THE INFLUENCE OF CORPORATE VENTURE CAPITAL ON INNOVATION: EVIDENCE FROM CHINA

A Dissertation
Submitted to
the Temple University Graduate Board

In Partial Fulfillment
of the Requirements for the Degree
DOCTOR OF BUSINESS ADMINISTRATION

---

by
Elizabeth Lee
Diploma Date June 2021

Examining Committee Members:

Oleg Rytchkov, Advisory Chair, Finance, Fox School of Business, Temple University
Xiaohui Gao Bakshi, Finance, Fox School of Business, Temple University
Connie Mao, Finance, Fox School of Business, Temple University
Xuan Tian, Finance, PBC School of Finance, Tsinghua University

ABSTRACT

This dissertation explores the influence of corporate venture capital (CVC) on the innovation of startups. Applying the ordinary least squares (OLS) regression and propensity score matching approach to the CVC investment data on China's listed companies, we document that the CVC investment can determine the innovation level of startups.

For further insight, invention patents and utility patents will be considered, in addition to a separate examination of the number of patent applications and patent grants. It is found that CVC participation, the number of CVC syndicate investors, and the level of CVC involvement, all have significantly positive effects on the total patent applications, total patent grants, utility patent applications, and utility patent grants in those listed startups after four years of their Initial Public Offering. However, CVC investments have no significant influence on the number of invention patent applications and patent grants. This result indicates that the influence of CVC investments on the innovation level of startups is still in the preliminary stage, and CVC investments only slightly affect the development of more challenging invention patents.

Keywords: corporate venture capital, startups, innovation level, patent grants, invention patent.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 Research Background

Due to inadequate credit records, asset-light structures and other financing difficulties, startups are frequently turned down by traditional funding channels, such as banks. The rise of venture investment is the solution to the funding hardship experienced by startups. For many years, venture investment helped boost startups, especially hi-tech enterprises, and indirectly promoted scientific and technological innovations. However, venture investment came with inherent limitations, encouraging researchers and practitioners to constantly explore new modes of investment.

On the other hand, large enterprises entering the mature stage of their life cycle, are troubled by various bottlenecks such as declining innovation capability, slower development, and transformation hardship. Many turned towards internal entrepreneurial activities or incubators for a breakthrough. Hence, the arrival of the CVC model that combines venture investment with corporate entrepreneurial activities.

CVC is an institutional mode of venture capital that is different to traditional Independent Venture Capital (IVC), which refers to corporate funds that directly invest in external startups, excluding internal investment and third-party investment (Chesbrough, 2002). Some scholars refer to CVC as the hybrid of venture investment and corporate internal research laboratories (Lerner, 2012).

The establishment, development, and termination of CVC programmes are closely related to the long-term development strategy of parent companies, which are usually non-financial.

The investment process covers three important bodies: parent companies, CVC funds, and startups. In terms of conventional IVC, the relationship between parent companies and startups is that of equity investors and revenue providers; under CVC mode, parent companies can participate in investments to realize long-term strategic goals, and startups are able to acquire extra value-added services from parent companies, such as human resource support, marketing, and technologies.

CVC resembles IVC in terms of investment model and investment target, but differs from it in many respects such as organizational structure, incentive patterns, and investment goals.

With regards to the organizational structure, IVC funds are of limited partnership, comprising of general partners (GP) and limited partners (LP); GPs are in charge of operating funds and collecting management fees, whilst LPs are funders with no involvement in company operations. On the other hand, CVC funds are fully funded by investment departments of non-financial corporates, or their independent subsidiaries. Therefore, they do not require cash flow from third parties, and are not restrained by contract terms.

As for incentive patterns, IVC incentives are performance-based, with IVC managers often being involved in startup investment. On the contrary, CVC managers earn the same fixed salaries as other employees in the parent companies, with extra bonuses linked with the performance of parent companies. Parent company managers and employees are not allowed to participate in investment.

In terms of investment goals, IVCs are only interested in financial returns, whilst CVCs consider both strategic goals and financial returns. Therefore, CVCs aim to facilitate long-term development strategies, improve the capacity of parent company innovation, and market competitiveness via investment. A survey showed that CVC strategic targets include acquiring technologies and new products, increasing chances of successful merger and acquisition, and optimizing production process. 49% of companies surveyed believed that acquiring new technologies was their major strategic target (Alter et al., 2000).

1.2 Why Study China's CVC?

CVC has already reached a relatively mature stage within both the global and Chinese markets. However, despite its widespread adoption, CVC remains underdeveloped and lacks academic attention. The main reason is that CVC data is limited compared to other financial data, especially startup data, which is almost unobtainable before their IPO. Hence, academic research on CVCs has much potential, and is of profound significance.

CVC research by western countries is ahead of Chinese research, for whom the CVC market emerged relatively late. Due to its particularity, western findings may not be applicable to the Chinese market. Therefore, domestic financial problems shall be explored and solved based upon the characteristics of China's economy. Hence, Chinese research on CVCs is of much importance for the development of China's capital market.

Following domestic economic growth and the Growth Enterprise Market (GEM), China's CVC investment increased rapidly, playing an increasingly important role in the whole capital market. CVCs are also crucial for corporate innovation, hi-technological industry and the national economy. Innovation, science and technology are key drivers for national economic growth, and are vital for comprehensive strength and global competitiveness. However, characterized by long cycles, high-stake and high failure rate, it is hard to encourage innovation through traditional channels, making the research of innovative incentives an important focus for scholars and practitioners. Thus, studying China's CVC value creation, especially its effects on promoting innovation, is of great theoretical and practical significance.

On the other hand, China's capital market remains underdeveloped with various problems remaining: transformation hardship in sunset industries; funding challenges for small and medium enterprises; high frequency risky acquisitions, and speculative investment institutions. The study of the influence of CVCs on listed companies may shed new light on the above issues. It is particularly significant since the establishment of China's Science and Technology Innovation Board, and the adoption of the registration system during the IPO in 2019. More scientific and technological startups have earned themselves the chance to go public, creating more exiting channels for CVCs, and giving China's CVC market a promising future. Hence, CVC research is of much practical significance to China's capital market.

1.3 Structure of the Thesis

This dissertation studies the influence of CVCs on corporate value creation, based upon empirical evidence from China's listed companies. Comprises of six chapters, this dissertation explores how CVCs influence parent and investment companies. Chapter 1 introduces the research background and significance of the dissertation. Chapter 2 is a literature review, gathering and discussing literatures from the perspectives of both parent companies and startups. The existing CVC literature is described from two perspectives: motivation research and value creation. Chapter 3 focuses on the history of CVC development and its current status in China and globally. Chapter 4 presents the empirical analyses, including data sources, variable design, descriptive statistics, empirical model, and result analyses. Chapter 5 contains conclusions, strategic suggestions and expected contributions.

CHAPTER 2
LITERATURE REVIEW

2.1 Literature Review from the Perspective of Parent Companies

Most available literatures consider the creation of parent companies, investigating what motivates companies to choose CVC investment, and how they influence the value of parent companies.

2.1.1 Studies on Motivation of Parent Companies

Domestic and foreign scholars have explored what motivates companies to choose CVC investment from a theoretical and empirical viewpoint, focusing on financial and strategic investment targets. In general, most scholars believed that strategic targets were the major motivation behind corporate CVC investments.

Foreign scholars have carried out theoretical studies on the motivation behind CVC investment from a strategic and financial perspective. Sykes (1990) conducted investigations and interviews on 31 large companies, which had adopted CVCs, and collected data on their strategic targets. He concluded that frequent interaction between parent companies and invested companies contributed to the realization of strategic targets. The most effective means of interaction was through strategic cooperative partnership; financial returns came with strategic rewards. Assuming that the major target of CVC was strategic or financial, and the operational connection between parent and invested companies, Chesbrough (2002) built a framework that divided CVC patterns into four types: driving investment; enabling investment; emergent investment, and passive investment. Three of these prioritized strategic targets. Weber & Weber (2003) sampled 20 CVC institutions, analyzing their strategic targets, organizational structures and investment standards, and then compared the data to those from other European countries and the USA. The study showed that CVC organizations focusing on a single target outperformed those with both financial and strategic targets. Ernst et al. (2005) analyzed 21 German CVC institutions, investigating whether or not they pursued external innovation strategic goals. Findings showed that short-term financial CVC investment targets may hinder the realization of external innovations, and long-term strategic interests. Reichardt & Weber (2006) analyzed the major strategic, investment and organizational features of German CVC investments (2000-03), and concluded that the sustainable implementation of the CVC plan depended not only on the performance level, but also on whether or not expectations of the parent company were fulfilled. The general trend was that CVCs were more strategically-targeted. Dushnitsky & Lavie (2010) believed that the strategic alliance between CVC companies and invested companies strengthened their partnership, because both parties complement and share resources and networks, thus further boosting CVC investment. Otherwise, the redundancy of external resources and constraints of internal resources allocation may weaken CVC investment. Basu et al. (2010) analyzed the data of 477 companies from 1990-2000 examining the circumstances in which these companies may turn to CVC. They concluded that when companies were involved with industries undergoing radical technological change, intense competition and weaker appropriability, they preferred involvement in CVC investment. Moreover, companies with stronger technologies and better market resources were more likely to participate in CVC activities.

Fewer studies were conducted by domestic scholars regarding the motivation behind CVC investment. Liu Wei et al. (2014) held that when mutual trust between CVC and invested companies is low, the investment decision and amount depends on the value of technology within the invested companies. However, in cases with high mutual trust, the investment decision is determined by both technological value and the level of mutual trust. Liu Wei &

Huang Jianglin (2016) considered 204 manufacturing companies listed in China's GEM (2009-11), and analyzed CVC data from their IPOs until 2014. The findings showed that technological resources and adequate cash flows had positive effects on the decision by listed companies to employ the CVC strategy, whilst business reputation had an insignificant effect on the CVC preferences of listed companies. Ma (2016) constructed a CVC life cycle theory to verify the assumption that companies acquire innovation information from startups through CVC investment. He found that when facing internal innovation hardship, companies turn to CVC for external information. He also argued that during the CVC operation stage, companies choose to invest in companies in similar technological domains, but with a different knowledge base, and may then actively utilize this newly-acquired information by upgrading human resources. Once the marginal benefits of such external information have reduced, CVC projects would be terminated.

2.1.2 Studies on Value Creation for Parent Companies

Another perspective considered by previous academic research is the value generated by CVC activities for parent companies, of which there are numerous related literatures.

As earlier times, most foreign scholars believe that CVC can yield positive values for parent companies. Gompers & Lerner (2000) conducted research on over 30,000 venture investment deals, and found the success rates of CVC investments were no lower than those of IVC investments, especially when strategic arrangements of parent companies overlapped those of invested companies. They also suggested that CVC investors preferred to offer a higher premium, which was not high enough for strategically favourable investments. Keil (2004) constructed a model based on two large European enterprises, and concluded that companies could utilize CVC for acquisitive learning, and gaining competitiveness through building internal and external connections with invested startups. Weber & Weber (2007) proposed a new theoretical concept, “relational fit”; they empirically verified the “relational fit” between German CVC companies and their innovation investment portfolios, and how it influenced knowledge transfer and creation. They found that the success of invested companies not only brought parent companies high financial return, but also stimulated radial strategic innovation. Dushnitsky & Lenox (2005) adopted 20 years of open data, and studied the benefits of CVCs on the innovative ability of companies. For the first time, they identified the positive impact of CVCs on parent company innovation levels, especially apparent when the intellectual property mechanism was not fully presented, and parent companies had strong absorption capacity. Dushnitsky & Lenox (2006) further explored the role of CVCs in the value creation of parent companies, and empirically proved that CVC could help improve the value of parent companyies (measured with Tobin's Q Ratio). Such value boosting effect would become more evident when parent companies were clearly pursuing the strategic target of utilizing new technologies. Benson & Ziedonis (2009) conducted a study, based on the return rates of 242 startup acquisitions made by 34 CVC investors, and found that information acquired through CVC investments helped parent companies to improve the internal innovation of investors, and promoted returns and performances. Vrande & Vanhaverbeke (2013) studied the relationship between CVC investment companies, examining how the invested companies affect the possibility of entering strategic alliances. Their findings revealed that when faced with increasing market and technological uncertainties, CVC investment portfolios may offer investment companies better opportunities. Positive technological prospects, enable strategic alliances and follow-up investments. Belderbos et al. (2018) studied 55 CVC projects in various sectors, and argued that greater geographic diversity in the CVC investment portfolio may improve investment company performance. This is providing the company avoided knowledge redundancy caused by the geographical overlap of technological sources, management complexity, high coordination costs, as well as resource constraints in pursuit of technical synergy and CVC diversity.

Chinese scholars began studying the value creation of parent companies relatively late, and mainly focused on empirical research based on China's listed companies. The empirical research by Sun Jian & Bai Quanmin (2010) on Chinese listed companies with CVC projects using Tobin's Q Ratio, found that despite CVC investment starting late in China, the development characteristics are consistent with those of foreign CVC investments; promotion of scientific and technological innovation, and faster economic growth. Using data from China's listed companies, Lin Ziyao & Li Xinchun (2012) studied the relationship between CVC and financial performance, innovative performance and growth value; the influence of CVC goals and investment intensity on listed company performance was also explored. Wan Kunyang & Lu Wencong (2014) sampled 62 companies listed on the Shanghai and Shenzhen mainboard, and conducted empirical verification of their CVC investment data (2000-11). Results showed a linear relationship between the number of CVCs within investment portfolios, and the technological innovation level of parent companies. Besides, the absorbing capacity and involvement of parent companies had positive regulating effects on such relationships. Based on the options market, Liu Dandan & Li Chaoping (2016) found that with the diversification of the CVC portfolio, corporate value initially decreased, but then increased. In addition, financial constraints may affect the relationship between CVC investment portfolio and corporate value. Fu Jiacheng & Song Yanqiu (2016) combined 78 companies established between 1999-2015, and analyzed 1,853 venture investments and 342 exits; they concluded that investment in familiar industries was the easiest way to exit CVC investments, followed by industrial chain optimization with the invested companies, or offering them management guidance. Joint investment with other VCs was considered the easiest way of generating high ROI. Phased investment was identified as relatively rare, and there was no significant correlation between investment and ROI, irrespective of whether or how the investment was phased.

