency theory on the concentration of ownership in terms of innovation.

Another interpretation is that a high degree of concentrated ownership assists in the optimal allocation and integration of internal or external resources (Lacetera, 2001). Even though a change in innovation performance is not based on different levels of concentrated ownership, it does not mean concentrated ownership has an indifferent innovation performance with non-concentrated ownership.

In sum, concentred ownership benefits innovation performance, and that is inconsistent with hypothesis H1.

5.2.2.2 Insider Ownership

Insider ownership and R&D intensity are not related. Reasons include insider ownership being less developed in China (Choi et al., 2011), managers focusing on public relations rather than performance (Bisot and Child, 1996; Xin and Pearce, 1996; Peng, 2000), and the imprecision of agency theory in explaining the relationship between insider ownership and innovation (Suk et al., 2012). The data (Appendix B) supports Choi et al. (2011)'s claim that over one-third of the companies are non-insider owned. About half of the observed data hold less than 20% insider ownership (excluding non-insider ownership). It highlights that underdeveloped insider ownership is still a common phenomenon among listed firms in China.

In addition, high and low levels of insider ownership are more conducive to innovation than non-insider ownership, and even the high-level is more predominant than the low-level. It may be caused by the fact that firm owners have long-term aspirations for the company, and employees actively seek innovation in order to achieve self-worth and obtain stable employment.

Another reason is that the low level of shareholdings may be held by employees who have contributed significantly to the firm. Equity incentives also motivate other employees in the company to innovate actively, thus creating a positive correlation between a low level of insider ownership and innovation.

On the other hand, insider ownership positively affects innovation performance due to the efficient monitoring scheme at the high level of firm ownership.

In short, the low and high levels of insider ownership are beneficial to innovation performance, although insider ownership is relatively uncommon among Chinese listed companies. The thresholds for the positive impact of insider ownership on innovation performance are the level of insider ownership below 5% and greater than 20%. Both regression results deny hypothesis H2.

5.2.2.3 State Ownership

Unexpectedly, there is a non-relationship between state ownership and R&D intensity. One interpretation is that listed state-owned companies may raise funds from the market and be less reliant on state resources than unlisted state-owned companies (Zhou et al., 2017). It may also be explained by an absence from the list of highly sophisticated state-owned enterprises that have invested heavily in innovation owing to technological secrecy as well as political and commercial reasons.

In terms of different levels of state ownership, it offers a different perspective with the low-level state ownership promoting innovation, unlike the medium-level and the high-level. A low level of state ownership (i.e. < 5%) can exploit resource benefits without concern about the state seizing control of the firm.

In summary, regression results partly agree with hypothesis H3. When state ownership is less than 5%, there is a positive influence of state ownership on innovation performance.

5.2.2.4 Institutional Ownership

Institutional ownership and R&D intensity are not related, as regression analyses indicate it in both continuous and categorical institutional ownership. While almost all listed firms are held by institutions, only about a fifth of the total sample size has more than 20% institutional ownership. If institutional ownership is low, institutional investors will not be able to actively monitor the firm to alleviate managers' concerns about R&D failure (Bushee, 1998). In addition, most institutional investors are short-term financial investors. If the holding period is too short, institutional investors are unable to reap the long-term benefits of their R&D investments.

To sum up, there is no relationship between institutional ownership and innovation performance. Results from the regressions with continuous institutional ownership and categorical institutional ownership are not in accordance with the hypothesis H4.

5.2.2.5 Foreign Ownership

Both regression analyses of continuous and categorical foreign ownership illustrate a negative impact of foreign ownership on R&D intensity. However, there is no association between the low and medium levels of foreign ownership with innovation intensity, but the high level of foreign ownership has a significant negative impact on innovation intensity.

Owing to the costs and resources associated with research and development, subsidiaries invested by foreign firms are more likely to acquire advanced technologies directly from foreign parent firms than innovating locally. Furthermore, most foreign investors keep a low level of firm shares. As a consequence, those foreign investors may not offer critical technology or other resources for innovation activities, unlike multinational firms (Teece, 1986).

Briefly speaking, regression results of the negative relationship between foreign ownership and innovation performance disagree with hypothesis H5.

