GOVERNMENT VENTURE CAPITAL, CORPORATE INNOVATION, AND FIRM VALUE: EVIDENCE FROM SMALL AND MEDIUM SIZED FIRMS IN CHINA

Yali Wang

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Yali Wang

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Supervisors:

Prof. Xiuping Hua

Prof. Sanjay Banerji

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ABSTRACT

Steadily rising importance of governmental venture capital firms (hereafter, GVC) in many countries attracts researchers to evaluate their performance and impacts (Lerner, 1999; Gompers and Lerner, 2004; Bottazzi et al., 2008; Howell, 2014; Guerini and Quas, 2016; Zhang and Mayes, 2018; Dong et al., 2021). Despite the well-noted rationale of addressing market failures by filling in "funding gap" of entrepreneurial start-ups or innovative firms (Alperovych et al., 2020), empirical evidence on GVC performance or impact is rather mixed. Some prior studies document the successful experiences of promoting both the local venture capital markets and corporate innovation activities, such as the Small Business Investment Company (SBIC) in the US and the Yozma Program in Israel (Lerner, 1999; Gompers and Lerner, 2004; Howell, 2014). But others warn about a bunch of failures of government efforts in fostering venture capital industries and enhancing firm productivities, such as in Canada and European countries (Cumming and Macintosh, 2006; Brander et al., 2008; Cumming et al., 2017; Grilli and Murtinu, 2014). Overall evidence in this strand of studies suggests that GVC funds do not add extra value to their investees, underperform their private peers, or even crowd-out private investment (Alperovych et al., 2020).

The institutional features of the China's venture market are very unique. China is renowned for state capitalism (Lazzarini, 2015; Li et al., 2015; Bardhan, 2016; Sun and Cao, 2018; Lazzarini et al., 2020). The Chinese state has played an important role of coordinating between various industrial and innovation policies, but misallocation of innovation resources by governments are not unusual (Boeing, 2016; Wei et al., 2017). Although a substantial body of economic research indicate potential negative

consequences of government sponsored or supported venture capital investments in some developed countries (Cumming and Macintosh, 2006; Brander et al., 2008; Wallsten, 2000; Grilli and Murtinu, 2014; Alperovych et al., 2020), China have embraced the development of GVC without reservation since 1997, in particularly after 2009, and shifted a large proportion of government capital supply from subsides to venture capital. Thus, China's state sponsored or supported VC industry has developed very fast in the last two decades and ranked top 1 in the world in term of total investment value since 2019.

Despite the policy interest, due to a lack of detailed data, there is relatively little well-identified empirical evidence evaluating how GVC affect innovative activities and performance of relatively young or small- and medium sized companies (hereafter, SME) in China. Only a very limited number of studies examine whether China's GVC affect portfolio firms, such as Zhang and Mayes (2018), Ke and Wang (2020) and Dong et al. (2021), and almost all of them suggest GVC underperform their private peers, or generate negative consequences on investees. Zhang and Mayes (2018) show that portfolio companies backed by GVC underperform those backed by PVC in going public. Ke and Wang (2020) find that on average GVC underperform domestic PVC in both exit and innovation performance. Dong et al. (2021) document that GVC negatively affects green innovation, which is potentially attributed to the risk aversion and adverse selection of the GVC managers.

Building upon the existing literature that examines the impacts of GVC, we employ the sample with 13475 companies in the China's National Equities Exchange and Quotations (NEEQ) market over the period of 2009 to 2020. The institutional features of China's NEEQ make it a unique experience to explore. Being established upon over-the-counter equities market in Beijing, the NEEQ market is widely known as the New Third Board, namely the third-tier national equity trading revenue just after Shanghai and Shenzhen stock exchanges. Since its formal registration, it has been dedicated to providing equity financing support and trading service for innovative, high-growth SME in China. The development of NEEQ has gradually boosted the financial and innovation practice of SME by offering trading systems and infrastructures, improving market liquidity, and enhancing information disclosure quality, and so on. To mitigate endogeneity and establish causality, we employ propensity score matching (PSM) event study approach and difference-in-differences (DID) technique, providing conforming evidence that supports our hypothesis. To test the robustness of the results, we use alternative samples, econometric models and variable definitions.

In the first empirical chapter, we examine the impacts of venture capital (VC), particularly government venture capital (GVC), on innovation activity of China's small- and medium-sized enterprises (SME). Using a difference-in-differences framework, our study finds that firms backed by GVC achieve higher patent number than their counterparties, however, they cannot obtain significantly higher proportion of novel patents. These results demonstrate that GVC can only increase patent quantity of portfolio firms, instead of patent quality. The GVC-backed firms patent more than non-GV-backed firms but these patents are not substantive and more incremental. We further disentangle two potential mechanisms: devoting resource channel and value-added channel. GVC investments facilitate their portfolio firms to obtain higher long-term leverage but lower short-term leverage, firms invest more funds in innovation activity after receiving funding. No evidence is found that GVC investors provide value added service to improve innovation capability of portfolio firms.

The second empirical chapter empirically examines the impacts of syndication investment of venture capital (VC), particularly government venture capital (GVC) with other types of venture capitals, on innovation activity of China’s small- and medium-sized enterprises (SME). Our study find that firms backed by syndication investment achieve a better innovation capability than their counterparties, however, the increase in patents activities do not translate to better firm performance for GVC-backed firms. Firms backed by syndication investments achieve better innovation capability in terms of patents number, the proportion of novel patents, citing number, family size and citation number, which indicates the interplay of GVC and PVC play an important role in helping Chinese SMEs to improve innovation capability in this pilot over-the-counter equities market. We further investigate that GVC investments facilitate their portfolio firms to obtain higher long-term leverage but lower average leverage. In addition, we investigate additional evidence that indicates that firms backed by syndication investments get their patent approval from patent application faster than non-GVC-backed firms and therefore achieve higher patent number. However, no evidence is found that syndication firms can outperform PVC backed firm in terms of ROA, ROE, sale growth, and employee growth, suggesting that the increase in patents activities do not translate to better firm performance for GVC-backed firms.

The third empirical chapter studies whether and how governmental venture capital firms (GVC) affect success of innovative companies in China's third-tier equity market. Using a comprehensive set of data for Chinese small and medium sized firms listed in NEEQ, we find, compared to insignificant impacts of standalone investments from only GVC or private venture capital firms (PVC), syndicated investing of GVC and PVC significantly enhances success chance of firm graduation (IPO) to main stock markets. We also identify the three mechanisms through which syndications help firms graduate to main stock markets, namely resource allocation, information sharing, and innovation nurturing. Further investigation based on a quasi-natural experiment indicates that syndication impacts are more pronounced for nine key sectors that were supported by a national innovation-driven development strategy. Moreover, GVC as a later-stage investor in the syndication are more likely to enhance firm performance than those being an earlier-stage investor, which indicates that they play a facilitating rather than leading role in value creation process.

CHAPTER I: INTRODUCTION

1.The development of GVC in China

1.1.1 Definition of GVC

The term GVCs appears in the extant literature with different meanings, for example government-owned venture capital firms (Bottazzi *et al.*, 2008), public ownership of VC firms (Buzzacchi et al., 2013), governmental venture capital (Alperovych *et al.*, 2015; Colombo et al., 2014) and government-managed venture capital (Grilli & Murtinu, 2014a). In this paper we use the concept which best maps into actual behaviour in China and use the term GVCs to refer to "Government-established, owned and operated venture capital firms", with the following three features.

First, GVCs refer to governmental VC firms rather than governmental VC funds. The mixing-up of these two terms would cause confusion in analyzing the characteristics of GVC firms and the effect of government financial support for the VC industry. Governmental funds refer to the funds which come entirely or mainly from the government budget but can by operated by any kinds of venture capital firms. Some governmental VC funds are similar to subsidies to PVCs, which can be regarded as the support of PVCs' fundraising (Grilli & Murtinu, 2014b; Leleux & Surlemont, 2003). The governments only act as the fund resource (Limited Partner) rather than players (General Partner). Typical examples are the Israeli Yozma program, the U.S. Small Business Innovation Research program and the New Zealand Seed Investment

Fund (Lerner, 2009). The investment decision of this kind of governmental VC funds is made by selected qualified private VC firms, without establishing government VC firms[1].

By contrast, governmental venture capital firms are set up by governments and operated by managers appointed by governments. The governments adopt a “hands-on” (Grilli & Murtinu, 2014b) policy approach, involving themselves intensively in the investment choices and decision-making of GVCs. This mode is not unique to China. European countries have also set up GVCs, which share similar features to GVCs in China. Secondly, GVCs in China rely on local government budgets as the primary funding resources, where the said localities are larger than most European countries. The most frequently used name of a GVC is the combination of the province/city name and “high-tech venture capital”, which reflects the strong relationship between GVCs and local governments. Most GVCs have a mandate to invest locally to favor the development of the local economy. The local knowledge and network endow each GVC with the strength in accessing local resources. Third, state ownership is the distinctive feature of GVCs, which must obey the regulations relating to state-owned assets. Like other state-owned enterprises, GVCs are regulated by the local State-owned Asset Supervision and Administration Commission and must meet the annual assessment goals set by SASAC.

[1] The Chinese government has also set up such governmental VC funds known as Government-guided Venture Capital Fund after 2009, which adopt the form of Fund of Funds (FOFs) and are operated in a more market-oriented way (J. Chen, 2010). However, due to its short history, it is not the focus of this research.

In this paper, a venture capital firm is designated as a GVC if it meets the following criteria: First, the funding resource of the VC firms when established is mainly from local government, and the decision of further funding is also dependent upon local government; secondly, the VC firms have the advantages in accessing to local resources due to their special relationship with local government; thirdly, the VC firms are under the supervision of SASAC. VC firms in China which meet the criteria include those established by:

- Local government
- Bureau of Finance in local government
- Bureau (or Commission) of Science and Technology in local government
- Local State-owned Asset Supervision and Administration Commission
- Asset management companies set up by local SASAC
- City construction and development companies set up by local government
- Local Economic Development Zone Management Committee

The number of these funds has been increasing explosively since 2014, largely having benefited from the government's desire to make full use of its fiscal reserves. The number of such funds grew from 68 in 2013 all the way up to a peak of 533 funds in 2016, before coming in a bit lower in recent years. It is worth mentioning that the boundary of venture capital and private equity (PE) firms is blurry in China. Even though venture capital is only a special type of private equity that mainly focuses on early-stage investment in the United States, in China the two terms are often used strategies used by Chinese venture capital and private equity firms.

Recently, there has been growing interest in the role of government in catalyzing the development of the venture capital market. To bring both funding and players to their domestic venture capital market, many countries have set up governmental venture capital firms. Given their increasing importance, there has therefore been increasing concern about the performance of GVCs. GVCs in China are governed as state-owned enterprises, which are assessed annually by the government; one the other hand, GVCs enjoy the privileged access to IPO quota allocated to each region, which is crucial to the successful exit from portfolios. At the same time, GVCs in China also share some common characteristics with GVCs in EU countries in terms of the establishment statute and compensation mechanism. Thus, the results of this research can be also generalized to other countries.

1.2. Purpose of setting up GVCs

The primary consideration in establishing governmental venture capital firms is to bridge the gap between the strong funding demand of SMEs (small and medium-sized enterprises) and high-tech industries, and the limited funding supply from traditional financial sector (White et al., 2002). When the Chinese VC industry was still in its infancy in the 1990s, it was believed the intervention of the government can lead to a virtuous cycle in the immature market when all participants (entrepreneurs, venture capitalists, intermediaries such as lawyers and accountants, and institutional investors) become familiar and confident with the VC process (Lerner & Watson, 2008). Thus, GVCs were established to bring players as well as fund resources for the VC industry at the very beginning.

Furthermore, the motivation of establishing GVCs stems particularly from the wish to invest in Seed and early stage projects, which have higher risk and are less attractive to private VC firms (Yu et al., 2014). GVCs set up by local authorities dominated the VC market in China before 1996 (Liu et al., 2006). By the end of 2000, there was increasing participation of both domestic and foreign PVCs in the market. As a consequence, the proportion of GVCs dropped to 53% by the year 2002 and less than half afterwards (S. Wang, 2005).

Importantly, government venture capital is not purely profit-driven. With a limited amount of money funded mainly by the government, the purpose of such funds is to enjoy the leverage amplification effect by guiding and attracting more money from the market to special sectors, cities, or certain investment stages. GVC in China mainly aim to serve national strategies, optimize the layout of state-owned capital and enhance industrial competitiveness. According to the requirements for the layout and structural optimization of state-owned capital, they hold strategic businesses in essential industries and key areas related to national security and the lifeblood of the national economy. With the goal of central enterprises' innovation and collaborative development, state-owned capital participates in establishing sub-funds, and state-owned enterprises, central enterprises and social capital jointly initiate the establishment of industrial funds. Funds with state-owned capital, primarily government-guided funds, are policy-oriented, established to drive local economic development and promote industrial restructuring. As a result, it faces some restrictions, such as investment areas and regions, by setting the return ratio.

1.3. Characteristic of GVCs in China

China's GVC firstly appeared in the VC market in 1997. In 2007, the Interim Management Measures for high-tech SME Venture Capital Guidance Funds was jointly prepared and issued by the MOF and Ministry of Science and Technology, and China's first state-level high-tech SME venture capital guidance fund be launched. In October 2008, Chinese State Council issued the Guideline on Standardized Establishment and Operation of Venture Capital Guidance Funds that was jointly by proposed by National Development and Research Committee, Ministry of Finance and Ministry of Commerce. The Emerging Industries Venture Capital Plan shall be operated in accordance with the Interim Management Measures for the Emerging Industries Venture Capital Plan to Invest in Venture Capital Funds issued by MOF and NDRC in 2011.

Data summary statistics in Table 1.1 reveal that by the end of 2020, there are about 7222 GVCs in China, which is about 20% of total number of VCs. Total investment deals of GVC are about 34,341, about 20% of total VC deals. Total investment amount of GCV is about 2,771,300 million, about 30% of total VC value. GVC are more likely to invest in Pre-IPO firms or mature companies, and invest the least in seed stage of entrepreneurial firms. The average investment of GVCs, 366.33 million is higher than that of VCs, 246.75 million. It is generally consistent with the argument of Dong et al. (2021) that Chinese GVC managers receive fixed remuneration and are held accountable in case of loss or failure of a GVC investment, and thus a natural risk aversion in managing its portfolios. Thus, GVC are more likely to invest in later-stage rounds.

Table 1.1 Overview of GVC and VC investments in China

Panel A: Institutions, Deals and Amount	GVC	VC	Percentage
No. of Institutions	7,222	35,999	0.20
Total Investment Deals	34,341	120,509	0.28
Total Investment Amounts (Million)	2,671,300	8,882,657	0.30
Ave. Investment Deals	4.71	3.35	1.41
Ave. Investment Amounts (Million)	366.33	246.75	1.49
Panel B: Investment Rounds	GVC	VC	Percentage
Seed	2,266	11,871	0.19
A	14,860	50,781	0.29
B	5,727	21,605	0.27
C	2,504	10,354	0.24
D	1,017	4,357	0.23
E	395	1,783	0.22
F	139	757	0.18
G	86	359	0.24
Pre-IPOx	4,627	10,953	0.42
Panel C: Investment Stages	GVC	VC	Percentage
Seed Stage	3,245	16,323	0.20
Initial Stage	5,696	26,587	0.21
Expansion Stage	14,578	49,873	0.29
Mature Stage	10,469	25,794	0.41

Table 1.2 Year Distribution of VC and GVC institutions.

Year	New VC	Total VC	New GVC	Total VC	Percentage of GVC
1979	7	137	1	2	0.01
1980	12	149	0	2	0.01
1981	15	164	1	3	0.02
1982	12	176	1	4	0.02
1983	15	191	1	5	0.03
1984	17	208	2	7	0.03
1985	18	226	4	11	0.05
1986	22	248	4	15	0.06
1987	17	265	2	17	0.06
1988	13	278	2	19	0.07
1989	33	311	5	24	0.08
1990	22	333	1	25	0.08
1991	30	363	4	29	0.08
1992	52	415	20	49	0.12
1993	57	472	13	62	0.13
1994	66	538	17	79	0.15
1995	59	597	9	88	0.15
1996	79	676	9	97	0.14
1997	99	775	9	106	0.14
1998	93	868	17	123	0.14
1999	139	1007	24	147	0.15
2000	293	1300	49	196	0.15
2001	263	1563	35	231	0.15
2002	195	1758	26	257	0.15
2003	210	1968	22	279	0.14
2004	228	2196	22	301	0.14
2005	236	2432	22	323	0.13
2006	366	2798	26	349	0.12
2007	689	3487	50	399	0.11
2008	776	4263	106	505	0.12
2009	971	5234	127	632	0.12
2010	1830	7064	214	846	0.12
2011	2851	9915	261	1107	0.11
2012	1814	11729	289	1396	0.12
2013	1954	13683	300	1696	0.12
2014	3834	17517	496	2192	0.13
2015	7070	24587	1176	3368	0.14
2016	4643	29230	1416	4784	0.16
2017	3505	32735	1218	6002	0.18
2018	1683	34418	668	6670	0.19
2019	984	35402	416	7086	0.20
2020	597	**35999**	136	**7222**	**0.20**

Table 1.3 Year Distribution of VC and GVC investment amount.

Year	VC Investment Amount	GVC Investment Amount	Percentage
1992	0.85		0.00
1993	584.16		0.00
1994	277.3		0.00
1995	2135.47		0.00
1996	1217.07		0.00
1997	1387.23	307.4	0.22
1998	1250.12	115.5	0.09
1999	3946.1	391.48	0.10
2000	4923.48	811	0.16
2001	10557.14	569.62	0.05
2002	4733.91	553.73	0.12
2003	10627.42	1666.73	0.16
2004	15562	808.08	0.05
2005	87136.43	2989.51	0.03
2006	142596.75	6252.21	0.04
2007	120369.33	14788.17	0.12
2008	117908.29	16023.44	0.14
2009	157839.13	45017.62	0.29
2010	246425.25	61841.36	0.25
2011	336796.89	114301.71	0.34
2012	265159.72	78066.8	0.29
2013	283292.6	109331.16	0.39
2014	644780.71	202420.26	0.31
2015	896179.31	303990.33	0.34
2016	1108623.64	299863.4	0.27
2017	1414647.2	568221.85	0.40
2018	1013995.29	246512.76	0.24
2019	1088405.56	284229.4	0.26
2020	901298.45	312226.68	0.35
Total	**8,882,656.80**	**2,671,300.20**	**0.30**

The overall management scale of fund managers with state-owned backgrounds occupies a large proportion of the equity market, and the scale is relatively large. As of 2019, about 26.6% of the managers of private equity and venture capital funds registered in the CFPA have a state-owned background, while the scale of funds under their management subscriptions accounts for 60.5% of the overall scale. Compared with private capital, fund managers with state-owned backgrounds have relatively stronger financial resources and more cases with a contribution scale of over 1 billion.

Table 1.2 displays the annual increase of new VC and GVC institutions between 1979 and 2020. The percentage of GVC represents the cumulative number of GVC institutions as a proportion of the number of VC institutions between 1979 and 2020.

GVC have started to invest more aggressively since 2009. Based on statistics provided by Zero2IPO data vendor in China (Table 1.3), in 2008, the total amount of GVC investments in China was only 16,023.44 million, which was about 14% of total VC investment, 117,90.29 million, but this number increased to 45,017.62 million (29% of total VC investment of 157,839.13 million) in 2009, and 312,226.68 million (35% of total VC value of 901,298.45 million) in 2020.

Table 1.4 Industry distribution of VC and GVC investment cases.

Industry	VC	GVC	Percentage
Chemical Raw Materials and Processing	3807	1664	0.44
Machinery Manufacturing	7078	3021	0.43
Energy and Minerals	1815	764	0.42
Semiconductor and Electronic Equipment	8942	3737	0.42
Clean Technology	4648	1932	0.42
Agriculture / Forestry / Animal Husbandry / Fishery	1436	567	0.39
Radio & TV & Digital TV	321	126	0.39
Architecture/Engineering	2023	787	0.39
Textile & Garment	687	228	0.33
Food & Beverage	1631	521	0.32
Automotive	2557	803	0.31
Biotechnology/Healthcare	16129	4908	0.30
Entertainment & Media	5178	1322	0.26
IT	20988	5207	0.25
Logistics	1404	334	0.24
Real Estate	2105	486	0.23
Chain & Retail	2695	600	0.22
Telecommunications and Value-Added Business	6163	1338	0.22
Finance	5982	1176	0.20
Education and Training	1630	312	0.19
Internet	18851	3286	0.17
Total	116070	33119	0.29

Table 1.4 displays VC and GVC investment cases in different industries between 1984 and 2020. Percentage represents the ratio of GVC to VC investment cases. The data we collected indicate that compared to PVC, GVC in China invest heavily in industries of Raw Chemical Materials and Processing, Machinery Manufacturing, Energy and Minerals, Semiconductor and Electronic Equipment, and Clean Technology, but invest less in Internet, Education and Training, and Finance industries (See Table 2). We also find that Chinese GVC are more likely to (or have mandate to) originate transactions locally.

2.The development of innovation in China

2.1 Innovation Policy in China

China follows a state capitalism model wherein the state plays a direct role in promoting and influencing economic development through reform policies (e.g., Zhang & Greve,2018) and uses SOEs as an important channel to influence the economy and society (e.g., Xu, 2011). In recent years, the state has actively promoted innovation to enhance the innovativeness and, thus, the long-term value of firms and the country. Patents resulting from indigenous innovation in China have increased because of economic development (Hu & Jefferson, 2009; Huang, 2010). Moreover, it was only in 2006 that the state started to fully pursue this policy goal through major political campaigns originating from the central level and systematically build an incentive system to promote domestic innovation. Among the most important overarching policy guidelines for promoting indigenous innovation in China are "China's National Medium- to Long-term Plan for the Development of Science and Technology (2006–2020)" by the State Council of China in 2006 and the follow-up "National Intellectual Property Strategy (2008)," which called for the enhancement of overall innovation capability and for the transformation of China into an innovative society by 2020 (Abrami et al., 2014). These policies were included in the 12th Five-Year Plan, which stipulated that China would pursue an ambitious program of technological development that would enable the country to enter the ranks of innovative countries by 2020 and become a global scientific power by mid-century.

These policies also explicitly encourage indigenous inventions and patents filed with the State Intellectual Property Office (SIPO), China's equivalent agency to the United States Patent and Trademark Office (USPTO). To implement these overarching general policy guidelines, subsequent policies specified several channels to reach these goals, including the pro-indigenous innovation government procurement policy that we utilize in our empirical analysis.

These policy guidelines and subsequent public policies reward the following innovation outcomes. First, the state designed comprehensive and actionable plans for faster accumulation of patents. The aforementioned policy directives included specific clauses that mandated the overall national patenting targets—that is, achieving a set number of patents within a given length of time. For example, the state decreed that local firms must apply for two million patents by 2015 (The Economist, 2014).

The overall targets were then allocated to local governments, and many local governments accordingly adopted policies to provide direct monetary incentives to apply for patents. For instance, Zhangjiagang City in Jiangsu Province increased its patent subsidy in June 2006 for an invention patent application from RMB 1,500 to RMB 3,000 and added a reward of RMB 10,000 if the application was eventually granted (e.g., Lei, Sun, &Wright, 2013). As documented in many media reports, the quantity of patent production became a dominant metric in the incentive system created by the Chinese state to promote indigenous innovation (e.g., The Economist, 2010, 2014).

2.2 Innovation data in China

It is obvious to see in figure 1.1 that before 2008, the number of patents of any type was very low, after that, the number of industrial designs increased by 2 million in 12 years until 2020, and the number of utility models also exceeded 500,000, while the number of inventions patents is also close to this number. The reason for such a large number of industrial designs is that it is relatively difficult to apply for this type of patent. In contrast, the professional requirements for utility models are higher, and the application for invention patents is the most difficult because of its high value.

Figure 1.1 Dynamic shift of invention, utility model and industrial design.

Figure 1.2 illustrates the number of applications for invention patents and the number of granted patents from 2000 to 2020, as well as the change trend of the grant ratio. It is obvious that the ratio of grants passed from 2008 to 2015 has increased significantly, which may be because it was related to the loose patent policy at that time. There was a slow increase in the number of invention patent filings before the watershed in 2014, after which the growth rate increased significantly. Meanwhile, the patent authorization pass rate returned to a relatively low state, indicating that the threshold for review has increased.

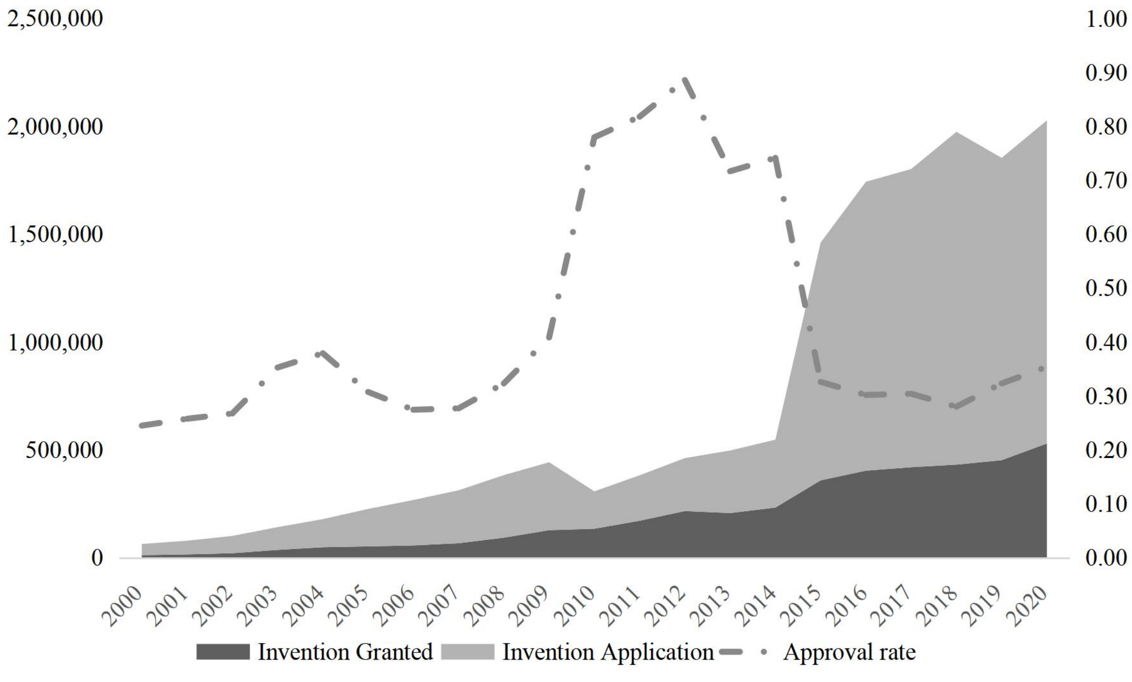


Figure 1.2 Dynamic shift of invention, utility model and industrial design grant ratio

Table 1.5 is about the IPC distribution of inventions and utility models, in which invention patents are mainly distributed in physics, electricity and chemistry. On the other hand, the proportion of utility models in Performing operations and Transporting is significantly higher than other. The conclusion can be drawn uncomplicated, that is, the development of basic science is more likely to lead to the generation of invention patents, and the output of utility models is more in some interdisciplinary fields. The development of electricity, physics and chemistry can greatly promote the number of invention patents, and in turn, the introduction of invention patents will also promote the expansion of the corresponding scientific fields.