2.2 Literature Review from the Perspective of Startups

Compared with literatures from the perspective of parent companies, CVC literatures considering the perspective of startups has been lagging behind, mainly because startups play passive roles.

2.2.1 Studies on Motivation of Startups

As traditional corporate financing theories, such as pecking order financing theory, were already fully developed, only a few scholars have separated CVC from IVC in this research field. Almost all previous research studies on startup motivation were conducted by western scholars, and most were theoretical instead of empirical research.

Motivation studies on startups mainly analyzed the dilemma facing startups when determining whether or not to accept CVC investment. To analyze interest conflicts between startups and strategic investors, Hellmann (2002) divided such conflicts into three scenarios. Regarding supplementary entrepreneurs, the best option was to attack investment from strategic investors. Entrepreneurs may have considered IVC a weak alternative, but their best option was syndication mode of venture investment, as lead by IVC and involve with strategic investors when they became strong alternatives. Katlia (2008) studied the "Shark's Plight" faced by startups, namely considering when entrepreneurs should choose CVC, with the high-risk that cooperation partners may swallow them up. It was observed that entrepreneurs were prepared to take the risk when they needed resources from investment companies, or when they had an effective self-defensive mechanism. Maula et al. (2009) used CEO data from CVC-invested newly established technology companies in the USA. Findings showed that higher complementarity between the invested company and CVC investors led to a higher level of social interaction from startups, and thus greater learning benefits. In other words, it was not necessary for invested companies to draw on various types of social relationships in order to protect themselves. In relation to CVC investors, these findings highlighted the need for invested companies to strike a good balance between openness and self-protection. Park & Steensma (2012) explored the dilemma faced by invested companies when considering whether or not to accept CVC funds. On one hand, the investment is a supplementary asset to enhance the commercialization of new venture technology; on the other hand, close connections with specific investors may affect accessibility to other open market assets. After examining companies engaged in computer science, semiconductor and wireless industries, CVCs were found to particularly benefit startups needing special supplementary assets, or those operating in uncertain environments. Using biotech startups in the USA, Park & Bae (2018) found that CVC received after obtaining IVC, promoted invested company innovation. The patent and pipeline of startups may also affect their investment choices before obtaining CVC. Xu Xiangyang et al. (2018) studied listed companies in China's A-share market, and found that patent signals may affect the valuation, investment amount, and possibility of startups obtaining venture capital in the first round of financing. However, such signal effect became weaker in the following rounds of financing. In addition, they also found that patent signals were more sensitive to private venture capital, CVC and extensive patent protection, and were positively related to the internal rate of return when exiting.

2.2.2 Studies on Value Creation of Startups

Since most startups are small companies with their data undisclosed, empirical studies on the value creation role of CVCs are not as rich as theoretical studies. Comprehensive data may only be disclosed for research when startups are being listed or acquired.

Although foreign scholars also face limited data availability, they began conducting relevant theoretical studies before China. McNally (1994) studied 48 British startups, proposing that CVCs benefitted startup equity financing. He found that skill and marketing training, as well as market reputation promotion, could yield added value. Ivanov & Xie (2008) argued that CVC could only create value for startups with strategic synergy with CVC parent companies. They also found that CVCs could provide different resources to satisfy specific startup needs in different industries. CVC-backed startups could have higher evaluation than non-CVC startups in IPOs, and higher acquisition premium in M&A. Chemmanur et al. (2014) was the first study to empirically prove the benefits of CVCs for startup innovation, and found that CVC-backed startups exceeded IVC-backed startups in both innovation quantity and quality. They summarized that CVC-backed companies were younger and of higher uncertainty, and further explained the closer technical ties and higher failure tolerance of CVCs.

Relevant studies started late in China, but gradually studies are being carried out as more data becomes available. So far, the conclusions reached have been conflicting. Zhao Tianqiang (2013) completed a comparative study on the performance of CVC-backed and IVC-backed companies after IPO. He concluded that CVC and IVC investments differ slightly in terms of IPO preparation time, and issuing costs and prices. Secondly, CVC-backed companies are superior to IVC-backed companies in terms of sales, net profit, and EPS growth. Moreover, CVC-backed companies had higher excess returns one year after IPO. Wan Kunyang (2015) analyzed the CVC projects of 78 listed companies on the main board from 2000-12, and found that under the non-controlling governance structure, a U-shaped feature can be observed with the value of the invested company firstly decreasing, and then bouncing back as the CVC portfolio expands. During this process, organizational redundancy could positively adjust the relationship between CVC portfolio and invested company value. After studying listed companies with CVC projects recorded in national SMEs stock transfer system (2007-14), Xu Ziyao (2016) found that strategic collaboration between the startup and parent company of the CVC project could increase corporate value. However, it was difficult for CVC-backed startups to obtain high evaluation or boost their business performance during IPO. Kang Yongbo et al. (2017) selected samples from CVC projects of 419 listed companies from 2010-15, and proposed that the exchanges between CVC investment and invested companies would affect the innovation productivity of invested companies. They further added that higher industrial uncertainty, would cause a positive regulating effect of inter-organizational learning on the technical level of invested companies. As investment increased, the innovation productivity of invested companies initially decreased, but then increased. Reputation of venture investment may positively regulate the relationship between venture investment and innovation. For CVC projects targeted at strategic investment, an inverted U-shaped relationship was revealed between the investment scale and technological innovation of invested company; the U-shaped relationship can be observed for projects with financial targets. Xu Jingjing (2018) studied 135 companies listed on GEM between 2009-14, and found that CVC outperformed IVC in terms of innovation. Therefore, it is believed that the promotion of CVC development, could generate innovation and obtain innovation achievements, thus creating company value. Targeted to financing difficulties and high financing costs, Wu Jin et al. (2019) analyzed financial data from 17 textile companies listed on the SMEs board (2015-17), and concluded that CVC investment helped to reduce startup financial constraints, and promoted their sound development. Qi Yarong (2019), through statistical analysis of 149 IPO companies on GEM and SME boards, argued that CVC investment in China was concentrated in the patentintensive industries of well-developed regions. With the development of intellectual property rights protection, innovation input of the invested companies initially decreased, and then increased. However, the innovation output showed a reverse trend, firstly increasing and then decreasing. Wang Lei & Qi Yarong (2019) studied industrial relations between CVC parent companies and the invested companies on the GEM and SME boards. Their findings summarized that the more obvious the industry synergy effect, the more likely invested companies would obtain huge investment from CVC parent company, but there would be less output. Secondly, the fiercer the industry competition, the more likely the CVC parent company would choose startups in the same industry, which was conducive to the innovation input-output ratio of startups. Thirdly, frequent intervention in the management of the invested company by CVC parent company is beneficial to the development of startups.

In conclusion, there are relatively few studies on the influence of China's CVC investment on startup innovation levels. This is mainly due to the fact that there is no open database containing complete CVC data in China. This dissertation attempts to make up for research deficiencies, especially those of Chinese CVCs, by conducting empirical verification based on self-compiled exclusive CVC data, and systematically exploring the influence of CVCs on startup innovation from a more comprehensive perspective.

CHAPTER 3
CVC DEVELOPMENT HISTORY

This chapter introduces the history and development of CVCs both globally and in China, and considers their future prospects.

3.1 Global CVC Development

The global development of CVCs has undergone three major waves. Dominated by large group venture capitals, the first wave was in the USA in the mid-1960s, two decades after founding the first IVC. As early as 1914, DuPont invested in various industrial sectors including chemistry, automobile, and motion picture film. After the Great Depression in the 1930s, the USA implemented anti-monopoly laws, making it difficult for large businesses to make breakthroughs in single business sectors, forcing many to develop an interest in multiple sectors, and CVC investments for higher profits. For example General Electric Company invested across multiple industrial sectors: manufacturing, entertainment and financial. During its heyday, profits brought by investment in the General Electric Company were even higher than their major business.

In the early stages, industries were attracted to CVC investments for profit growth purposes. During the first wave, CVC investment companies were mainly industrial giants such as: Dupont; Boeing; Dow; Ford; GE; General Dynamics; Mobil; Monsanto; 3M; Alcoa; Ralston Purina; Singer; WR; Grace and Union Carbide.

In the early days, the technology industry was still in its infancy, so unlike current CVC projects, most CVC investment projects were established out of consideration for internal incubation, or for the overall development strategy of parent companies. Take for example the the Post-it note invented by the American business, 3M; their original business model had been based around sandpaper, reflective traffic signs, audio tapes, and shoe soles. It is said that the invention of the Post-it notes came from a failure; a scientist at 3M had not succeeded in developing a highly viscous glue. His colleagues kept picking up dropped notes from the notepad due to the weakly adhesive glue, and one of them came up with the idea of Post-it notes, which was accepted and pursued by 3M. Further products such as Magic Hook were then based on Post-it notes.

In the first CVC wave, Exxon's CVC investment expanded from one single field to multiple sectors, eventually resorting back to one single field again. Exxon was the biggest oil company at the time. From the early 20th century until the 1970s, oil exploitation in Latin America and the discovery of large-scale oilfields in the Middle East, meant the two leading oil companies, Exxon and Mobil, experienced a rapid development from crude oil extraction in the two regions. The outbreak of wars in the Middle East and the Iranian Revolution contributed to soaring oil prices, leading to a surge in sales revenues and profits for oil companies, bringing ample cash flow and paving the way for CVC investment. On the other hand, due to changes in crude oil production output, oil companies pursued investment in other industries for greater wealth. In the 1970s, Exxon initiated investments in various sectors such as scoring machines, printers, surgical devices, computers, and new energy equipment. By then, Exxon had become a high-tech company with extensive and diversified CVC investment in computing, telecommunications, materials and new energy. However, this brought no excessive revenue to Exxon. Until the 1980s, Exxon decided to sell many of their earlier CVC investments, and switched focus back to oil sector when crude oil supply became sufficient and prices fell. In the 1990s, Exxon acquired Mobil to strengthen its competitiveness.

CVC investment fever lasted from 1960s-70s. In 1973, with IPO scaling down and investment return declining, both ICV and CVC saw a gradual downturn. Starting with the abundant cash flow of industrial giants, the first CVC wave ended with an economic recession and stagflation crisis that caused the collapse of the IPO market, and the refinance failure of listed companies to CVC projects. Furthermore, the anti-monopoly law issued in the late 1870s had been weakened, and the separation of corporate ownership and operating rights gave corporate managers greater power. Combined with the short-term oriented management style, these factors led to the end of first CVC trend featuring the American industrial giants. By 1978, only 20 companies in the USA still operated CVC investment projects.

The second wave of CVC stemmed from the relaxation of USA regulatory policies in the late 1970s. The American government introduced the new *Revenue Act* (1978) reducing capital gains tax; the next year, the *Employee Retirement Income Security Act* was modified, allowing pension into venture capital. The *Small Business Investment Act* (1980) ratified the rule requiring the registration of small businesses under a sole address. With these encouraging policies, IVC and CVC were again popular.

Moreover, the invention of computers and the birth of Silicon Valley during this period also accelerated CVC development. They not only witnessed the growth of high-tech companies like Intel and National Semiconductor, but also drove the growth of many venture capital companies such as Sequoia Capital, Kleiner Perkins Caufield and Byers. Entrepreneurs could see that the computer industry would soon be flourishing. Public data showed that in 1977, CVC investment of listed companies reached about $1.025 billion, which increased to $1.8 billion in 1982, with a compound annual growth rate of 10%.

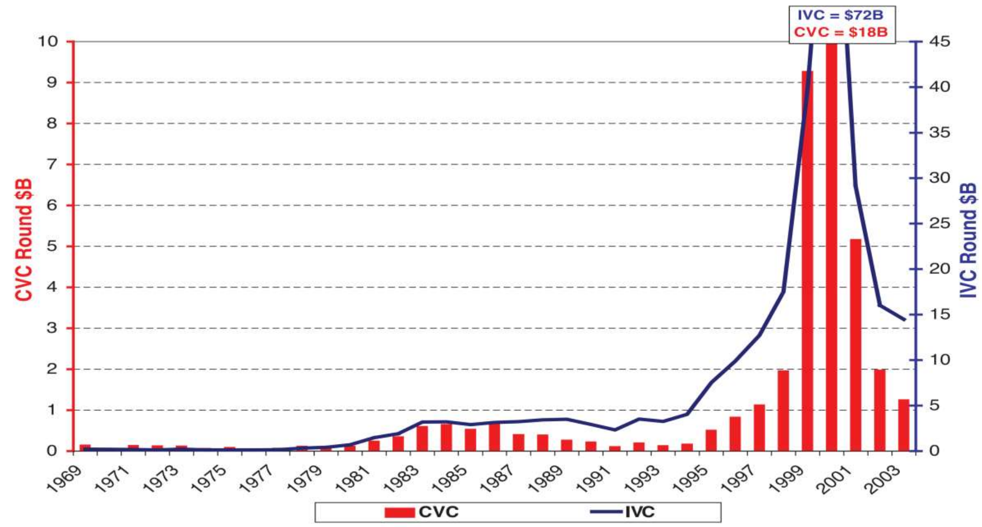
CVC investment models also further diversified in various ways: (1) Indirect investment model that was the most common CVC model at the time. Venture capital companies made CVC investment after receiving company funds, and returned funds and dividends to the investment company when exited. This LP/GP model, which contributed to approximately $483 million in total by 1989, is still in use today; (2) Wholly-owned subsidiary: an independent fund established by the company alone or jointly with other large companies, and managed by external investment managers. About 102 investment companies adopted this model in 1987; (3) Strategic investment department, established by companies, and whereby funds are managed by in-house staffs who also make investment decisions. CVCs under this model increased from 28 in 1982 to 76 in 1988; (4) Other special strategies such as investment in their own employee startup ideas, regardless of their relevance to the core business of the company. In general, the second CVC wave was more rational than the first wave, thanks to external independent investment companies and independent investment funds established alone or jointly. These investments in startups greatly improved the innovation level of investment companies.