5.2.3 Depth of Innovation and Diversity of Innovation

The empirical results suggest that firm ownership is not related to innovation specialisation or diversification. Knowledge acquisition may be dependent on firm ownership, for example spillover effect of foreign direct investment. The decision to specialise or diversify innovation may, however, be more of an external one. It could be national demand, national policy, the knowledge base of the inventor, or inappropriate thresholds used in classifying firm ownership.

5.2.4 Control Variables

5.2.4.1 Firm Size

Firm size plays a vital role in R&D intensity. The larger the firm, the less willing it is to innovate. It is possible that large firms have complex internal organisational structures and heavy bureaucracy, and react slowly when the market environment changes. If the market does not allow outsiders or makes it difficult for them to gain a foothold in the market, then the vested interests of the large companies drive them to maintain the status quo and to stop focusing on the actual and potential interests of their customers.

5.2.4.2 Firm Age

Firm age plays a vital role in R&D intensity, the depth of innovation and the diversity of innovation. Nevertheless, such effects of firm age are trivial.

R&D intensity increases as firm age increases. According to the learning-by-doing model, the older a firm is, the more business experience and foresight it has (Arrow, 1962; Sorensen and Stuart, 2000; Chang et al., 2002).

Firm age harms the depth of innovation but benefits the diversity of innovation. The primary goal of young firms is to survive in the market, and so that they only can R&D in a single field with limited resources. Over time, they grow from a small firm to a large firm with sufficient resources, capability and capacity to develop in multiple areas.

5.2.4.3 Long-term Investment

The minor and positive effect of long-term investment on R&D intensity suggests that innovation performance increases as long-term investment increases. The long-term investment could be an R&D investment if investing in patents, research institutions and experimental equipment, for example.

Regardless of ownership, long-term investment has a positive effect on diversified innovation but rather a negative effect on specialised innovation. Even if the effect is paltry, it reiterates that firms are willing to research in different fields. As a result, it may benefit the firm and innovation performance in the long term.

5.2.4.4 Knowledge Stock

Knowledge stock is the total number of patents firms hold. An increase in the total number of patents may foster firms to widen the type of patents.

5.2.4.5 Industry Dummies

Full names of the industry codes are described in the Research methodology (i.e. Table 3.3). The baseline is agriculture, forestry, animal husbandry and fisheries. No matter what the firm ownership is, firms in the following fields have a greater R&D intensity than the baseline: (1) manufacturing industry; (2) information transmission, software and information technology services; (3) scientific research and technical service industry; (4) education industry; and (5) health and social work. One interpretation is that an equity-compensation scheme is prevalent in those industries to promote innovative performance.

R&D intensity in the wholesale and retail sector are below the baseline in all five ownerships.

5.3 Contributions

Firstly, this study presents a comprehensive analysis of the impact of firm ownership on innovation performance in the context of One Belt and One Road, using the most recent data available.

Secondly, firm ownership is divided into different levels, and innovation performance differences between different groups are examined to derive thresholds of firm ownership.

Based on the above two points, the results show that concentrated ownership has a significantly positive impact on innovation, which is different from the results of previous studies (Wen et al., 2016). Insider ownership below 5% or above 20% has a positive impact on innovation performance. In particular, insider ownership over 20% has a higher impact on innovation performance than insider ownership below 5%. The outcome partly agrees with Song et al. (2015)'s work. Furthermore, state ownership is positively associated with innovation performance only when it is less than 5%, which is partially in line with previous research findings (Choi et al., 2011). In addition, the results show that institutional ownership and innovation performance are not related, which is inconsistent with the view of Rong et al. (2017). Finally, foreign ownership is unexpectedly negatively related to innovation performance. However, in the analysis using different levels of foreign ownership, it is found that only firms with foreign ownership over 20% have a negative impact on innovation performance. The result is not the same as Choi et al. (2011)'s findings.

Thirdly, the report examines how firm ownership affects innovation specialisation and diversification. The results indicate that firm ownership is unrelated to innovation specialisation or diversification. Instead, innovation specialisation or diversification is more associated with external factors.

5.4 Limitations

First, this thesis does not include the performance of listed companies on the One Belt and One Road. It is still vague on how Belt and Road affects the relationship between firm ownership and innovation performance.