Table 1.5 IPC Distribution of invention and utility model.

Classification	Invention		Utility Model	
	Number	rate	Number	rate
Section A: Human necessities	46,210	0.09	378,949	0.16
Section B: Performing operations and Transporting	93,532	0.18	865,604	0.36
Section C: Chemistry and Metallurgy	73,712	0.14	83,292	0.04
Section D: Textiles and Paper	7,236	0.01	35,766	0.02
Section E: Fixed constructions	21,279	0.04	204,354	0.09
Section F: Mechanical engineering and Lighting and Heating and Weapons and Blasting	37,541	0.07	290,637	0.12
Section G: Physics	132,967	0.25	272,572	0.11
Section H: Electricity	117,650	0.22	246,049	0.10
Total	530,127	1.00	2,377,223	1.00

Figure 1.3 presents the geographic distribution of the accumulated number of invention patents at municipal level from 2000 to 2019. As shown in this figure, urban innovation activity is unevenly distributed in space and can be classified in five tiers. First of all, Beijing, the capital of China, and Shenzhen, the special developed zone in China, obtain more than 300 thousand invention patents during 2000 to 2019, making them as the most innovative regions in China. The second-tier innovative cities are eastern coastal cities, such as Qingdao, Suzhou, Hangzhou, and Guangzhou, achieve significant higher number of invention patent. The patent number of Shanghai and Qingdao is between 100 thousand and 200 thousand and is placed at third tire. Cities such as Anhui, Xi’an, Zhengzhou, and Changsha, located in middle of China, achieve more than 50 thousand patents and are placed as tire four. Cities in west China, such as Taiyuan, Lanzhou, Xinjiang and Xizang only accumulate less than 500 thousand patents, therefore, is the least innovative city in China. This results clearly shows that urban innovation activity is unevenly distributed over space in China.

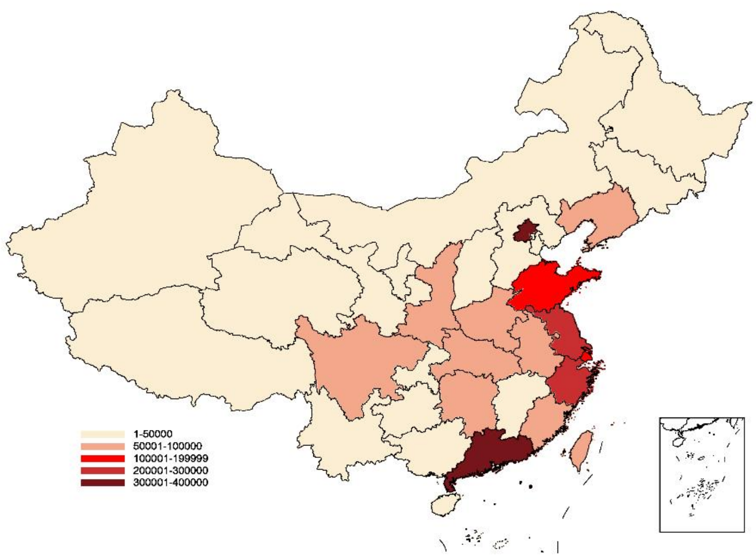


Figure 1.3 The spatial concentration of Chinese patents at city level.

3. The development of NEEQ

NEEQ, being an emerging equity market in China, is currently un-investigated by international press and research papers. Hence, we give below descriptions to familiarize readers with our novel sample as well as current situation Chinese SMEs are facing.

Existed as the predecessor of New Over-The-Counter (OTC) Market i.e. NEEQ, the birth of Old OTC Market dated backed to 2001. The foundation of it was laid to serve mission of undertaking delisted firms from main board and firms transferred from Securities Trading Automated Quotations System (STAQ) and National Exchange and Trading System (NET) after operational cessation of these two systems (Li et al., 2015)[2]. In 2006, the symbolic event of evolution from Old OTC Market into New OTC Market marked the big-bang of universe filled with fortune for firms who failed to conform main board listing qualifications, as they could be publicly traded in New OTC Market now. From 2006 to 2011 of this transitional epoch, only firms in Beijing's Zhongguancun Technology Park was readily consented for listing on this system. Release of regimented geographical limit ensued in 2012, developed cities such as Shanghai and Tianjin joined in. As a verdict of major regulatory momentousness, China Securities Regulatory Commission (CSRC) published *National Equities Exchange and Quotations. National SME share transfer system Investors Management Regulations (Trial)* in 2013 and signified green light for firms

[2] NEEQ information in Chinese is exhaustive in its official website, but NEEQ information in English remains incomplete and inexplicit due to its short presence and currently un-investigated by international press. Limited amount of English literature could be found to trace its background information. Li et al. (2015) gave concise introduction of NEEQ in their paper. Several official press conference records in English official website of China Securities Regulatory Commission are available for reader's further information.

all over China to be listed on this market. Conforming to this official document, CSRC expressly contrived for buttressing number of listed micro enterprise and SMEs, and to bail them out of fund-raising dilemma, as NEEQ has remarkably more achievable listing requirements which bears striking contrasts to main board (Shanghai and Shenzhen stock exchange). To ensure the high-tech firms prerogative, CSRC endowed privilege for those who possessed High and New Technology Enterprise (HNTE) certificate to expedite their procedures of listing on NEEQ.

Without the labyrinth of standards and regulations as main board, NEEQ burst forth rapidly[3]. In 2013, only 356 firms were listed in the market, and the figure quadrupled during 2014, reaching 1572, when market value also grew to 4591.42 million which is more than eight times from the original 553.06 million. In 2015, the number of listed firms increased to 5129 and the market value grew more than five times to reach 4591.42 million. The explosive surge came in 2016 with the number of listing firms broke through ten thousand to reach 10163 and the market vale break through four trillion to reach 4.056 trillion. Listing activity was a ballistic rocket and the market mania is sweeping the vast expanse of micro enterprise and SMEs. While numerical trends and figures seem inspiring for SMEs who wish to be publicly traded there, reality turns out to be 73% of the shares listed never ever had a single trade since the time they were listed. Inexplicably, Firms continued to rushed to NEEQ and are zealous to have their stocks listed there, despite of the signs of illiquid market trading. We hence consider why firms crowd in this market mania and how it would prosper or

[3] Following numbers and trends referred to official summary statistics on its official website (i.e. http://www.neeq.com.cn).

hurt innovation.

Table 1.6 Year distribution of firms listed on NEEQ.

Year	No. of NEEQ firms	Percentage
2001	2	0.00
2005	1	0.00
2006	10	0.00
2007	14	0.00
2008	17	0.00
2009	20	0.00
2010	16	0.00
2011	25	0.00
2012	105	0.01
2013	156	0.01
2014	1233	0.09
2015	3570	0.26
2016	5090	0.38
2017	2176	0.16
2018	577	0.04
2019	250	0.02
2020	136	0.01
2021	77	0.01
Total	13475	1.00

Above mentioned basic characteristics of NEEQ made it ideal targeted market of micro-enterprise, SMEs and innovative firms, which are exactly what we want to research on. Exogenously, major events of its regulating action and market mania make us wonder the effect on its innovation, as other related literature had been elaborating on these topics (Ovtchinnikov, 2010, Ozmel et al., 2013). Furthermore, the internal mechanism of early stage SMEs also remains an intriguing topic as China as the government had inject much effort hoping to nurture their innovation. Absorptive capacity related to employee education has been selected as an indicator for us to look on, after reviewing relevant literature on firm's mechanism (Østergaard et al., 2011). Conjointly with capital structure and innovation, this paper will further embrace the variables and analysis of exogenous factors as regulation, market mania and internal mechanisms as absorptive capacity.

Table 1.7 Segment market distribution of firms listed on NEEQ.

Segment Market	No.of NEEQ firms	Percentage
Base	5802	0.43
Innovation	1229	0.09
Graduates	399	0.03
Delisted	6045	0.45
Total	13475	1.00

Table 1.8 Year distribution of found year of NEEQ firms.

Year	No. of firms	Percentage
1992-2000	9	0.00
2001	3	0.00
2002	2	0.00
2003	1443	0.11
2004	11999	0.89
2006	1	0.00
2007	2	0.00
2008	3	0.00
2009	2	0.00
2011	3	0.00
2013	4	0.00
2014	4	0.00
Total	13475	1.00

Table 1.9 Ownership distribution of NEEQ firms

Ownership	No. of NEEQ firms	Percentage
Center SOE	91	0.01
Local SOE	490	0.04
POE	12678	0.94
FOE	216	0.02
Total	13475	1.00

CHAPTER II: THE LIMITS OF GOVERNMENT VENTURE CAPITAL: EVIDENCE FROM CHINA’S INDIGENOUS INNOVATION COMPETITION

Abstract

This study examines the impacts of venture capital (VC), particularly government venture capital (GVC), on innovation activity of China’s small- and medium-sized enterprises (SME). Using a difference-in-differences framework, our study finds that firms backed by GVC achieve higher patent number than their counterparties, however, they cannot obtain significantly higher proportion of novel patents. These results demonstrate that GVC can only increase patent quantity of portfolio firms, instead of patent quality. The GVC-backed firms patent more than non-GV-backed firms but these patents are not substantive and more incremental. We further disentangle two potential mechanisms: devoting resource channel and value-added channel. GVC investments facilitate their portfolio firms to obtain higher long-term leverage but lower short-term leverage, firms invest more funds in innovation activity after receiving funding. No evidence is found that GVC investors provide value added service to improve innovation capability of portfolio firms. These results are robust to a variety of estimations and controlling for endogeneity.

Keywords: government venture capital, innovation capability, devoting resource.

JEL Classification: G24 · G38

1. Introduction

The US has the largest venture capital (VC) market in the world and many studies examine whether and how VC financing creates value or improves efficiency in private firms (Jain and Kini, 1995b, Kortum and Lerner, 2000, Chemmanur et al., 2011b, Tian, 2011a, Alperovych et al., 2015, Guerini and Quas, 2016;Gompers, 2020). During the late 1970s and 1980s, state governments in the US adopted GVC programs, which took direct equity or royalty stakes in new private enterprises to promote high-technology economic development, and by 1990, there were 17 state-funded GVC programs (Leicht and Jenkins, 1998). In addition to GVC, American governments regularly subsidize new ventures to spur innovation, often in the form of Research and Development (R&D) grants (Howell, 2017), and both GVC and R&D grant programs constitute direct economic interventions in the VC investment market since state governments are investing public funds in private enterprises. Between 1983 and 1997, the Small Business Innovation Research (SBIR) program in the United States had provided over $7 billion to small high-technology firms and such awards had played an important role in certifying firm quality (Lerner, 2000). Based on a dataset of applications of 7,436 small high-tech firms to the U.S. Department of Energy's (DOE) SBIR program and over $884 million in awards from 1983 to 2013, Howell (2017) reveals that a SBIR award approximately doubles the probability that a firm receives subsequent venture capital and has large, positive impacts on patenting and the likelihood of achieving revenue.

Government around the globe have been eager to duplicate the success of the fast-growing U.S. venture capital industry. The creation of an active VC market has therefore been become a priority on the agenda of European policy makers (Cumming et al., 2014). Many governments in Europe, such as UK, France, Spain, Italy, Finland, and Belgium, established a number of government-owned or managed VC funds to complement the small supply of private venture capital. Overseas, much of the recent growth in high-tech firms in such nations as Israel, Singapore, and Taiwan has been attributed to government venture capital initiatives (Lerner, 2000).

Among those countries, China is a relatively later comer but China's government-backed venture capital (GVC) funds have amassed the world's biggest startup pool. Since 2006, China has ranked at second after the US, the world's largest economy which has been leading in the venture capital investments in mobilizing the venture capital funds (Guo and Jiang, 2013). Just in 2015 the VC investment in the world's second largest economy have witnessed an encouraging growth rate of 24 percent and reached a number of $20.2 billion, while the venture capital investments in the US were $58.8 billion in 2015, based on data provided by Zero2IPO and Thomson Reuters. As of 2016, active VC firms on Chinese market have numbered up to over 10,000 and the total number of investment amount is more than 35.82 billion RMB in China.

In order to ease the slowing Chinese economy into a consumer-based rather than heavy industry-focused one, during May 2013 to December 2015, the State Council in China issued at least 23 official documents (opinions) to boost mass entrepreneurship and innovation, which has been viewed as a new engine for China's industry upgrading and economic growth. To facilitate mass entrepreneurship and innovation, many municipal governments in China have established GVC funds to complement the inadequate supply of private VC (PVC) to high-tech entrepreneurial companies in the past several years. According to Zero2IPO and Bloomberg, China reportedly established 721 GVC and raised about 1.5 trillion yuan, or $231 billion, in GVC funds through 2015. By the end of 2016, 498 new GVC were born in China and 1219 GVC have established in total.

While prior research makes a useful contribution, we highlight three deficiencies in the literature. First, despite China's being secondly largest VC market in the world and making tremendous GVC investments in the past several years, the role of GVC in China has attracted virtually no scrutiny and little is known regarding whether GVC firms can screen the market, select promising entrepreneurial companies and certify them to PVC firms. Guo and Jiang (2013) find that VC-backed firm generally outperform non-VC-backed firms in term of financial performance, R&D activities, sales growth and labor productivity, based on the panel data of Chinese manufacturing firms during 1998 and 2007. Using a similar panel dataset, Guo et al. (2016) investigates the effects of government R&D programs on firm innovation outputs, which are measured by the number of patents, sales from new products and finds that government grant-backed firms generate significantly higher technological and commercialized innovation out-puts compared with their non-government fund-backed counterparts and the same firms before winning the grant. Hua et al. (2016) find that venture capital financing not only spurs innovation in Chinese market, but also exhibits significantly positive impact on financial performance by using an unbalanced panel data of 2699 SMEs in the National Equity Exchange and Quotation (NEEQ) market, during 2005-2014. However, they have not moved further to examine the significant role of GVC in the process of VC investment market in China.

Secondly, although China had become the second biggest venture capital market in the world, the Chinese context, in particular, small and medium-sized enterprises' (SMEs) in China, has only attracted limited interest (Guo and Jiang, 2013, Hua et al., 2016). It is evident from the previously mentioned few studies about the relationship between venture capital investment and the performance and innovation of listed firms at mature stock exchanges with relatively larger size and revenues. To our knowledge, little research has systematically securitized the nexus between China's small and medium-sized enterprises' (SMEs) use of venture capital and innovation performance relationships. The National Equities Exchange and Quotations (NEEQ) system is a newly-established national over-the-counter equities market and aims to provide equity financing and trading for SMEs. More than 10,000 SMEs are listed on NEEQ and trading volume reached 0.85 billion yuan. However, few studies have explored how venture capital investment affect the innovation capability of SMEs in this unique market setting of over-the-counter equities trading market in China.

Therefore, the purpose of our article is two-fold: first, to explore whether government venture capital (GVC) investment in China can positively affect the technology innovation of SMEs traded in NEEQ, and second, to shed light on how GVC draws impact on innovation capability of SMEs. We use an observable investment outputs, namely the number of patenting, in our empirical tests as this helps us to assess the success of investment in terms of innovation. Using a difference-in-differences framework, our study finds that firms backed by GVC achieve higher patent number than their counterparties, however, they cannot obtain significantly higher proportion of novel patents. These results demonstrate that GVC can only increase patent quantity of portfolio firms, instead of patent quality. The GVC-backed firms patent more than non-GV-backed firms but these patents are not substantive and more incremental. Our results are robust to a variety of specifications and control variables, and confirm the positive effects for venture operations.

The rest of the paper is organized as follows. In the second section, we explore the theoretical and empirical evidence of GVC and firm performance in the existing literature, and put forward the testable hypotheses. In section 3, we describe the data and methodology adopted in the empirical tests. The baseline empirical result and the cross-sectional heterogeneity are then presented in Section 4. Section 5 discusses the three plausible influencing channels. Section 6 presents the robustness check results as well as further corrections for possible endogeneity. Finally, the conclusion is drawn and the future research is discussed in Section 7.

2. Backgrounds, Literature and Conceptual Framework

In this section, we briefly describe the Conceptual Framework of GVC and innovation. discuss the experimental setting of the 2007 innovation policy, develop theoretical arguments on the impact of GVC on firm performance, and we also posit that there are several research hypotheses for GVC to exert effects.

2.1 Conceptual Framework

There are two reasons why GVCs are particularly interested in sustaining innovation. First, because of knowledge spillovers, invention and innovation have a social value beyond what is captured by the innovative companies. Second, knowledge spillovers have a very important local component, which means that the positive externalities of invention and innovation will benefit local companies the most. To this extent, a GVC may support invention and innovation because they are instrumental to regional or national economic development.

Theoretically, there are several mechanisms that GVC are able to support early stage firms. The first one is "certification", namely decision-making of government conveys positive information to outside investors (including PVC firms) about the firm's potential and the receipt of GVC financing acts as a "stamp of approval", which facilitates the company's access to the PVC market(Lerner, 2002, Guerini and Quas, 2016) .The second is "screening" mechanism, namely GVC has the capacity to screen the market and select promising entrepreneurial companies with the potential of resulting in good investment opportunities(Guerini and Quas, 2016). Entrepreneurial literature points out that venture capital investments outperform traditional financial intermediaries in term of selecting promising portfolio firms and alleviating information asymmetry (Denis, 2004, Gompers and Lerner, 2001, Gorman and Sahlman, 1989, Sahlman, 1990). However, some literature indicates that VC investors, a kind of typical institution investors, may be affected by "herding" attitude and prefer to invest in a few specific industries which are more likely to gain highest growth potential (Devenow and Welch, 1996, Lerner, 2002). Therefore, despite the existence of private venture capital, a market failure in the financing of high-tech companies can still justify government intervention (Guerini and Quas, 2016). The third one is "prototyping" channel, namely the startup might use the government grant to prove the viability of its technology and hence to reduce investor uncertainty (Guerini and Quas, 2016).

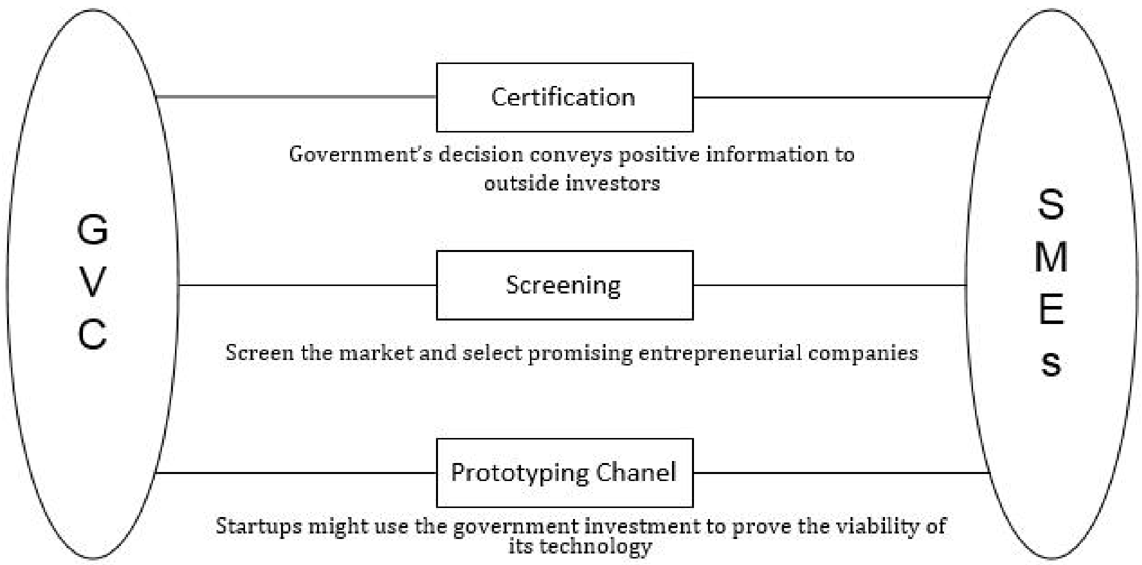


Figure 2.1 Theoretical mechanisms that GVC are able to support early stage firms

On the contrary, venture capital literature has found that GVC may tend to involve in a counterproductive way. First, GVC are often managed by civil servant and government employees, and as such are lack of motivation and experience to select optimal portfolio companies. Second, compared with performance-based incentive structure, the incentive structure of GVCs is quite different, which is comparatively invariant across manager and fund, and invariant over time. Finally, and more damaging to the industry as a whole, GVCs may face pressure to pursue some expected return for their policy objectives, such as employment maximization, which is non-financial related goals. They may end up attracting the best projects, leaving only ‘‘lemons’’ for private VC firms to fund, making the entry of new, independent private equity funds more difficult. In this way, involvement of GVC may result in capital misallocation and additional entry barrier of venture capital industry (Leleux and Surlemont, 2003).

Empirically, to our best knowledge, recent researchers focusing on this issue have been discussing whether the intervention of GVC to the VC industry crow in or crow out the PVC investment at the country and/or industry level (del-Palacio et al., 2012, Jeng and Wells, 2000). For instance, the generally positive interplay in the US GVC and PVC industries motivate the creation of an active local venture capital (VC) market through establishing government-managed VC funds to be a priority on the agenda of policy makers of some other countries, including the UK, Finland, France, Italy, Spain, Israel, and China (Lerner, 1999; Da Rin et al., 2006; Guerini and Quas, 2016). del-Palacio et al. (2012) investigate that the establishment of public policy for encouraging technology entrepreneurship is dramatically encouraging the booming of VC industry in Spain after comparing 755 investment events made by public and private investors before and after public VC program was started. However, Cumming and MacIntosh (2006) analyzed a Canadian tax-based venture capital program named ‘Labor Sponsored Venture Capital Corporation” (LSVCC) during the period of 1977 to 2001. They demonstrate that this program not only crow out other types of Canadian venture capital funds, but also lead to a significant reduction in the aggregate pool of venture capital in Canada.

However, empirical evaluation of the impact of GVC on portfolio companies’ performance, such as profitability, operation efficiency and innovation capability, found mixed evidence (Alperovych et al., 2015, Bertoni and Tykvová, 2015, Grilli and Murtinu, 2014, Robyn Owen et al., 2019,). Robyn Owen et al (2019) investigate that UK government venture capital schemes can provide more effective targeted funding to high growth firms and also bring positive impacts on portfolio firms in term of turnover and employment based on the interviews with 16 fund managers,3ACF investment committee members, 16 private investors and 6 finance industry experts. Pierrakis and Saridakis (2017) empirically analyses the characteristics of 4113 investment deals made to 2359 UK based companies and find that obtaining investment solely from publicly backed VC funds, reduces the probability of the recipient company to apply for a patent compared with those companies that receive investments from private VC funds. Based on a sample of 515 portfolio companies from 1998 to 2007 in Belgian, Alperovych et al. (2015) investigate that GVC-backed companies achieve a statistically significant subprime operation efficiency both in all three post transaction years and in the overall efficiency level compared with their counterparties. No significant differences in efficiency are found in firms backed by private VC compared with their non-VC-backed peers. Bertoni and Tykvová (2015) support that GVCs are an effective complement of IVCs rather than an ineffective substitute. Based on a novel database that include 665 European biotechnology start-ups and young companies, 125 of which are VC-backed. They found evidence that generally GVC-backed companies cannot give rise to more patent stock than either IVC-backed companies or non-VC-backed firms. Using a new European Union-sponsored firm-level longitudinal dataset, Grilli and Murtinu (2014) show that the main statistically robust and economically relevant positive effect is exerted by IVC investors on firm sales growth. Conversely, the impact of GVC alone appears to be negligible.

Contrary to IVCs, which are independent from the fund providers and have purely financial objectives, GVCs have to respond to economic policy objectives set by the public entity that established them. Specifically, while IVCs are interested in invention and innovation only to the extent to which they increase their return on the investment, GVCs can interested in invention and innovation per se. There are two reasons why GVCs are particularly interested in sustaining innovation. First, because of knowledge spillovers, invention and innovation have a social value beyond what is captured by the innovative companies (Griliches, 1992). Addressing this market failure is one of the fundamental reasons why GVCs are created (Lerner,1999). Second, knowledge spillovers have a very important local component (Anselin et al., 1997; Breschi and Lissoni, 2001), which means that the positive externalities of invention and innovation will benefit local companies the most. To this extent, a GVC may support invention and innovation because they are instrumental to regional or national economic development. Hereby, this study expects the following two hypotheses:

Hypothesis 1a: Innovation capability of firms backed by governmental venture capitalists outperforms those of those backed by private venture capitalists at the NEEQ market.

Hypothesis 1b: Innovation capability of firms backed by governmental venture capitalists underperforms those of those backed by private venture capitalists at the NEEQ market.