During this time, CVC investment was also developing in other countries. For example in Japan, "Yen CVC Fund", was established as a project investment; amongst all CVC projects in the USA, 60 were financed from Japan. In Europe, the number of venture capital funds also surged in 1990, 138 of which were CVC investments. Investment is a two-way activity, with startups also beginning to set up investment funds. For instance, the investment fund established jointly by DuPont, Apple and IBM, aimed to invest in valuable European startups and contributed greatly to the CVC development in Europe.

Although CVC investments may yield huge returns, they do not last long since they may cause polarized remuneration, and huge salary discrepancy within the organization. It is proved statistically that from 1988-96, CVC projects only lasted for 2.5 years from investment to exit; it was about 7.5 years on average for independent IVCs.

The crash of the US stock market in 1987 struck listed companies severely, and ended the second CVC wave. From 1987-92, the number of companies with independent CVC projects plummeted, with only two-thirds remaining in comparison to the peak time.

Figure 1: Global CVC and IVC Investment from 1969 to 2004[1]



Data Source: Venture Economics（Unit: 2014 dollars）

It can be seen in Figure 1 that CVC investment saw a small peak in 1986, reaching 250 million US dollars in total investment scale (denominated in USD that year). However, the American stock market crisis in 1987 caused the decline of IPO. Both funding capacity and return on exit of CVC suffered. After experiencing a dramatic shrink, CVC investment remained sluggish until 1992.

Until the late 20th century, with stock markets rising again, CVC embraced its third wave by taking advantages of the explosive Internet development. IT giants such as Intel and Google made extensive CVC investments in startups, spreading CVC globally. Countries around the world began to introduce foreign advanced technologies through CVC investment. By 2000,

[1] Dushnitsky G, Lenox M J, When does corporate venture capital investment create firm value? [J]. Journal of Business Venturing, 2006, 21(6):753-772.

CVC investment reached a record-breaking 16 billion US dollars (denominated in USD that year). The third wave gradually drew to an end following the collapse of Internet bubbles in 2001.

Global venture capital has seen a turnaround in recent years with both CVC and IVC increasing steadily; IVC is still playing the lead role, but the number of CVC institutions is also gradually increasing worldwide.

3.2 China's CVC Development

Whilst China's CVC only began growing towards the end of the 20th century, development was rapid in the early stages.

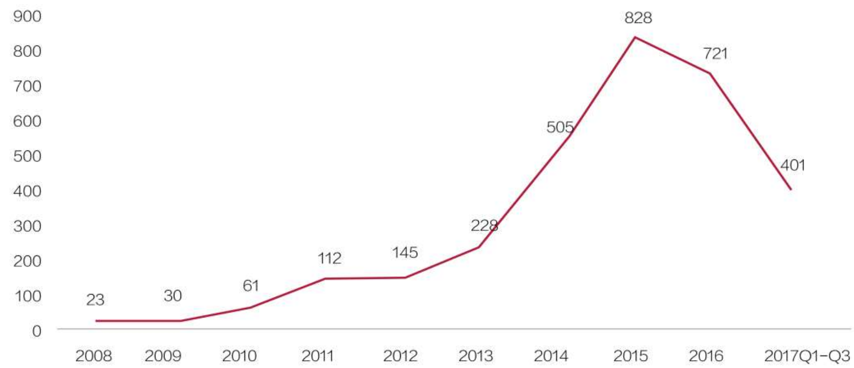
The curtain of China's venture capital investment was unveiled in 1998 when Mr. Cheng Siwei, central president of the China Democratic National Construction Association, submitted the *Proposal on Accelerating National Venture Capital Development*, in the first session of the Ninth National Committee of Chinese People's Political Consultative Conference. Known as "Proposal No. 1", the document attracted great national interest, sparking echos in the technological and financial sectors.

The first large-scale CVC investment was made by Start Group on Mintech in 1998. In 1999, Shanghai No.1 Department Store invested in Seemile, known as "first venture capital investment of listed companies". Following 20 years of development, China's CVC took its shape as an indispensable part of China's capital market, largely complementing traditional venture capital investment. "BAT" (Baidu, Alibaba and Tencent), China's leading IT companies, constructed a series of CVC investment funds, which largely contributed to China's increased innovation level, and the transformation of Chinese lifestyle.

Prime Minister Li Keqiang announced the "Mass Entrepreneurship and Innovation" initiative on the Summer Davos Forum in September 2014. Then, the *Law of the People's Republic of China on the Promotion of Application of Scientific and Technological Achievements* was revised in 2015, clarifying that: “Venture investment organizations are encouraged to invest in the commercialization of scientific research findings. Venture capital guidance funds set up by the government should be used to lead and support these organizations’ investing in small and medium-sized technology-based companies in their early stages. Funds for the commercialization of research findings and VC funds are encouraged by the government, and are applied in supporting high-investment, high-risk and high-return research findings’ commercialization, as well as accelerating the industrialization of major scientific and technological achievements.”

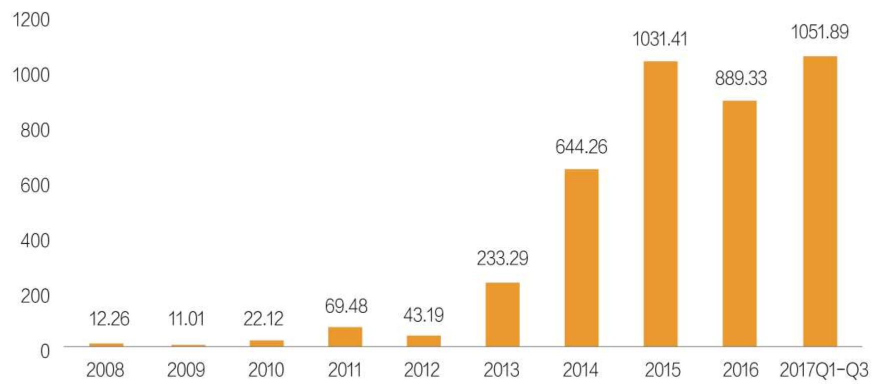
Encouraging startup policies and innovation greatly boosted the development of China’s venture capital market, bringing explosive growth in CVC investment with up to 828 new cases added, and a total investment amount exceeding 100 billion yuan at its peak in 2015. However, struck by the “capital winter” in 2016, CVC investment began to scale down again. As can be seen in Figure 3 and Figure 4, China’s CVC market showed a general upward trend between 2008-17, but slowed down and fluctuated due to slackening growth in recent years.

Figure 2 Numbers of China's CVC Investment from 2008-17[2]



Source: PEdata

Figure 3 China's CVC Investment Amount from 2008-17[2]



Source: PEdata (Unit: 100 million yuan)

In 2017, whilst the number of CVC cases continued to decline, CVC investment amount recovered, and exceeded the total investment amount in the first three quarters of 2015. It indicated the gradual recovery of large-scale investments in CVC market, also reflecting the maturing and rationality of CVCs in China. The survey showed the investment amount of a

[2] Tian Xuan et.al. 2018 China's CVC Industry Development Report, 2019.
[3] Tian Xuan et.al. 2018 China's CVC Industry Development Report, 2019.

single CVC transaction to be higher than the profit-chasing IVC investments (Chemmanur et al., 2014). In brief, CVC investment style is, “generous investment or no investment”.

CVC investment in China began in 1998, which also marked the beginning of high-speed Internet development. Today China continues to primarily depend on the booming internet sector, with the majority CVC investments concentrating on technological industries such as the Internet, telecommunications, entertainments and media. The leading CVC parent companies in China are all Internet based companies, such as Tencent, Alibaba, JD, Xiaomi and 360, and their major investment targets are Internet startups, possibly enabling industrial synergy between the two parties. It can be said that the Internet industry has cultivated strongest CVC investments in China.

More recently, the rapid expansion of private equity, has meant that CVC began earlier than before. CVC investors make their investments in the initial stages, whilst IVC investors typically invest in mature and expanding companies for higher financial return in a short time span. Hence why the exit channel became particularly important to the development of CVCs.

As China’s capital market improved, IPO and acquisition as potential exit channels for CVC, also matured gradually. Small and medium-sized boards, and the GEM board also facilitated CVC exits. However, since IPO and acquisition are policy-sensitive, there remain uncertainties over whether CVC exit may hinder its development in China. It is also believed that China’s CVC industry may be promoted by the establishment of the Sci-Tech innovation board and registration system, as they may help broaden exit channels for high-tech CVC projects.

CHAPTER 4
EMPIRICAL ANALYSES

4.1 Data Sources

Due to the lack of CVC data from open databases in China, we first identified a list of VC investment institutions from the PEdata database, and then matched each fund with their corresponding parent company. Financial companies, multiple companies, foreign companies and unidentified classes were removed from the list. A total number of 823 CVC institutions were identified from 5,832 investment institutions after manual screening. The remaining investment institutions were defined as IVC.

Then, institutions exited after IPO in the PEdata database were matched with the screened VC list, and identified 712 venture capital-backed listed companies. Amongst those, 61 were CVC-backed and 651 were IVC-backed companies. All of them were listed from 2009-17 on the main boards, SME and GEM boards of Shanghai, and Shenzhen stock exchanges. Their corresponding financial data was extracted from the CSMAR database according to the stock codes. Financial data is highly needed to study innovation, as it directly links innovation to output. Therefore, this research was limited to listed companies because data from unlisted companies was not available.

Innovation data from 2009-17 was obtained from the CSMAR China patent database for matching with data on listed companies, enabling the study with patent data four years after their IPO. The CSMAR China patent database takes authorized data files from the State Intellectual Property Bureau (SIPB), and separates Invention Patent data from Utility Patent data. As specified in the "*Patent Law of the People's Republic of China (2008 Amendment)*", patents in China are divided into three types: inventions; utility models and appearance designs.

Invention patents refer to new technical solutions of products, methods or improvements; utility patents refer to pragmatic technical solutions on product shapes, structures, or both. This dissertation separated patent applications data from patent grants data, but design appearance was not considered in this study in line with foreign literatures. The CSMAR database then further separated data into patent applications, patent acceptances and patent grants. However, as there is little data regarding acceptance procedures, only the other two categories were explored. Patent data is taken from 2017 because data from the past two years is not available. However, due to the two year time span between patent applications and patent grants, patent data may have truncation problems. Thus, choosing patent date up to 2017, can partly avoid the truncation issue.

Data constraints, meant it was impossible to distinguish between breakthrough innovation and incremental innovation. Besides, representing innovation productivity with patent data is still limited, as different industries vary in patent numbers. Therefore, there is no discussion about industrial differences. Moreover, because of the absence of citation data in China, it is impossible to evaluate innovation quality by the number of patent citations. All above limitations can be addressed in further studies. Nevertheless, innovation quality was evaluated to a certain extent by distinguishing invention patents from utility patents, and separating the number of patent applications from patent grants. Compared to utility patents, invention patents served as a more precise measurement for innovation quality, and the number of patent grants can better evaluate innovation quality compared to the number of patent applications.

4.2 Variable Design

CVC investment was selected as the independent variable. It was measured by three indicators: whether or not the company received the CVC investment (CVC-backed Dummy);

number of CVC investments (CVC Number) and, investor share in all venture investors of CVC projects (CVC Share).

The dependent variable of this study was innovation level. Taking reference from previous literatures, this paper measured the innovation level of listed companies by patent-related data, which can better evaluate innovation levels compared to R&D expenditure (Kogan et al., 2012; Seru, 2014). Specifically, the total annual patent applications of each listed company (Total Applications) was employed to measure innovation quantity, and the number of patents eventually granted (Total Grants) measured innovation quality. In addition, the innovation patents and utility patents category was further separated into four dependent variables: invention applications; invention grants; utility applications, and utility grants. All indicators of patent numbers were calculated for four years after IPO.

With regards to controlled variables, financial data (in the year of their IPO) of listed companies was obtained, and then a series of variables was constructed, which may influence innovation levels based on the previous literature. Control variables included the industry concentration ratio, Herfindahl-Hirschman Index (HHI), and their squared values, HHI^2 (Aghion et al., 2005), corporate sizes featured by logarithms of total assets (Size), logarithms of listed company ages (Age), R&D share against total assets (R&D Share), state-owned companies or not (SOE Dummy), leverage, tangibility, Tobin's Q value, return on assets (ROA) and financing restrictions (HP index) (Hadlock & Pierce, 2010). Variable definitions are listed in Table 1.