Second, the ownership of companies used in this article is only broadly classified into five categories - concentrated ownership, insider ownership, state ownership, institutional ownership and foreign ownership. In fact, however, firm ownership can be subdivided into various categories. For example, insider ownership can be subdivided into management ownership, employee ownership and family ownership. The different types of insider ownership also have a different impact on innovation, as reviewed in Chapter 2. Therefore, mixing them together might have made the results unreliable to a certain extent.

Third, due to the paucity of literature on the link between firm ownership and innovation specialisation, hypothesis testing of the link between firm ownership and innovation specialisation is based on the link between firm ownership and innovation diversification in the opposite direction. It also poses some problems in proposing hypothesis tests.

Fourth, the thresholds used in the paper (i.e. 5% and 20%) are not very helpful in examining the effects of firm ownership on innovation specialisation and innovation diversification.

5.5 Recommendations and Future Research

First, due to the lack of information on Belt and Road among listed companies, future research could collect such relevant information and identify more intuitively the impact of Belt and Road on the relationship between firm ownership and innovation performance.

Secondly, future research could provide a detailed classification of firm ownership in order to identify precisely the association between firm ownership and innovation performance.

Thirdly, only one set of thresholds (5% and 20%) is used in the paper. While thresholds of 5% and 20% had a significant effect on the relationship between firm ownership and innovation performance, they did not significantly affect the relationship between firm ownership and specialised or diversified innovation. Future research could focus on thresholds based on 5% and 20% to see if changes in thresholds have a significant impact on innovation specialisation or innovation diversification.

As the two thresholds of 5% and 20% have implications for insider ownership and state ownership, future research could design mixed ownership stakes in SOEs based on these two thresholds. This would not only benefit multiple parties but would also allow the resources of each party to be fully utilised.

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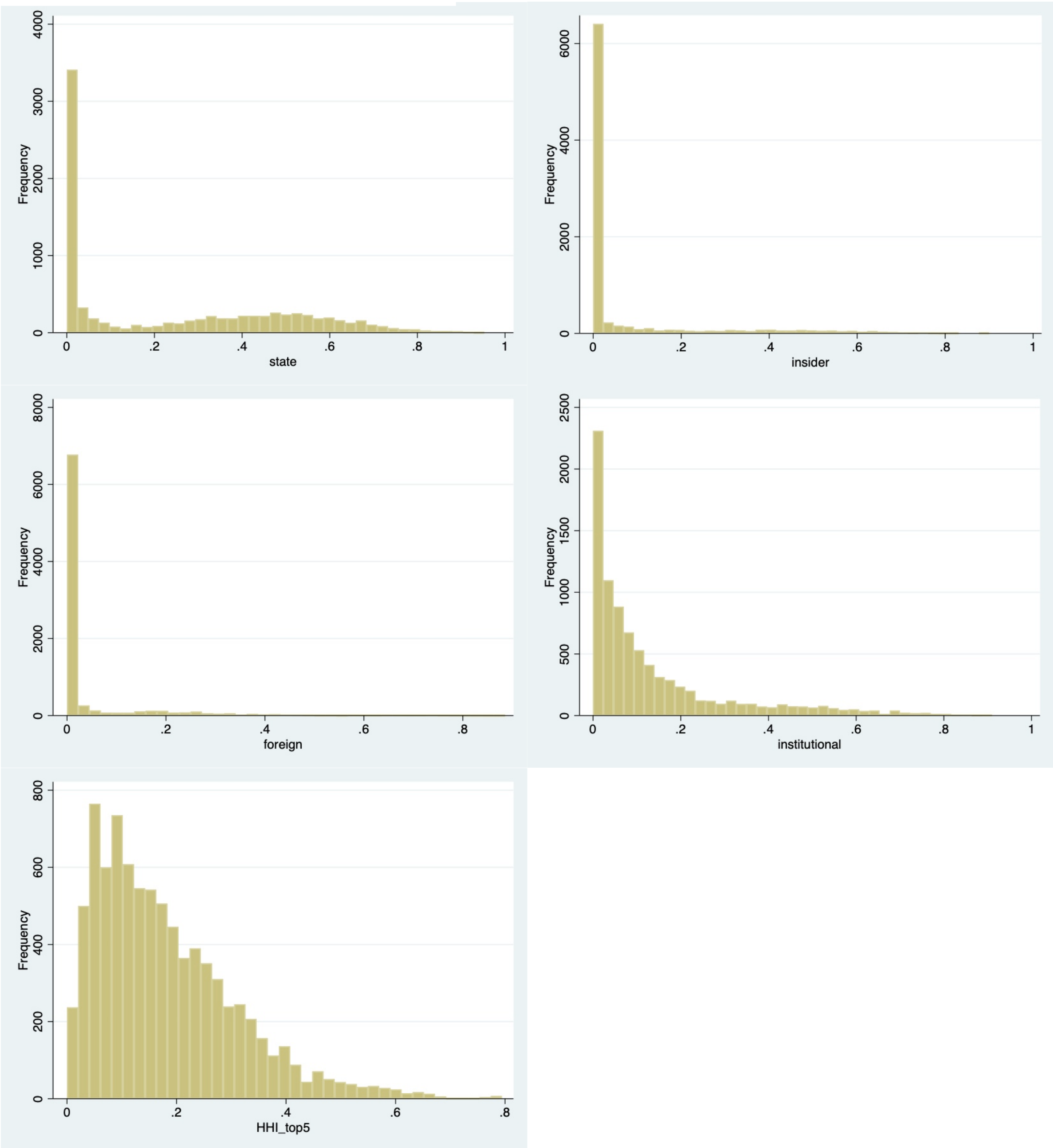
Appendix