2.2 Innovation Policy in China

China follows a state capitalism model wherein the state plays a direct role in promoting and influencing economic development through reform policies (e.g., Zhang & Greve,2018) and uses SOEs as an important channel to influence the economy and society (e.g., Xu, 2011). In recent years, the state has actively promoted innovation to enhance the innovativeness and, thus, the long-term value of firms and the country. Patents resulting from indigenous innovation in China have increased because of economic development (Hu & Jefferson, 2009; Huang, 2010). Moreover, it was only in 2006 that the state started to fully pursue this policy goal through major political campaigns originating from the central level and systematically build an incentive system to promote domestic innovation. Among the most important overarching policy guidelines for promoting indigenous innovation in China are "China's National Medium- to Long-term Plan for the Development of Science and Technology

(2006–2020)" by the State Council of China in 2006 and the follow-up "National Intellectual Property Strategy (2008)," which called for the enhancement of overall innovation capability and for the transformation of China into an innovative society by 2020 (Abrami et al., 2014). These policies were included in the 12th Five-Year Plan,3 which stipulated that China would pursue an ambitious program of technological development that would enable the country to enter the ranks of innovative countries by 2020 and become a global scientific power by midcentury.

These policies also explicitly encourage indigenous inventions and patents filed with the State Intellectual Property Office (SIPO), China's equivalent agency to the United States Patent and Trademark Office (USPTO). To implement these overarching general policy guidelines, subsequent policies specified several channels to reach these goals, including the pro-indigenous innovation government procurement policy that we utilize in our empirical analysis.

These policy guidelines and subsequent public policies reward the following innovation outcomes. First, the state designed comprehensive and actionable plans for faster accumulation of patents. The aforementioned policy directives included specific clauses that mandated the overall national patenting targets—that is, achieving a set number of patents within a given length of time. For example, the state decreed that local firms must apply for two million patents by 2015 (The Economist, 2014). The overall targets were then allocated to local governments, and many local governments accordingly adopted policies to provide direct monetary incentives to apply for patents. For instance, Zhangjiagang City in Jiangsu Province increased its patent subsidy in June 2006 for an invention patent application from RMB 1,500 to RMB 3,000 and added a reward of RMB 10,000 if the application was eventually granted (e.g., Lei, Sun, &Wright, 2013). As documented in many media reports, the quantity of patent production became a dominant metric in the incentive system created by the Chinese state to promote indigenous innovation (e.g., The Economist, 2010, 2014).

Hypothesis 2a. When government adopts metrics that rely on quantifying innovation outcomes, firms with GVC investment will generate a larger quantity of innovation compared to firms without GVC investment.

Hypothesis 2b. When government adopts metrics that rely on quantifying innovation outcomes, firms with GVC investment will generate a smaller quantity of innovation compared to firms without GVC investment.

In addition to the quantity outcome, the novelty of patents constitutes another important dimension. However, despite the importance of patent novelty to policymakers, minimal checks on the quality or novelty of patents have been implemented in pro innovation public policies in China, and policy documents have failed to produce specific and actionable plans for quality checks, which is a stark contrast to the various metrics implemented to assess the quantities of patents (e.g., Liang, 2012). In summary, the Chinese state adopted evaluation metrics characterized by heavy reliance on directly measurable outcomes of the quantity of patents and minimum specifications regarding the evaluation of patent novelty. This approach dominated the formulation and implementation of many follow-up policies. Therefore, the state's implementation of the pro-innovation policy constitutes an example of a principal (of SOEs) that adopts metrics that more heavily rely on quantifiable outcomes to evaluate the innovation performance of agents. Thus, the post policy periods (2007 on) constitute a good indicator of the adoption of these metrics.

Hypothesis 3a. When government adopts metrics that rely on quantifying innovation outcomes, firms with GVC investment will generate a larger proportion of novel patent compared to firms without GVC investment.

Hypothesis 3b. When government adopts metrics that rely on quantifying innovation outcomes, firms with GVC investment will generate a smaller proportion of novel patent compared to firms without GVC investment.

2.3 Screening and Value added

There are several reasons to believe that GVC firms would like to and are able to identify promising companies when screening the investment proposals that are submitted to them. First, as Lerner (2002) notes, it is not implausible that government officials can effectively screen such proposals. For instance, GVC investors affiliated to the Ministry of Innovation and Technology may rely on specialists that have considerable insights into which technologies and companies are the most promising. Second, entrepreneurial companies can hesitate when asked to share sensitive information that is necessary to the evaluation of their investment projects with PVC investors because of appropriability concerns (Ueda, 2004). However, GVC investors do not represent the same appropriability threat, which lowers information asymmetries and facilitates the GVC evaluation process. Finally, GVC investors may be more motivated to screen investment projects than PVC investors because of free-riding problems. PVC investors may be reluctant to engage in costly screening activities when other private investors may also benefit from their efforts. In this respect, extant evidence suggests that GVC investors put more effort in screening proposals than private investors. In a survey of European VC investors, GVC investors claim that they spend more time evaluating proposals and selecting targets for investments than PVC investors (Luukkonen et al., 2012).

It is often argued that the value added by experienced venture capital rests not only in its ‘hard’ financing aspects but also in ‘soft’ advice and knowledge roles (Kaplan and Stromberg, 2001; Pinch and Sunley, 2009; Hall and Lerner, 2010; Luukkonen et al., 2013). VC often provides a variety of services that considerably enhances the success probability of invested firms can be provided by VCs, such as helping in making strategic decisions, fostering innovation by increasing research and develop (RD) expenses and patenting activities, bringing in broader contact networks in the product market, providing better management and employee incentives, helping in recruitment of competent management, and so on (Casamatta, 2003; Hellmann, 1998; Kortum and Lenrer, 2000; Spiegel and Tookes, 2008). Contrary to IVCs, which are independent from the fund providers and have purely financial objectives, GVCs have to respond to economic policy objectives set by the public entity that established them. Specifically, while IVCs are interested in invention and innovation only to the extent to which they increase their return on the investment, GVCs can interested in invention and innovation per se. GVCs thus might be more willing to devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000). Additionally, GVCs can offer government network, certification, government subsidy and related industry policy to portfolio firm. Hereby, this study expects the following:

Hypothesis 4a: Portfolio companies monitored by GVC outperform those who are not monitored by GVCs in term of innovation capability.

Hypothesis 4b: Portfolio companies monitored by GVC underperform those who are not monitored by GVCs in term of innovation capability.

3. Data, Variables, and Methods

3.1. Data descriptions and sample characteristics

We compile all firms floated on China's over-the-counter equities market, namely the National Equity Exchange and Quotation (NEEQ) market, from WIND, which consists of 5,186 firms by the end of 2016. NEEQ was established to provide equity financing support and trading for small and medium size enterprises (SMEs) in China. Especially, NEEQ focuses on SMEs with significant innovation activities. In comparison with other equity markets in China, the NEEQ does not have any profit threshold requirements, and thus is the ideal starting point for high technology companies in the domestic capital market. There were only 356 companies listed on NEEQ at the end of 2013, but the number had grown to 5,186 by the end of 2015 and the market value grew more than five times to reach 4591.42 million. Above mentioned basic characteristics of NEEQ made it ideal targeted market of micro-enterprise, SMEs and innovative firms, which are exactly what we want to research on.

We obtain information on NEEQ firms' patenting activity from the China national intellectual property administration (CNIPA) Patent Database, which provides complete information on all granted patent from 1985 to 2019 on patent assignee names, the application and publication number of patents, application and grant year, IPC classification number, type of the patent, and the number of citations received by each patent, family size and the number of citing of each patent.

We hand collect data on venture capital investments from annual reports and legal opinions of listed firms at the NEEQ system during the period of 2005 to 2015 as no specific database has published information about VC investments on NEEQ-listed firms systematically. We find that 1,876 firms were invested by venture capital; in particular, 493 firms were invested by government venture capital. Therefore, our sample consists of 5,186 firms which listed on

NEEQ by the end of 2015. 1,876 firms were invested by venture capital; in particular, 493 firms were invested by government venture capital. Sample period spans from 2005 to 2015.

Table 2.1 Overview of GVC investments on NEEQ

Classifications	**No. of firms**
Firms listed on NEEQ by the end of 2015	5186
VC investment events on NEEQ	5089
VC backed firms	1876
Percentage of VC backed firms (of No. of NEEQ firms)	0.36
No. of VC institutions	3024
Pure GVC	166
Syndication of GVC and PVC	288
Pure PVC	1368

Due to the missing or abnormal financial data of firms listed on NEEQ, an emerging over the counter (OTC) market, we select data based on the following steps. First, we screen out the sample with negative total asset and negative R&D expenditures. Second, we drop the sample with leverage higher than 1 or lower than 0. Finally, to minimize the effect of outliers, we winsorized all variables at the top and bottom 1% of each variable's distribution.

3.2. Variables and summary statistics

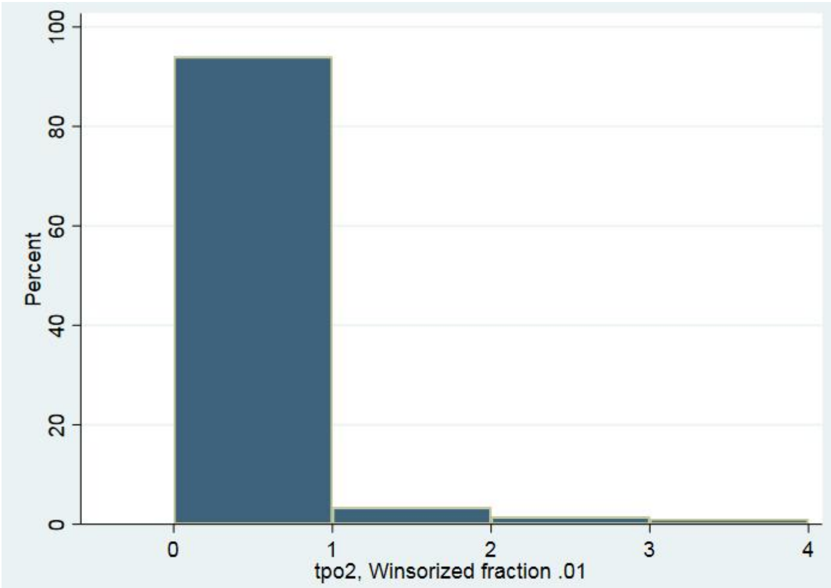
Dependent Variables--Measuring Innovation

Previous literature has developed two proxies to measure the innovation capability of a firm: R&D intensity and patent activity. Compared to R&D intensity, patenting activity is regarded as a better proxy, since it is able to capture the innovation output and calculate s how effectively a firm has utilized its innovation inputs. Therefore, following previous studies, for example, Guo and Jiang (2013) for publicly traded firms and Tian (2011) for privately held firms, we use a firm's patenting activity to measure innovation.

Based on the information retrieved from the CNIPA patent database, the CNIPA grants three types of patents: invention, utility model, and design patents. Compared with the other two categories, invention patents are the most substantive and rigorously examined patent, as they face the highest scrutiny and the strictest screening for quality and novelty in the approval process. Invention patents granted by the CNIPA also correspond better to the invention patents granted by the United States Patent and Trademark Office (USPTO) used in prior studies. Therefore, we follow the method developed by Wang, Li, and Furman (2017) and measure the number of invention patent applications a firm files in a year that are eventually granted. We use a patent's application year instead of its grant year as the application year is argued to better capture the actual time of innovation (Griliches et al., 1986). And follow the method developed by Nan and Kenneth (2019), we construct PROPORTION OF NOVEL PATENT $_{t+1}$ denotes the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$.

We address an inherent limitation of the patents data –truncation bias. Truncation bias affects data on patent applications because it typically takes several years to process a patent application (Hall et al., 2001). As a result, a large proportion of patent applications near the end date of a database can be missing because they have not been granted as yet (N. Dass et al., 2017). We extend our final patent sample year from 2015 to 2018 and exclude the final two years of patent data in order to make a correction for truncation bias. Using the 2018 dataset allows us to obtain relatively bias-free information on patent applications over the span of the prior 2015 dataset.

To address the truncation bias, previous studies tend to follow three different approaches to adjust the currently available information on patent citations. The first method is to exclude the final two to three years of patent data in order to ensure that the data is relatively free of truncation bias, when dating patents according to application year. The second method relies on historical patterns to forecast future realizations of patent citations. The third method adjusts the number of patents and citations for the fixed effects of each technology class and year. However, a potential drawback is that the fixed effects also absorb any meaningful variation in innovation across sectors. In this paper, we use the first method and update patents dataset, which extending the sample from 2015 to 2018, to make a correct for truncation bias. Using the 2018 dataset allows us to obtain relatively bias-free information on patent applications over the span of the prior 2015 dataset.



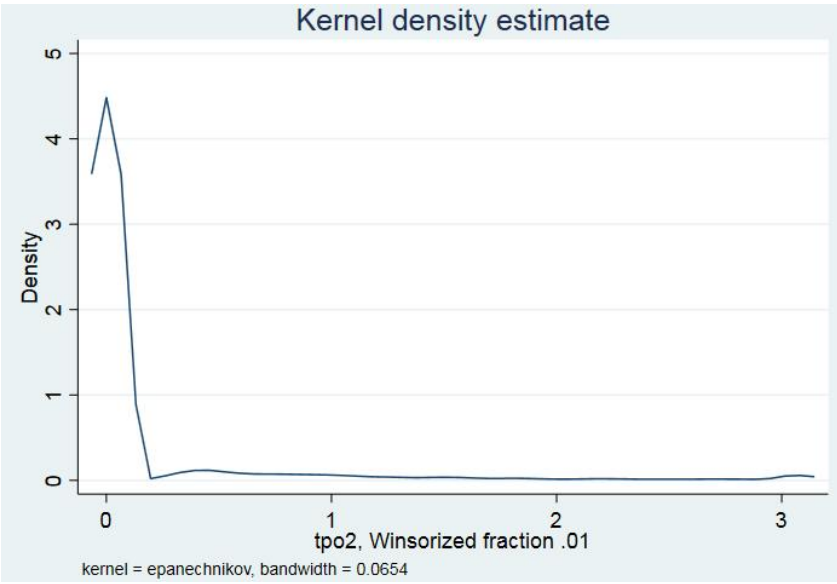


Figure 2.2 Truncation bias of patent data

According to the examination of the historical application-grant time-lag, the percentage of patents granted within 1 years after filing an application is about 93%, within 2 years after filing an application is about 97%, therefore, when dating patents according to application year, we exclude the final two years of patent data in order to ensure that the data is relatively free of truncation bias. Additionally, it is necessary to acquire patent data in 2016 since post GVC entry should be considered. Therefore, we construct a new patent dataset, where the patents applied by the end of 2016 and eventually granted by the end of 2018, to better correct the truncation bias.

To further assess a patent's influence, we followed the methods developed by Hall et al., (2001) and count a firm's total citing number of all patents filed (and eventually granted) in given year, which measure the technical innovativeness of patent. We count a firm's total family number of all patents filed (and eventually granted) in given year, which measure the value of patent. We count total number of citations a patent received in given year, which measure the quality of patent. And we also compute PTO, which denotes firm i's average application-grant time-lag of invention patents applied in year $_{t+1}$.

Independent Variables-- Measuring Venture Capital Investment

We hand collect data on venture capital investments from annual reports and legal opinion of listed firms at the NEEQ system during the period of 2005 to 2015 as no specific database has published information about VC investments on NEEQ-listed firms systematically. For each VC-backed firm, we document detailed information about investment events of VC companies and portfolio firms. Data on VCs consist of name, ownership structure, nationality, location, establishment time, and reputation ranking. Data on portfolio firms constitute of investment timing, industry, the number of employees, location, the amount of VC investment fund, investment round, investment stage, currency, investment approach such as syndication and staging, and so on. Follow the previous studies (Grilli and Murtinu, 2014, Bertoni and Tykvová, 2015, Guerini and Quas, 2016), we construct GVC DUMMY, a dummy variable which is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. BOARD, a dummy variable, which is equal to one when GVC becomes a board member in portfolio companies, otherwise, equal to zero.

Control Variables

Following the innovation literature, we control for a variety of firm and industry characteristics that may affect a firm's innovation performance. The financial performance data for SMEs at the NEEQ market during 2005 to 2015 are collected from WIND dataset, which is a comprehensive database on China's financial markets. Basic introduction provided by WIND makes up with code, name, establishment time, listed time, industry according to the classification criteria of China Security Regulatory Commission (CSRC), state ownership structure, nationality, location. Variables on accounting and financial conditions include total number of employees, total assets, total liability, total equity, total sales, net profit, returns on assets (ROA), R&D expenses, and so on. The definitions of some key variables are as follows. Total asset (ASSETS) is a key indicator that represents firm size of firms, which is measure by the total assets of a firm in calculated year divided by 1 million. HIGHTECH is a dummy variable, which is equal to one if the firm belongs to a high-tech industry, otherwise, equal to zero. Return to Assets (ROA) is a key indicator that represents the profitability of firms, which is measure by net profit divided by total assets at the calculated year. Earn per share (EPS) which refers to the market value of a film at the end of fiscal year t. LIQUIDITY refers to the current asset ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t TANGIBILITY refers to the ratio of tangible assets to the total assets in a sample company. R&D intensity, which is the indicator of R&D activity, is measured by R&D expenditure scaled by sales revenues.

Table 2.2 Definition of key variables

Variable	Definition
Panel A: Innovation measures	
Number of $Patent_{t+1}$	Number of $Patent_{t+1}$ denotes the firm i's total number of invention patents filed (and eventually granted).
Proportion of novel patent $_{t+1}$(Year)	Proportion of novel patent $_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1, which is based on application year.
PTO_{t+1}	PTO $_{t+1}$ denotes firm i's average application-grant time-lag of invention patents applied in year t+1.
Panel B: VC characteristics	
GVC Dummy	A dummy variable, which is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero.
Panel C: Financial Characteristics	
Hightech	A dummy variable, which is equal to one if the firm belong to a high-tech industry, otherwise, equal to zero.
Age	Age refers to the operation duration of each firm.
Employee	Employee refers to the number of employees the firm has acquired in given year.
Employee growth	EMPLOYEE GROWTH $_{t+1}$ denotes the growth rate of employee of portfolio companies in year, which measure the financial performance of entrepreneur firms.
Assets	The natural logarithm of total assets of a firm in calculated year.
ROA	ROA refers to the profitability of a firm at the end of fiscal year, defined as net profit divided by total assets at the calculated year.
ROE	ROE refers to the profitability of a firm at the end of fiscal year, defined as net profit divided by total equity at the calculated year.
EPS	EPS refers to earning per share, measured at the end of fiscal year t
Sales	Sales denotes the total number of sales of portfolio companies in year t+1, which measure the financial performance of entrepreneur firms.
Leverage	LER refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t
Liquidity	LIQUIDITY refers to the current asset's ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t
Tangibility	TANGIBILITY refers to the tangible asset ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t
R&D intensity	R&D intensity refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing.

3.3. Methodology

To compare GVC-backed and non-GVC-backed firms in terms of innovation activities, we use propensity score matching (PSM) method to construct a control group for comparison purposes. We build the control group in several steps to ensure that our results are not driven by a specific matching method. First, we select all VC backed firms from our sample and then classify all firms into GVC backed firms and non GVC backed firms. We then match the GVC backed firms with non GVC backed firms by industry (at the three-digit SIC level), location (at the provincial level), age (operation period), size (total assets), leverage and sales. Finally, we employ the methodology of randomly drawing one-to-one matched pairs to build the control group. To ensure that our control group is representative, we repeat this random draw methodology 5 times, and the results are consistent (Guo and Jiang, 2013).

The dependent variables, *the number of patents*, are a highly right-skewed count variable that takes on non-negative integer values. Hence, we use nonlinear regression approaches to avoid heteroskedastic, non-normal residuals (Hausman, Hall, & Griliches, 1984). We employ fixed-effects Poisson estimator, negative binomial regression and Tobit model to deal with the non-negative nature of these dependent variables (Wooldridge,1997) .

For dependent variable, *proportion of novel patent*, is denoted as the proportion of novel patents among all the patents produced by the focal firm in year t+1 which is a fraction constrained between 0 and 1, but it can be 0 or 1, we estimate a fractional response model and double-censored Tobit model (Papke and Wooldridge 2008). We also use firm random effects and industry or year fixed effect in the model estimation regarding financial performance.

We estimate the following benchmark specifications to explore the innovation impacts of VC investments and the general formula of regressions models adopted in this paper are as follows.

$$PATENT\_NUMBER_{i,t+1} = \alpha + \beta_1 GVC\_DUMMY_{i,t} + \beta_2 ASSETS_{i,t} + \beta_3 HIGHTECH_{i,t} + \beta_4 ROA_{i,t} + \beta_5 EPS_{i,t} + \beta_6 \, LIQUIDITY_{i,t} + \beta \quad TANGABILITY_{i,t} + \beta_7 R\&D_{i,t} + FIRM_i + YEAR_t + \varepsilon_{i,t}$$

$$PATENT\_Novelty_{i,t+1} = \alpha + \beta_1 GVC\_DUMMY_{i,t} + \beta_2 ASSETS_{i,t} + \beta_3 HIGHTECH_{i,t} + \beta_4 ROA_{i,t} + \beta_5 EPS_{i,t} + \beta_6 \, LIQUIDITY_{i,t} + \beta \quad TANGABILITY_{i,t} + \beta_7 R\&D_{i,t} + FIRM_i + YEAR_t + \varepsilon_{i,t}$$

4. Empirical result

4.1. Descriptive summary

Table 2.3 Number of Firms and patents by CSRC Industry Classification.

Industry	No. of Firms	Total No. of Patent	Average No. of patent
Agriculture, Forestry, Animal Husbandry and Fishery	125	862	6.90
Mining	25	373	14.92
Manufacturing	2762	65846	23.84
Electricity, Heat, Gas and Water Production and Supply	35	310	8.86
Construction	158	2047	12.96
Wholesale and Retail Trade	175	665	3.80
Transportation, Warehousing and Postal Service	62	90	1.45
Accommodation and Catering Industry	11	0	0.00
Information Transmission, Software and Information Technology	1016	8266	8.14
Finance	106	9	0.08
Real Estate Industry	27	9	0.33
Leasing and Commercial Service	206	565	2.74
Scientific Research and Technical Service	219	2764	12.62
Water Resources, Environment and Public Facilities Management	79	1393	17.63
Residents Service, Repair and Other Services	13	51	3.92
Education	21	110	5.24
Health and Social Work	24	50	2.08
Culture, Sports and Entertainment	108	341	3.16
Others	14	0	0.00
Total	5186	83751	16.15

Table 2.3 gives the information of number of firms, total number of patents and average of patent across 19 industries by CSRC industry classification. As shown in the table, a large number of patents are concentrated in manufacturing, Information Transmission, Software and Information Technology industry, and Scientific Research and Technical Service. Accommodation and Catering Industry, Finance and Real Estate Industry has the smallest number of patents.

Table 2.4 Statistical Descriptive

Variables	Obs	Mean	Std. Dev.	Min	Max
GVC dummy	17,952	0.26	0.44	0.00	1.00
Number of patent	17,952	0.780	2.91	0.00	87.00
Proportion of novel patent(Day)	17,952	0.030	0.14	0.00	1.00
Proportion of novel patent(Year)	17,952	0.034	0.17	0.00	1.00
Proportion of novel patent(18Months)	17,952	0.037	0.17	0.00	1.00
Hightech	17,952	0.61	0.49	0.00	1.00
Age	17,952	5.97	4.95	0.00	21.00
Employee	3,773	297.24	410.35	10.00	2543.00
Employee growth	2,146	0.24	1.25	-0.91	48.86
Assets	6,903	2.28	3.71	0.03	28.00
ROA	6,903	0.05	0.12	-0.61	0.38
ROE	6,882	0.10	0.25	-1.16	1.01
Leverage	6,903	0.45	0.28	0.02	5.09
Sales	6,902	18.02	1.49	8.16	24.19
EPS	6,594	0.34	1.62	-69.00	67.58
Liquidity	17,952	0.27	0.37	0.00	0.99
Tangibility	17,952	0.18	0.27	-0.02	0.90
R&D intensity	17,952	0.03	0.06	0.00	0.40

Table 2.4 presents the descriptive statistics of portfolio firms in terms of mean, standard deviation, minimum value and maximum value of financial indicators. As can be seen in the table 3, 429 (26.29%) firms have received finance from government venture capital at their

first round of financing in the sample of 1632 VC backed firms. Averagely, each firm listed on NEEQ acquired 1.54 invention patent in a given year. The maximization of patent number a firm achieved is 300, which indicates that most of firms listed on NEEQ is high tech oriented and keeps consistent with the industry distribution of patent number in Table 2.3.

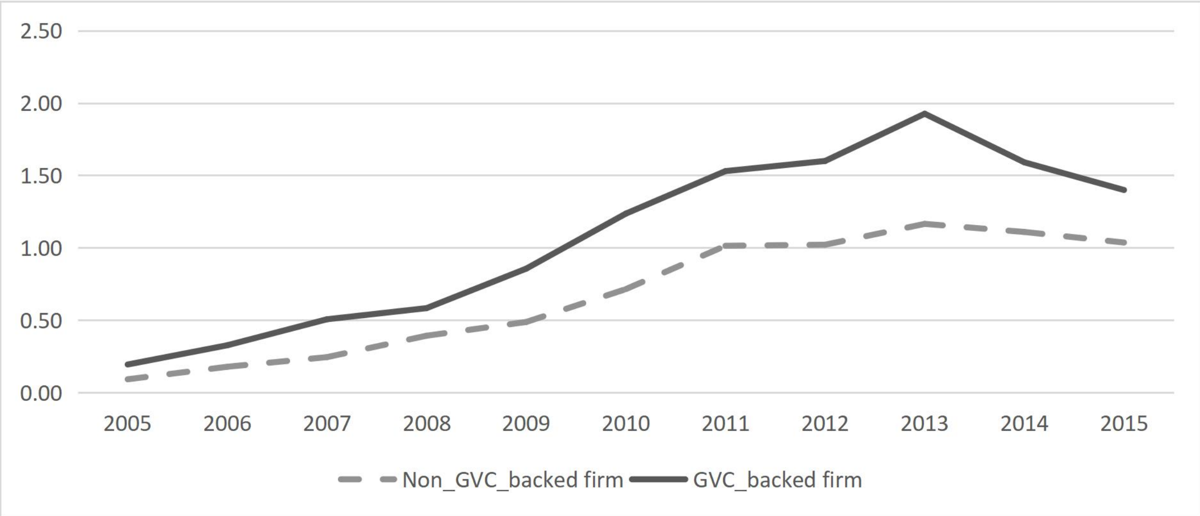


Figure 2.3 Average number of granted invention patents of Non_GVC_backed firms and GVC_backed firms.