Table 1 Variable Definitions

Variable Type	Variable Name	Variable Definition
Independent Variables	CVC-backed Dummy	CVC investment involvement or not: Yes=1, No=0
	CVC Number	Number of involved CVC
	CVC Share	Number of involved CVC/Total Number of VC involved
Dependent Variables	Total Applications	Total patent application number
	Total Grants	Total patent grant number
	Invention Application	Application number of invention patents
	Invention Grants	Grant number of invention patents
	Utility Application	Application number of utility patents
	Utility Grants	Grant number of utility patents
Control Variables	Size	ln (total assets)
	Age	ln (age at IPO year)
	R&D share	R&D expenditure / total assets
	Soe	state-owned companies or not: yes=1, no=0
	Leverage	Total debt / total assets
	Tangibility	PPE / total assets
	Hhi	Herfindahl-Hirschman index of product market competition
	Hhi2	Square of Herfindahl-Hirschman Index
	Tobins Q	Market value / replacement value
	Roa	Return on assets
	Sa	Hadlock-Pierce Index of financial constraints

4.3 Regression Models

Model 1 estimated whether or not CVC investment contributes to corporate innovation:

$$\boldsymbol{y} = \boldsymbol{\alpha} + \beta \text{CVC\_back} + \boldsymbol{\gamma}' \text{controls} + \varepsilon$$

Model 2 estimated whether or not the number of CVCs has positive influence on corporate

$$\boldsymbol{y} = \boldsymbol{\alpha} + \beta \text{CVC\_number} + \boldsymbol{\gamma}' \text{controls} + \varepsilon$$

innovation:

Model 3 estimated whether CVC investment share positively affects corporate innovation:

$$\boldsymbol{y} = \boldsymbol{\alpha} + \beta CVC\_share + \boldsymbol{\gamma}' controls + \varepsilon$$

4.4 Descriptive Statistics

The summary statistics for the main variables used in the analysis are presented in Table 2.

Table 2 Summary Statistics

Panel A: IPO Firm's Innovation Productivity (observation unit: IPO firm)						
	Mean	sd	p25	p50	p75	N
Total Applications	99.7992	157.1652	16	45.5	120.5	712
Total Grants	73.5660	131.8995	9	30	80.5	712
Invention Applications	39.1405	69.1483	6	15.5	43.5	712
Invention Grants	13.0997	37.9600	0	3	12	712
Utility Applications	47.6390	79.0529	4	18.5	57	712
Utility Grants	47.4832	78.9087	4	18	57	712
Panel B: Control Variables (observation unit: IPO firm)						
	Mean	sd	p25	p50	p75	N
Size	20.9840	0.7306	20.4970	20.8372	21.3455	712
Age	2.3209	0.5857	2.0794	2.3979	2.7081	712
RD Share	0.0259	0.0203	0.0152	0.0219	0.0316	712
SOE	0.0730	0.2604	0.0000	0.0000	0.0000	712
Leverage	0.2537	0.1576	0.1292	0.2238	0.3496	712
Tangibility	0.1479	0.1115	0.0620	0.1223	0.2139	712
HHI	0.0637	0.1072	0.0147	0.0163	0.0462	712
HHI2	0.0155	0.0450	0.0002	0.0003	0.0022	712
TobinsQ	1.8363	0.7199	1.3616	1.6395	2.0509	712
ROA	0.0710	0.0300	0.0514	0.0669	0.0869	712
SA	3.5902	0.2229	3.4388	3.5699	3.7207	712

From Panel A of Table 2, it can be seen that amongst all 712 observed values at the level of IPO-firm, all six dependent variables have their medians lower than mean values. This can be explained by the fact that many large companies have huge amounts of patents, leading to right-skewed distribution of all numbers. In the following analysis, the logarithm value is taken as the dependent variable. To avoid zero target values, 1 is added to all patent variables before taking logarithms.

For 712 listed startups, each of them has average 99.80 patent applications, and 73.57 patent grants. To be more specific, 39.14 invention patent applications, 13.10 invention patent grants, 47.64 utility patent applications, and 47.48 utility patent grants in four years after IPO. It can be seen from the data that invention grants are less than invention applications, whilst utility applications are almost the same as grants. This is because the application cycle for invention patents normally lasts for 2-3 years, and has higher quality requirements, whilst the utility patents approval cycle is complete within a year, because they are examined after receiving authorization. In addition, invention patents emphasize technical breakthroughs or innovations, whilst utility patents are normally of lower technical level. Hence, compared to utility patents, applications and grants of invention patents can better help predict innovation quality. Meanwhile, patent grants predict innovation quality rather than patent applications.

Table 2 Panel B shows that for 712 observed values at IPO-firm level, medians and mean values of all control variables are similar. “Data of Size and Age” are based on “Total Assets and Age” after taking logarithms at IPO year.

Table 3 Univariate Analysis: Mean

Firm Characteristics	IVC-Backed	CVC-Backed	Differences
Panel A: Post-IPO Number of Patents			
ln Total_App	3.731	4.273	-0.542***
ln Total_Grants	3.226	3.974	-0.747***
ln Invention_App	2.806	3.128	-0.322*
ln Invention_Grants	1.438	1.824	-0.386**
ln Utility_App	2.767	3.474	-0.707***
ln Utility_Grants	2.762	3.47	-0.708***
Panel B: Firm Characteristics at the IPO Year			
Size	20.956	21.286	-0.331***
Age	2.328	2.241	0.087
RD_Share	0.026	0.025	0.001
SOE	0.074	0.066	0.008
Leverage	0.253	0.26	-0.007
Tangibility	0.147	0.159	-0.012
HHI	0.063	0.075	-0.012
HHI2	0.015	0.019	-0.003
TobinsQ	1.855	1.632	0.223**
ROA	0.071	0.069	0.002
SA	3.592	3.573	0.018

CVC-backed companies are then separated from IVC-backed companies. As can be seen in Panel A of Table 3, “Total Applications”, “Total Grants”, “Invention Applications”, “Invention Grants”, “Utility Applications”, and “Utility Grants” are all shown in the mean values of their logarithms. For all six indexes, CVC-backed companies outperform IVC-backed companies, indicating that CVC-backed startup companies have more patent applications and grants, and higher innovation productivity after IPO.

Panel B also illustrates that CVC-backed and IVC-backed companies have no apparent differences for most control variables, which to some extent proves that the innovation productivity of both types of startups does not greatly vary in control variables such as financial performance. It is worth mentioning that CVC-backed companies have significantly lower

Tobin Q ratio than IVC-backed companies, indicating that IVC-backed companies have higher evaluation to asset ratio at the time of IPO. It can be explained that the value of innovation requires longer time to be observed through market commercialization. In other words, the market reacts relatively slowly to CVC-backed company innovation values.

Table 4 Univariate Analysis: Median

Firm Characteristics	IVC-Backed	CVC-Backed	Differences	Chi2
Panel A: Post-IPO Number of Patents				
ln Total App	3.738	4.174	-0.436	9.485***
ln Total Grants	3.367	3.829	-0.462	15.438***
ln Invention App	2.773	3.258	-0.485	4.034**
ln Invention Grants	1.099	1.792	-0.693	2.896*
ln Utility App	2.89	3.584	-0.694	6.473**
ln Utility Grants	2.833	3.584	-0.751	6.708***
Panel B: Firm Characteristics at the IPO Year				
Size	20.808	21.16	-0.352	6.473**
Age	2.485	2.303	0.182	0.795
RD Share	0.022	0.02	0.002	0.448
SOE	0	0	0	0.055
Leverage	0.222	0.246	-0.024	0.448
Tangibility	0.123	0.121	0.002	0.161
HHI	0.016	0.016	0	0
HHI2	0	0	0	0
Tobins Q	1.64	1.63	0.01	0.018
ROA	0.067	0.067	0	0.018
SA	3.57	3.544	0.026	0.448

Table 4 shows that the medians for six patent related dependent variables, are higher in CVC-backed companies than in IVC-backed companies. The conclusion is similar to the previous conclusion: CVC-backed companies have higher innovation productivity than IVC-backed companies.

It is proposed that such results may be due to resource advantages, social relationships and channels provided by CVC investment to support startup innovation activities. To verify whether or not CVCs can improve startup innovation productivity, empirical regression is used.

4.5 Results of Linear Regression

To understand how CVC investments influence startup innovation productivity after their IPOs, the OLS multiple linear regression was adopted as the empirical approach. “CVC-backed Dummy”, “CVC Number” and “CVC Share” are explaining variables to represent CVC investment participation, whilst explained variables are “ln(Total Grants)”, “ln(Invention Grants)”, “ln(Utility Grants)”, “ln(Total Application)”, “ln(Total Invention Application)”, “ln(Total Utility Application)”, with the addition of responding control variables.

Table 5 OLS Regression: Post-IPO Patent Grants

Panel A: Total Grants			
Variables	ln_Total_Grants	ln_Total_Grants	ln_Total_Grants
CVC_back	0.504***		
	(0.193)		
CVC_number		0.388**	
		(0.167)	
CVC_share			0.524*
			(0.285)
HHI	-6.254***	-6.214***	-6.175***
	(1.737)	(1.739)	(1.742)
HHI2	12.74***	12.69***	12.60***
	(4.128)	(4.133)	(4.139)
Size	0.522***	0.522***	0.533***
	(0.0964)	(0.0966)	(0.0965)
Age	-0.267**	-0.260**	-0.273**
	(0.119)	(0.119)	(0.119)
RD Share	-3.727	-3.756	-3.588
	(2.800)	(2.803)	(2.807)
SOE	0.122	0.123	0.0980
	(0.216)	(0.217)	(0.217)
Leverage	-0.656	-0.644	-0.663
	(0.452)	(0.453)	(0.453)
Tangibility	-1.631***	-1.617***	-1.593***
	(0.518)	(0.518)	(0.519)
TobinsQ	-0.364***	-0.366***	-0.364***
	(0.0855)	(0.0855)	(0.0857)
ROA	-4.940**	-4.866**	-5.041**
	(2.073)	(2.076)	(2.078)
SA	-0.764**	-0.777**	-0.758**
	(0.316)	(0.316)	(0.317)
Constant	-2.629	-2.603	-2.856

Table 5, Continued

	(2.063)	(2.068)	(2.064)
Observations	712	712	712
R-squared	0.201	0.199	0.197
Panel B: Invention Grants			
Variables	ln_Inven_Grants	ln_Inven_Grants	ln_Inven_Grants
CVC_back	0.199		
	(0.172)		
CVC_number		0.106	
		(0.148)	
CVC_share			0.141
			(0.253)
HHI	-4.557***	-4.514***	-4.502***
	(1.542)	(1.542)	(1.543)
HHI2	11.39***	11.31***	11.29***
	(3.663)	(3.665)	(3.666)
Size	0.254***	0.258***	0.261***
	(0.0855)	(0.0857)	(0.0855)
Age	-0.370***	-0.369***	-0.372***
	(0.105)	(0.105)	(0.105)
RD_Share	-0.247	-0.242	-0.196
	(2.485)	(2.486)	(2.486)
SOE	0.308	0.305	0.298
	(0.192)	(0.192)	(0.192)
Leverage	-1.957***	-1.962***	-1.967***
	(0.401)	(0.401)	(0.401)
Tangibility	-1.382***	-1.373***	-1.367***
	(0.459)	(0.460)	(0.460)
TobinsQ	-0.430***	-0.431***	-0.431***
	(0.0758)	(0.0759)	(0.0759)
ROA	-5.413***	-5.400***	-5.448***
	(1.839)	(1.841)	(1.840)
SA	-0.967***	-0.975***	-0.970***
	(0.280)	(0.280)	(0.281)
Constant	2.422	2.374	2.303
	(1.830)	(1.834)	(1.828)
Observations	712	712	712
R-squared	0.244	0.243	0.243
Panel C: Utility Grants			
Variables	ln_Utility_Grants	ln_Utility_Grants	ln_Utility_Grants
CVC_Back	0.510**		
	(0.204)		
CVC_Number		0.417**	
		(0.176)	
CVC_Share			0.662**
			(0.301)
HHI	-4.247**	-4.221**	-4.214**

	(1.832)	(1.833)	(1.834)

Table 5, continued

HHI2	6.895	6.876	6.854
	(4.354)	(4.356)	(4.359)
Size	0.412***	0.410***	0.418***
	(0.102)	(0.102)	(0.102)
Age	-0.211*	-0.203	-0.218*
	(0.125)	(0.125)	(0.125)
RD_Share	-5.591*	-5.629*	-5.442*
	(2.953)	(2.955)	(2.956)
SOE	0.0203	0.0234	-0.00300
	(0.228)	(0.228)	(0.228)
Leverage	0.317	0.334	0.325
	(0.476)	(0.477)	(0.477)
Tangibility	-1.086**	-1.074**	-1.050*
	(0.546)	(0.546)	(0.546)
TobinsQ	-0.274***	-0.276***	-0.273***
	(0.0901)	(0.0901)	(0.0903)
ROA	-3.510	-3.426	-3.620*
	(2.186)	(2.188)	(2.188)
SA	-0.567*	-0.579*	-0.552*
	(0.333)	(0.333)	(0.334)
Constant	-2.201	-2.144	-2.373
	(2.175)	(2.179)	(2.173)
Observations	712	712	712
R-squared	0.139	0.138	0.137

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Panel A of Table 5 demonstrates the OLS regression results, with the dependent variable being total patent grants in four years after IPO. All three independent variables of CVC investment participation have positive coefficients and are statistically significant, indicating that CVC participation before IPO can improve startup patent outcomes after IPO, and their innovation quality is also improved to a certain extent. Specifically, the first row of Panel A shows that CVC-backed listed companies have 50.4% more patent grants in four years after IPO under 1% confidence interval. On the second row, it can be seen that each new CVC investor yields 38.8% more patent grants in joint venture investment, with 5% confidence interval. The third row indicates that every 1% increase of CVC ratio in joint venture investment helps to yield 0.52% more patent grants, under the confidence interval of 10%.

In Panel B of Table 5, we can see the regression results with "ln (invention grants)" as dependent variables; coefficients of all three independent variables that measure CVC investment are not significant, indicating CVC investments have no influence on invention patent grants. Since invention patents can better evaluate innovation quality compared to utility patents, it is evident that the influence of CVC investment on innovation is mainly reflected on utility patents, but is not obvious on invention patent productivity. The quality of innovation is low.