Appendix A Histograms of Five ownership structures



Appendix B Frequency Table for Five ownership structures

	Concentrated	Insider	State	Institutional	Foreign
	Freq (Percent)	Freq (Percent)	Freq (Percent)	Freq (Percent)	Freq (Percent)
Zero (0%)		2,821 (33.15)	3,011 (35.38)	670 (7.873)	5,747 (67.53)
Low (< 5%)	1,095 (12.87)	3,847 (45.21)	744 (8.743)	2,885 (33.90)	1,324 (15.56)
Medium (5% - 20%)	4,295 (50.50)	642 (7.544)	612 (7.192)	3,110 (36.55)	636 (7.474)
High (≥ 20%)	3,115 (36.63)	1,200 (14.10)	4,143 (48.68)	1,845 (21.68)	803 (9.436)
Number of Firms	1,409	1,409	1,409	1,409	1,409
Total	8505	8510	8510	8510	8510

Appendix C P-values from Pairwise Comparisons

		R&D Intensity	Depth of Innovation	Diversity of Innovation
State Ownership	Low - Zero	0.4365	0.2101	0.2211
	Medium - Zero	0.0000	0.6921	0.7340
	High - Zero	0.0000	0.0000	0.0000
	Medium – Low	0.0348	0.9562	0.9468
	High – Low	0.0000	0.0008	0.0001
	High - Medium	0.0005	0.0003	0.0000
Insider Ownership	Low - Zero	0.0000	0.0339	0.0056
	Medium - Zero	0.0000	0.5721	0.4605
	High - Zero	0.0000	0.0095	0.0025
	Medium – Low	0.0000	0.0067	0.0008
	High – Low	0.0000	0.0000	0.0000
	High - Medium	0.0742	0.6744	0.6012
Foreign Ownership	Low - Zero	0.9080	0.0013	0.0001
	Medium - Zero	0.8135	0.4437	0.1389
	High - Zero	0.5779	0.3018	0.1403
	Medium – Low	0.6337	0.6153	0.6933
	High – Low	0.4178	0.5377	0.4393
	High - Medium	0.9967	1.0000	0.9948
Institutional Ownership	Low - Zero	0.0061	0.0527	0.0103
	Medium - Zero	0.2185	0.9245	0.8356
	High - Zero	0.0001	0.8284	0.9343
	Medium – Low	0.1106	0.0068	0.0008
	High – Low	0.2512	0.0000	0.0000
	High - Medium	0.0007	0.1364	0.1661
Concentrated Ownership - HHI	Medium - Low	0.4411	0.2237	0.1575
	High - Low	0.6955	0.0000	0.0000
	High - Medium	0.9733	0.0000	0.0000