Figure 2.3 presents the average number of patents of GVC-backed firms and their counterparties during 2005 to 2015. As shown in this figure, GVC-backed firms generate more patent number than Non-GVC-backed firms. Furthermore, the average number of patents of GVC-backed firms increase more than their peers. This indicates that GVC involvement spur innovation capability of their target companies in term of patenting number.

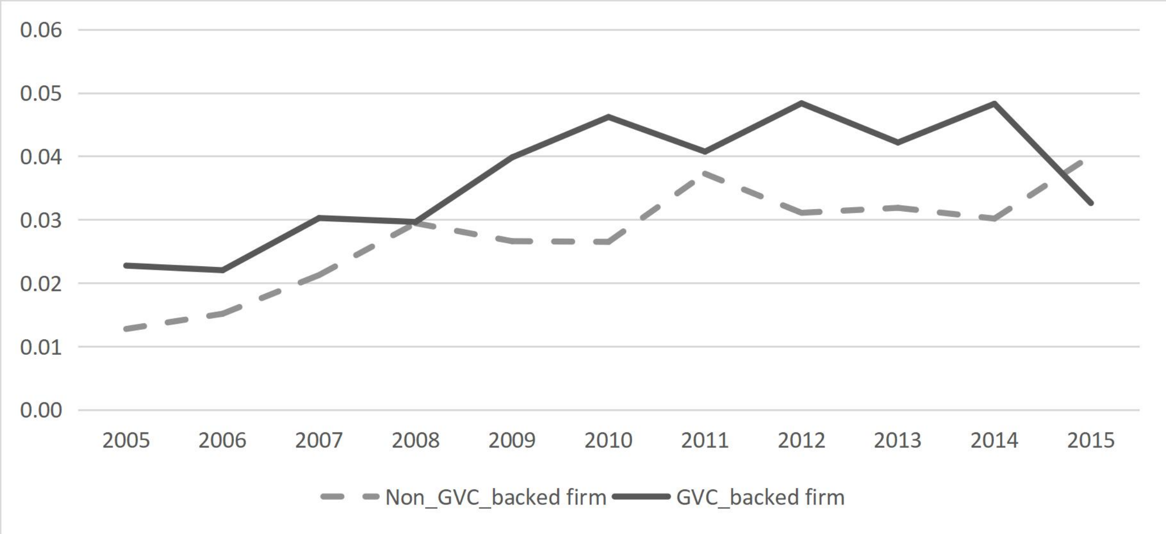


Figure 2.4 Average proportion of novel patents of Non_GVC_backed firms and GVC_backed firms.

Figure 2.4 presents the average number of novel patents of portfolio firms and their counterparties. As shown in this figure, there is no significant novel patent difference between portfolio firms and their counterparties in term of average novel patent number. This indicates that GVC's investment activities do not bring impacts on innovation capability of their target companies, in terms of patent quality.

4.2. Baseline results

In this part we report the estimation results on how GVCs influence firm's innovation capability measured by patent number. The benefit of the government background VC is more evident in table 5. We notice that the key dependent variable for the GVC background keeps significant in all five models' specifications at 1% level, supporting our working hypothesis that the involvement of governmental venture capitalists promotes the quantity of patent number of portfolio firms' in China. This result is different with the evidence in the existing literature on the relationship between GVC and firm innovation in Europe. In addition, the dummy variable for high-tech industry is consistently positive and highly significant at 1% level.

Table 2.5 Relationship between GVC investments and patent number of firms listed on NEEQ China (PSM).

	(1) Poisson	(2) RE Poisson	(3) NBR	(6) Tobit
GVC DUMMY	0.189***	0.364***	0.220***	0.313*
	(7.72)	(3.88)	(3.76)	(2.09)
ASSETS	0.553***	0.270***	0.475***	0.476***
	(47.04)	(11.44)	(19.60)	(9.41)
HIGHTECH	0.339***	0.532***	0.287***	0.595**
	(10.54)	(6.07)	(3.87)	(3.10)
ROA	1.274***	1.342***	0.947**	0.427
	(7.50)	(5.37)	(3.10)	(0.98)
EPS	-0.0194	-0.0239	0.00600	-0.00237
	(-1.50)	(-0.95)	(0.25)	(-0.10)
LIQUIDITY	0.134*	-0.372**	0.127	-0.240
	(1.99)	(-2.69)	(0.84)	(-0.87)
TANGIBILITY	-0.0532	-0.206	0.0449	0.191
	(-0.77)	(-1.87)	(0.32)	(0.82)
R&D	3.881***	0.644*	3.989***	1.830**
	(25.51)	(2.05)	(10.45)	(2.86)
_CONS	-31.07	-5.167***	-31.34	-8.852***
	(-0.01)	(-10.92)	(-0.00)	(-4.29)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
N	5656	5656	6594	5656
Log pseudolikelihood	-709464	-229388	-14145	-12157

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number and the proportion of novel patent of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: $PATENT_{t+1}$, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT $_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year $_t$; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year $_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year $_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year $_t$; R&D refers to R&D expenditures divided by book value of total sales at year $_t$, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 2.6 reports the estimation results on how GVCs influence firm's innovation measured by and proportion of novel patent. We notice that the key dependent variable for the GVC background keeps insignificant in all five models' specifications at 1% level, not supporting our working hypothesis that the involvement of governmental venture capitalists promotes portfolio firms' innovation capability in China, in terms of patent quality.

Table 2.6 Relationship between GVC investments and proportion of novel patent of firms listed on NEEQ China (PSM Sample).

	(1) Poisson	(2) RE Poisson	(3) NBR	(6) TOBIT
GVC DUMMY	0.136	0.138	0.130	0.00544
	(1.00)	(1.02)	(0.99)	(0.98)
ASSETS	0.246***	0.283***	0.295***	0.00916***
	(3.77)	(4.87)	(5.55)	(4.36)
HIGHTECH	0.0622	0.270	0.257	0.00220
	(0.38)	(1.86)	(1.89)	(0.31)
ROA	2.393*	1.834*	1.736*	0.0259
	(2.36)	(2.11)	(2.19)	(1.20)
EPS	-0.0188	-0.0219	-0.0218	-0.000408
	(-0.22)	(-0.41)	(-0.43)	(-0.29)
LIQUIDITY	-0.0940	-0.568	-0.632*	-0.00417
	(-0.26)	(-1.78)	(-2.13)	(-0.33)
TANGIBILITY	-0.133	-0.292	-0.219	0.00421
	(-0.35)	(-0.85)	(-0.69)	(0.38)
R&D	0.534	-0.611	-0.328	0.0174
	(0.47)	(-0.60)	(-0.35)	(0.57)
_CONS	-22.84	-8.245***	-8.466***	-0.166
	(-0.01)	(-6.86)	(-7.72)	(-1.31)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
N	1962	1962	2216	2216
Log pseudolikelihood	-886	-953	-1059	-2391

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number and the proportion of novel patent of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: $PATENT_{t+1}$, denotes the firm i’ s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT $_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year $_t$; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal $year_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year $_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year $_t$; R&D refers to R&D expenditures divided by book value of total sales at year $_t$, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* p < 0.05, ** p < 0.01, *** p <0.001.

4.3. Difference-in-difference Framework

To directly test the main hypothesis, we use a difference-in-differences (DiD) design to examine whether companies with GVCs show greater post-investment improvement in their innovation output.

We begin by using propensity score matching (PSM) to match companies backed by GVC with those backed by Non_GVC. This mitigates the concern that these companies may differ in other qualities beyond the GVC. We build the control group in several steps to ensure that our results are not driven by a specific matching method. First, we select all VC backed firms from our sample and then classify all firms into GVC backed firms and non GVC backed firms. We then match the GVC backed firms with non GVC backed firms by industry (at the three-digit SIC level), location (at the provincial level), age (operation period), size (total assets), ROA, leverage and R&D intensity. Finally, we employ the methodology of randomly drawing one-to-one matched pairs to build the control group.

To assess the accuracy of the matching procedure, we conduct diagnostic test. We conduct univariate comparisons between companies backed by GVC and Non GVC companies in the year of VC financing and report their corresponding t-statistics in Table 7. As shown, none of the observed differences in the characteristics between the two groups of companies is statistically significant after propensity score matching. Overall, our diagnostic tests reinforce the ability of our propensity score matching process to remove meaningful observable differences in financial performance, corporate governance, and innovation output between the company pairs within each matching. Therefore, we can interpret any observed significant differences in post-investment performance between the two groups of companies as being likely due to GVC financing.

Table 2.7 Propensity score matching: Diagnostic tests (one to one)

		Pre-match		Post-match	
	GVC backed firms	Non VC backed firms	Difference	Non VC backed firms	Difference
Firm size	18.658	18.633	0.025**	18.633	0.023
Firm age	2.220	2.223	-0.003***	2.223	0.006
ROA	0.069	0.074	-0.005***	0.074	0.002
Leverage	0.430	0.473	-0.042***	0.474	-0.043
R&D intensity	0.071	0.064	0.007***	0.070	0.002

This table shows the propensity score matching (PSM) results and reports the same logit regression using the post-matching sample after the one to one PSM without replacement. P-values computed using heteroscedasticity robust standard errors are displayed in parentheses. Industry- and VC investment year- fixed effects are included in both columns in Panel A. Panel B reports the univariate comparisons in post-match company characteristics between the GVC backed firms and Non GVC backed companies and their corresponding t-statistics. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% level, respectively.\

Using our matched sample, we conduct our DiD analysis and present the results in Table 8. We notice that the key dependent variable for the GVC background keeps significant in terms of number of patents, which indicates after GVC investment, Portfolio firms can achieve higher patent number. This result supports our working hypothesis that the involvement of governmental venture capitalists promotes the quantity of patent number of portfolio firms' in China. This result is consistent with the evidence in baseline model.

Table 2.8 The difference-in-difference estimation of GVC backed firms and Non-VC backed firms on innovation after propensity score matching.

	Number of Patents		Number of Novel Patents	
	(1) Poisson	(2) NBR	(3) Poisson	(4) NBR
GVC post	0.635***	0.423*	0.108	-0.096
	(0.161)	(0.233)	(0.437)	(0.492)
Firm size	0.121	0.217	1.193*	1.693**
	(0.212)	(0.180)	(0.722)	(0.664)
Firm age	-1.461***	0.339	-3.895***	-4.054***
	(0.478)	(0.453)	(1.447)	(1.528)
ROA	0.968	1.616*	2.665	2.661
	(0.664)	(0.938)	(2.440)	(2.617)
Leverage	-1.074	3.473**	0.068	0.945
	(0.832)	(1.576)	(2.259)	(2.661)
Growth Rate	-0.466***	-0.264	-0.563	-0.598
	(0.139)	(0.174)	(0.478)	(0.488)
Tangible Asset	-1.881***	1.957	1.535	2.844
	(0.725)	(1.463)	(2.234)	(2.555)
R&D intensity	-1.136	1.173	0.114	1.458
	(0.909)	(1.245)	(4.915)	(5.391)
Firm fixed effects	Yes	Yes	Yes	Yes
N	1,055	1,055	1,043	1,043
Log likelihood	-3609	-3391	-4297	-4145

Legend: this is a series of difference-in-difference estimation of GVC backed firms and Non-VC backed firms on innovation after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and RD intensity of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: $PATENT_{t+1}$, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL $PATENT_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in $year_{t+}1$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal $year_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal $year_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal $year_t$; R&D refers to R&D expenditures divided by book value of total sales at $year_t$, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Using our matched sample, we further conduct our DiD analysis and present the results in Table 2.8 and table 2.9. We notice that the key dependent variable for the GVC background keeps significant in terms of proportion of novel patents in these two tables, which indicates after GVC investment, Portfolio firms cannot achieve more novel patent or higher proportion of novel patent. This result supports our working hypothesis that the involvement of governmental venture capitalists promotes the quality of patent number of portfolio firms' in

China. This result is consistent with the evidence in baseline models.

Table 2.9 The difference-in-difference estimation of GVC backed firms and Non VC backed firms on innovation after propensity score matching.

	Percentage of Novel Patents		
	(1) Tobit model	(2) Fractional Response model (Probit)	(3) Fractional Response model (Logit)
GVC post	0.071	0.074	0.172
	(0.122)	(0.115)	(0.244)
Firm size	0.162***	0.122**	0.238**
	(0.062)	(0.050)	(0.104)
Firm age	0.001	0.092	0.207
	(0.127)	(0.110)	(0.230)
ROA	0.903	0.638	1.325
	(0.636)	(0.438)	(0.912)
Leverage	0.416	0.972	2.320
	(0.818)	(0.759)	(1.717)
Growth Rate	-0.211	-0.299**	-0.652**
	(0.129)	(0.117)	(0.254)
Tangibility	0.346	0.858	2.038
	(0.791)	(0.708)	(1.585)
R&D intensity	0.069	-0.570	-1.339
	(0.658)	(0.675)	(1.494)
Firm fixed effects	Yes	Yes	Yes
N	1043	1043	1043
Log likelihood	-845	-500	500

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: $PATENT_{t+1}$, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL $PATENT_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year $_t$; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year $_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year $_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year $_t$; R&D refers to R&D expenditures divided by book value of total sales at year $_t$, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Mechanism analysis

In Our main results show a positive association between GVC investments and innovation capability of portfolio firms. In this section, we research into the mechanisms that potentially drive the impacts of GVC investments on portfolio firms and look for potential explanations. We explore several dimensions of heterogeneity and find three potential channels that plausibly explain the association and change. The results of the empirical tests of the mechanisms are presented in this section.

VC often provides a variety of services that considerably enhances the success probability of invested firms can be provided by VCs, such as helping in making strategic decisions, fostering innovation by increasing research and develop (RD) expenses and patenting activities, bringing in broader contact networks in the product market, providing better management and employee incentives, helping in recruitment of competent management, and so on (Casamatta, 2003; Hellmann, 1998; Kortum and Lenrer, 2000; Spiegel and Tookes, 2008). Contrary to IVCs, which are independent from the fund providers and have purely financial objectives, GVCs have to respond to economic policy objectives set by the public entity that established them. Specifically, while IVCs are interested in invention and innovation only to the extent to which they increase their return on the investment, GVCs can interested in invention and innovation per se. GVCs thus might be more willing to devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000). Additionally, GVCs can offer government network, certification, government subsidy and related industry policy to portfolio firm.

5.1. Devoting resource hypothesis

The first hypothesis, the devoting resources hypothesis, argues that GVCs devote more resources to their portfolio companies than do other VCs, resulting in a greater number of patents. For instance, devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000). Additionally, GVCs can offer government network, certification, government subsidy and related industry policy to portfolio firm.

Table 2.10 The relationship between GVC investments and financial leverage measured by average leverage, long term leverage, short term leverage by the firm in the given year (PSM Sample).

	(1) LEVERAGE	(2) LONGTERN LEVERAGE	(3) SHORT TERM LEVERAGE
GVC DUMMY	-0.827*	1.298***	-1.287**
	(-2.21)	(2.18)	(-3.05)
ASSETS	0.0802*	0.435***	-0.0303
	(2.01)	(6.61)	(-0.69)
HIGHTECH	-1.004*	0.752	-1.406**
	(-2.08)	(0.98)	(-2.60)
ROA	-3.744***	-2.379	0.717
	(-3.76)	(-1.40)	(0.67)
EPS	0.0420	0.0203	0.0628
	(0.71)	(0.20)	(1.00)
LIQUIDITY	21.49***	-18.97***	29.05***
	(32.63)	(-17.27)	(40.68)
TANGIBILITY	-91.45***	1.823*	-83.82***
	(-168.14)	(1.98)	(-143.35)
R&D	-14.25***	2.122	-10.55***
	(-9.58)	(0.85)	(-6.58)
_ CONS	72.21***	23.89***	60.28***
	(42.43)	(6.15)	(24.68)
N	5708	5708	5708
Industry Effect	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: $PATENT_{t+1}$, denotes the firm i's total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL $PATENT_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year $_t$; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year $_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year $_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year $_t$; R&D refers to R&D expenditures divided by book value of total sales at year $_t$, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 2.10 reports a series of estimations results for financial performance, particularly leverage, with GVC dummy to identify the impact of GVC on the leverage of portfolio firms. Generally, we notice that the dummy variable GVC DUMMY keeps negative association with average leverage, which presents that GVC investment helps portfolio firms to receive more funding. We further disentangle that GVC investments facilitate their portfolio firms to obtain higher long-term leverage but lower short-term leverage. This result implies that GVC introduces more long-term financing, such as bank loan, to firms to release financial constraint and firms may allocate more resource on innovation activity.

Table 2.11 The relationship between GVC investments and R&D intensity measured by the total amount of research and development expenditures divided by total sales by the firm in the given year (PSM Sample).

	(R&D Intensity)$_{t+1}$	
	(1)	(2)
	TOBIT	RE
GVC DUMMY	0.00674**	0.00603*
	(3.24)	(1.69)
ASSETS	-0.00244***	-0.00197***
	(-8.45)	(-5.48)
HIGHTECH	0.02529***	0.0268***
	(9.03)	(5.85)
ROA	-0.22301***	-0.203***
	(-22.84)	(-23.74)
EPS	0.00135*	0.00112*
	(2.02)	(2.21)
LIQUIDITY	-0.02088***	-0.0134*
	(-4.61)	(-2.25)
TANGIBILITY	0.05384***	0.0278***
	(10.96)	(5.67)
_CONS	-0.02923	-0.0104
	(-0.27)	(-0.28)
Industry Effect	Yes	Yes
Year Effect	Yes	Yes
N	5656	5656
Log pseudo likelihood	6871.42	

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENT$_{t+1}$, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT$_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year $_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year$_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year $_t$; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* p < 0.05, ** p < 0.01, *** p <0.001.

Table 2.11 reports a series of Tobit and random effect model with industry and year fixed effect results for R&D intensity with GVC dummy, to picture the impact of GVC investment on the innovation input of portfolio firms. It is shown that the dummy variable GVC DUMMY is positively significant with R&D intensity, which demonstrates that GVC backed firms invest more funds in innovation activity after receiving funding form GVC investors.

5.2. Value added hypothesis

There are several reasons to believe that GVC firms would like to and are able to identify promising companies when screening the investment proposals that are submitted to them. First, as Lerner (2002) notes, it is not implausible that government officials can effectively screen such proposals. For instance, GVC investors affiliated to the Ministry of Innovation and Technology may rely on specialists that have considerable insights into which technologies and companies are the most promising. Second, entrepreneurial companies can hesitate when asked to share sensitive information that is necessary to the evaluation of their investment projects with PVC investors because of appropriability concerns (Ueda, 2004). However, GVC investors do not represent the same appropriability threat, which lowers information asymmetries and facilitates the GVC evaluation process. Finally, GVC investors may be more motivated to screen investment projects than PVC investors because of free-riding problems. PVC investors may be reluctant to engage in costly screening activities when other private investors may also benefit from their efforts. In this respect, extant evidence suggests that GVC investors put more effort in screening proposals than private investors. In a survey of European VC investors, GVC investors claim that they spend more time evaluating proposals and selecting targets for investments than PVC investors (Luukkonen et al., 2012).

Table 2.12 Relationship between GVC value-added activity and innovation of POE firms listed on NEEQ China (PSM Sample).

	(1) $PATENT_{t+1}$	(2) $CITING_{t+1}$	(3) $FAMILY_{t+1}$	(4) $CITATION_{t+1}$	(5) $(PROPORTION\ OF\ NOVEL\ PATENT)_{t+1}$
BOARD	0.565	0.103	0.507	2.526	0.0117
	(0.27)	(0.26)	(0.19)	(0.19)	(0.33)
ASSETS	0.852***	-0.00984	1.295***	4.603***	0.0114***
	(8.17)	(-0.25)	(7.60)	(6.54)	(3.65)
HIGHTECH	1.979	0.427	2.800	13.94	0.0722*
	(1.21)	(1.34)	(1.36)	(1.34)	(2.50)
ROA	-8.328**	1.138	-14.82**	-30.58	0.00757
	(-3.09)	(0.83)	(-3.17)	(-1.66)	(0.08)
EPS	0.0173	-0.0202	0.0698	0.0435	-0.0113
	(0.13)	(-0.28)	(0.30)	(0.05)	(-0.00)
LIQUIDITY	-2.203	-1.053	-1.793	-23.42	-0.151**
	(-1.12)	(-1.51)	(-0.57)	(-1.77)	(-2.69)
TANGIBILITY	1.913	-1.125	1.456	-0.453	0.0288
	(1.33)	(-1.71)	(0.59)	(-0.05)	(0.60)
R&D	0.497	1.638	6.602	4.811	0.103
	(0.13)	(0.98)	(1.03)	(0.19)	(0.82)
_CONS	2.079	1.547**	2.655	23.48	0.233***
	(1.09)	(2.64)	(0.95)	(1.88)	(4.92)
Industry Effect	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
N	1855	1855	1855	1855	1855
Log pseudo likelihood	-7005	-5586	-7923	-10544	-641

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: $PATENT_{t+1}$, denotes the firm i's total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT $_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year $_t$; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year $_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year $_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year $_t$; R&D refers to R&D expenditures divided by book value of total sales at year $_t$, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 2.12 reports the estimation results for the patenting activity of portfolio companies with GVC board member to identify whether GVC monitoring activities can improve firm's innovation measured by patent number. We notice that the dummy variable for BOARD is not significant in all models, which is against our working hypothesis that monitoring activities of governmental venture capitalists promote portfolio firms' innovation. This finding might indicate that, on one hand, GVC has no advantage of coaching or monitoring portfolio companies to achieve better innovation performance. On the other hand, GVC has advantage in screening process, which means that GVC can select more promising and innovative portfolio companies.

6. Supplementary analyses and further robustness check

Table 2.13 The relationship between GVC investments and innovation activity of firms listed on NEEQ China using Heckman two-stage selection model.

	(1) $PATENT_{t+1}$	(2) $CITATION_{t+1}$	(3) $(PROPORTION\ OF\ NOVEL\ PATENT)_{t+1}$
GVC DUMMY	1.537^{***}	9.530^{***}	0.0447^{***}
	(4.97)	(4.91)	(4.67)
ASSETS	0.524^{***}	3.033^{***}	0.0110^{***}
	(12.88)	(11.88)	(8.71)
HIGHTECH	1.341^{***}	7.589^{***}	0.0709^{***}
	(4.40)	(3.97)	(7.52)
ROA	-0.836	-0.544	0.0982^{*}
	(-0.61)	(-0.06)	(2.32)
EPS	-0.00151	0.00127	0.00121
	(-0.02)	(0.00)	(0.43)
LIQUIDITY	-1.434^{*}	-10.54^{*}	-0.156^{***}
	(-2.10)	(-2.46)	(-7.40)
TANGIBILITY	1.016	2.266	0.0694^{***}
	(1.51)	(0.54)	(3.34)
R&D	4.337^{*}	43.45^{***}	0.331^{***}
	(2.44)	(3.89)	(6.01)
_CONS	0.890	5.860	0.151^{***}
	(1.56)	(1.64)	(8.56)
SELECTION			
LOCATION	0.0104	0.0104	0.00354^{***}
	(0.69)	(0.68)	(3.56)
INDUSTRY	-0.0001	-0.0001	-0.0001^{***}

	(-0.33)	(-0.33)	(-3.42)
AGE	0.0796*	0.0796*	0.00776**
	(2.53)	(2.53)	(2.65)
ASSETS	-0.147	-0.147	-0.0442***
	(-1.71)	(-1.71)	(-7.54)
LEVERAGE	0.822	0.822	0.260***
	(1.68)	(1.68)	(4.46)
NETPROFIT RATIO	-0.0026	-0.0031	0.00089***
	(-0.02)	(-0.02)	(5.36)
_CONS	4.668**	4.678**	3.330***
	(3.07)	(3.08)	(27.06)
ATHRHO	-0.0424	-0.0437	-16.59
	(-0.56)	(-0.56)	(-0.17)
INSIGMA	2.419***	4.255***	-1.057***
	(277.31)	(487.85)	(-122.75)
LAMBDA	-0.4756	-3.0777	-0.3475
N	6584	6584	6584

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: $PATENT_{t+1}$, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT $_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year $_t$; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year $_t$; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year $_t$; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The selection process between the startup firms in NEEQ and GVCs is a two-way process, which means that GVCs select firms but firms also choose GVCs. So, there is potential endogeneity here and we apply two stage Heckman selection model to double check endogeneity issue. Table 2.13 reports the two stage Heckman selection model results for the patenting activity of portfolio companies with GVC investment. GVC DUMMY keeps significantly positive relationship with patent number, citation number and proportion of novel patent, which is consistent with the results in our baseline models and the results is robust.

7. Conclusions

As we all know that the role of venture capital (VC) financing in creating value for SMEs in emerging countries has been widely debated in both the academic and practitioner literature. Our study provides new evidence to the literature about the relationship between governmental venture capital (GVC) investments and technological innovation of SMEs listed on National Equity Exchange Quotation (NEEQ) during the period of 2005 to 2015. Empirical tests show that GVC's entry into SMEs is able to make a concerted and effective effort to fill major gaps in their innovation capacity. The bulk of venture financing supports innovative activities of SMEs at NEEQ market in the perspective of patenting numbers across industries during 2005-2015. However, GVC has no significant impacts on the proportion of novel patents, which is focusing on the patent quality. These findings are rather significant and consistent across alternative proximity measures, control variables, and econometric approaches.

We further disentangle the mechanisms of the impacts of GVC investment on portfolio firms. We investigate that GVC investments facilitate their portfolio firms to obtain higher long-term leverage but lower short term leverage, which implies that GVC introduces more long-term financing, such as bank loan, to firms to release financial constraint and firms may allocate more resource on innovation activity. And portfolio firms invest more funds in innovation activity after receiving funding. Furthermore, there is no significant evidence to show GVC draw a positive value added service to portfolio firms.

Innovation and entrepreneurship are taken as the key drivers of economic growth in the China at present. Our paper confirms that GVC financing, among heterogeneous capital goods, is a key engine that drive innovation and entrepreneurship in China The straightforward finding that Chinese GVCs have released financial constraints, created values and generated innovation gains to SMEs contains strong implications for policy makers who concern with industrial upgrading and structural changes in the Chinese economy. Promoting the development of the VC industry in China's multi-layer capital market, encouraging more syndicated VC investments and letting venture capitalists with government background play a bigger role are rather important in nurturing innovation and entrepreneurship in future's China.