Panel C of Table 5 presents regression of utility patents with "ln (utility grants)" as dependent variables. Coefficients of all three independent variables are positive, indicating that CVC investments promote utility grants and enhance the innovation productivity. To be more specific, CVC-backed listed companies have 51% more utility grants than those without IVC investment. 41.7% more utility grants can be generated by CVC investor yields, and every 1% increase of CVC ratio in joint venture investment drives extra 0.66% utility grants, at the confidence interval of 5%.

Table 6 OLS Regression: Post-IPO Patent Applications

Panel A: Total Applications			
Variables	ln_Total_App	ln_Total_App	ln_Total_App
CVC_back	0.325*		
	(0.171)		
CVC_number		0.236	
		(0.147)	
CVC_share			0.331
			(0.251)
HHI	-5.109***	-5.075***	-5.056***
	(1.532)	(1.533)	(1.534)
HHI2	10.81***	10.77***	10.72***
	(3.639)	(3.642)	(3.645)
Size	0.514***	0.515***	0.521***

Table 6, contunied

	(0.0850)	(0.0852)	(0.0850)
Age	-0.188*	-0.184*	-0.192*
	(0.105)	(0.105)	(0.105)
RD_Share	4.497*	4.483*	4.586*
	(2.469)	(2.471)	(2.472)
SOE	0.104	0.104	0.0886
	(0.191)	(0.191)	(0.191)
Leverage	-0.506	-0.501	-0.511
	(0.398)	(0.399)	(0.399)
Tangibility	-1.417***	-1.407***	-1.393***
	(0.457)	(0.457)	(0.457)
TobinsQ	-0.306***	-0.308***	-0.307***
	(0.0753)	(0.0754)	(0.0755)
ROA	-3.711**	-3.669**	-3.776**
	(1.827)	(1.829)	(1.830)
SA	-0.592**	-0.601**	-0.588**
	(0.279)	(0.279)	(0.279)
Constant	-3.268*	-3.268*	-3.417*
	(1.818)	(1.822)	(1.817)
Observations	712	712	712
R-squared	0.175	0.173	0.172

Panel B: Invention Applications

Variables	ln_Inven_App	ln_Inven_App	ln_Inven_App
CVC_back	0.138		
	(0.170)		
CVC_number		0.0413	
		(0.146)	
CVC_share			0.0840
			(0.250)
HHI	-4.460***	-4.411***	-4.417***
	(1.525)	(1.525)	(1.525)
HHI2	10.93***	10.84***	10.85***
	(3.623)	(3.625)	(3.625)
Size	0.484***	0.490***	0.490***
	(0.0846)	(0.0848)	(0.0845)
Age	-0.186*	-0.186*	-0.187*
	(0.104)	(0.104)	(0.104)
RD_Share	11.18***	11.20***	11.22***
	(2.457)	(2.459)	(2.458)
SOE	0.172	0.167	0.165
	(0.190)	(0.190)	(0.190)
Leverage	-0.697*	-0.706*	-0.705*
	(0.396)	(0.397)	(0.397)
Tangibility	-1.325***	-1.316***	-1.314***

Table 6, continued

	(0.454)	(0.455)	(0.454)
TobinsQ	-0.227***	-0.229***	-0.228***
	(0.0750)	(0.0750)	(0.0751)
ROA	-2.946	-2.949	-2.969
	(1.819)	(1.820)	(1.820)
SA	-0.477*	-0.484*	-0.480*
	(0.277)	(0.277)	(0.278)
Constant	-4.388**	-4.461**	-4.476**
	(1.810)	(1.813)	(1.808)
Observations	712	712	712
R-squared	0.146	0.145	0.145

Panel C: Utility Applications

Variables	ln_Utility_App	ln_Utility_App	ln_Utility_App
CVC_back	0.509**		
	(0.204)		
CVC_number		0.416**	
		(0.176)	
CVC_share			0.659**
			(0.301)
HHI	-4.251**	-4.225**	-4.218**
	(1.833)	(1.833)	(1.835)
HHI2	6.899	6.879	6.857
	(4.355)	(4.357)	(4.360)
Size	0.411***	0.410***	0.418***
	(0.102)	(0.102)	(0.102)
Age	-0.209*	-0.201	-0.216*
	(0.125)	(0.125)	(0.125)
RD_Share	-5.593*	-5.631*	-5.445*
	(2.954)	(2.956)	(2.957)
SOE	0.0204	0.0236	-0.00277
	(0.228)	(0.228)	(0.228)
Leverage	0.344	0.360	0.351
	(0.476)	(0.477)	(0.477)
Tangibility	-1.077**	-1.065*	-1.041*
	(0.546)	(0.546)	(0.547)
TobinsQ	-0.276***	-0.277***	-0.274***
	(0.0901)	(0.0902)	(0.0903)
ROA	-3.429	-3.345	-3.539
	(2.187)	(2.188)	(2.189)
SA	-0.564*	-0.576*	-0.548
	(0.333)	(0.333)	(0.334)
Constant	-2.213	-2.156	-2.385
	(2.176)	(2.180)	(2.174)
Observations	712	712	712

Table 6, continued

R-squared	0.139	0.138	0.137

Standard errors in parentheses

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

With patent applications as explained variables, and CVC investments as explanatory variables, the results of the OLS regression are presented in Table 6.

By examining data in Panel A of Table 6, it is evident that CVC investment can increase the total patent applications, which partly explains the elevation of innovation productivity. More specifically, CVC-backed companies have 32.5% more patent applications than IVC-backed companies. However, there is no significant influence of CVC investment number on patent applications.

Using invention applications as explained variables, as shown in Panel B of Table 6, all three CVC investment explanatory variables are insignificant. Therefore, CVC investment has no influence on invention applications, which is probably because the long innovation cycle of invention patents blurs the impact in a relatively short time period. Additionally, Panel B shows that when utility applications are the explained variable, three CVC investment explanatory variables are significant under 5% confidence interval, indicating that CVC investment helps boost startup utility applications. Specifically, CVC-backed firms have 50.9% more utility applications than IVC-backed firms. The per unit increase of CVC number increases utility applications by 41.6%, and each 1% increase of CVC ratio in joint investment yields 0.66% more utility grants.

Generally, CVC investment does not significantly influence patent applications, but it has significant positive effects on patent grants. It can be concluded that CVC investment emphasizes innovation quality rather than quantity. Patent grants reflect innovation quality more precisely than patent applications since low-quality and invalid innovations are eliminated. It is also predicted that CVC investment has no strict requirements on the patent quantity of invested companies, and it follows the principle that quality comes before quantity, instead of introducing low-quality innovations to increase quantity.

Specifically, CVC investment can greatly increase utility applications and grants, but it has no significant effect on invention applications and grants, suggesting that the influence of CVC investments on innovation can only be found in utility patents, because it has little effect on sophisticated high-quality invention patents.

4.6 Robustness Test

The robustness test is conducted on the above empirical results, and the fixed effect approach is adopted in handling features of year and industry, with all other data remaining the same. Results are presented in Table 7 and Table 8.

Table 7 OLS Regression with Fixed Effect: Post-IPO Patent Grants

Panel A: Total Grants			
Variables	ln Total Grants	ln Total Grants	ln Total Grants
CVC_Back	0.346**		
	(0.165)		
CVC_Number		0.293**	
		(0.143)	
CVC_Share			0.317
			(0.244)
HHI	-1.508	-1.518	-1.354
	(2.036)	(2.036)	(2.038)
HHI2	2.092	2.122	1.787
	(4.335)	(4.337)	(4.341)
Size	0.436***	0.434***	0.447***
	(0.0854)	(0.0856)	(0.0854)
Age	-0.0730	-0.0668	-0.0753
	(0.104)	(0.104)	(0.104)
RD_Share	4.320*	4.317*	4.427*
	(2.465)	(2.465)	(2.469)
SOE	-0.000454	0.00218	-0.0183
	(0.189)	(0.189)	(0.189)
Leverage	0.961**	0.977**	0.961**

Table 7, continued

	(0.418)	(0.418)	(0.419)
Tangibility	-1.195**	-1.183**	-1.170**
	(0.463)	(0.463)	(0.464)
TobinsQ	-0.178*	-0.179*	-0.177*
	(0.0915)	(0.0915)	(0.0917)
ROA	0.626	0.709	0.571
	(1.851)	(1.852)	(1.855)
SA	0.139	0.133	0.145
	(0.279)	(0.279)	(0.280)
Constant	-5.625***	-5.567***	-5.847***
	(1.856)	(1.860)	(1.855)
Observations	712	712	712
R-squared	0.432	0.432	0.430
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

Panel B: Invention Grants

Variables	ln_Inven_Grants	ln_Inven_Grants	ln_Inven_Grants
CVC_Back	0.0149		
	(0.123)		
CVC_Number		-3.70e-05	
		(0.106)	
CVC_Share			-0.0873
			(0.181)
HHI	-3.316**	-3.301**	-3.246**
	(1.513)	(1.514)	(1.512)
HHI2	5.415*	5.385*	5.279
	(3.223)	(3.224)	(3.220)
Size	0.236***	0.237***	0.240***
	(0.0635)	(0.0636)	(0.0633)
Age	-0.114	-0.114	-0.113
	(0.0774)	(0.0774)	(0.0774)
RD_Share	8.025***	8.031***	8.038***
	(1.832)	(1.832)	(1.831)
SOE	0.114	0.113	0.113
	(0.140)	(0.140)	(0.140)
Leverage	0.172	0.171	0.162
	(0.311)	(0.311)	(0.311)
Tangibility	-0.388	-0.386	-0.386
	(0.344)	(0.344)	(0.344)
TobinsQ	0.0154	0.0154	0.0154
	(0.0680)	(0.0680)	(0.0680)
ROA	0.583	0.580	0.582
	(1.376)	(1.377)	(1.376)
SA	0.179	0.179	0.173
	(0.207)	(0.207)	(0.208)

Table 7, continued

Constant	-2.658*	-2.676*	-2.729**
	(1.380)	(1.383)	(1.376)
Observations	712	712	712
R-squared	0.623	0.623	0.623
Industry Fixed Effects	yes	yes	yes
Year Fixed Effects	yes	yes	yes

Panel C: Utility Grants

Variables	ln_Utility_Grants	ln_Utility_Grants	ln_Utility_Gran ts
CVC_Back	0.367**		
	(0.187)		
CVC_Number		0.323**	
		(0.161)	
CVC_Share			0.466*
			(0.275)
HHI	1.213	1.188	1.295
	(2.297)	(2.298)	(2.297)
HHI2	-4.326	-4.267	-4.492
	(4.892)	(4.893)	(4.893)
Size	0.339***	0.336***	0.345***
	(0.0964)	(0.0966)	(0.0962)
Age	-0.0835	-0.0766	-0.0873
	(0.118)	(0.118)	(0.118)
RD_Share	1.205	1.197	1.308
	(2.781)	(2.781)	(2.782)
SOE	-0.0632	-0.0596	-0.0822
	(0.213)	(0.213)	(0.213)
Leverage	1.597***	1.616***	1.610***
	(0.472)	(0.472)	(0.472)
Tangibility	-0.850	-0.838	-0.824
	(0.522)	(0.522)	(0.523)
TobinsQ	-0.128	-0.129	-0.127
	(0.103)	(0.103)	(0.103)
ROA	0.779	0.872	0.718
	(2.089)	(2.090)	(2.090)
SA	0.151	0.145	0.165
	(0.315)	(0.315)	(0.315)
Constant	-4.873**	-4.793**	-5.030**
	(2.095)	(2.098)	(2.091)
Observations	712	712	712
R-squared	0.299	0.299	0.298
Industry Fixed Effects	yes	yes	yes
Year Fixed Effects	yes	yes	yes

Standard errors in parentheses

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

Table 8 OLS Regression with Fixed Effect: Post-IPO Patent Applications

Panel A: Total Applications			
Variables	ln_Total_App	ln_Total_App	ln_Total_App
CVC_Back	0.191		
	(0.147)		
CVC_Number		0.156	
		(0.126)	
CVC_Share			0.152
			(0.216)
HHI	-1.654	-1.653	-1.555
	(1.804)	(1.805)	(1.805)
HHI2	2.705	2.706	2.509
	(3.842)	(3.844)	(3.843)
Size	0.450***	0.449***	0.457***
	(0.0757)	(0.0759)	(0.0756)
Age	-0.0371	-0.0337	-0.0381
	(0.0923)	(0.0923)	(0.0924)
RD_Share	11.06***	11.06***	11.12***
	(2.184)	(2.185)	(2.186)
SOE	-0.0142	-0.0132	-0.0240
	(0.167)	(0.167)	(0.167)
Leverage	0.793**	0.801**	0.790**
	(0.370)	(0.371)	(0.371)
Tangibility	-1.119***	-1.112***	-1.105***
	(0.410)	(0.410)	(0.410)
TobinsQ	-0.142*	-0.142*	-0.141*
	(0.0811)	(0.0811)	(0.0812)
ROA	0.601	0.644	0.571
	(1.641)	(1.642)	(1.642)
SA	0.153	0.149	0.155
	(0.247)	(0.247)	(0.248)
Constant	-5.875***	-5.852***	-6.011***
	(1.645)	(1.649)	(1.642)
Observations	712	712	712
R-squared	0.407	0.407	0.406
Industry Fixed Effects	yes	yes	yes
Year Fixed Effects	yes	yes	yes

Panel B: Invention Applications			
Variables	ln_Inven_App	ln_Inven_App	ln_Inven_App
CVC_Back	0.0124		
	(0.147)		
CVC_Number		-0.0348	
		(0.127)	
CVC_Share			-0.0804
			(0.217)