Appendix D Pairwise Correlations for Innovation Performance

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) R&D Intensity	1.000												
(2) Concentrated	-0.089	1.000											
(3) insider	0.244	-0.027	1.000										
(4) state	-0.207	0.431	-0.404	1.000									
(5) institutional	-0.043	0.028	-0.064	-0.102	1.000								
(6) foreign	0.001	0.221	-0.012	-0.059	0.080	1.000							
(7) Firm Size	-0.195	0.242	-0.274	0.392	0.042	0.211	1.000						
(8) Firm Age	-0.093	-0.238	-0.167	-0.033	0.010	-0.050	0.056	1.000					
(9) Knowledge Stock	0.023	0.149	-0.024	0.097	-0.036	0.063	0.189	-0.030	1.000				
(10) Leverage	0.005	-0.026	0.041	-0.015	-0.011	-0.009	-0.002	0.017	-0.003	1.000			
(11) Public A-shares	-0.004	0.726	0.207	0.247	0.231	0.334	0.274	-0.243	0.110	-0.052	1.000		
(12) ln_long_term_~v	-0.059	0.252	-0.091	0.261	0.032	0.207	0.707	-0.098	0.194	-0.002	0.324	1.000	
(13) ind_num	-0.111	0.012	-0.103	0.125	0.088	-0.040	0.165	0.139	-0.078	-0.010	0.001	-0.091	1.000

Appendix E Pairwise Correlations for Innovation Specialisation and Diversification

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) depth	1.000								
(2) diversity	-0.978	1.000							
(3) R&D Intensity	-0.028	0.004	1.000						
(4) Firm Size	-0.163	0.197	-0.195	1.000					
(5) Firm Age	0.052	-0.054	-0.093	0.056	1.000				
(6) Knowledge Stock	-0.152	0.194	0.023	0.189	-0.030	1.000			
(7) Leverage	-0.070	0.080	0.005	-0.002	0.017	-0.003	1.000		
(8) Public A-shares	-0.079	0.095	-0.004	0.274	-0.243	0.110	-0.052	1.000	
(9) Long-term Investment	-0.185	0.219	-0.059	0.707	-0.098	0.194	-0.002	0.324	1.000

Abbreviation	Full Name
Caihong	Caihong Display Devices
CPC	Communist Party of China
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
HKSC	Hong Kong Securities Clearing Company
HS test	Hausman Specification (HS) test
IQR	Interquartile Range
LM test	Breusch-Pagan Lagrange multiplier (LM) test
OBOR	One Belt One Road
OEM	Original Equipment Manufacturer
R&D	Research and Development
SME	Small and Medium Enterprises
SOE	State-owned Enterprises
TCE	Transaction Cost of Economy

Appendix G Innovation Performance for Five Ownership (Continuous Variables)