It is important to acknowledge, however, that our research has also some limitations. This paper only scratches the surface in studying the role and effectiveness of GVC investments in promoting innovation. In the future studies, how entrepreneurs and venture capitalists interact in China's SMEs shall also be examined through field research.

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Appendix

Patent Novelty Analysis

We search each IPC class combination of NEEQ firms in IPC combination pool to identify whether this IPC class appeared for the first time based on its **application date, application year** and **18 months from application date of the focal patent** respectively. As for application date basis, if IPC combination A of patent N appears for the first time, this IPC class combination is novel; if IPC combination A appears in patent B which has earlier application date, patent A does not have novelty and supportive evidence will be attached. We regard patent as novel patent if patent have at least one pairwise novel combination. On application year basis, if in the same application year, two separate patents carry the same novel first-time combination of IPC classes, both patents are considered novel. This is because patent applications are not disclosed until 18 months after filing. For 18 months from application date of the focal patent, if two separate patents carry the same novel first time combination of IPC classes within 18 months from application date of the focal patent, both patents are considered novel. An example is shown below.

Table 2.14 Patent Novelty Analysis

=			Application Date		Application Year		18 Months from Application Date	
Application ID	IPC	IPC combination	Novel_Dum	Novel_Num	Novel_Dum	Novel_Num	Novel_Dum	Novel_Num
CN200710117743.7	C07D309/10; A61K31/352; A61K36/286; A61P9/10	A61K31#A61K36; A61K31#A61P09; A61K31#C07D309; A61K36#A61P09; A61K36#C07D309; A61P09#C07D309;	0	0	1	2	1	3

Novel_Dum indicates that the number of novel IPC combination of a patent based on 6-digit IPC class. Novel_Dum is a dummy variable denoting 1 if Novel_Num > 0.

Variable Construction

Once getting the novelty indicator of each 6-digit IPC combination, we can identify the novelty of each patent and the number of novel patents of each firm in the observation year. Finally, we can calculate the proportion of novel patent of each firm in the observation year by the number of novel invention patent divided by total number of invention patent that eventually granted in the observation year.

$$Proportion\ of\ novel\ patent = \frac{\text{the number of } novel \text{ invention patent}}{\text{total number of invention patent}}$$

Table 2.15 Data summary of Each Step

Patent Item	Domestic Patent	Parent Company	Subsidiary	Former Name	Total
Granted invention patent	3,596,262	28,695	5,986	1,572	36,253
Granted invention patent with single IPC	1,412,283	10,324	2,438	476	13,238
Granted invention patent remains one IPC after removing duplication in first 6 digit of IPCs.	121,267	3,348	798	187	4,333
Granted invention patent has more than one IPC after removing duplication in first 6 digit of IPCs.	2,062,712	15,023	2,750	909	18,682
All two-pair IPC combination created to date, after removing duplication.	228,003				
The number of novel patents					
Application Date		2,025	413	130	**2,568**
Application Year		3,794	686	248	**4,728**
18 Months from Application Date		4,433	799	277	**5,509**
Percentage of novel patent (the number of novel patent/the number of patent with more than one IPC)					
Application Date		0.135	0.150	0.143	**0.137**
Application Year		0.253	0.249	0.273	**0.253**
18 Months from Application Date		0.295	0.291	0.305	**0.295**
Percentage of novel patent(the number of novel patent/the number of all patent)					
Application Date		0.071	0.069	0.083	**0.071**
Application Year		0.132	0.115	0.158	**0.130**
18 Months from Application Date		0.154	0.133	0.176	**0.152**

As table 2.15 shows that the overall proportion of novel patents of NEEQ firms is 7.08%, 13.04%, and 15.20% based on application date, application year and 18 months from application date of the focal patent respectively.

Table 2.16 Average number of granted invention patents of Non_GVC_backed firms and GVC_backed firms.

Year	GVC_backed firms	Non_GVC_backed firms
2005	0.193	0.091
2006	0.326	0.178
2007	0.506	0.244
2008	0.583	0.392
2009	0.855	0.487
2010	1.235	0.714
2011	1.529	1.013
2012	1.599	1.021
2013	1.925	1.165
2014	1.590	1.109
2015	1.399	1.036

Table 2.17 Average proportion of novel patents of Non_GVC_backed firms and GVC_backed firms.

Year	GVC_backed firms	Non_GVC_backed firms
2005	0.023	0.013
2006	0.022	0.015
2007	0.030	0.021
2008	0.030	0.029
2009	0.040	0.027
2010	0.046	0.026
2011	0.041	0.037
2012	0.048	0.031
2013	0.042	0.032
2014	0.048	0.030
2015	0.033	0.040

Table 2.18 The relationship between innovation measured by all patent number and GVC investments

	(1) Ln(1+PAT)	(2) Ln(1+PAT)	(3) Ln(1+PAT)	(4) Ln(1+PAT)	(5) Ln(1+PAT)
GVC	0.343^{***}	0.220^{***}	0.223^{***}	0.219^{***}	0.148^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HIGHTECH	0.261^{***}	0.329^{***}	0.324^{***}	0.320^{***}	0.136^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AGE	0.161^{***}	0.0433^{*}	0.0427^{*}	0.0472^{*}	-0.0243
	(0.000)	(0.021)	(0.022)	(0.012)	(0.312)
ASSETS		0.163^{***}	0.167^{***}	0.167^{***}	0.236^{***}
		(0.000)	(0.000)	(0.000)	(0.000)
STATEOWN			-0.213^{***}	-0.210^{***}	-0.0796
			(0.000)	(0.000)	(0.268)
LEVERAGE				-0.0386^{*}	-0.0783^{*}
				(0.032)	(0.038)
R&D					0.122^{***}
					(0.000)
_CONS	-0.165	-2.921^{***}	-2.976^{***}	-2.943^{***}	-3.744^{***}
	(0.090)	(0.000)	(0.000)	(0.000)	(0.000)
N	20193	20193	20193	20193	14588
Firm Effect	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
P-value for Chi2	0.000	0.000	0.000	0.000	0.000

Table 2.18 reports the REM estimates how GVCs influence firm's innovation measured by patent number. The benefit of the government background VC is more evident in this table. We notice that the dummy variable for the government VC background is significant in all five model specifications at 1% level, supporting our second working hypothesis that involvement of governmental venture capitalists promotes portfolio firms' innovation. This finding can support the hypothesis that GVC can facilitate enterprise to improve innovation capability. However, this result is different with the evidence in the existing literature on the relationship between GVC and firm innovation in Europe. The dummy variable for high-tech industry is consistently positive and highly significant at 1% level. The dummy variable for state own is consistently negative and highly significant at 1% level.

Table 2.19 The relationship between innovation measured by all patent number and GVC investments

	(1) Ln(1+PAT)$_{t+1}$	(2) Ln(1+PAT)$_{t+2}$	(3) Ln(1+PAT)$_{t+3}$
GVC	0.219***	0.260***	0.250***
	(0.000)	(0.000)	(0.000)
HIGHTECH	0.320***	0.333***	0.325***
	(0.000)	(0.000)	(0.000)
AGE	0.0472*	0.0841***	0.114***
	(0.012)	(0.000)	(0.000)
ASSETS	0.167***	0.170***	0.174***
	(0.000)	(0.000)	(0.000)
STATEOWN	-0.210***	-0.157**	-0.137*
	(0.000)	(0.005)	(0.023)
LEVERAGE	-0.0386*	-0.00942	0.000236
	(0.032)	(0.637)	(0.992)
_CONS	-2.943***	-3.222***	-3.430***
	(0.000)	(0.000)	(0.000)
N	20193	14969	9782
Firm Effect	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes
P-value for Chi2	0.000	0.000	0.000

Standard errors in parentheses. ***, ** and *denotes significant at 1%,5% and 10% confident level respectively.

Table 2.19 reports the relationship between firm innovation activities measured by patent number and GVC investments. We replace the dependent variable with the natural logarithm of the number of patents filed in two and three years, respectively. Empirical result demonstrates that patent number in the future two and three years have significantly strong positive relationship with GVC dummy. Control variables, such as high-tech, age, assets, stateown and leverage, keep significant in all three regressions. The regression results of the robustness tests are qualitatively similar to our baseline results and some of them are reported in Table 6 (Test of Hypothesis 2).

CHAPTER III: THE INTERPLAY OF PUBLIC AND PRIVATE VENTURE CAPITAL INVESTMENT: EVIDENCE FROM CHINA'S SMALL- AND MEDIUM-SIZED ENTERPRISES

Abstract

This study examines the impacts of syndication investment of venture capital (VC), particularly government venture capital (GVC) with other types of venture capitals, on innovation activity of China' s small- and medium-sized enterprises (SME). Our study find that firms backed by syndication investment achieve a better innovation capability than their counterparties, however, the increase in patents activities do not translate to better firm performance for GVC-backed firms. Firms backed by syndication investments achieve better innovation capability in terms of patents number, the proportion of novel patents, citing number, family size and citation number, which indicates the interplay of GVC and PVC play an important role in helping Chinese SMEs to improve innovation capability in this pilot over-the-counter equities market. We further investigate that GVC investments facilitate their portfolio firms to obtain higher long-term leverage but lower average leverage. In addition, we investigate additional evidence that indicates that firms backed by syndication investments get their patent approval from patent application faster than non-GVC-backed firms and therefore achieve higher patent number. However, no evidence is found that syndication firms can outperform PVC backed firm in terms of ROA, ROE, sale growth, and employee growth, suggesting that the increase in patents activities do not translate to better firm performance for GVC-backed firms. These results are robust to a variety of estimations and specifications.

Key words: government venture capital, innovation, interplay, translate.

1. Introduction

Syndication is an important interaction between actors in financial markets and is one of the distinctive investment approaches in venture capital industry. Government venture capital(GVC), private venture capital(PVC), and ventures may have complex trilateral interactions in the VC ecosystem (Bertoni, Colombo, & Quas, 2019). For example, the receipt of prestigious GVCs' funding could have a lasting effect on the investee ventures, including signaling firm quality and potential to external stakeholders like PVCs. Importantly, GVCs have close relationships with public authorities and can endow the engaging private actor with idiosyncratic competencies through provision of nonmarket resources. All these may help ventures overcome difficulties in raising subsequent funding from PVCs (Söderblom, Samuelsson, Wiklund, & Sandberg, 2015; Zhao & Ziedonis, 2020) or acquiring further resources such as talents (Söderblom et al., 2015). Alternatively, GVCs may work with PVCs more closely by forming a syndicate and attracting PVCs to invest in ventures in some strategic important industries or niches (Bertoni et al., 2019) and improve the chances to address equity market failure in those areas (Alperovych, Groh, & Quas, 2020). Ventures or PVCs that cooperate with GVCs can therefore access to nonmarket resources, valuable information, and domestic stock market (Wang & Wu, 2020; Zhang, 2018), accumulating political capital embedded in the relationships. As such, the interactions between GVCs, PVCs, and ventures (e.g., subsequent investment, syndication, political networking) can be a resourceful research context to investigate public-private engagement in the entrepreneurial financing context.

China's developing capital market provides an ideal research context to study the interplays among GVCs, PVCs, and ventures. First, despite lack of formal legal institutions, Chinese VC market has been developing for more than 30 years and become the second largest VC market in terms of total venture deal value in 2018 (PitchBook, 2019). Second, China's capital market is still highly regulated where the government controls critical resources and retain discretion in the policy interpretation and implementation. Third, in China, the utilization of informal networks and personal connections ('Guanxi') is an important element and carries important implications for organizational strategy, management, and policy implications (e.g., Wang & Wu, 2020). The political connection to GVCs may compensate for the nascent institution and facilitate property rights protection for ventures (Zhou, 2013).

This work contributes to public-private interaction literature (e. g., Kivleniece & Quelin, 2012; Klein, Mahoney, McGahan, & Pitelis, 2013; Luo & Kaul, 2018; Mahoney *et al*., 2009). Public connection can be an effective tool to mitigate high risks and deal with information costs for private firms (PVC and venture). This paper proposes to use secondary data to explore the mechanisms of the public ownership of and political connection to GVCs in shaping the organizing and functioning of mixed PVC-GVC syndications to GVCs, PVCs, and ventures. This attempt can yield crucial insights into the underlying mechanisms of the organizing and functioning of mixed VC syndication, despite of potential contesting private and public interests. Further, this work adds more insight into the VC syndication literature where there is a dearth of research on the syndication and co-financing activities between different types of VCs (Grilli & Murtinu, 2014). This work is among the earliest attempts to explicitly examine the mixed VC syndication between GVC and PVC, and argues that private actors could be triggered by the political connections to GVCs. This work sheds light on a previously ignored avenues and carries important managerial and policy implications.

The rest of the paper is organized as follows. In the second section, we explore the theoretical and empirical evidence of GVC and firm performance in the existing literature, and put forward the testable hypotheses. In section 3, we describe the data and methodology adopted in the empirical tests. The baseline empirical result and the cross-sectional heterogeneity are then presented in Section 4. Section 5 discusses the three plausible influencing channels. Section 6 presents the robustness check results as well as further corrections for possible endogeneity. Finally, the conclusion is drawn and the future research is discussed in Section 7.

2.Backgrounds, Literature and Conceptual Framework

In this section, we briefly describe the conceptual framework of syndication investment and innovation. discuss the experimental setting of the 2007 innovation policy, develop theoretical arguments on the impact of GVC on firm performance, and we also posit that there are several research hypotheses for GVC to exert effects.

2.1 Conceptual Framework

Syndication is one of the distinctive investment approaches in venture capital industry, which can be dated back to as early as 1870 (Galston, 1925). It is also well known that in the American venture capital market, cooperation among VC investors is an enduring and striking feature, and investments are often syndicated, which means that two or more venture capitalists share in the financing of a particular venture(Brander et al., 2002). Of the approximately 30,000 entrepreneurial firms that receive VC financing between 1980 and 2005, about 70% are the recipients of investments by two or more VC investors (Tian, 2011a). In sharp comparison, a larger proportion of VC investments in China are standalone, and the syndicated investments only occupied a relatively small proportion of total VC investments at our sample by the end of 2014, which is only around 10%.

Syndication is reputed to be beneficial for several reasons. Selection hypothesis, suggested by Lerner (1994), is one rationale of syndication. More than two venture capitalists can pick up one project with better efficiency than a standalone venture capitalist because they share information and expertise with each other to achieve better risk diversification(Lerner, 1994). In addition, syndicated venture capital investment can not only prevent competition between investors when an attractive investment opportunity takes places but also can provide more value-added service and increase monitoring capability for portfolio firms (Casamatta and Haritchabalet, 2007). Hence, VC backed firms have capability to improve their performance if syndicated financing is accepted. Another important economic benefit from syndication for venture capitalists is know-how transfer(Tykvová, 2007). In details, venture capitalists can benefit from skills and competence of their partners if they lack capability in certain industry. Know-how transfer is a vital determinant for the further evolution of venture capital industry.

In contrast to what previous research suggested, syndication cannot acquire a higher return from portfolio firms. Firstly, the most promising project would be taken up as standalone investment as the investor is not willing to share attractive profit with other partners. Meanwhile, moderate promising projects would be put in syndication pool, which indicates that syndicated investment may yield lower return rate than standalone investment and this is against the selection hypothesis. Apart from the benefits of syndicating, it also incurs costs. The financier who syndicates his deal must share the profit with his partners. Moreover, the asymmetry of information causes moral hazard problems. When the effort of each investor is neither observable nor verifiable, they may shirk. Among others, Alchian and Demsetz (1972) or Holmstrom (1982) analyzed this free-rider problem within a team. Furthermore, he added that hold-up problems may emerge.

Empirically, Brander et al. (2002) employ Canadian sample and find evidence that syndicated investment offered more management assistance for portfolio firms compared with standalone investment and thus are capable of improving the performance of portfolio firms. Using data covering all venture financing rounds of American private firms from1980 to 2003, Das et al. (2011) demonstrate that syndication plays a multifaceted role in portfolio firm by improving operating performance, accomplishing higher exit likelihood and faster speed of exit. TIAN (2011b) analyze 21141 syndicated backed entrepreneurial firms and discovered that VC syndication created value for entrepreneurial firm in US by increasing their product market value, nurturing innovation, and helping them to maintain high post-issue operating performance. In addition, VC syndicated-backed firms have more possibility to exit successfully, enjoy a lower IPO under-pricing and achieve a relatively high IPO make valuation. Guo and Jiang (2013) indicate that syndication investment can spur innovation capability of Chinese entrepreneurial enterprises in term of R&D intensity.

However, Biais and Perotti (2008) empirically confirm that investors do not syndicate the most profitable deals because they are afraid that their partner might steal the project idea and exploit it on his own account. This situation draws negative influence on firms back by syndicated venture capital investment. Chahine et al. (2012) discover the principal-principal agency conflicts within venture capital syndication by matching 274 VC-backed firms in the U.S.A and the UK. They confirmed that higher underprice and lower aftermarket performance occurred in firms with VC syndication, and these negative impacts were higher in the US.

Previous literature on the syndication of GVC and PVC has widely discussed. Standaert and Manigart (2018) find that portfolio companies backed by hybrid independent venture capital funds show greater employment growth than those backed by hybrid captive or hybrid government venture capital funds in 108 American portfolio companies . Cumming et al. (2014) figure out that syndicated investment of GVC and PVC generate a higher probability of positive exit of portfolio companies than those of PVC-backed by collecting a sample of 8370 firms, 759 of which are VC-backed in Europe. Brander et al. (2014) use a very broad database, seeking to assess the role of government support for VC on a global basis. They collected a sample of 20446 enterprises that obtained their first VC funding between 2000 and 2008, based in twenty-five countries and covered a variety of industries. Their empirical analysis indicates that portfolio companies backed by both GVCs and PVCs can receive more VC investment amount than those purely backed by PVCs, and also can receive much more investment funding than those funded by standalone GVC investors. Furthermore, syndication of GVCs and PVCs draw a significant positive impact on the successful exit of portfolio companies, as measured by initial public offering and acquisition. Bertoni and Tykvová (2015) found that GVCs can only spur innovation of portfolio companies when syndicating with IVCs, which indicate that GVCs may be beneficial to invention by complementing the resources provided by IVCs.

There are a number of reasons why GVC–IVC syndicated relations may enhance performance of portfolio firms. First, by syndicating with IVCs, the investee firms financed by GVCs still enjoy the structural advantages of IVC limited partnerships, which are not compromised by sole financing with a less efficient GVC structure. Second, investee firms are likewise not compromised by sole financing from GVCs with less efficient compensation terms, and enjoy the benefits associated with IVC compensation terms. To the extent that GVC and IVC efforts are substitutable for growing the entrepreneurial firm, the disadvantages of inefficient GVC compensation can be significantly mitigated. Third, decision making is independent among IVCs (i.e., not subject to influence from institutional investors), and not subject to political pressure. This independence mitigates the agency problems of inefficient decision making associated with political pressure from government bodies affecting GVC investment decisions. Finally, an advantage of the GVC–IVC partnership is that the independent sources of networks and contacts that can help the entrepreneurial firms grow are more expansive than merely an IVC syndicate. GVCs would be expected to have access to governmental contacts that may be beneficial to the entrepreneurial firm, which could include government-related suppliers and customers, and enable streamlined and faster regulatory approval of business matters that are in the entrepreneurial firm's interest. GVCs enhance IVC value-added by expanding the scope of networks and enabling connections to government-related suppliers and customers that could expand the investee firm's set of opportunities to maximize growth. In short, because political connections are valuable, and because IVCs can mitigate the cost of inefficient GVC structures, IVC–GVC syndicated partnership are expected to enable entrepreneurial firms perform better. Hereby, this study mainly expects the following:

Hypothesis a: Innovation capability of firms backed by syndication investments outperforms those of those backed by private venture capitalists at the NEEQ market.

Hypothesis b: Innovation capability of firms backed by syndication investments underperforms those of those backed by private venture capitalists at the NEEQ market.

3. Data, Variables, and Methods

3.1. Data descriptions and sample characteristics

We compile all firms floated on China's over-the-counter equities market, namely the National Equity Exchange and Quotation (NEEQ) market, from WIND, which consists of 5,186 firms by the end of 2016. NEEQ was established to provide equity financing support and trading for small and medium size enterprises (SMEs) in China. Especially, NEEQ focuses on SMEs with significant innovation activities. In comparison with other equity markets in China, the NEEQ does not have any profit threshold requirements, and thus is the ideal starting point for high technology companies in the domestic capital market. There were only 356 companies listed on NEEQ at the end of 2013, but the number had grown to 5,186 by the end of 2015 and the market value grew more than five times to reach 4591.42 million. Above mentioned basic characteristics of NEEQ made it ideal targeted market of micro-enterprise, SMEs and innovative firms, which are exactly what we want to research on.

We obtain information on NEEQ firms' patenting activity from the China national intellectual property administration (CNIPA) Patent Database, which provides complete information on all granted patent from 1985 to 2019 on patent assignee names, the application and publication number of patents, application and grant year, IPC classification number, type of the patent, and the number of citations received by each patent, family size and the number of citing of each patent.

We hand collect data on venture capital investments from annual reports and legal opinions of listed firms at the NEEQ system during the period of 2005 to 2015 as no specific database has published information about VC investments on NEEQ-listed firms systematically. We find that 1,876 firms were invested by venture capital; in particular, 493 firms were invested by government venture capital. Therefore, our sample consists of 5,186 firms which listed on NEEQ by the end of 2015. 1,876 firms were invested by venture capital; in particular, 493 firms were invested by government venture capital. Sample period spans from 2005 to 2015.

Table 3.1 Overview of GVC investments on NEEQ.

Classifications	**No. of firms**
Firms listed on NEEQ by the end of 2015	5186
VC investment events on NEEQ	5089
VC backed firms	1876
Percentage of VC backed firms (of No. of NEEQ firms)	0.36
No. of VC institutions	3024
Pure GVC	166
Syndication of GVC and PVC	288
Pure PVC	1368

Due to the missing or abnormal financial data of firms listed on NEEQ, an emerging over the counter (OTC) market, we select data based on the following steps. First, we screen out the sample with negative total asset and negative R&D expenditures. Second, we drop the sample with leverage higher than 1 or lower than 0. Finally, to minimize the effect of outliers, we winsorized all variables at the top and bottom 1% of each variable's distribution.

3.2. Variables and summary statistics

Dependent Variables--Measuring Innovation

Previous literature has developed two proxies to measure the innovation capability of a firm: R&D intensity and patent activity. Compared to R&D intensity, patenting activity is regarded as a better proxy, since it is able to capture the innovation output and calculate s how effectively a firm has utilized its innovation inputs. Therefore, following previous studies, for example, Guo and Jiang (2013) for publicly traded firms and Tian (2011) for privately held firms, we use a firm's patenting activity to measure innovation.

Based on the information retrieved from the CNIPA patent database, the CNIPA grants three types of patents: invention, utility model, and design patents. Compared with the other two categories, invention patents are the most substantive and rigorously examined patent, as they face the highest scrutiny and the strictest screening for quality and novelty in the approval process. Invention patents granted by the CNIPA also correspond better to the invention patents granted by the United States Patent and Trademark Office (USPTO) used in prior studies. Therefore, we follow the method developed by Wang, Li, and Furman (2017) and measure the number of invention patent applications a firm files in a year that are eventually granted. We use a patent's application year instead of its grant year as the application year is argued to better capture the actual time of innovation (Griliches et al., 1986). And follow the method developed by Nan and Kenneth (2019), we construct PROPORTION OF NOVEL PATENT $_{t+1}$ denotes the proportion of novel patents among all the patents produced by the focal firm in year $_{t+1}$.

We address an inherent limitation of the patents data –truncation bias. Truncation bias affects data on patent applications because it typically takes several years to process a patent application (Hall et al., 2001). As a result, a large proportion of patent applications near the end date of a database can be missing because they have not been granted as yet (N. Dass et al., 2017). We extend our final patent sample year from 2015 to 2018 and exclude the final two years of patent data in order to make a correction for truncation bias. Using the 2018 dataset allows us to obtain relatively bias-free information on patent applications over the span of the prior 2015 dataset.

To address the truncation bias, previous studies tend to follow three different approaches to adjust the currently available information on patent citations. The first method is to exclude the final two to three years of patent data in order to ensure that the data is relatively free of truncation bias, when dating patents according to application year. The second method relies on historical patterns to forecast future realizations of patent citations. The third method adjusts the number of patents and citations for the fixed effects of each technology class and year. However, a potential drawback is that the fixed effects also absorb any meaningful variation in innovation across sectors. In this paper, we use the first method and update patents dataset, which extending the sample from 2015 to 2018, to make a correct for truncation bias. Using the 2018 dataset allows us to obtain relatively bias-free information on patent applications over the span of the prior 2015 dataset.

According to the examination of the historical application-grant time-lag, the percentage of patents granted within 1 years after filing an application is about 93%, within 2 years after filing an application is about 97%, therefore, when dating patents according to application year, we exclude the final two years of patent data in order to ensure that the data is relatively free of truncation bias. Additionally, it is necessary to acquire patent data in 2016 since post GVC entry should be considered. Therefore, we construct a new patent dataset, where the patents applied by the end of 2016 and eventually granted by the end of 2018, to better correct the truncation bias.

To further assess a patent's influence, we followed the methods developed by Hall et al., (2001) and count a firm's total citing number of all patents filed (and eventually granted) in given year, which measure the technical innovativeness of patent. We count a firm's total family number of all patents filed (and eventually granted) in given year, which measure the value of patent. We count total number of citations a patent received in given year, which measure the quality of patent. And we also compute PTO, which denotes firm i's average application-grant time-lag of invention patents applied in year t+1.

Independent Variables-- Measuring Venture Capital Investment

We hand collect data on venture capital investments from annual reports and legal opinion of listed firms at the NEEQ system during the period of 2005 to 2015 as no specific database has published information about VC investments on NEEQ-listed firms systematically. For each VC-backed firm, we document detailed information about investment events of VC companies and portfolio firms. Data on VCs consist of name, ownership structure, nationality, location, establishment time, and reputation ranking. Data on portfolio firms constitute of investment timing, industry, the number of employees, location, the amount of VC investment fund, investment round, investment stage, currency, investment approach such as syndication and staging, and so on. Follow the previous studies (Grilli and Murtinu, 2014, Bertoni and Tykvová, 2015, Guerini and Quas, 2016), we construct GVC DUMMY, a dummy variable which is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. BOARD, a dummy variable, which is equal to one when GVC becomes a board member in portfolio companies, otherwise, equal to zero.