Table 8, continued

HHI	-3.025*	-2.969	-2.962
	(1.810)	(1.811)	(1.809)
HHI2	6.096	5.986	5.974
	(3.856)	(3.857)	(3.853)
Size	0.461***	0.464***	0.465***
	(0.0759)	(0.0761)	(0.0758)
Age	-0.0586	-0.0591	-0.0576
	(0.0926)	(0.0926)	(0.0926)
RD_Share	16.77***	16.80***	16.79***
	(2.192)	(2.192)	(2.191)
SOE	0.0180	0.0149	0.0174
	(0.168)	(0.168)	(0.168)
Leverage	0.492	0.485	0.482
	(0.372)	(0.372)	(0.372)
Tangibility	-0.985**	-0.982**	-0.983**
	(0.412)	(0.412)	(0.412)
TobinsQ	-0.0127	-0.0124	-0.0127
	(0.0814)	(0.0814)	(0.0814)
ROA	0.475	0.458	0.475
	(1.646)	(1.647)	(1.646)
SA	0.220	0.219	0.214
	(0.248)	(0.248)	(0.248)
Constant	-7.320***	-7.391***	-7.384***
	(1.651)	(1.654)	(1.647)
Observations	712	712	712
R-squared	0.376	0.376	0.376
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

Panel C: Utility Applications

Variables	ln_Utility_App	ln_Utility_App	ln_Utility_App
CVC_Back	0.366*		
	(0.187)		
CVC_Number		0.322**	
		(0.161)	
CVC_Share			0.464*
			(0.276)
HHI	1.198	1.172	1.281
	(2.300)	(2.300)	(2.300)
HHI2	-4.287	-4.228	-4.455
	(4.898)	(4.899)	(4.899)
Size	0.338***	0.335***	0.345***
	(0.0965)	(0.0967)	(0.0964)
Age	-0.0823	-0.0755	-0.0861
	(0.118)	(0.118)	(0.118)
RD_Share	1.195	1.187	1.298
	(2.785)	(2.784)	(2.786)

Table 8, continued

SOE	-0.0620	-0.0584	-0.0810
	(0.213)	(0.213)	(0.213)
Leverage	1.617***	1.637***	1.630***
	(0.472)	(0.472)	(0.473)
Tangibility	-0.837	-0.825	-0.811
	(0.523)	(0.523)	(0.523)
TobinsQ	-0.130	-0.131	-0.129
	(0.103)	(0.103)	(0.103)
ROA	0.852	0.945	0.791
	(2.091)	(2.092)	(2.093)
SA	0.152	0.146	0.166
	(0.315)	(0.315)	(0.316)
Constant	-4.863**	-4.783**	-5.020**
	(2.097)	(2.101)	(2.093)
Observations	712	712	712
R-squared	0.298	0.298	0.297
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to results in Table 7 and Table 8, CVC investment still has significant influence on "Total Grants", "Utility Grants" and "Utility Applications" considering the fix effect, indicating that regression results are basically robust. However, CVC influence on "Total Applications" is no longer apparent, and all results are less evident. This suggests that features of industry and year may affect innovation productivity to a certain degree, requiring further research.

4.7 Propensity Score Matching

To mitigate effects of company features, propensity score matching (PSM) is adopted. Amongst the control variables in the above descriptive statistics, medians of size, Tobin Q and other indexes have disparities between CVC-backed firms and IVC-backed firms, imposing certain effects on subsequent regression results. Therefore, to control disparities between the treated group (CVC-invested companies) and the control group (companies with no CVC investment), we adopt propensity score matching on various finance and performance indexes.

Firstly, a probit regression is run on all observations in the sample. The CVC-backed dummy is selected as the dependent variable, and independent variables include all control variables that may affect the startup innovation level. The regression model is as follows:

$$Prob(CVC\_back = 1)$$
$$= \Phi(\beta_0 + \beta_1 Size + \beta_2 Age + \beta_3 RD\_Share + \beta_4 SOE + \beta_5 Leverage$$
$$+\beta_6 Tangiblity + \beta_7 HHI + \beta_8 HHI2 + \beta_9 TobinsQ + \beta_{10} ROA + \beta_{11} SA)$$

Then, based on the Probit regression results, the propensity matching score (PScore) of each startup is calculated, representing a startup's probability of obtaining CVC investment. Each CVC-backed startup in the sample is matched with an IVC-backed startup based on the propensity of startups obtained from the Probit model.

Table 9 Propensity Score Matching; Post-Matching Balance Test

Variables	Treated	Control	t	p>t
Size	21.286	21.164	0.76	0.45
Age	2.2411	2.2965	-0.48	0.634
RD_Share	0.02469	0.02411	0.19	0.853
SOE	0.06557	0.03279	0.83	0.407
Leverage	0.26046	0.22597	1.3	0.195
Tangibility	0.15889	0.15098	0.36	0.72
TobinsQ	1.6325	1.5982	0.44	0.664
ROA	0.06938	0.06626	0.65	0.519
SA	3.5734	3.5833	-0.24	0.813
HHI	0.0751	0.06574	0.48	0.63
HHI2	0.01853	0.01399	0.63	0.533
N	61	61		

Table 9 shows no apparent disparities between the treated group and the control group after propensity score matching at the ratio of 1:1. Regression sample analyses after matching can avoid differences in firm features to some extent. In addition, propensity score matching can avoid linear hypothesis in OLS regressions that may not fully match the data.

Considering the small sample size, propensity score matchings at the ratio of 1:3, 1:5 and 1:7, are conducted simultaneously to increase samples.

Table 10 Propensity Score Matching Results

Panel A: Grants					
		CVC	IVC	Diff	t
1:1					
ln_Total_Grants	Unmatched	3.97	3.23	0.75***	3.56
	Matched	3.97	3.29	0.69**	2.35
ln_Inven_Grants	Unmatched	1.82	1.44	0.39**	2.01
	Matched	1.82	1.64	0.19	0.66
ln_Utility_Grants	Unmatched	3.47	2.76	0.71***	3.32
	Matched	3.47	2.79	0.69**	2.15
1:3					
ln_Total_Grants	Unmatched	3.97	3.23	0.75***	3.56
	Matched	3.97	3.26	0.72***	3.22
ln_Inven_Grants	Unmatched	1.82	1.44	0.39**	2.01
	Matched	1.82	1.51	0.31	1.4
ln_Utility_Grants	Unmatched	3.47	2.76	0.71***	3.32
	Matched	3.47	2.82	0.65***	2.71
1:5					
ln_Total_Grants	Unmatched	3.97	3.23	0.75***	3.56
	Matched	3.97	3.28	0.69***	3.33
ln_Inven_Grants	Unmatched	1.82	1.44	0.39**	2.01
	Matched	1.82	1.49	0.33	1.58
ln_Utility_Grants	Unmatched	3.47	2.76	0.71***	3.32
	Matched	3.47	2.84	0.63***	2.77
1:7					

ln_Total_Grants	Unmatched	3.97	3.23	0.75***	3.56
	Matched	3.97	3.33	0.64***	3.19
ln_Inven_Grants	Unmatched	1.82	1.44	0.39**	2.01
	Matched	1.82	1.50	0.32	1.55
ln_Utility_Grants	Unmatched	3.47	2.76	0.71***	3.32
	Matched	3.47	2.85	0.62***	2.86
Panel B: Applications					
		CVC	IVC	Diff	t
1:1					
ln_Total_App	Unmatched	4.27	3.73	0.54***	2.97
	Matched	4.27	3.75	0.52**	1.99
ln_Inven_App	Unmatched	3.13	2.81	0.32*	1.80
	Matched	3.13	2.86	0.27	1.12
ln_Utility_App	Unmatched	3.47	2.77	0.71***	3.31
	Matched	3.47	2.79	0.69**	2.15
1:3					
ln_Total_App	Unmatched	4.27	3.73	0.54***	2.97
	Matched	4.27	3.76	0.51***	2.56
ln_Inven_App	Unmatched	3.13	2.81	0.32*	1.8
	Matched	3.13	2.87	0.26	1.37
ln_Utility_App	Unmatched	3.47	2.77	0.71***	3.31
	Matched	3.47	2.82	0.65***	2.71
1:5					
ln_Total_App	Unmatched	4.27	3.73	0.54***	2.97
	Matched	4.27	3.77	0.51***	2.69
ln_Inven_App	Unmatched	3.13	2.81	0.32*	1.8
	Matched	3.13	2.84	0.29	1.57
ln_Utility_App	Unmatched	3.47	2.77	0.71***	3.31
	Matched	3.47	2.85	0.63***	2.77
1:7					
ln_Total_App	Unmatched	4.27	3.73	0.54***	2.97
	Matched	4.27	3.81	0.47***	2.53
ln_Inven_App	Unmatched	3.13	2.81	0.32*	1.8
	Matched	3.13	2.86	0.27	1.52
ln_Utility_App	Unmatched	3.47	2.77	0.71***	3.31
	Matched	3.47	2.85	0.62***	2.86

Table 10, continued

The above Table 10 shows the comparison of innovation productivity by using samples that are treated with propensity score matching at ratios of 1:1, 1:3, 1:5 and 1:7. It can be seen that CVC-backed companies outperformed IVC-backed companies in all six innovation productivity variables. It further proves that CVC-backed companies have higher innovation quality and innovation productivity, indicating that CVC still plays an important role in promoting the innovation of the invested companies after eliminating the self-selection factors adopted by propensity score matching.

4.8 Post-Matching Regression Results

The regression test is conducted on samples after propensity score matching, with results as follows:

Table 11 PSM Post-Matching Regression: Patent Grants (1:1 sample)

Panel A: Total Grants			
Variables	ln_Total_Grants	ln_Total_Grants	ln_Total_Grants
CVC_Back	0.727***		
	(0.248)		
CVC_Number		0.522**	
		(0.206)	
CVC_Share			0.599*
			(0.342)
HHI	-9.338**	-9.764**	-9.916**
	(3.968)	(3.997)	(4.057)
HHI2	16.31	17.95*	18.22*
	(10.56)	(10.62)	(10.79)
Size	0.483**	0.457**	0.480**
	(0.191)	(0.193)	(0.195)
Age	-0.0515	-0.00314	-0.106
	(0.264)	(0.268)	(0.270)
RD_Share	-7.239	-8.103	-7.205
	(8.566)	(8.636)	(8.798)
SOE	-0.191	-0.150	-0.347
	(0.677)	(0.683)	(0.701)
Leverage	0.508	0.880	1.055

	(1.252)	(1.251)	(1.266)
Tangibility	-1.739	-1.708	-1.554
	(1.110)	(1.120)	(1.140)
TobinsQ	-0.811**	-0.797**	-0.735**
	(0.334)	(0.337)	(0.342)
ROA	-1.358	0.159	-0.883
	(5.817)	(5.822)	(6.004)
SA	-1.195	-1.274*	-1.112
	(0.758)	(0.766)	(0.778)
Constant	-0.498	0.110	-0.717
	(4.302)	(4.349)	(4.409)
Observations	122	122	122
R-squared	0.343	0.330	0.310
Panel B: Invention Grants			
Variables	ln_Inven_Grants	ln_Inven_Grants	ln_Inven_Grants
CVC_Back	0.381		
	(0.241)		
CVC_Number		0.195	
		(0.200)	
CVC_Share			0.216
			(0.327)
HHI	-0.917	-1.224	-1.286
	(3.850)	(3.869)	(3.879)
HHI2	-0.158	0.951	1.068
	(10.25)	(10.28)	(10.32)
Size	0.0417	0.0323	0.0411
	(0.185)	(0.187)	(0.187)
Age	-0.214	-0.201	-0.239
	(0.256)	(0.260)	(0.258)
RD_Share	-9.159	-9.690	-9.372
	(8.312)	(8.360)	(8.413)
SOE	-0.311	-0.292	-0.363
	(0.656)	(0.661)	(0.670)
Leverage	-0.641	-0.412	-0.347
	(1.215)	(1.211)	(1.211)
Tangibility	-1.696	-1.679	-1.624
	(1.077)	(1.084)	(1.090)
TobinsQ	-1.091***	-1.077***	-1.054***
	(0.324)	(0.326)	(0.327)
ROA	-5.830	-4.891	-5.255
	(5.644)	(5.636)	(5.741)
SA	-1.435*	-1.465*	-1.405*

	(0.736)	(0.742)	(0.744)
Constant	9.102**	9.332**	9.026**
	(4.174)	(4.210)	(4.216)
Observations	122	122	122
R-squared	0.314	0.304	0.301

Panel C: Utility Grants

Variables	ln_Utility_Grants	ln_Utility_Grants	ln_Utility_Grants
CVC_Back	0.688**		
	(0.283)		
CVC_Number		0.522**	
		(0.235)	
CVC_Share			0.773**
			(0.385)
HHI	-6.498	-6.872	-6.908
	(4.536)	(4.546)	(4.565)
HHI2	6.771	8.241	8.110
	(12.08)	(12.08)	(12.14)
Size	0.419*	0.392*	0.414*
	(0.218)	(0.219)	(0.220)
Age	-0.0248	0.0253	-0.0831
	(0.302)	(0.305)	(0.304)
RD_Share	-6.316	-7.107	-5.799
	(9.793)	(9.822)	(9.900)
SOE	0.0135	0.0534	-0.197
	(0.773)	(0.777)	(0.789)
Leverage	0.953	1.293	1.453
	(1.432)	(1.422)	(1.425)
Tangibility	-1.261	-1.233	-1.035
	(1.269)	(1.274)	(1.283)
TobinsQ	-0.548	-0.537	-0.470
	(0.382)	(0.383)	(0.384)
ROA	-5.017	-3.630	-5.250
	(6.650)	(6.621)	(6.756)
SA	-1.021	-1.100	-0.914
	(0.867)	(0.871)	(0.876)
Constant	-0.712	-0.104	-1.000
	(4.918)	(4.946)	(4.961)
Observations	122	122	122
R-squared	0.258	0.251	0.245

Table 11, continued

It can be seen from Table 11 that after propensity score matching, three independent variables (CVC-backed Dummy, CVC Number and CVC Share), and two dependent variables (Total Grants and Utility Grants) generate positive regression coefficients, which fully proves the positive effects of CVC investments on patent quality. Specifically, CVC-backed companies have 72.7% more total grants and 68.8% more utility grants than IVC-backed companies. Each new CVC investor can yield 52.2% more total grants, and 52.2% more utility grants. Every 1% increase of CVC ratio in joint venture investment yields 0.60% more patent grants and 0.77% more utility grants. After propensity score matching, CVC still has no effect on invention grants. Therefore, it can be similarly concluded that CVC hardly influences invention patents, which are relatively more challenging.