VARIABLES	(1) H1 Fixed Effects Robust	(3) H2 Fixed Effects Robust	(5) H3 Fixed Effects Robust	(7) H4 Fixed Effects Robust	(9) H5 Fixed Effects Robust
Concentrated	0.0127*				
	(0.0072)				
Insider		0.0133			
		(0.0138)			
State			0.0012		
			(0.0033)		
Institutional				0.0001	
				(0.0042)	
Foreign					-0.0246**
					(0.0098)
Firm Size	-0.0024**	-0.0025**	-0.0025**	-0.0025**	-0.0024**
	(0.0010)	(0.0011)	(0.0010)	(0.0010)	(0.0010)
Firm Age	0.0016***	0.0015***	0.0015***	0.0015***	0.0015***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Knowledge Stock	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Leverage	0.0005	0.0007	0.0005	0.0005	0.0005
	(0.0009)	(0.0012)	(0.0009)	(0.0009)	(0.0009)
Public A-shares	-0.0069	-0.0037	-0.0028	-0.0026	-0.0007
	(0.0062)	(0.0057)	(0.0057)	(0.0065)	(0.0057)
Long-term Investment	0.0006**	0.0006**	0.0006**	0.0006**	0.0006**
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Industry 2	0.0059	0.0071	0.0068	0.0069	0.0065
	(0.0129)	(0.0129)	(0.0129)	(0.0129)	(0.0129)
Industry 3	0.0168**	0.0169**	0.0171**	0.0171**	0.0172**
	(0.0082)	(0.0080)	(0.0082)	(0.0081)	(0.0082)
Industry 4	0.0021	0.0028	0.0029	0.0029	0.0028
	(0.0085)	(0.0083)	(0.0085)	(0.0084)	(0.0084)
Industry 5	-0.0016	-0.0011	-0.0011	-0.0010	-0.0007
	(0.0142)	(0.0141)	(0.0142)	(0.0141)	(0.0141)
Industry 6	-0.0047***	-0.0044***	-0.0046***	-0.0045***	-0.0045***
	(0.0005)	(0.0005)	(0.0006)	(0.0005)	(0.0005)
Industry 7	0.0112	0.0109	0.0115	0.0115	0.0115
	(0.0104)	(0.0101)	(0.0104)	(0.0105)	(0.0104)
Industry 8	0.0119	0.0105	0.0110	0.0107	0.0122
	(0.0118)	(0.0116)	(0.0118)	(0.0118)	(0.0119)
Industry 9	0.0442**	0.0441**	0.0447**	0.0447**	0.0447**
	(0.0196)	(0.0189)	(0.0195)	(0.0195)	(0.0195)
Industry 10	0.0126	0.0127	0.0127	0.0127	0.0120
	(0.0080)	(0.0078)	(0.0080)	(0.0079)	(0.0079)
Industry 11	0.0041	0.0044	0.0046	0.0046	0.0046

continued

	(0.0088)	(0.0085)	(0.0088)	(0.0087)	(0.0087)
Industry 12	0.0112	0.0113	0.0115	0.0116	0.0116
	(0.0117)	(0.0115)	(0.0117)	(0.0117)	(0.0117)
Industry 13	0.0332*	0.0302*	0.0322*	0.0319*	0.0321*
	(0.0173)	(0.0166)	(0.0178)	(0.0177)	(0.0178)
Industry 14	0.0009	0.0013	0.0014	0.0014	0.0015
	(0.0113)	(0.0110)	(0.0113)	(0.0111)	(0.0113)
Industry 15	0.1320***	0.1322***	0.1326***	0.1326***	0.1327***
	(0.0072)	(0.0069)	(0.0072)	(0.0072)	(0.0071)
Industry 16	0.0588***	0.0586***	0.0593***	0.0590***	0.0587***
	(0.0099)	(0.0097)	(0.0099)	(0.0104)	(0.0099)
Industry 17	0.0082	0.0080	0.0084	0.0085	0.0082
	(0.0144)	(0.0143)	(0.0143)	(0.0143)	(0.0142)
Industry 18	0.0179	0.0182	0.0183	0.0183	0.0183
	(0.0126)	(0.0123)	(0.0126)	(0.0125)	(0.0126)
Constant	0.0249	0.0287	0.0271	0.0270	0.0256
	(0.0212)	(0.0224)	(0.0215)	(0.0217)	(0.0214)
Observations	8,286	8,284	8,286	8,286	8,286
Number of Firms	1,409	1,409	1,409	1,409	1,409
Adjusted R-squared	0.0806	0.0823	0.0799	0.0798	0.0815
Log-likelihood	23946	23959	23942	23942	23949
FIRM FE	YES	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(2) Fixed Effects Robust	(4) Fixed Effects Robust	(6) Fixed Effects Robust	(8) Fixed Effects Robust	(10) Fixed Effects Robust
Low		0.0025***	0.0031*	0.0005	-0.0006
(< 5%)		(0.0009)	(0.0017)	(0.0012)	(0.0007)
Medium	-0.0015	0.0017	-0.0018	0.0008	-0.0026
(5% - 20%)	(0.0019)	(0.0022)	(0.0028)	(0.0014)	(0.0020)
High	-0.0004	0.0103*	-0.0008	0.0007	-0.0080***
(≥ 20%)	(0.0021)	(0.0053)	(0.0021)	(0.0019)	(0.0028)
Firm Size	-0.0025**	-0.0025**	-0.0025**	-0.0025**	-0.0024**
	(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Firm Age	0.0015***	0.0015***	0.0015***	0.0015***	0.0015***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Knowledge Stock	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Leverage	0.0005	0.0005	0.0005	0.0005	0.0005
	(0.0009)	(0.0010)	(0.0009)	(0.0009)	(0.0009)
Public A-shares	-0.0024	-0.0030	-0.0021	-0.0031	-0.0012
	(0.0053)	(0.0056)	(0.0057)	(0.0065)	(0.0056)
Long-term Investment	0.0006**	0.0006**	0.0006**	0.0006**	0.0007**
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Industry 2	0.0066	0.0081	0.0069	0.0068	0.0066
	(0.0131)	(0.0126)	(0.0128)	(0.0130)	(0.0129)
Industry 3	0.0173**	0.0187**	0.0173**	0.0171**	0.0172**
	(0.0082)	(0.0080)	(0.0081)	(0.0082)	(0.0082)
Industry 4	0.0030	0.0048	0.0024	0.0030	0.0029
	(0.0085)	(0.0082)	(0.0084)	(0.0084)	(0.0085)
Industry 5	-0.0007	0.0012	-0.0005	-0.0009	-0.0007
	(0.0141)	(0.0139)	(0.0142)	(0.0141)	(0.0141)
Industry 6	-0.0045***	-0.0021*	-0.0047***	-0.0046***	-0.0044***
	(0.0005)	(0.0011)	(0.0005)	(0.0005)	(0.0006)
Industry 7	0.0114	0.0129	0.0105	0.0116	0.0116
	(0.0105)	(0.0102)	(0.0105)	(0.0104)	(0.0104)
Industry 8	0.0113	0.0108	0.0105	0.0107	0.0123
	(0.0118)	(0.0114)	(0.0118)	(0.0118)	(0.0120)
Industry 9	0.0448**	0.0456**	0.0448**	0.0447**	0.0448**
	(0.0196)	(0.0186)	(0.0195)	(0.0195)	(0.0195)
Industry 10	0.0124	0.0147*	0.0124	0.0128	0.0121
	(0.0081)	(0.0079)	(0.0079)	(0.0079)	(0.0079)
Industry 11	0.0045	0.0065	0.0040	0.0046	0.0047
	(0.0088)	(0.0086)	(0.0087)	(0.0087)	(0.0087)
Industry 12	0.0115	0.0135	0.0114	0.0117	0.0117
	(0.0118)	(0.0115)	(0.0117)	(0.0116)	(0.0117)
Industry 13	0.0325*	0.0335*	0.0323*	0.0318*	0.0321*
	(0.0179)	(0.0180)	(0.0177)	(0.0178)	(0.0178)