Control Variables

Following the innovation literature, we control for a variety of firm and industry characteristics that may affect a firm's innovation performance. The financial performance data for SMEs at the NEEQ market during 2005 to 2015 are collected from WIND dataset, which is a comprehensive database on China's financial markets. Basic introduction provided by WIND makes up with code, name, establishment time, listed time, industry according to the classification criteria of China Security Regulatory Commission (CSRC), state ownership structure, nationality, location. Variables on accounting and financial conditions include total number of employees, total assets, total liability, total equity, total sales, net profit, returns on assets (ROA), R&D expenses, and so on. The definitions of some key variables are as follows. Total asset (ASSETS) is a key indicator that represents firm size of firms, which is measure by the total assets of a firm in calculated year divided by 1 million. HIGHTECH is a dummy variable, which is equal to one if the firm belongs to a high-tech industry, otherwise, equal to zero. Return to Assets (ROA) is a key indicator that represents the profitability of firms, which is measure by net profit divided by total assets at the calculated year. Earn per share (EPS) which refers to the market value of a film at the end of fiscal year t. LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t TANGIBILITY refers to the ratio of tangible assets to the total assets in a sample company. R&D intensity, which is the indicator of R&D activity, is measured by R&D expenditure scaled by sales revenues.

Table 3.2 Definition of key variables

Variable	Definition
	Panel A: Innovation measures
$PATENT_{t+1}$	$PATENT_{t+1}$ denotes the firm i's total number of invention patents filed (and eventually granted) after one year that companies received investment.
PROPORTION OF NOVEL PATENT $_{t+1}$	PROPORTION OF NOVEL PATENT $_{t+1}$ denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1.
CITING $_{t+1}$	CITING $_{t+1}$ denotes $_{firm}$ i's total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent.
FAMILY $_{t+1}$	FAMILY $_{t+1}$ denotes firm i's total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent.
CITATION $_{t+1}$	CITATION $_{t+1}$ denotes firm i's total number of citations a patent received in year t+1, which measure the quality of patent.
PTO_{t+1}	PTO $_{t+1}$ denotes firm i's average application-grant time-lag of invention patents applied in year t+1.
	Panel B: VC characteristics
GVC DUMMY	A dummy variable, which is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero.
GVC	A dummy variable, which is equal to one if the firm is backed by purely GVC (including GVC standalone and GVC syndicates with GVC), otherwise, equal to zero.
SYNDICATION	A dummy variable, which is equal to one if the firm is backed by syndication investment between GVC and PVC, equal to zero.
	Panel C: Financial Characteristics

ASSETS	The total assets of a firm in calculated year divided by 1 million.
HIGHTECH	A dummy variable, which is equal to one if the firm belong to a high-tech industry, otherwise, equal to zero.
ROA	ROA refers to the profitability of a firm at the end of fiscal year, defined as net profit divided by total assets at the calculated year.
EPS	EPS refers to earning per share, measured at the end of fiscal year t
LIQUIDITY	LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t
TANGIBILITY	TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t
R&D	R&D expenditures divided by book value of total sales at year t, set to zero if missing.
LEVERAGE	LER refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t
$(\text{LONG-TERM LEVERAGE})_{t+1}$	LONG TERM LEVERAGE $_{t+1}$ denotes the number of long term debt divided by the total number of assets in year t+1, which measure the financial constraint of portfolio companies.
$(\text{SALES GROWTH})_{t+1}$	SALES GROWTH $_{t+1}$ denotes the growth rate of sales of portfolio companies in year t+1, which measure the financial performance of entrepreneur firms.
$(\text{EMPLOYEE GROWTH})_{t+1}$	EMPLOYEE GROWTH $_{t+1}$ denotes the growth rate of employee of portfolio companies in year t+1, which measure the financial performance of entrepreneur firms.

3.3. Methodology

To compare GVC-backed and non-GVC-backed firms in terms of innovation activities, we use propensity score matching (PSM) method to construct a control group for comparison purposes. We build the control group in several steps to ensure that our results are not driven by a specific matching method. First, we select all VC backed firms from our sample and then classify all firms into GVC backed firms and non GVC backed firms. We then match the GVC backed firms with non GVC backed firms by industry (at the three-digit SIC level), location (at the provincial level), age (operation period), size (total assets), leverage and sales. Finally, we employ the methodology of randomly drawing one-to-one matched pairs to build the control group. To ensure that our control group is representative, we repeat this random draw methodology 5 times, and the results are consistent (Guo and Jiang, 2013).

The dependent variables, *the number of patents*, are a highly right-skewed count variable that takes on non-negative integer values. Hence, we use nonlinear regression approaches to avoid heteroskedastic, non-normal residuals (Hausman, Hall, & Griliches, 1984). We employ fixed-effects Poisson estimator, negative binomial regression and Tobit model to deal with the non-negative nature of these dependent variables (Wooldridge,1997) .

For dependent variable, *proportion of novel patent*, is denoted as the proportion of novel patents among all the patents produced by the focal firm in year t+1 which is a fraction constrained between 0 and 1, but it can be 0 or 1, we estimate a fractional response model and double-censored Tobit model (Papke and Wooldridge 2008). We also use firm random effects and industry or year fixed effect in the model estimation regarding financial performance.

We estimate the following benchmark specifications to explore the innovation impacts of VC investments and the general formula of regressions models adopted in this paper are as follows.

$$PATENT\_NUMBER_{i,t+1} = \alpha + \beta_1 GVC\_DUMMY_{i,t} + \beta_2 ASSETS_{i,t} + \beta_3 HIGHTECH_{i,t} + \beta_4 ROA_{i,t} + \beta_5 EPS_{i,t} + \beta_6\, LIQUIDITY_{i,t} + \beta \quad TANGABILITY_{i,t} + \beta_7 R\&D_{i,t} + FIRM_i + YEAR_t + \varepsilon_{i,t}$$

4. Empirical Analysis

4.1. Descriptive summary

Table 3.3 gives the information of number of firms, total number of patents and average of patent across 19 industries by CSRC industry classification. As shown in the table, a large number of patents are concentrated in manufacturing, Information Transmission, Software and Information Technology industry, and Scientific Research and Technical Service. Accommodation and Catering Industry, Finance and Real Estate Industry has the smallest number of patents.

Table 3.3 Number of Firms and patents by CSRC Industry Classification.

Industry	No. of Firms	Total No. of Patent	Average No. of patent
Agriculture, Forestry, Animal Husbandry and Fishery	125	862	6.90
Mining	25	373	14.92
Manufacturing	2762	65846	23.84
Electricity, Heat, Gas and Water Production and Supply	35	310	8.86
Construction	158	2047	12.96
Wholesale and Retail Trade	175	665	3.80
Transportation, Warehousing and Postal Service	62	90	1.45
Accommodation and Catering Industry	11	0	0.00
Information Transmission, Software and Information Technology	1016	8266	8.14
Finance	106	9	0.08
Real Estate Industry	27	9	0.33
Leasing and Commercial Service	206	565	2.74
Scientific Research and Technical Service	219	2764	12.62
Water Resources, Environment and Public Facilities Management	79	1393	17.63
Residents Service, Repair and Other Services	13	51	3.92
Education	21	110	5.24
Health and Social Work	24	50	2.08
Culture, Sports and Entertainment	108	341	3.16
Others	14	0	0.00
Total	5186	83751	16.15

Table 3.4 presents the descriptive statistics of portfolio firms in terms of mean, standard deviation, minimum value and maximum value of financial indicators. As can be seen in the table 3, 429 (26.29%) firms have received finance from government venture capital at their first round of financing in the sample of 1632 VC backed firms. Averagely, each firm listed on NEEQ acquired 1.54 invention patent in a given year. The maximization of patent number a firm achieved is 300, which indicates that most of firms listed on NEEQ is high tech oriented and keeps consistent with the industry distribution of patent number in Table 3.2.

Table 3.4 Descriptive Statistics of three types of VC investment.

	No. of firms	Mean	Median	St.dev.

Panel A: Pure GVC_backed firms				
Number of patents	143	**0.69**	0.00	2.07
Number of novel patent (Year)	143	**0.10**	0.00	0.42
Proportion of novel patent (Year)	143	**0.04**	0.00	0.16
Age	143	9.48	9.00	5.60
Size	143	18.93	19.01	1.35
ROA	143	0.03	0.04	0.13
Leverage	143	0.43	0.42	0.21
R&D intensity	143	**0.12**	0.06	0.20
High-tech	143	0.61	1.00	0.49
Panel B: SYND_backed firms				
Number of patents	316	**0.93**	0.00	3.46
Number of novel patent (Year)	316	**0.15**	0.00	1.34
Proportion of novel patent (Year)	316	**0.03**	0.00	0.14
Age	316	9.38	9.00	5.67
Size	316	19.18	19.23	1.39
ROA	316	0.03	0.05	0.14
Leverage	316	0.41	0.39	0.22
R&D intensity	316	**0.10**	0.06	0.14
High-tech	316	0.62	1.00	0.49
Panel C: Pure PVC_backed firms				
Number of patents	1238	**0.52**	0.00	2.31
Number of novel patents (Year)	1238	**0.08**	0.00	0.57
Proportion of novel patents (Year)	1238	**0.02**	0.00	0.13
Age	1238	8.64	8.00	5.44
Size	1238	18.67	18.76	1.41
ROA	1238	0.03	0.04	0.16
Leverage	1238	0.43	0.41	0.26
R&D intensity	1238	**0.10**	0.06	0.15
High-tech	1238	0.60	1.00	0.49
Panel D: Non VC_backed firms				
Number of patents	3489	**0.35**	0.00	2.22
Number of novel patents (Year)	3489	**0.05**	0.00	0.34
Proportion of novel patents (Year)	3489	**0.02**	0.00	0.12
Age	3489	8.54	8.00	5.73
Size	3489	18.20	18.22	1.37
ROA	3489	0.03	0.04	0.16
Leverage	3489	0.47	0.44	0.35
R&D intensity	3489	**0.09**	0.06	0.13
High-tech	3489	0.55	1.00	0.50

Figure 3.1 presents the average number of patents of three types of VC investment during 2005 to 2015. As shown in this figure, syndication investment backed firms generate highest patent number than any other VC backed firms with the mean of 0.93. GVC backed firms generate

more patent number than pure PVC backed firms and non-VC backed firms with the mean of 0.69. This indicates that GVC involvement spur innovation capability of their target companies in term of patenting number.

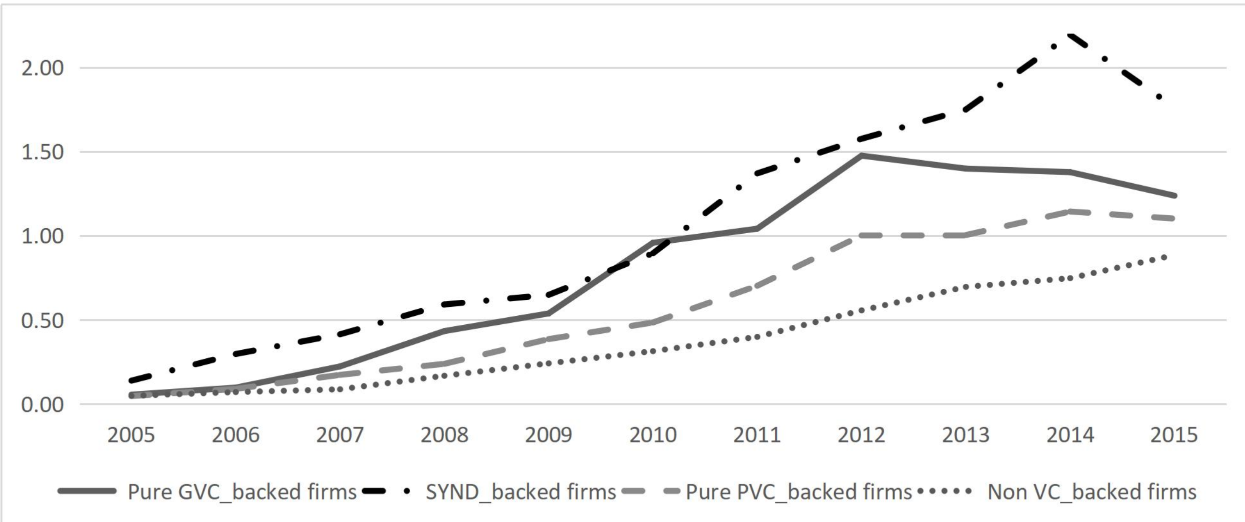

Figure 3.1 Average number of granted invention patents of all three types of VC investment.

Figure 3.2 presents the average number of novel patents of portfolio firms and their counterparties. As shown in this figure, there is significant novel patent difference between syndication investments backed firms and their counterparties in term of average novel patent number. This indicates that syndication investment activities do

bring impacts on innovation capability of their target companies, in terms of patent quality.

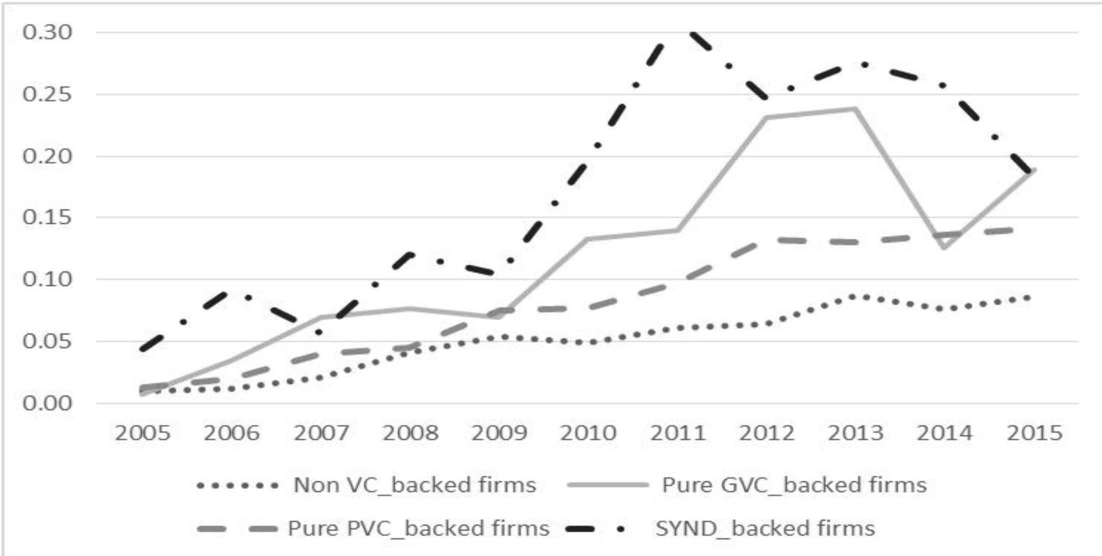

Figure 3.2 Average number of novel patents of all three types of VC investment.

4.2. Baseline results

In this part we report the estimation results on how syndication investments of GVC and other types of VCs draw influence on firm's innovation capability measured by patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. we notice that the key dependent variable for the syndication keeps significant in all five models' specifications at 1% level, supporting our working hypothesis that the involvement of governmental venture capitalists promotes the innovation capability of portfolio firms' in China, both in quantity and quality.

In table 3.4, we notice that the key dependent variable for the syndication keeps significant in all five models' specifications at 1% level, supporting our working hypothesis that the involvement of governmental venture capitalists promotes the innovation capability of portfolio firms' in China, both in patents number and the proportion of novel patents. This result is different with the evidence in the existing literature on the relationship between syndication and firm innovation in Europe. In addition, the dummy variable for high-tech industry is consistently positive and highly significant at 1% level.

In table 3.5, we notice that the key dependent variable for the syndication keeps significant in all five models' specifications at 1% level in terms of citing number, family size and citation number, supporting our working hypothesis that the involvement of governmental venture capitalists promotes the innovation capability of portfolio firms' in China, both in patents number and the proportion of novel patents.

Table 3.5 Relationship between GVC investments and innovation activity of POE firms listed on NEEQ China (PSM Sample).

	(1) Poisson	(2) NBR	(3) TOBIT	(4) FRM	(5) TOBIT
	$PATENT_{t+1}$	$PATENT_{t+1}$	$PATENT_{t+1}$	(PROPORTION OF NOVEL PATENT) $_{t+1}$	(PROPORTION OF NOVEL PATENT) $_{t+1}$
SYNDICATION	0.251***	0.272***	1.024*	0.121***	0.0341***
	(16.28)	(3.70)	(2.43)	(3.48)	(3.35)
ASSETS	0.477***	0.460***	0.991***	0.0157***	0.00423**
	(65.06)	(14.52)	(7.29)	(3.34)	(2.99)
HIGHTECH	0.165***	0.189	0.900	0.189***	0.0618***
	(8.20)	(1.91)	(1.67)	(4.10)	(4.46)
ROA	1.126***	1.420***	1.090	0.468*	0.124*
	(11.13)	(3.53)	(0.97)	(2.51)	(2.49)
EPS	-0.00235	0.0310	0.0270	0.0232	0.00345
	(-0.26)	(1.21)	(0.43)	(1.81)	(1.14)
LIQUIDITY	0.372***	0.211	-0.140	-0.219*	-0.0619*
	(8.69)	(1.09)	(-0.19)	(-2.43)	(-2.42)
TANGIBILITY	-0.188***	-0.191	0.166	0.0684	0.0202
	(-4.44)	(-1.03)	(0.27)	(0.78)	(0.83)
R&D	4.194***	4.436***	4.685**	1.509***	0.454***
	(45.59)	(8.73)	(2.82)	(6.60)	(6.98)
_CONS	-29.39	-9.327***	-18.89***	-5.864***	-0.138
	(-0.01)	(-13.92)	(-3.58)	(-15.25)	(-0.55)
Industry Effect	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
N	5656	5656	5656	5656	5656
Log pseudo likelihood	-26379	-9533	-19374	-1773	-2147

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include SYNDICATION, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i' s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i' s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i' s total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.6 Relationship between GVC investments and innovation activity of POE firms listed on NEEQ China (PSM Sample).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Poisson	NBR	TOBIT	Poisson	NBR	TOBIT	Poisson	NBR	TOBIT
	$CITATION_{t+1}$	$CITATION_{t+1}$	$CITATION_{t+1}$	$FAMILY_{t+1}$	$FAMILY_{t+1}$	$FAMILY_{t+1}$	$CITING_{t+1}$	$CITING_{t+1}$	$CITING_{t+1}$
SYNDICATION	0.260^{***}	0.178^{***}	5.541^{*}	0.304^{***}	0.420^{***}	1.967^{**}	1.136^{***}	1.668^{***}	0.179^{***}
	(41.38)	(3.42)	(2.06)	(27.78)	(5.85)	(2.77)	(13.03)	(5.48)	(3.42)
ASSETS	0.0792^{***}	0.0277^{***}	1.693^{***}	0.0721^{***}	0.0898^{***}	0.578^{***}	0.0962^{***}	0.0755	-0.00472
	(138.10)	(4.63)	(5.55)	(69.74)	(6.75)	(7.08)	(9.21)	(1.34)	(-0.73)
HIGHTECH	0.213^{***}	0.551^{***}	9.981^{***}	0.0752^{***}	0.0181	1.192	0.123	0.691^{*}	0.0583
	(26.26)	(9.40)	(3.80)	(5.39)	(0.18)	(1.29)	(1.10)	(2.16)	(1.12)
ROA	1.666^{***}	0.841^{**}	26.50^{**}	1.414^{***}	2.003^{***}	4.950^{*}	3.124^{***}	8.000^{**}	0.413
	(42.75)	(3.29)	(2.88)	(21.55)	(4.88)	(2.20)	(5.28)	(2.75)	(1.93)
EPS	-0.00251	0.00432	-0.112	-0.000352	0.0303	0.0971	-0.432^{***}	-0.326	-0.00635
	(-0.86)	(0.27)	(-0.21)	(-0.11)	(1.22)	(0.76)	(-3.54)	(-0.81)	(-0.51)
LIQUIDITY	0.233^{***}	-0.736^{***}	-4.249	0.0803^{**}	-0.0335	-0.904	0.0486	0.122	0.136
	(13.63)	(-6.19)	(-0.82)	(2.68)	(-0.18)	(-0.65)	(0.23)	(0.16)	(1.22)
TANGIBILITY	-0.252^{***}	-0.0661	-11.38^{*}	0.130^{***}	-0.0415	2.062	1.238^{***}	-1.528	-0.0548
	(-14.94)	(-0.54)	(-2.45)	(4.37)	(-0.23)	(1.71)	(5.79)	(-1.70)	(-0.52)
R&D	2.963^{***}	0.556	20.27	2.237^{***}	2.638^{***}	7.197^{*}	3.421^{***}	4.798^{*}	0.0161
	(79.08)	(1.82)	(1.59)	(32.22)	(5.38)	(2.22)	(7.75)	(2.15)	(0.06)
_CONS	-20.87	-2.718^{***}	12.89^{**}	-20.09	-23.48	-5.213	-30.50	-3.819^{***}	-0.0689
	(-0.01)	(-26.85)	(2.94)	(-0.01)	(-0.00)	(-0.54)	(-0.00)	(-5.95)	(-0.74)
Industry Effect	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
Year Effect	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
N	5656	5656	5656	5656	5656	5656	5656	5656	5656
Log pseudo likelihood	-180494	-12002	-31350	-51026	-12172	-23298	-2041	-1329	-271

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i's total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i's total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i's total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i's total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

We further distinguish the difference in the impact of syndication and GVC standalone investment on the innovation capability of portfolio firms measured by patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm.

Table 3.7 summarize the estimate results on difference in the impact of syndication and GVC standalone investment on the innovation capability of portfolio firms quantitively, which is measured by patent number. It is not surprising to find that the dummy variable for the Syndication of GVC and PVC (SYN) is consistently positive and significant at 1% level in all model specifications. The coefficient of syndication is larger than that of GVC dummy. This provides strong evidence for our working hypothesis that syndicated investments encourage the patenting activity of portfolio firm more than those firms invested by single Venture Capital. The interplay of GVC and PVC make contributions to the improvement of innovation of portfolio companies. Like in other estimations, the dummy variable for high-tech industry is consistently positive and highly significant at 1% level.

However, in table 3.8, we notice that the key dependent variable syndication keeps significant in terms of the proportion of novel patent, meanwhile, the coefficient of GVC fails to keep significant on proportion of novel patents. These results demonstrate that the interplay of GVC and PVC can further promote quality patent. In table 9, we find that the key dependent variable syndication keeps significant in terms of citing number, citing number, family size and citation number, supporting our working hypothesis that the involvement of governmental venture capitalists promotes the innovation capability of portfolio firms' in China, both in patents number and the proportion of novel patents.

Table 3.7 Difference in the impact of Syndication and GVC standalone investment on the innovation capability of firms (PSM Sample).

	(1) Poisson $PATENT_{t+1}$	(2) NBR $PATENT_{t+1}$	(3) TOBIT $PATENT_{t+1}$	(4) FRM (PROPORTION OF NOVEL PATENT)t+1	(5) TOBIT (PROPORTION OF NOVEL PATENT)t+1
SYNDICATION	0.406***	0.369***	1.594***	0.204**	0.0377*
	(24.57)	(4.25)	(3.35)	(3.13)	(2.25)
GVC	0.364***	0.416***	1.472**	0.0886	0.0156
	(19.38)	(4.14)	(2.62)	(1.12)	(0.79)
ASSETS	0.0709***	0.0855***	0.257***	0.0269***	0.00329
	(49.08)	(6.18)	(6.24)	(3.45)	(1.89)
HIGHTECH	0.132***	0.208*	0.649	0.316***	0.0659***
	(6.59)	(2.06)	(1.25)	(4.07)	(3.46)
ROA	1.262***	2.144***	2.017*	0.743*	0.0645
	(13.79)	(5.01)	(2.18)	(2.37)	(1.29)
EPS	0.00983	0.0268	0.0148	0.0441*	0.00283
	(1.35)	(0.89)	(0.26)	(2.02)	(1.00)
LIQUIDITY	0.0648	-0.0204	-0.381	-0.384*	-0.0589
	(1.54)	(-0.10)	(-0.58)	(-2.52)	(-1.96)
TANGIBILITY	-0.250***	-0.437*	0.478	0.113	0.0383
	(-6.04)	(-2.25)	(0.90)	(0.77)	(1.45)
R&D	3.049***	3.725***	2.923*	2.537***	0.265***
	(34.05)	(7.37)	(2.00)	(6.63)	(3.71)
_CONS	-20.06	-23.35	-1.439	-1.801***	0.0746
	(-0.01)	(-0.00)	(-0.32)	(-7.87)	(0.34)
Industry Effect	Yes	Yes	Yes	No	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
N	5656	5656	6594	5656	5656
Log pseudo likelihood	-27334	-9564	-22340	-2893	-2667

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i’s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i’s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i’s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i’s total number of citations a patent received in year t+1, which measure the quality of patent. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.8 Difference in the impact of Syndication and GVC standalone investment on the innovation capability of firms (PSM Sample).