Table 12 PSM Post-Matching Regression: Patent Applications (1:1 sample)

Panel A: Total Applications			
Variables	ln_Total_App	ln_Total_App	ln_Total_App
CVC_Back	0.531**		
	(0.226)		
CVC_Number		0.370*	
		(0.188)	
CVC_Share			0.416
			(0.309)
HHI	-6.832*	-7.156*	-7.270*
	(3.616)	(3.635)	(3.669)
HHI2	11.71	12.95	13.16
	(9.627)	(9.660)	(9.758)
Size	0.443**	0.424**	0.441**
	(0.174)	(0.175)	(0.177)
Age	0.0754	0.109	0.0363
	(0.240)	(0.244)	(0.244)
RD_Share	-1.058	-1.701	-1.085
	(7.806)	(7.853)	(7.958)
SOE	0.0670	0.0970	-0.0403
	(0.617)	(0.621)	(0.634)
Leverage	0.289	0.565	0.690
	(1.141)	(1.137)	(1.145)
Tangibility	-1.898*	-1.876*	-1.769*
	(1.011)	(1.019)	(1.031)
TobinsQ	-0.649**	-0.638**	-0.594*

	(0.304)	(0.306)	(0.309)
ROA	-2.133	-1.003	-1.712
	(5.301)	(5.294)	(5.431)
SA	-0.898	-0.954	-0.841
	(0.691)	(0.697)	(0.704)
Constant	-0.892	-0.460	-1.043
	(3.921)	(3.955)	(3.988)
Observations	122	122	122
R-squared	0.288	0.278	0.264

Panel B: Invention Applications

Variables	ln_Inven_App	ln_Inven_App	ln_Inven_App
CVC_Back	0.294		
	(0.218)		
CVC_Number		0.127	
		(0.181)	
CVC_Share			0.160
			(0.296)
HHI	-3.925	-4.187	-4.214
	(3.492)	(3.506)	(3.509)
HHI2	7.148	8.076	8.109
	(9.297)	(9.318)	(9.334)
Size	0.276	0.270	0.275
	(0.168)	(0.169)	(0.169)
Age	0.161	0.167	0.142
	(0.232)	(0.235)	(0.234)
RD_Share	7.097	6.664	6.916
	(7.539)	(7.575)	(7.611)
SOE	0.388	0.403	0.350
	(0.595)	(0.599)	(0.606)
Leverage	-0.217	-0.0307	0.0105
	(1.102)	(1.097)	(1.095)
Tangibility	-1.782*	-1.769*	-1.728*
	(0.977)	(0.982)	(0.986)
TobinsQ	-0.565*	-0.552*	-0.537*
	(0.294)	(0.295)	(0.295)
ROA	-6.534	-5.768	-6.069
	(5.119)	(5.106)	(5.194)
SA	-0.451	-0.470	-0.429
	(0.667)	(0.672)	(0.673)
Constant	-0.108	0.0431	-0.164
	(3.786)	(3.814)	(3.814)
Observations	122	122	122
R-squared	0.194	0.185	0.183

Panel C: Utility Applications

Variables	ln_Utility_App	ln_Utility_App	ln_Utility_App
CVC_Back	0.687**		
	(0.283)		

CVC_Number		0.521**	
		(0.234)	
CVC_Share			0.769**
			(0.385)
HHI	-6.585	-6.960	-6.996
	(4.533)	(4.543)	(4.562)
HHI2	6.992	8.460	8.334
	(12.07)	(12.07)	(12.13)
Size	0.423*	0.396*	0.418*
	(0.218)	(0.219)	(0.220)
Age	-0.0216	0.0284	-0.0798
	(0.301)	(0.305)	(0.304)
RD_Share	-6.383	-7.173	-5.872
	(9.786)	(9.815)	(9.894)
SOE	0.00975	0.0496	-0.200
	(0.773)	(0.776)	(0.788)
Leverage	0.975	1.315	1.475
	(1.431)	(1.421)	(1.424)
Tangibility	-1.280	-1.251	-1.054
	(1.268)	(1.273)	(1.282)
TobinsQ	-0.545	-0.534	-0.466
	(0.381)	(0.383)	(0.384)
ROA	-4.896	-3.510	-5.120
	(6.645)	(6.617)	(6.752)
SA	-1.024	-1.103	-0.917
	(0.866)	(0.871)	(0.875)
Constant	-0.810	-0.203	-1.097
	(4.915)	(4.943)	(4.958)
Observations	122	122	122
R-squared	0.259	0.252	0.246

Standard errors in parentheses

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

Table 12, continued

It can be seen from Table 12 that after propensity score matching, three independent variables (CVC-backed Dummy, CVC Number and CVC Share) impose greater influence on two dependent variables (Total Applications, Utility Applications). That fully proves patent applications are more susceptible to company features such as industry sector and year. Specifically, CVC-backed companies have 53.1% more total applications and 68.7% more utility applications than IVC-backed companies. Each new CVC investor brings 37% more total applications, and 52.1% more utility applications. Every 1% increase of CVC ratio in joint venture investment yields 0.77% more utility applications. After propensity score matching, it can be concluded that CVC does not influence invention applications, therefore indicating that results are robust.

Propensity score matching at the ratio of 1:3 is also conducted, and the results (listed in the Appendix) are basically the same. The results are robust to alternative choices of matched firms.

CHAPTER 5
CONCLUSION

5.1 Main Conclusions and Contribution

The primary contribution of this paper is that it supplements the CVC literatures with Chinese empirical data. By adopting methods such as descriptive statistics, OLS regression and propensity score matching, an empirical analyses of CVC effects was made using original data on CVC investments amongst Chinese listed companies.

Through analyzing descriptive statistics, it is found that CVC-backed companies greatly outperform those without CVC investments in terms of patent quantity after four years of IPO. CVC-backed listed companies usually have more patent applications and grants, suggesting that innovation productivity in CVC-backed startups is of higher quality and quantity.

Empirical analyses show that participation in CVC investments or not (CVC Dummy), CVC investment number (CVC Number), and CVC participation level (CVC Share), all have positive effects on the number of patent grants and applications, with both total patents and utility patents increasing largely. CVC investments can significantly improve the quality of innovation output, and positively affect startup innovation productivity. It is also found that CVC investments have no significant influence on invention grants and applications, which indirectly illustrates that they have less impact on innovation quality.

Conclusions in this paper regarding the influence of CVCs on startup innovation productivity in China, are almost consistent with those of foreign studies. This paper innovatively distinguishes invention patents from utility patents, with the former usually being of higher quality than the latter, and it evaluates innovation level more precisely than total patents.

It can also be concluded that patent grants can reflect innovation quality more accurately, whilst patent applications with a certain amount of low-quality and invalid innovations, only indicate innovation quantity. Many previous literatures measure innovation merely with patent applications, whilst this paper adopts patent grants, which better indicate innovation quality.

The reason is that parent companies involved in CVC investments are mainly large groups with rich resources and wealth. They can provide startups with funds, technologies, marketing channels and human resources, as well as offer professional guidance on development strategies based on their own management experience.

5.2 Problems and Policy Suggestions

It should be highlighted that possible problems in China's CVC market, could potentially hinder long-term CVC development and innovation. It is therefore necessary to identify those possible problems, and offer relevant policy suggestions.

Firstly, incentives for CVC managers must be considered. Unlike IVC investors, the income of CVC investors is neither ROI-based nor short-term performance-oriented, which makes it difficult to evaluate. When CVC investment managers have similar income to other department employees, it is difficult for the investment company to attract top talent from other PEs and VCs, thus weakening the competitiveness of CVC funds. On the other hand, investors may lose the motivation to fulfill strategic investments. Investment companies should highlight incentives for CVC managers, and establish innovative performance-based systems, rather than simply adopting an ROI based evaluation system, or the same evaluation standards as other employees. For example, quality of innovation output can be used to evaluate the performance of CVC managers. They should be given greater time tolerance and higher failure tolerance to better serve the long-term company strategy (Chemmanur et al., 2014; Tian & Wang, 2014).

Secondly, intellectual property protection is crucial. Imperfect intellectual property protection mechanisms in China make startups reluctant to invest in CVCs. Worried that core technologies may be copied or imitated by CVC parent companies, startups may turn to IVCs. The solution is government intervention through introducing CVC laws and regulations to protect the rights and interests of startups. Startup companies should not equate receiving CVC investments to tolerating illegal deeds such as intellectual property theft or embezzling. Protection of patents and intellectual properties is the best encouragement for innovators (Hellmann, 2002).

Thirdly, exit channels form the bottleneck of CVC in China. The “approval system” makes it challenging for investors to find adequate IPO exit channels. Consequently, many CVC investors exit after acquisition, leaving few opportunities for excellent startups to go public, and giving secondary market little hope of benefitting from startup growth. The inadequate exit channel impedes the development of CVC funds, and the whole industry. Hence, offering more CVC exit channels is of great significance. The Science and Technology Innovation Board gave permission to IPOs through registrations in 2019, also relaxing admission requirements such as profit making for three consecutive years. These actions enable more innovative startups to go public, giving them higher tolerance of their track record, benefitting their long-term innovation, and promoting the positive cycle of CVC industry (Fu Jiacheng & Song Yanqiu, 2016).

There are three major problems facing the current CVC market listed in this chapter: insufficient incentives for CVC investors; lack of protection on intellectual properties, and blocked exit channels. In response to these problems, there are a several policy suggestions: improving the performance-based incentive system for CVC managers; enhancing the intellectual property protection system, and expanding CVC exit channels.

In conclusion, the strength of Chinese innovation is still behind that of developed countries. However, with more CVC investments, startups could overcome financial hardship, and improve their innovation productivity. Therefore, the need for government promotion of CVC market development is of great significance in strengthening the overall growth of Chinese innovation.

REFERENCES

Alter, Murray, Larry Buchsbaum. Corporate Venturing: Goals, Compensation and Taxes. The Corporate Venturing Directory and Yearbook, Wellesley, MA: Asset Alternatives Inc., 2000.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. Competition and innovation: An inverted U relationship [J]. *Quarterly Journal of Economics*, 2005. 120:701–28.

Basu S, Phelps C, Kotha S. Towards understanding who makes corporate venture capital investments and why[J]. *Journal of Business Venturing*, 2011, 26(2):0-171.

Benson D, Ziedonis R H. Corporate Venture Capital as a Window on New Technologies: Implications for the Performance of Corporate Investors When Acquiring Startups[J]. *Organization Science*, 2009, 20(2):329-351.

Belderbos René, Jacob J, Lokshin B. Corporate venture capital (CVC) investments and technological performance: Geographic diversity and the interplay with technology alliances[J]. *Journal of Business Venturing*, 2018, 33(1):20-34.

Chemmanur T, Loutskina E, Tian X. Corporate Venture Capital, Value Creation, and Innovation[J]. *Review of Financial Studies*, 2014, 27: 2434-2473

Chesbrough H W. Making Sense of Corporate Venture Capital[J]. *Harvard Business Review*, 2002, 80(3):90-99.

Dushnitsky G, Lenox M. When Do Incumbents Learn from Entrepreneurial Ventures? : Corporate Venture Capital and Investing Firm Innovation Rates[J]. *Research Policy*, 2005, 34.

Dushnitsky G, Lenox M J. When does corporate venture capital investment create firm value?[J]. *Journal of Business Venturing*, 2006, 21(6):753-772.

Dushnitsky G, Lavie D. How alliance formation shapes corporate venture capital investment in the software industry: a resource-based perspective[J]. *Strategic Entrepreneurship Journal*, 2010, 4(1):22-48.

Ernst H, Witt P, Brachtendorf G. Corporate venture capital as a strategy for external innovation: An exploratory empirical study[J]. *R & D Management*, 2005, 35(3):233-242.

Fu Jiacheng, Song Yanqiu. An Empirical Study on Investment Strategy and Investment Performance of Chinese Corporate Venture Capital (CVC) [J]. *Investment Research*, 2016 (6): 29-44.

Gompers P A, Lerner J. The Determinants of Corporate Venture Capital Successes: Organizational Structure [J]. *Incentives, and Complementarities*, NBER Working Papers, 2009(6):17-54.

Hadlock, C., and J. Pierce. *New evidence on measuring financial constraints: Moving beyond the KZ Index*. *Review of Financial Studies*, 2010, 23:1909–40.

Kang Yongbo, Wang Susheng, Peng Ke. Research on the Impact of Corporate Venture Capital on Enterprise Technology Innovation – From the Perspective of Interorganizational Learning [J]. *R&D Management*, 2017 (05): 91-102.

Katila R, Rosenberger J D, Eisenhardt K M. Swimming with Sharks: Technology Ventures, Defense Mechanisms and Corporate Relationships[J]. *Administrative Science Quarterly*, 2008, 53(2):295-332.

Keil T. Building External Corporate Venturing Capability*[J]. *Journal of Management Studies*, 2004, 41(5):27.

Kogan, L., D. Papanikalaou, A. Seru, and N. Stoffman. Technological innovation and growth [J]. *Quarterly Journal of Economics*, 2017, 132: 665–712.