continued

Industry 14	0.0018	0.0028	0.0012	0.0015	0.0015
	(0.0113)	(0.0108)	(0.0113)	(0.0112)	(0.0113)
Industry 15	0.1320***	0.1328***	0.1322***	0.1328***	0.1327***
	(0.0074)	(0.0068)	(0.0071)	(0.0070)	(0.0072)
Industry 16	0.0593***	0.0605***	0.0586***	0.0590***	0.0588***
	(0.0100)	(0.0098)	(0.0100)	(0.0101)	(0.0099)
Industry 17	0.0084	0.0096	0.0084	0.0084	0.0081
	(0.0143)	(0.0141)	(0.0142)	(0.0144)	(0.0142)
Industry 18	0.0185	0.0200	0.0177	0.0184	0.0183
	(0.0126)	(0.0124)	(0.0124)	(0.0125)	(0.0126)
Constant	0.0281	0.0253	0.0281	0.0270	0.0252
	(0.0212)	(0.0213)	(0.0216)	(0.0216)	(0.0214)
Observations	8,286	8,286	8,286	8,286	8,286
Number of Firms	1,409	1,409	1,409	1,409	1,409
Adjusted R-squared	0.0802	0.0846	0.0820	0.0797	0.0815
FIRM FE	YES	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES	YES
Log-likelihood	23944	23965	23953	23942	23950

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix I Depth of Innovation and Diversity of Innovation for Five Ownership