	(1) Poisson	(2) NBR	(3) TOBIT	(4) Poisson	(5) NBR	(6) TOBIT	(7) Poisson	(8) NBR	(9) TOBIT
	$CITATION_{t+1}$	$CITATION_{t+1}$	$CITATION_{t+1}$	$FAMILY_{t+1}$	$FAMILY_{t+1}$	$FAMILY_{t+1}$	$CITING_{t+1}$	$CITING_{t+1}$	$CITING_{t+1}$
SYNDICATION	0.292***	0.178**	7.135*	0.325***	0.178**	7.135*	0.311***	1.259***	0.125*
	(42.77)	(3.04)	(2.39)	(27.34)	(3.04)	(2.39)	(3.82)	(3.55)	(2.21)
GVC	0.303***	0.110	7.649*	0.288***	0.110	7.649*	1.021***	0.967*	0.157*
	(38.87)	(1.58)	(2.16)	(20.87)	(1.58)	(2.16)	(12.07)	(2.28)	(2.32)
ASSETS	0.0797***	0.0309***	1.623***	0.0724***	0.0309***	1.623***	0.0948***	0.0611	-0.00509
	(137.75)	(5.06)	(5.76)	(69.39)	(5.06)	(5.76)	(9.11)	(1.14)	(-0.86)
HIGHTECH	0.205***	0.561***	9.242***	0.0693***	0.561***	9.242***	0.0668	0.605	0.0520
	(25.34)	(9.55)	(3.78)	(4.97)	(9.55)	(3.78)	(0.60)	(1.42)	(1.11)
ROA	1.665***	0.795**	22.72**	1.415***	0.795**	22.72**	2.900***	7.556*	0.306
	(42.68)	(3.09)	(2.99)	(21.52)	(3.09)	(2.99)	(4.91)	(2.54)	(1.73)
EPS	-0.00160	0.00393	-0.0888	0.0000690	0.00393	-0.0888	-0.370**	-0.519	-0.00502
	(-0.55)	(0.25)	(-0.19)	(0.02)	(0.25)	(-0.19)	(-3.08)	(-1.08)	(-0.44)
LIQUIDITY	0.220***	-0.707***	-4.012	0.0662*	-0.707***	-4.012	0.104	1.270	0.118
	(12.77)	(-5.94)	(-0.86)	(2.20)	(-5.94)	(-0.86)	(0.47)	(1.41)	(1.20)
TANGIBILITY	-0.250***	0.0145	-8.414*	0.131***	0.0145	-8.414*	1.398***	-0.301	-0.0430
	(-14.74)	(0.12)	(-2.11)	(4.39)	(0.12)	(-2.11)	(6.47)	(-0.32)	(-0.48)
R&D	2.978***	0.638*	15.00	2.245***	0.638*	15.00	3.689***	3.137	-0.0627
	(79.29)	(2.08)	(1.34)	(32.27)	(2.08)	(1.34)	(8.12)	(1.56)	(-0.25)
_CONS	0.292***	0.178**	7.135*	0.325***	0.178**	7.135*	0.311***	1.259***	0.125*
	(42.77)	(3.04)	(2.39)	(27.34)	(3.04)	(2.39)	(3.82)	(3.55)	(2.21)
Industry Effect	Yes	No	No	Yes	No	No	Yes	Yes	
Year Effect	Yes	Yes	No	Yes	Yes	No	Yes		
N	6592	6592	6592	5656	6592	6592	5656	5656	6594
Log pseudo likelihood	-200571	-11806	-35990	-50731	-11806	-35990	-2055	-1309	-11487

Legend: this is a series of Poisson model, Tobit model, negative binomial regression, and fractional random model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i’s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i’s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i’s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i’s total number of citations a patent received in year t+1, which measure the quality of patent. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5. Mechanism analysis

In Our main results show a positive association between syndication investments and innovation capability of portfolio firms. In this section, we research into the mechanisms that potentially drive the impacts of syndication investments on portfolio firms and look for potential explanations. We explore several dimensions of heterogeneity and find three potential channels that plausibly explain the association and change. The results of the empirical tests of the mechanisms are presented in this section.

5.1. Resource Allocation Channel

The first channel, the resource allocation channel, argues that GVCs devote more resources to their portfolio companies than do other VCs, resulting in a greater number of patents. For instance, devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000). Additionally, GVCs can offer government network, certification, government subsidy and related industry policy to portfolio firm.

Table 8 reports a series of OLS and random effect model with industry and year fixed effect results for long term leverage with GVC dummy to identify the impact of GVC on the leverage of portfolio firms. We notice that the dummy variable GVC DUMMY is positively significant with long term leverage, which might indicate that GVC syndicating with PVC facilitate their portfolio firms to obtain higher long term leverage. This result implies that syndication still introduces more long term financing, such as bank loan, to firms to release financial constraint and firms may allocate more resource on innovation activity, which will be examined in next stage. The result keeps the same when GVC standalone.

Table 3.9 reports a series of Tobit and random effect model with industry and year fixed effect results for R&D intensity with GVC dummy, to identify the impact of GVC investment on the innovation input of portfolio firms. We notice that the dummy variable GVC DUMMY is positively significant with R&D intensity, which demonstrates that GVC backed firms invest more funds in innovation activity to improve their innovation capability. The result keeps significant when GVC syndicated with PVC.

5.2. Networking Facilitating Channel

VC often provides a variety of services that considerably enhances the success probability of invested firms can be provided by VCs, such as helping in making strategic decisions, fostering innovation by increasing research and develop (RD) expenses and patenting activities, bringing in broader contact networks in the product market, providing better management and employee incentives, helping in recruitment of competent management, and so on (Casamatta, 2003; Hellmann, 1998; Kortum and Lenrer, 2000; Spiegel and Tookes, 2008).

Table 3.10 reports the estimation results on how GVCs influence POE's innovation capability measured by average application-grant time-lag of invention patents after PSM. The benefit of the government background VC is more evident in this table. We notice that the dummy variables for the government VC background (GVC DUMMY) and syndication investment (SYNDICATION) keep negatively significant in all of these models, which demonstrates that firms backed by governmental venture capitalists spend less time to get patent granted successfully. This result indicates that the involvement of governmental venture capitalists facilitates portfolio firms to apply for patent and therefore improve their innovation capability.

Table 3.9 The relationship between GVC investments and financial leverage measured by average leverage, long term leverage, short term leverage by the firm in the given year.

	(Long Term Leverage)$_{t+1}$		(Long Term Leverage)$_{t+1}$	
	(1)	(2)	(4)	(5)
	OLS	RE	OLS	RE
GVC DUMMY	1.337***	1.303*		
	(3.98)	(2.42)		
SYNDICATION			1.447***	1.330*
			(3.81)	(2.15)
GVC			1.061	1.242
			(1.92)	(1.42)
ASSETS	0.482***	0.441***	0.481***	0.440***
	(10.30)	(7.44)	(10.25)	(7.43)
HIGHTECH	0.553	0.585	0.551	0.585
	(1.21)	(0.84)	(1.21)	(0.84)
ROA	1.821	-1.264	1.786	-1.267
	(1.11)	(-0.83)	(1.09)	(-0.84)
EPS	0.0122	0.00740	0.0135	0.00749
	(0.11)	(0.08)	(0.13)	(0.08)
LIQUIDITY	-21.97***	-18.28***	-21.97***	-18.28***
	(-25.98)	(-18.54)	(-25.98)	(-18.54)
TANGIBILITY	1.552	1.647*	1.532	1.645*
	(1.94)	(2.00)	(1.91)	(2.00)
R&D	17.68***	2.714	17.70***	2.712
	(8.29)	(1.21)	(8.30)	(1.21)
_CONS	24.12***	28.50***	24.10***	22.47***
	(5.61)	(11.12)	(5.61)	(6.47)
N	5708	5708	5708	5708
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes

Legend: this is a series of Tobit model, negative binomial regression and random effect model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i' s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i' s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i' s total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.10 Difference in the impact of GVC investment, Syndication and GVC standalone investment on the R&D intensity, defined as the R&D expenditure divided by total sales by the firm in the given year (PSM Sample).

	(R&D Intensity)$_{t+1}$		(R&D Intensity)$_{t+1}$	
	(1)	(2)	(4)	(5)
	TOBIT	RE	TOBIT	RE
GVC DUMMY	0.00674**	0.00603*		
	(3.24)	(1.69)		
SYNDICATION			0.00129	0.000596*
			(0.56)	(0.14)
GVC			0.00608 *	0.00519
			(2.14)	(1.06)
ASSETS	-0.00244***	-0.00197***	-0.00216***	-0.000919**
	(-8.45)	(-5.48)	(-7.59)	(-2.70)
HIGHTECH	0.02529***	0.0268***	0.02482***	0.0271***
	(9.03)	(5.85)	(8.79)	(5.91)
ROA	-0.22301***	-0.203***	-0.22961 ***	-0.215***
	(-22.84)	(-23.74)	(-23.56)	(-25.24)
EPS	0.00135*	0.00112*	0.00150**	0.00123*
	(2.02)	(2.21)	(2.24)	(2.39)
LIQUIDITY	-0.02088***	-0.0134*	-0.02121***	-0.0162**
	(-4.61)	(-2.25)	(-4.04)	(-2.73)
TANGIBILITY	0.05384***	0.0278***	0.06137***	0.0422***
	(10.96)	(5.67)	(12.86)	(9.12)
_CONS	-0.02923	-0.0104	0.02218***	0.0250*
	(-0.27)	(-0.28)	(3.20)	(2.46)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes		Yes
N	5656	5656	5656	5656
Log pseudo likelihood	6871.42		6838.76	

Legend: this is a series of Tobit model, negative binomial regression and random effect model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i' s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i' s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i' s total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.11 The relationship between GVC investments and PTO of POE firms listed on NEEQ China, in which IPTO is measured by average application-grant time-lag of invention patents (PSM Sample).

	PTOt+1					
	(1) Poisson	(2) NBR	(3) TOBIT	(4) Poisson	(5) NBR	(6) TOBIT
GVC DUMMY	-0.0336***	-0.277***	-34.87			
	(11.92)	(-3.58)	(-0.95)			
SYNDICATION				-0.0664***	-0.325***	-17.43
				(21.31)	(-3.78)	(-0.41)
GVC				-0.0137***	0.0970	-4.413
				(3.61)	(0.97)	(-0.09)
ASSETS	0.184***	0.459***	84.81***	0.182***	0.462***	83.85***
	(159.12)	(15.05)	(6.15)	(157.37)	(15.03)	(6.07)
HIGHTECH	0.504***	0.542***	102.7*	0.502***	0.550***	102.0*
	(159.28)	(6.50)	(2.25)	(158.69)	(6.58)	(2.23)
ROA	0.916***	0.728	185.0	0.906***	0.735	185.6
	(59.42)	(1.75)	(1.37)	(58.72)	(1.76)	(1.37)
EPS	-0.00297**	-0.0427	2.252	-0.00260*	-0.0439	2.158
	(-2.64)	(-0.95)	(0.21)	(-2.30)	(-0.97)	(0.20)
LIQUIDITY	-0.240***	-0.257	-16.86	-0.246***	-0.234	-17.32
	(-35.53)	(-1.47)	(-0.23)	(-36.26)	(-1.33)	(-0.23)
TANGIBILITY	-0.465***	0.290	41.71	-0.467***	0.295	41.11
	(-68.65)	(1.75)	(0.65)	(-68.88)	(1.78)	(0.64)
R&D	1.486***	2.442***	499.4**	1.482***	2.439***	494.5**
	(90.86)	(5.80)	(2.97)	(90.72)	(5.77)	(2.94)
_CONS	1.035***	-11.21***	-2295***	1.066***	-11.32***	-2287.5***
	(43.37)	(-17.96)	(-6.15)	(44.58)	(-17.94)	(-6.11)
Industry Effect			Yes			Yes
Year Effect			Yes			Yes
N	5708	5708	5708	5708	5708	5708
Log pseudo likelihood	-887096	-14264	-12319	-886915	-14263	-12320

Legend: this is a series of Tobit model, negative binomial regression and random effect model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i' s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i' s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i' s total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6. Supplementary analyses and further robustness check

We disentangle the mechanisms of the impacts of GVC investment on portfolio firms. Table 8 summarizes the estimate results for the relationship between firms' financial performance measured by ROA and ROE with GVC investment. We figure out that the dummy variable for syndication is not significant with either ROA or ROE. This finding might indicate that, GVC investments cannot help their portfolio firms to obtain higher financial performance.

Table 3.11 summarizes the estimate results for the relationship between firms' financial performance measured by ROA and ROE with GVC investment. We figure out that the dummy variable for GVC DUMMY is not significant with either ROA or ROE. This finding might indicate that, GVC investments cannot help their portfolio firms to obtain higher financial performance. This result keeps insignificant whenever GVC investment or syndication investment.

We further exam the impact of GVC investment on the growth capability of portfolio firms in terms of employee growth and sales growth. Table 3.12 reports a series of estimation results for employee growth and sales growth produced by the firm with GVC dummy and syndication dummy. It demonstrates that the dummy variable for GVC DUMMY is not significant with employee growth and sales growth. GVC-backed firms produce significantly more patents than non-GVC-backed firms. However, the ROA, ROE, sales growth and other firm performance indicators between GVC-backed firms and non-GVC-backed firms are not different. So this suggests that the increase in patents activities do not translate to better firm performance for GVC-backed firms.

Table 3.12 Difference in the impact of GVC investment, Syndication and GVC standalone investment on financial performance measured by ROA and ROE produced by the firm in the given year(PSM Sample).

	ROA_{t+1}		ROE_{t+1}	
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
GVC DUMMY	0.00850		0.0144	
	(1.77)		(1.48)	
SYNDICATION		0.417		2.286
		(0.12)		(1.38)
GVC		-0.354		-1.039
		(-0.06)		(-0.42)
ASSETS	0.000597	-0.228	0.00128	0.0142
	(1.15)	(-0.55)	(1.13)	(0.07)
HIGHTECH	0.00197	-1.952	0.000350	-0.925
	(0.32)	(-0.42)	(0.03)	(-0.46)
LIQUIDITY	0.0596***	7.891	0.139***	4.440
	(6.80)	(0.91)	(7.17)	(1.20)
TANGIBILITY	0.138***	-2.863	0.110***	-4.747
	(19.18)	(-0.33)	(6.70)	(-1.30)
R&D	-0.454***	-14.06	-0.704***	-8.736
	(-23.82)	(-0.69)	(-16.24)	(-0.92)
_CONS	0.000597	58.20	0.00128	-3.024
	(1.15)	(1.66)	(1.13)	(-0.13)
N	5878	5878	5878	4454
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes

P-values in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Legend: this is a series of Tobit model, negative binomial regression and random effect model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i's total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i's total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i's total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i's total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* p < 0.05, ** p < 0.01, *** p < 0.001

Table 3.13 The relationship between GVC investments and financial performance measured by employee growth and sales growth produced by the firm in the given year. (PSM Sample).

	$(\text{Employee Growth})_{t+1}$		$(\text{Sales Growth})_{t+1}$	
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
GVC DUMMY	0.246		1.367	
	(0.08)		(0.93)	
SYNDICATION		0.417		2.286
		(0.12)		(1.38)
GVC		-0.354		-1.039
		(-0.06)		(-0.42)
ASSETS	-0.224	-0.228	0.0290	0.0142
	(-0.55)	(-0.55)	(0.15)	(0.07)
HIGHTECH	-1.950	-1.952	-0.908	-0.925
	(-0.42)	(-0.42)	(-0.45)	(-0.46)
ROA	-8.620	-8.487	2.793	2.618
	(-0.38)	(-0.37)	(0.37)	(0.35)
EPS	6.398	6.373	-0.167	-0.171
	(1.49)	(1.48)	(-0.30)	(-0.31)
LIQUIDITY	7.871	7.891	4.469	4.440
	(0.91)	(0.91)	(1.21)	(1.20)
TANGIBILITY	-2.740	-2.863	-4.517	-4.747
	(-0.32)	(-0.33)	(-1.24)	(-1.30)
R&D	-14.11	-14.06	-9.034	-8.736
	(-0.70)	(-0.69)	(-0.95)	(-0.92)
_CONS	58.08	58.20	-3.132	-3.024
	(1.66)	(1.66)	(-0.13)	(-0.13)
N	1898	1898	4454	4454
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes

Legend: this is a series of Tobit model, negative binomial regression and random effect model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i' s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i' s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i' s total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.14 Relationship between innovation activity and financial performance of POE firms listed on NEEQ China (PSM Sample).

	(1)	(2)	(3)	(4)
	ROA_{t+1}	ROE_{t+1}	(Sales Growth)$_{t+1}$	(Employee Growth)$_{t+1}$
PATENT	0.000310	0.000493	-0.0457	-0.00145
	(1.97)	(1.36)	(-0.54)	(-0.36)
ASSETS	0.000198	0.000268	0.108	0.0319***
	(0.40)	(0.24)	(0.50)	(3.59)
HIGHTECH	0.00225	0.000822	-0.876	-0.133
	(0.39)	(0.07)	(-0.39)	(-1.03)
ROA	0.0164***	0.0334***	0.0444	0.0168
	(22.77)	(19.63)	(0.10)	(0.35)
EPS	0.0564***	0.133***	5.135	-0.257
	(6.69)	(7.01)	(1.28)	(-1.35)
LIQUIDITY	0.136***	0.105***	-5.827	-0.628***
	(19.46)	(6.51)	(-1.56)	(-3.95)
TANGIBILITY	-0.442***	-0.675***	-6.806	-0.523
	(-23.86)	(-15.79)	(-0.70)	(-1.56)
R&D	0.000310*	0.000493	-0.0457	-0.00145
	(1.97)	(1.36)	(-0.54)	(-0.36)
_CONS	0.0128	-0.0350	-1.388	1.412**
	(0.23)	(-0.25)	(-0.06)	(3.06)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
N	5656	5656	4434	1899

Legend: this is a series of Tobit model, negative binomial regression and random effect model for the patent number, the proportion of novel patent, citing number, family size and citation number of GVC backed and PVC backed firms, after performing GVC backed firms a one to five propensity score matching with replacement by location, industry, age, total assets, leverage and sales of the firm. Independent variables include GVC DUMMY, a dummy variable that is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. The dependent variables include: PATENTt+1, denotes the firm i' s total number of invention and utility patents filed (and eventually granted) after one year that companies received investment. PROPORTION OS NOVEL PATENT t+1 denotes as the proportion of novel patents among all the patents produced by the focal firm in year t+1. CITING t+1 denotes firm i' s total citing number of all patents filed (and eventually granted) in year t+1, which measure the technical innovativeness of patent. FAMILY t+1 denotes firm i' s total family number of all patents filed (and eventually granted) in year t+1, which measure the value of patent. CITATION t+1 denotes firm i' s total number of citations a patent received in year t+1, which measure the quality of patent. Control variables include ASSETS, which is measured by the total assets of a firm in calculated year divided by 10 million; LEVERAGE refers to the leverage ratio of the company, defined as the value of debt divided by the value of total assets measured at the end of fiscal year t; HIGHTECH is a dummy variable, equals to one if the firm belongs to high technology industry on the classification of CSRC and zero if otherwise; EPS refers to earning per share, measured at the end of fiscal year t; LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t; TANGIBILITY refers to the tangible assets ratio of the company, defined as the value of tangible assets divided by the value of total assets measured at the end of fiscal year t; R&D refers to R&D expenditures divided by book value of total sales at year t, set to zero if missing. Industry and year dummies are included in the estimates (coefficients are omitted in the table). t statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.14 reports the estimation results on the impacts of innovation capability, measured by patent number, on POE's financial performance and growth capability, measured by ROA, ROE, employee growth and sales growth produced by the firm in the given year. It is shown the dummy variable for PATENT is not significant with all dependent variables, including ROA, ROE, employee growth and sales growth. This finding demonstrates that, firms with more patent number cannot obtain higher financial performance and growth capability and further indicates these patents are not substantive and more incremental.

7. Conclusions

Previous literature demonstrates that different type of VC investors has a different impact on the innovation capability of their portfolio companies. Ours study provides new evidence to the literature about the relationship between governmental venture capital (GVC) investments and development of SMEs in China. Our study find that firms backed by GVC achieve a better innovation capability than their counterparties in terms of patent number, the proportion of novel patent, citing number, family size and citation number. The positive effects on innovation are even stronger for those syndicated investments and, which are consistent with the dynamic interactions between VCs and portfolio firms. The interplay of GVC and PVC play an important role in helping Chinese SMEs to improve innovation capability in this pilot over-the-counter equities market. These results are robust to a variety of estimations and specifications.

We further disentangle the mechanisms of the impacts of syndication investment on portfolio firms. We investigate that syndication investments facilitate their portfolio firms to obtain higher long-term leverage but lower short term leverage, which implies that syndication investment introduces more long-term financing, such as bank loan, to firms to release financial constraint and firms may allocate more resource on innovation activity. And portfolio firms invest more funds in innovation activity after receiving funding. In addition, we investigate additional evidence that firms backed by governmental venture capitalists spend less time to get patent granted successfully. This result indicates that syndication firms get their patent approval from patent application faster than non-GVC-backed firms and therefore achieve higher patent number.

However, no evidence is found that syndication firms can outperform PVC backed firm in terms of ROA, ROE, sale growth, and employee growth, suggesting that the increase in patents activities do not translate to better firm performance for GVC-backed firms. No evidence is found that GVC investors provide value added service to improve innovation capability of portfolio firms. This suggests that the increase in patents activities do not translate to better firm performance for GVC-backed firms.

Innovation and entrepreneurship are taken as the key drivers of economic growth in the China at present. Our paper confirms that GVC financing, among heterogeneous capital goods, is a key engine that drive innovation and entrepreneurship in China The straightforward finding that Chinese GVCs have released financial constraints, created values and generated innovation gains to SMEs contains strong implications for policy makers who concern with industrial upgrading and structural changes in the Chinese economy. Promoting the development of the VC industry in China's multi-layer capital market, encouraging more syndicated VC investments and letting venture capitalists with government background play a bigger role are rather important in nurturing innovation and entrepreneurship in future's China.

It is important to acknowledge, however, that our research has also some limitations. This paper only scratches the surface in studying the role and effectiveness of GVC investments in promoting innovation. In the future studies, how entrepreneurs and venture capitalists interact in China's SMEs shall also be examined through field research

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Appendix

Table 3.15 Average number of granted invention patents of Pure_GVC_backed firms and Pure PVC_backed firms.

	Pure GVC_backed firms	Pure PVC_backed firms
2005	0.06	0.05
2006	0.10	0.09
2007	0.22	0.17
2008	0.43	0.24
2009	0.54	0.39
2010	0.96	0.48
2011	1.04	0.70
2012	1.48	1.00
2013	1.40	1.00
2014	1.38	1.14
2015	1.24	1.10

Table 3.16 Average number of novel patents of Pure_GVC_backed firms and Pure PVC_backed firms.

	Pure GVC_backed firms	Pure PVC_backed firms
2005	0.01	0.01
2006	0.03	0.02
2007	0.07	0.04
2008	0.08	0.05
2009	0.07	0.08
2010	0.13	0.08
2011	0.14	0.10
2012	0.23	0.13
2013	0.24	0.13
2014	0.13	0.14
2015	0.19	0.14

Table 3.17 Average percentage of novel patents of Pure_GVC_backed firms and Pure PVC_backed firms.

	Pure GVC_backed firms	Pure PVC_backed firms
2005	0.00	0.01
2006	0.02	0.01
2007	0.03	0.02
2008	0.04	0.02
2009	0.04	0.03
2010	0.04	0.03
2011	0.07	0.03
2012	0.07	0.04

2013	0.08	0.03
2014	0.03	0.03
2015	0.08	0.03

Table 3.18 Descriptive Statistics of three types of syndication investment.

variable	No. of firms	Mean	Median	St.dev.
Panel A: GVC leads Syndication				
Number of patent	91	**1.36**	0	5.11
Number of novel patent(Year)	91	**0.27**	0	2.33
Proportion of novel patent(Year)	91	**0.04**	0	0.15
Age	91	9.89	9	5.71
Size	91	19.24	19.25	1.32
ROA	91	0.03	0.04	0.13
Leverage	91	0.42	0.4	0.22
R&D intensity	91	0.10	0.06	0.11
High-tech	91	0.66	1	0.48
Panel B:GVC and PVC syndicated at same round				
Number of patent	83	**0.91**	0	2.89
Number of novel patent(Year)	83	**0.13**	0	0.55
Proportion of novel patent(Year)	83	**0.04**	0	0.15
Age	83	9.44	9	5.81
Size	83	19.28	19.25	1.47
ROA	83	0.04	0.05	0.12
Leverage	83	0.42	0.41	0.23
R&D intensity	83	0.11	0.06	0.16
High-tech	83	0.60	1	0.49
Panel C: PVC leads Syndication				
Number of patent	142	**0.64**	0	2.02
Number of novel patent(Year)	142	**0.07**	0	0.4
Proportion of novel patent(Year)	142	**0.02**	0	0.13
Age	142	8.98	9	5.53
Size	142	19.06	19.18	1.38
ROA	142	0.03	0.05	0.15
Leverage	142	0.40	0.38	0.23
R&D intensity	142	0.10	0.06	0.14
High-tech	142	0.61	1	0.49

CHAPTER IV: GOVERNMENTAL VENTURE CAPITAL AS A FREE RIDER OR A VALUE CREATOR? EVIDENCE FROM CHINA

Abstract

This papers studies whether and how governmental venture capital firms (GVC) affect success of innovative companies in China's third-tier equity market. Using a comprehensive set of data for Chinese small and medium sized firms listed in the National Equities Exchange and Quotations (NEEQ), we find, compared to insignificant impacts of standalone investments from only GVC or private venture capital firms (PVC), syndicated investing of GVC and PVC significantly enhances success chance of firm graduation (IPO) to main stock markets. We also identify the three mechanisms through which syndications help firms graduate to main stock markets, namely resource allocation, information sharing, and innovation nurturing. Further investigation based on a quasi-natural experiment indicates that syndication impacts are more pronounced for nine key sectors that were supported by a national innovation-driven development strategy. Moreover, GVC as a later-stage investor in the syndication are more likely to enhance firm performance than those being an earlier-stage investor, which indicates that they play a facilitating rather than leading role in value creation process.

Keywords Syndication, Resource allocation, Information sharing, Innovation nurturing

JEL Classification G24 · G38

1. Introduction

Steadily rising importance of governmental venture capital firms (GVC) in many countries attracts researchers to evaluate their performance and impacts (Lerner, 1999; Gompers and Lerner, 2004; Bottazzi et al., 2008; Howell, 2014; Guerini and Quas, 2016; Zhang and Mayes, 2018; Dong et al., 2021). Despite the well-noted rationale of addressing market failures by filling in "funding gap" of entrepreneurial start-ups or innovative firms (Alperovych et al., 2020), empirical evidence on GVC performance or impact is rather mixed. Some prior studies document the successful experiences of promoting both the local venture capital markets and corporate innovation activities, such as the Small Business Investment Company (SBIC) in the US and the Yozma Program in Israel (Lerner, 1999; Gompers and Lerner, 2004; Howell, 2014). But others warn about a bunch of failures of government efforts in fostering venture capital industries and enhancing firm productivities, such as in Canada and European countries (Cumming and Macintosh, 2006; Brander et al., 2008; Cumming et al., 2017; Grilli and Murtinu, 2014). Overall evidence in this strand of studies suggests that GVC funds do not add extra value to their investees, underperform their private peers, or even crowd-out private investment (Alperovych et al., 2020).