Hellmann T. A Theory of Strategic Venture Investing[J]. *Journal of Financial Economics*, 2002, 64(2):285-314.

Lerner, J. 2012. *The architecture of innovation: The economics of creative organizations*. Cambridge: Harvard Business Review Press.

Liu Dandan, Li Chaoping. Relationship between CVC Investment Portfolio Diversification and Corporate Value: Regulating Effects of Financing Constraints [J]. *Caixun*, 2016 (22): 64-64.

Liu Wei, Yang Beibei, Liu Yanyan. Game Analysis of Investment Object Selection Based on Trust Level and Technology Value in CVC [J]. *Forecasting*, 2014 (06): 68-72.

Liu Wei, Huang Jianglin. Corporate Resources' Influence on Newly-Listed Innovative Companies' Venture Capital Decision-Making- Analyses Based on GEM Manufacturing Industry [J]. *Science & Technology Progress and Policy*, 2016[2].

Lin Ziyao, Li Xinchun. Corporate Venture Capital and Listed Companies' Performance: Empirical Study Based on China Market Data[J]. *South China Journal of Economics*, 2012, 30(6):3-14.

Ma S. The Life Cycle of Corporate Venture Capital[J]. *Social Science Electronic Publishing*, 2015.

Maula M V J, Autio E, Murray G C. Corporate venture capital and the balance of risks and rewards for portfolio companies[J]. *Journal of Business Venturing*, 2009, 24(3):0-286.

Mcnally K. Corporate venture capital: the financing of technology businesses[J]. *International Journal of Entrepreneurial Behaviour & Research*, 1995, 1(3):9-43.

Park H D, Steensma H K. When does corporate venture capital add value for new ventures? [J]. *Strategic Management Journal*, 2012, 33(1):1-22.

Park J H, Bae Z T. When are ‘sharks’ beneficial? Corporate venture capital investment and startup innovation performance[J]. *Academy of Management Annual Meeting Proceedings*, 2018, 2015(1):14025-14025.

Qi Yarong. Impact Analysis of Intellectual Property Protection on Innovation Performance in CVC Investment [J]. *Modern Business*, 2019, 522 (05): 107-109.

Reichardt B, Weber C. Corporate venture capital in Germany: A comparative analysis of 2000 and 2003[J]. *Technological Forecasting and Social Change*, 2006, 73(7):813-834.

Seru, A. Firm boundaries matters: Evidence from conglomerates and R&D activity [J]. *Journal of Financial Economics*, 2014, 111:381–405.

Sun Jian, Bai Quanmin. An Empirical Study on the Influence of Corporate Venture Capital (CVC) on Corporate Value in China - From the Perspective of CVC Investors [J]. *Journal of Central University of Finance & Economics*, 2010 (09): 0-0.

Sykes H B. Corporate venture capital: Strategies for success[J]. *Journal of Business Venturing*, 1990, 5(1):37-47.

Vrande V V D, Vanhaverbeke W. How Prior Corporate Venture Capital Investments Shape Technological Alliances: A Real Options Approach[J]. *Entrepreneurship: Theory and Practice*, 2013, 37(5).

Wan Kunyang. The Impact Mechanism of Corporate Venture Capital on Corporate Value Creation: Based on the Perspective of Heterogeneity of CVC Projects [J]. *Journal of Industrial Technological Economics*, 2015 (2): 27-33.

Wan Kunyang, Lu Wencong, Corporate Venture Capital and Corporate Technological Innovation -Regulating Effects of Absorbing Capacity, Involvement Intensity and Governance Structure[J]. *Science of Science and Management of S.&T.*, 2014(11).

Wang Lei, Qi Yarong. CVC Competition Intensity and the Technological Innovation Performance of Invested Companies-Analysis of Mediation Effect Based on Involvement Intensity [J]. *Journal of Shanghai University of Finance and Economics*, 2019, 21 (02): 47-65.

Weber C, Weber B. Corporate Venture Capital Organizations in Germany: A Comparison[C]. *Social Science Research Center Berlin* (WZB), 2003.

Weber B, Weber C. Corporate venture capital as a means of radical innovation: Relational fit, social capital, and knowledge transfer[J]. *Journal of Engineering & Technology Management*, 2007, 24(1-2):11-35.

Xie I F. Do Corporate Venture Capitalists Add Value to Start-Up Firms? Evidence from IPOs and Acquisitions of VC-Backed Companies[J]. *Financial Management*, 2008, 39(1):129-152.

Xu Jingjing. Discussion on the Impact of Corporate Venture Capital on Innovation Performance of Startups [J]. *Technology and Economic Guide*, 2018, v.26; No.632 (06): 208 + 210.

Xu Xiangyang, Lu Haitian, Meng Wei. Venture Capital and Enterprise Innovation: From Perspective of Venture Capital Sensitivity to Patent Signals [J]. *Management Review*, 2018,30 (10): 60-74 + 120.

Xu Ziyao. Does Corporate Venture Capital Increase Value of Startups? [J]. *Economic Theory and Business Management*, 2016, No.304 (04): 47-56.

APPENDICES

Appendix A PSM Post-Matching Regression: Patent Grants (1:3 sample)

Panel A: Total Grants			
Variables	ln_Total_Grants	ln_Total_Grants	ln_Total_Grants
CVC_Back	0.648***		
	(0.211)		
CVC_Number		0.495***	
		(0.181)	
CVC_Share			0.606**
			(0.305)
HHI	-4.963	-4.986	-5.064
	(3.074)	(3.089)	(3.118)
HHI2	7.827	8.053	8.127
	(7.731)	(7.770)	(7.841)
Size	0.558***	0.547***	0.572***
	(0.153)	(0.154)	(0.155)
Age	-0.0728	-0.0391	-0.104
	(0.217)	(0.219)	(0.220)
RD_Share	-7.237	-7.488	-7.256
	(5.146)	(5.169)	(5.219)
SOE	0.100	0.129	0.0174
	(0.484)	(0.486)	(0.492)
Leverage	-0.674	-0.565	-0.542
	(0.823)	(0.827)	(0.835)
Tangibility	-1.408	-1.382	-1.317
	(0.890)	(0.894)	(0.902)
TobinsQ	-0.592**	-0.585**	-0.559**
	(0.244)	(0.245)	(0.247)
ROA	-3.636	-3.145	-3.895
	(4.030)	(4.048)	(4.096)
SA	-1.123*	-1.178*	-1.072*
	(0.596)	(0.599)	(0.605)
Constant	-2.352	-2.052	-2.757
	(3.467)	(3.490)	(3.514)
Observations	207	207	207
R-squared	0.276	0.269	0.256

Panel B: Invention Grants			
Variables	ln_Inven_Grants	ln_Inven_Grants	ln_Inven_Grants
CVC_Back	0.288		
	(0.198)		
CVC_Number		0.161	
		(0.169)	
CVC_Share			0.168

			(0.284)
HHI	-0.628	-0.627	-0.644
	(2.883)	(2.892)	(2.897)
HHI2	-0.959	-0.906	-0.904
	(7.250)	(7.273)	(7.286)
Size	0.146	0.146	0.155
	(0.143)	(0.144)	(0.144)
Age	-0.195	-0.186	-0.206
	(0.204)	(0.205)	(0.205)
RD_Share	-5.210	-5.338	-5.280
	(4.825)	(4.839)	(4.849)
SOE	0.368	0.377	0.344
	(0.454)	(0.455)	(0.457)
Leverage	-1.959**	-1.917**	-1.913**
	(0.772)	(0.774)	(0.776)
Tangibility	-1.093	-1.079	-1.059
	(0.834)	(0.837)	(0.838)
TobinsQ	-0.947***	-0.942***	-0.933***
	(0.229)	(0.229)	(0.230)
ROA	-6.412*	-6.211	-6.426*
	(3.779)	(3.790)	(3.805)
SA	-1.141**	-1.162**	-1.132**
	(0.559)	(0.560)	(0.563)
Constant	5.775*	5.836*	5.612*
	(3.251)	(3.267)	(3.265)
Observations	207	207	207
R-squared	0.270	0.266	0.264

Panel C: Utility Grants

Variables	ln_Utility_Grants	ln_Utility_Grants	ln_Utility_Grants
CVC_Back	0.599**		
	(0.233)		
CVC_Number		0.482**	
		(0.199)	
CVC_Share			0.700**
			(0.335)
HHI	-2.324	-2.350	-2.457
	(3.403)	(3.409)	(3.423)
HHI2	0.950	1.178	1.335
	(8.557)	(8.575)	(8.609)
Size	0.483***	0.471***	0.494***
	(0.169)	(0.170)	(0.170)
Age	-0.132	-0.0979	-0.164
	(0.240)	(0.242)	(0.242)
RD_Share	-8.811	-9.037	-8.742
	(5.696)	(5.705)	(5.730)

SOE	0.315	0.344	0.221
	(0.536)	(0.537)	(0.540)
Leverage	0.223	0.327	0.363
	(0.911)	(0.913)	(0.917)
Tangibility	-1.152	-1.130	-1.059
	(0.985)	(0.987)	(0.991)
TobinsQ	-0.352	-0.346	-0.319
	(0.270)	(0.270)	(0.271)
ROA	-2.913	-2.452	-3.292
	(4.461)	(4.468)	(4.497)
SA	-0.761	-0.813	-0.696
	(0.660)	(0.661)	(0.665)
Constant	-3.144	-2.836	-3.541
	(3.838)	(3.852)	(3.858)
Observations	207	207	207
R-squared	0.204	0.201	0.195

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B PSM Post-Matching Regression: Patent Applications (1:3 sample)

Panel A: Total Applications			
Variables	ln_Total_App	ln_Total_App	ln_Total_App
CVC_Back	0.492***		
	(0.189)		
CVC_Number		0.371**	
		(0.162)	
CVC_Share			0.463*
			(0.273)
HHI	-3.594	-3.610	-3.671
	(2.755)	(2.766)	(2.783)
HHI2	6.232	6.399	6.461
	(6.928)	(6.956)	(7.000)
Size	0.469***	0.461***	0.479***
	(0.137)	(0.138)	(0.138)
Age	0.0327	0.0578	0.00862
	(0.195)	(0.196)	(0.197)
RD_Share	2.728	2.536	2.716
	(4.611)	(4.628)	(4.659)
SOE	0.242	0.264	0.179
	(0.434)	(0.435)	(0.439)
Leverage	-0.243	-0.161	-0.143
	(0.738)	(0.741)	(0.746)
Tangibility	-1.421*	-1.402*	-1.352*
	(0.797)	(0.800)	(0.805)
TobinsQ	-0.580***	-0.575***	-0.555**
	(0.218)	(0.219)	(0.221)
ROA	-2.697	-2.326	-2.896
	(3.612)	(3.624)	(3.656)
SA	-0.840	-0.882	-0.802
	(0.534)	(0.536)	(0.540)
Constant	-1.768	-1.546	-2.076
	(3.107)	(3.124)	(3.137)
Observations	207	207	207
R-squared	0.226	0.220	0.210
Panel B: Invention Applications			
Variables	ln_Inven_App	ln_Inven_App	ln_Inven_App
CVC_Back	0.286		
	(0.184)		
CVC_Number		0.162	
		(0.158)	
CVC_Share			0.202
			(0.265)
HHI	-3.165	-3.165	-3.191

	(2.690)	(2.699)	(2.703)
HHI2	6.824	6.878	6.905
	(6.764)	(6.788)	(6.799)
Size	0.334**	0.334**	0.342**
	(0.134)	(0.135)	(0.134)
Age	0.138	0.147	0.126
	(0.190)	(0.191)	(0.191)
RD_Share	8.123*	7.996*	8.074*
	(4.502)	(4.516)	(4.525)
SOE	0.450	0.458	0.421
	(0.423)	(0.425)	(0.427)
Leverage	-0.360	-0.318	-0.310
	(0.720)	(0.723)	(0.724)
Tangibility	-1.194	-1.180	-1.159
	(0.778)	(0.781)	(0.782)
TobinsQ	-0.592***	-0.587***	-0.579***
	(0.213)	(0.214)	(0.214)
ROA	-3.543	-3.343	-3.592
	(3.526)	(3.537)	(3.551)
SA	-0.667	-0.689	-0.654
	(0.521)	(0.523)	(0.525)
Constant	-0.823	-0.760	-0.991
	(3.034)	(3.049)	(3.047)
Observations	207	207	207
R-squared	0.164	0.158	0.156

Panel C: Utility Applications

Variables	ln_Utility_App	ln_Utility_App	ln_Utility_App
CVC_Back	0.599**		
	(0.233)		
CVC_Number		0.482**	
		(0.199)	
CVC_Share			0.698**
			(0.335)
HHI	-2.403	-2.428	-2.535
	(3.404)	(3.410)	(3.424)
HHI2	1.139	1.367	1.523
	(8.560)	(8.578)	(8.613)
Size	0.485***	0.474***	0.496***
	(0.169)	(0.170)	(0.170)
Age	-0.128	-0.0944	-0.161
	(0.241)	(0.242)	(0.242)
RD_Share	-8.871	-9.096	-8.803
	(5.698)	(5.707)	(5.732)
SOE	0.318	0.347	0.224
	(0.536)	(0.537)	(0.540)
Leverage	0.251	0.354	0.391

	(0.911)	(0.913)	(0.917)
Tangibility	-1.166	-1.144	-1.073
	(0.985)	(0.987)	(0.991)
TobinsQ	-0.348	-0.343	-0.315
	(0.270)	(0.270)	(0.271)
ROA	-2.851	-2.389	-3.228
	(4.462)	(4.469)	(4.499)
SA	-0.762	-0.814	-0.696
	(0.660)	(0.661)	(0.665)
Constant	-3.203	-2.895	-3.600
	(3.839)	(3.853)	(3.860)
Observations	207	207	207
R-squared	0.205	0.202	0.196

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1