	Concentrated Ownership		Insider Ownership		State Ownership		Institutional Ownership		Foreign Ownership	
	(2)	(3)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	H6a	H6b	H7a	H7b	H8a	H8b	H9a	H9b	H10a	H10b
	Depth	Diversity	Depth	Diversity	Depth	Diversity	Depth	Diversity	Depth	Diversity
VARIABLES	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust
Low (< 5%)			0.0118	-0.0206	-0.0135	0.0224	0.0083	-0.0161	-0.0145	0.0287
			(0.0155)	(0.0281)	(0.0173)	(0.0309)	(0.0154)	(0.0267)	(0.0107)	(0.0194)
Medium (5% -20%)	-0.0048	-0.0006	-0.0239	0.0517	-0.0081	0.0316	0.0012	-0.0054	0.0139	-0.0272
	(0.0270)	(0.0480)	(0.0299)	(0.0522)	(0.0281)	(0.0506)	(0.0172)	(0.0302)	(0.0251)	(0.0441)
High (≥ 20%)	-0.0117	0.0075	0.0159	-0.0145	-0.0242	0.0466	-0.0098	0.0164	-0.0179	0.0024
	(0.0348)	(0.0617)	(0.0394)	(0.0668)	(0.0235)	(0.0403)	(0.0242)	(0.0430)	(0.0500)	(0.0889)
R&D Intensity	0.1254	-0.1640	0.1169	-0.1400	0.1256	-0.1480	0.1211	-0.1527	0.1077	-0.1425
	(0.2075)	(0.3483)	(0.2066)	(0.3484)	(0.2100)	(0.3531)	(0.2073)	(0.3478)	(0.2109)	(0.3539)
Firm Size	-0.0008	0.0274	0.0008	0.0245	0.0009	0.0249	-0.0010	0.0279	-0.0015	0.0279
	(0.0164)	(0.0304)	(0.0166)	(0.0307)	(0.0166)	(0.0307)	(0.0166)	(0.0306)	(0.0164)	(0.0301)

continued

Firm Age	-0.0106***	0.0197***	-0.0107***	0.0199***	-0.0106***	0.0196***	-0.0104***	0.0194***	-0.0101***	0.0187***
	(0.0026)	(0.0047)	(0.0026)	(0.0047)	(0.0025)	(0.0047)	(0.0026)	(0.0047)	(0.0026)	(0.0047)
Knowledge Stock	-0.0001*	0.0002**	-0.0001*	0.0002**	-0.0001*	0.0002**	-0.0001*	0.0002**	-0.0001*	0.0002**
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)
Leverage	-0.0071	0.0039	-0.0061	0.0028	-0.0059	0.0012	-0.0073	0.0038	-0.0077	0.0048
	(0.0106)	(0.0183)	(0.0111)	(0.0192)	(0.0105)	(0.0183)	(0.0103)	(0.0180)	(0.0104)	(0.0180)
Public A-shares	-0.0930	0.1794	-0.1019	0.1831	-0.1043	0.1866	-0.0849	0.1559	-0.1097	0.2066
	(0.0771)	(0.1359)	(0.0727)	(0.1284)	(0.0728)	(0.1287)	(0.0716)	(0.1273)	(0.0755)	(0.1325)
Long-term Investment	-0.0154***	0.0266***	-0.0156***	0.0270***	-0.0155***	0.0268***	-0.0154***	0.0267***	-0.0152***	0.0265***
	(0.0052)	(0.0091)	(0.0052)	(0.0092)	(0.0052)	(0.0092)	(0.0052)	(0.0091)	(0.0051)	(0.0091)
Constant	1.1882***	0.0719	1.1506***	0.1346	1.1625***	0.1014	1.1750***	0.0868	1.1986***	0.0627
	(0.3153)	(0.5896)	(0.3172)	(0.5930)	(0.3153)	(0.5894)	(0.3145)	(0.5851)	(0.3122)	(0.5789)
Observations	4,074	4,074	4,074	4,074	4,074	4,074	4,074	4,074	4,074	4,074
Number of Firms	958	958	958	958	958	958	958	958	958	958
Adjusted R-squared	0.0192	0.0286	0.0200	0.0296	0.0193	0.0288	0.0193	0.0287	0.0200	0.0295
FIRM FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY FE			1980	-326.0	1978	-327.7	1978	-327.8	1980	-326.2

continued

Log-likelihood	1977	-328.6	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1