Despite the policy interest, due to a lack of detailed data, there is relatively little well-identified empirical evidence evaluating how GVC affect innovative activities and performance of relatively young or small- and medium sized companies (hereafter, SME) in China. Only a very limited number of studies examine whether China's GVC affect portfolio firms, such as Zhang and Mayes (2018), Ke and Wang (2020) and Dong et al. (2021), and almost all of them suggest GVC underperform their private peers, or generate negative consequences on investees. Zhang and Mayes

(2018) show that portfolio companies backed by GVC underperform those backed by PVC in going public. Ke and Wang (2020) find that on average GVC underperform domestic PVC in both exit and innovation performance. Dong et al. (2021) document that GVC negatively affects green innovation, which is potentially attributed to the risk aversion and adverse selection of the GVC managers.

We start the sample with 13475 companies in the China's National Equities Exchange and Quotations (NEEQ) market over the period of 2009 to 2020. The institutional features of China's NEEQ make it a unique experience to explore. Being established upon over-the-counter equities market in Beijing, the NEEQ market is widely known as the New Third Board, namely the third-tier national equity trading revenue just after Shanghai and Shenzhen stock exchanges. Since its formal registration, it has been dedicated to providing equity financing support and trading service for innovative, high-growth SME in China. The development of NEEQ has gradually boosted the financial and innovation practice of SME by offering trading systems and infrastructures, improving market liquidity, and enhancing information disclosure quality, and so on.

We adopt a commonly used proxy for the successful exit from portfolio companies - exits through IPO, namely graduation to the main stock market, which represent the greatest profit for venture capitalists (Chen et al., 2010; Ewens and Rhodes-Kropf, 2015). The successful graduation of NEEQ firms provides a rare opportunity to explore GVC impact on innovation and performance of SME. Based on the statistics given by the China Ministry of Industry and Information Technology, SME contributes up to 60% of GDP and 70% of technological innovation in 2020 (Wang, et al., 2021). It is well noted that innovative SME experience more severe challenges in accessing external finance due to information asymmetries, lack of collaterals, and uncertainty in innovation activities (Lerner, 1999, 2002; Cressy, 2002; Alperovych et al., 2020). Thus, our investigation on effectiveness of GVC investment in SME provides important policy implications to the subject of innovation and economic growth.

The institutional features of the China's venture market are very unique. China is renowned for state capitalism (Lazzarini, 2015; Li et al., 2015; Bardhan, 2016; Sun and Cao, 2018; Lazzarini et al., 2020). The Chinese state has played an important role of coordinating between various industrial and innovation policies, but misallocation of innovation resources by governments are not unusual (Boeing, 2016; Wei et al., 2017). Although a substantial body of economic research indicate potential negative consequences of government sponsored or supported venture capital investments in some developed countries (Cumming and Macintosh, 2006; Brander et al., 2008; Wallsten, 2000; Grilli and Murtinu, 2014; Alperovych et al., 2020), China have embraced the development of GVC without reservation since 1997, in particularly after 2009, and shifted a large proportion of government capital supply from subsides to venture capital. Thus China's state sponsored or supported VC industry has developed very fast in the last two decades and ranked top 1 in the world in term of total investment value since 2019.

Guided by government innovation and industrial policies, China's GVC are usually committed to developing indigenous technological capabilities by collaborating with their private peers, or by fostering their own champion portfolio companies to close technology gaps with the rest of the world (Author interview). However, being equivalent to state owned enterprise (SOE), GVC also face severe challenges such as resource misallocation, risk aversion and agency problems, and thus may underperform or take a free ride of their private peers (Ke and Wang, 2020; and Dong et al., 2021). Institutional forces behind GVC as well as interactions between GVC and PVC involves high complexities and are likely to result in a significant impact on SME graduation performance in China's NEEQ market.

With Chinese GVC's unique institutional background in mind, we provide a conceptual framework in Section 2. After reviewing recent development of China's VC industry, we conjecture that syndicated investing of GVC and PVC significantly increases the likelihood that companies will graduate from NEEQ to main stock markets in China, while standalone investments from only GVC or private venture capital firms (PVC) are much less effective or valuable. We consider three plausible mechanisms through which the syndication of GVC and PVC influences firm innovation and graduation outcomes: (1) the resource allocation channel. That is; (2) the information sharing channel. (3) The innovation nurturing channel.

This study also exploits as an exogenous innovation policy shock and investigates the impact of exposure to this major change in policies on GVC investment behavior and outcomes. Government supports for promoting high quality innovation in a certain amount of strategic industries has become a national-level policy in China since 2016. On May 20, 2016, the Central Committee of Chinese Communist Party and the State Council jointly issued the *Outline of the National Innovation-driven Development Strategy*. The Outline has not only laid out the concrete targets and tasks of innovation development but also made arrangement for institutional innovation and ecosystem cultivation in the long run. It gave strategic importance to nine industries in the national innovation system, and thus represents an exogenous policy shift towards promoting a treatment group of innovative companies, making it an attractive natural experiment to assess GVC' reaction towards national industrial and innovation policies as well as the consequent impact on firm performance.

Consistent with our conjecture, we find that syndicated investments of both GVC and PVC have a significant positive impact on firm innovation and exit by graduation in the NEEQ market. In comparison, standalone investments from only GVC or PVC are not significantly associated with enhanced success chance of SME. One concern about our empirical strategy is that there are some omitting variables might be driving the determinants of the success chance of firm graduation. Thus, the last step of our empirical analyses is to further assess the robustness and to address endogeneity concerns. We adopt both propensity score matching (PSM), instrumental variables (IV), and difference-in-difference (DID) estimation methods to address the endogeneity concerns and find convincing support of main hypotheses. We also employ alternative definitions of our dependent and key explanatory variables and the main results continue to hold. Overall, the findings are consistently robust to the use of alternative econometric models and variable definitions.

The paper contributes to several streams of literature. First, this study makes a non-incremental contribution to the theoretical and empirical literature on effectiveness of government support in promoting innovation in developing countries like China. Prior literature document that government support is vital for nurturing and promoting corporate innovation, especially in young innovative companies (Zhou et al., 2017; Wang, 2018; Alperovych,et al., 2020). However, relatively little evidence has been provided on the GVC impact on innovation in China. Our study adds to the literature studying the effectiveness of government support in form of GVC investment by exploring a unique equity market in China.

Second, our paper enriches the understanding on VC syndication. In line with several studies such as Tian (2012), Cumming et al. (2014), Kovner and Lerner (2015) and Alperovych et al. (2020), it provides clear evidence for the existence of positive syndicated VC investment externalities on the innovative performance of SMEs due to three plausible channels, namely resource allocation, information sharing and innovation nurturing. Hence it complements the fast-growing literature exploring the interconnections among venture capital, public and private VC alliance, and firm innovation.

Third, it is related to the literature on the VC exits. Our research adds new and richer evidence to this strand of literature by examining heterogeneous interactive impacts of venture capital investments in promoting technology innovation of SMEs in developing countries.

Our empirical findings proffer insightful policy implications. In compared with PVCs, GVC has played a facilitating role rather than a leading role in facilitating innovation of SMEs in China. GVC, only when syndicated with PVC, are capable of creating value by channels of resource allocation, information sharing and innovation nurturing.

Besides, when GVC act as a later-stage investor, while their positive impact on firm performance is less significant when acting as an earlier-stage investor. The empirical results speak directly to recent trends in China's VC market and innovation policies that have attracted considerable attention from policy makers.

The rest of the paper is organized as follows. In the second section, we explore the theoretical and empirical evidence of GVC and firm performance in the existing literature, and put forward the testable hypotheses. In section 3, we describe the data and methodology adopted in the empirical tests. The baseline empirical result and the cross sectional heterogeneity are then presented in Section 4. Section 5 discusses the three plausible influencing channels. Section 6 presents the robustness check results as well as further corrections for possible endogeneity. Finally, the conclusion is drawn and the future research is discussed in Section 7.

2. Background, Literature and Conceptual Framework

In this section, we briefly describe the current development of China's VC industry, develop theoretical arguments on the impact of GVC on firm performance, and discuss the experimental setting of the 2016 innovation policy. We also posit that there are several influencing channels for syndication of GVC and PVC to exert effects.

2.1. Recent development of GVC in China

Since adoption of the economic reform policy in 1978, China has experienced more than four decades of rapid economic growth and industry development, which is partially based on the exploitation of low-wage and demographic advantages. However, it now confronts severe challenges such as higher wages and a shrinking workforce. Thus, China needs to move to a growth model that is based more on innovation and to embrace a shift to a more innovative economy (Wei et al., 2017). Globally, government support for innovation takes a variety of forms including state ownership, provision of tax allowances, loans, grants, education and training, special organizations, information supply, government procurement, registration, and regulation (Guan and Yam, 2015; Zhou et al., 2017). At present, China is employing a variety of policy tools to enhance its corporate innovation activities, and academic evidence generally shows that a large portion of firm R&D and innovation in China has been driven by the Chinese government (Guan and Yam, 2015; Guo et al., 2016). Among these policy tools, government venture capital has gained an increasing attention and occupied a more significant strategic importance.

China's GVC firstly appeared in the VC market in 1997. In 2007, the Interim Management Measures for high-tech SME Venture Capital Guidance Funds was jointly prepared and issued by the MOF and Ministry of Science and Technology, and China's first state-level high-tech SME venture capital guidance fund be launched. In October 2008, Chinese State Council issued *the Guideline on Standardized Establishment and Operation of Venture Capital Guidance Funds* that was jointly by proposed by National Development and Research Committee, Ministry of Finance and Ministry of Commerce. The Emerging Industries Venture Capital Plan shall be operated in accordance with the Interim Management Measures for the Emerging Industries Venture Capital Plan to Invest in Venture Capital Funds issued by MOF and NDRC in 2011.

GVC in China mainly aim to serve national strategies, optimize the layout of state-owned capital and enhance industrial competitiveness. According to the requirements for the layout and structural optimization of state-owned capital, they hold strategic businesses in essential industries and key areas related to national security and the lifeblood of the national economy. With the goal of central enterprises' innovation and collaborative development, state-owned capital participates in establishing sub-funds, and state-owned enterprises, central enterprises and social capital jointly initiate the establishment of industrial funds.

Funds with state-owned capital, primarily government-guided funds, are policy-oriented, established to drive local economic development and promote industrial restructuring. As a result, it faces some restrictions, such as investment areas and regions, by setting the return ratio. The state-owned venture capital fund, led by the China Reform Holdings Corporation Ltd., jointly established by central enterprises, manages a full scale of 200 billion yuan. GVC have started to invest more aggressively since 2009 (Figure 1). Based on statistics provided by Zero2IPO data vendor in China, in 2008, the total amount of GVC investments in China was only 16,023.44 million, which was about 14% of total VC investment, 117,90.29 million, but this number increased to 45,017.62 million (29% of total VC investment of 157,839.13 million) in 2009, and 312,226.68 million (35% of total VC value of 901,298.45 million) in 2020.

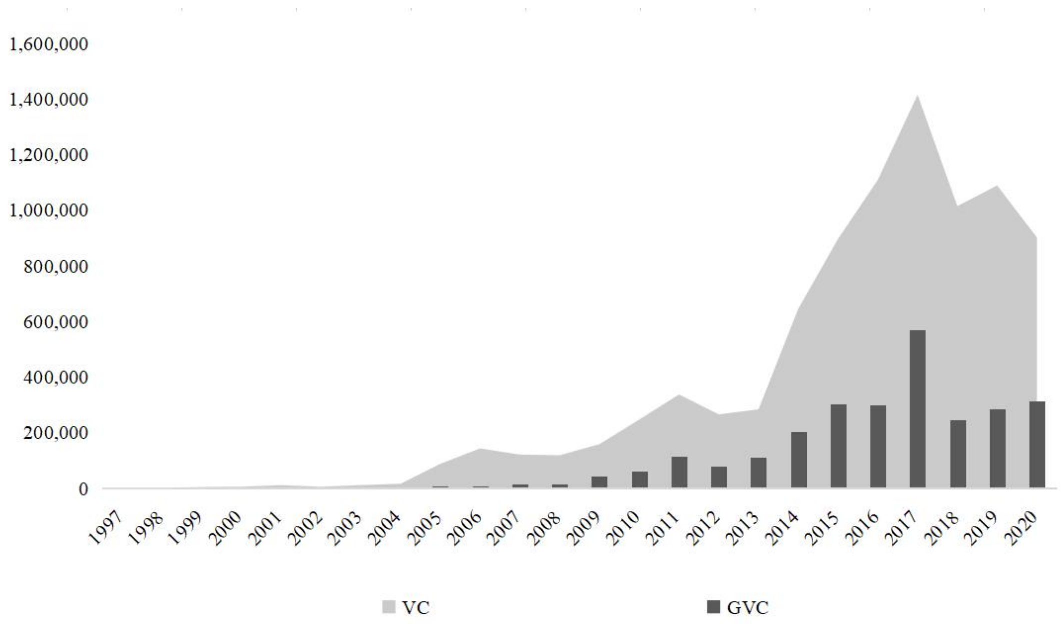

Figure 4.1 Total value of GVC and VC investments in China (Millions).

The overall management scale of fund managers with state-owned backgrounds occupies a large proportion of the equity market, and the scale is relatively large. As of 2019, about 26.6% of the managers of private equity and venture capital funds registered in the CFPA have a state-owned background, while the scale of funds under their management subscriptions accounts for 60.5% of the overall scale. Compared with private capital, fund managers with state-owned backgrounds have relatively stronger financial resources and more cases with a contribution scale of over 1 billion.

Data summary statistics in Table 1 reveal that by the end of 2020, there are about 7222 GVCs in China, which is about 20% of total number of VCs. Total investment deals of GVC are about 34,341, about 20% of total VC deals. Total investment amount of GCV is about 2,771,300 million, about 30% of total VC value. GVC are more likely to invest in Pre-IPO firms or mature companies, and invest the least in seed stage of entrepreneurial firms. The average investment of GVCs, 366.33 million is higher than that of VCs, 246.75 million. It is generally consistent with the argument of Dong et al. (2021) that Chinese GVC managers receive fixed remuneration and are held accountable in case of loss or failure of a GVC investment, and thus a natural risk aversion in managing its portfolios. Thus, GVC are more likely to invest in later-stage rounds.

Table 4.1 Overview of GVC and VC investments in China

Panel A: Institutions, Deals and Amount	GVC	VC	Percentage
No. of Institutions	7,222	35,999	0.20
Total Investment Deals	34,341	120,509	0.28
Total Investment Amounts (Million)	2,671,300	8,882,657	0.30
Ave. Investment Deals	4.71	3.35	1.41
Ave. Investment Amounts (Million)	366.33	246.75	1.49
Panel B: Investment Rounds	GVC	VC	Percentage
Seed	2,266	11,871	0.19
A	14,860	50,781	0.29
B	5,727	21,605	0.27
C	2,504	10,354	0.24
D	1,017	4,357	0.23
E	395	1,783	0.22
F	139	757	0.18
G	86	359	0.24
Pre-IPOx	4,627	10,953	0.42
Panel C: Investment Stages	GVC	VC	Percentage

Seed Stage	3,245	16,323	0.20
Initial Stage	5,696	26,587	0.21
Expansion Stage	14,578	49,873	0.29
Mature Stage	10,469	25,794	0.41

Note: This table provides the overview of GVC and VC investments in China. Panel A reports the cumulative number, deals and amount of GVC and VC institutions in 2020. Panel B reports the deals of GVC and VC investment in different investment rounds between 1984 and 2020. Panel C reports the deals of GVC and VC investment in different investment stages between 1984 and 2020. Percentage represents the ratio of GVC to VC in the category.

Alperovych et al. (2020) point out that GVC policy initiatives in many countries are often designed to target specific industries, most likely high-tech industries, in which both R&D cost and time-to-market are usually considerable. The data we collected indicate that compared to PVC, GVC in China invest heavily in industries of Raw Chemical Materials and Processing, Machinery Manufacturing, Energy and Minerals, Semiconductor and Electronic Equipment, and Clean Technology, but invest less in Internet, Education and Training, and Finance industries (See Table 2). We also find that Chinese GVC are more likely to (or have mandate to) originate transactions locally.

Table 4.2 Summary of VC investment on NEEQ firms and graduates

Panel A: NEEQ Firms	No. of Firms	Percentage
VC backed firms:	4433	0.33
Syndication backed firms	1794	0.13
Pure PVC backed firms	1686	0.13
Pure GVC backed firms	953	0.07
Non-VC backed firms	9042	0.67
Total NEEQ firms	13475	1.00
Panel B: NEEQ Graduates	No. of Firms	Percentage
Syndication backed firms	218	0.55
Pure PVC backed firms	61	0.15

Pure GVC backed firms	35	0.09
Non-VC firms backed firms	85	0.21
Total	399	1.00

Fund managers with state-owned backgrounds cluster in Beijing, Shanghai and Guangzhou. As the political and cultural center of China, Beijing gathers many regulatory departments and headquarters of central enterprises to register. The concentration of regulatory departments, large central enterprises and state-owned enterprises' headquarters are conducive to fund product filing, state-owned LP funding and supervision and other fund operation management. Guangdong, with its convenient geographical location and open policy conditions, has a good business environment, which provides an excellent economic foundation for the development of the equity investment market. In addition, Guangdong develops guiding funds and has conducted many policies to support opening up to other countries, industrial restructuring, business incubation and financial market services, facilitating state-owned capital operation from the superstructure level.

Table 4.3 Industry distribution of GVC and VC investment deals in China by 2020

Industry	GVC	VC	Percentage
Raw Chemical Materials and Processing	1,664	3,807	0.44
Machinery Manufacturing	3,021	7,078	0.43
Energy and Minerals	764	1,815	0.42
Semiconductor and Electronic Equipment	3,737	8,942	0.42
Clean Technology	1,932	4,648	0.42
Agriculture, Forestry, Animal Husbandry and Fishery	567	1,436	0.39
Radio, TV, and Digital TV	126	321	0.39
Architecture and Engineering	787	2,023	0.39
Textile and Garment	228	687	0.33
Food and Beverage	521	1,631	0.32
Automotive	803	2,557	0.31
Biotechnology and Healthcare	4,908	16,129	0.30
Entertainment & Media	1,322	5,178	0.26
Information and Technology	5,207	20,988	0.25
Logistics	334	1,404	0.24
Real Estate	486	2,105	0.23

Chain and Retail	600	2,695	0.22
Telecommunications and Value-Added Business	1,338	6,163	0.22
Finance	1,176	5,982	0.20
Education and Training	312	1,630	0.19
Internet	3,286	18,851	0.17
Total	33,119	116,070	0.29

Most of the core state-owned fund managers come from the government or state-owned financial institutions. These positions are part-time, short-term, or transferred, affecting the stability and continuity of fund management. Also, the compensation and ranking system of fund managers with a state-owned background cannot reflect the difference in value among positions, resulting in severe brain drain. According to PEdata, only 9.8% of practitioners in state-owned institutions receive project share revenue.

State-owned assets can ensure the safety and reasonable profitability of state-owned assets without or less with the help of market-oriented operation of private capital. State-owned capital has become more familiar with equity operation and fund investment after participating in the equity investment and promoting various policy documents issued by the government, such as the Implementation Opinions on Promoting the Reform Pilot of State-owned Capital Investment and Operation Companies.

GVCs have privileges to acquire governmental resources by leveraging state-owned capital to mobilize capital, access project resources, and even policy preferences in the fundraising, investment, and post-investment management stages. The process of listing is strictly controlled by the government, who has the right to decide whether companies can enter the stock market or not. Although the China Securities Regulatory Commission (CSRC) has abolished the mandatory approval of IPO prices and carried out two rounds of market-oriented reforms on IPO pricing, many cases show that the CSRC still has the final decision on a series of related issues to the listing. Therefore, GVC's investment projects have a better chance to obtain IPO approval. Due to capital attributes, its governance structure as a whole is more obviously politicized: complicated team settings, a high proportion of functional departments, a long investment decision-making process, and the need to face multiple levels of review. It sometimes chooses to moderate the sacrifice of state-owned capital operation efficiency and return level and control risks by setting up perfect investment decision-making and regulatory approval process, which is not conducive to grasping the first opportunity in the rapidly changing market.

2.2. Main hypothesis

It is well noted in the previous literature that venture capitalists (VC) are specialized to overcome problems of information asymmetry and high uncertainty through financing support, managing assistance, and active monitoring (Chemmanur et al., 2011; Kaplan and Stromberg, 2001, 2003, 2004). A growing stand of literature attempts to explain that VCs play significant roles in supporting portfolio firms by not only providing risk money but also supporting and monitoring the management and operation of portfolio companies (Chemmanur et al., 2011; Kortum and Lerner, 2000). Specifically, VCs are able to contribute to the greater success of firm innovation by supporting executives in innovative activities, creating a pro-innovation environment, implementing incentive plans, anticipating technological advancement, and identifying successful innovative projects (Bernstein et al., 2016).

In China, IPO financing is a very scarce resource controlled by the Chinese Securities Regulatory Commission (CRSC), a department of the central government that is equivalent to the Securities and Exchange Commission (SEC) in the US (Wang and

Wu, 2020). Thus GVC usually have more political ties to devote resources to their portfolio companies than PVC, which implies a greater likelihood of IPO approval of their investees.

Nevertheless, one of the major challenges that Chinese GVC usually face is that the majority of them receive funds from government agencies, and are supervised by a variety of government departments at either central or local levels. Thus their top managements have a natural risk aversion attitude due to fixed renunciation packages but being held accountable in case of capital losses of failures of portfolio projects (Zhang and Mayes, 2018; Dong et al., 2021; Author interview). GVC are equivalent to SOEs and potentially face the severe agency problems associated with government ownership. Ke and Wang (2020) argue that GVC in China are more likely to pursue political agendas, which in turn could negatively affect GVCs' managerial incentives. Western experiences have already indicated that solo GVC investments underperform PVC activities in terms of the probability of a successful exit via an IPO (Cumming et al. 2014; Kovner and Lerner 2015).

Another strand of papers attempts to spotlight the importance of VC syndication in the value creation process, e.g. Chemmanur and Tian (2011), Tian (2012), Cumming et al. (2014), Kovner and Lerner (2015). Tian (2012) argue that VC investors have heterogeneous skills, information, industry expertise, and networks, and thus co-investment between different VC is capable of providing a wider range of inputs of investee firms.

Specially, syndication among GVC and PVC funds is identified to have a significant positive impact on the ventures' innovation and exit performances (Cumming et al. 2014; Kovner and Lerner 2015; Alperovych et al., 2020). Bertoni and Tykvová (2015) find that GVC and PVC combine their objectives and resources in the process of syndicated innovation that is more supportive to innovation activities than when they invest on a stand-alone basis. Brand et al. (2015) document that co-investment between GVC and PVC help portfolio enterprise more likely to have a successful exit than solo PVC or GVC investment. Cumming et al. (2017) argue that the GVC and PVC partnership results in the more independent and diversified sources of networks that can facilitate the entrepreneurial firms grow more expansively than merely a PVC syndicate.

With reference to prior research on GVC and PVC programs, we conjecture that GVC-PVC syndication in China are able to allocate more resource, mitigate information asymmetry, promote more innovation, and thus create more value for investees than isolated GVC or solo PVC investment. The combined impact of GVC and PVC goes beyond individual impact of two types of VCs. Thus, we hypothesize as follows:

H1a: Ceteris paribus, the syndication of GVC and PVC funds significantly increases the success chance of innovative SMEs in the NEEQ market compared to solo GVC or PVC investment.

2.3. Plausible influencing mechanisms

Syndicated investments of GVC and PVC have a great potential to create the values to support entrepreneurship and innovation activities. Research investigating the causal mechanisms that relate syndicated VC investment to financial outcomes is abundant, but relatively less evidence is provided on how GVC-PVC alliance affect IPO of portfolio firms. In this section, we discuss three plausible influencing channels, namely resource allocation, government support, and innovation nurturing channels, that help to transmit the positive impact of VC syndication to graduation success of NEEQ firms in the presence of high uncertainty.

The first is the resource allocation channel. Prior literature reveals that fundraising capability of entrepreneurs with very limited access to traditional sources of capital is actually enhanced by venture capital. The recent finance literature records that. VCs often provide a variety of services that considerably enhances the success probability of invested firms can be provided by VCs, such as helping in making strategic decisions, fostering innovation by increasing research and develop (RD) expenses and patenting activities, bringing in broader contact networks in the product market, providing better management and employee incentives, helping in recruitment of competent management, and so on (Casamatta, 2003; Hellmann, 1998; Kortum and Lenrer, 2000; Spiegel and Tookes, 2008).Still other VC firms may excel at fundraising, which adds value by providing deep pockets and a high degree of security for entrepreneurial firms.GVC have better networks to help entrepreneurial firms recruit key employees, line up suppliers, and develop customer relations. Following these prior discussions, we assume that syndication of GVC and PVC can facilitate portfolio firms to raise funds. We propose this to be the resource allocation hypothesis, which is stated as below.

H2: There exist an influencing channel of resource allocation, that is, syndication investment helps firm to release financial constraint, and significantly increases the success likelihood of NEEQ firms.

The second possible channel is possibly transmitted by innovation nurturing channel. We conjecture that GVC are more driven by the long-term strategy and have a strong political incentive to invest larger amounts in riskier and more Research and Development (R&D) intensive firms in strategic industries that take longer to achieve profitability. However, due to lack of selection capabilities and the natural risk aversion attitude, they prefer to follow PVC in detecting promising programs.

Innovation promoting channel, which argues that that GVCs devote more resources to their portfolio companies than do other VCs, resulting in a greater number of patents. For instance, devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000). Additionally, GVCs can offer government network, certification, government subsidy and related industry policy to portfolio firm.

Contrary to IVCs, which are independent from the fund providers and have purely financial objectives, GVCs have to respond to economic policy objectives set by the public entity that established them. Specifically, while IVCs are interested in invention and innovation only to the extent to which they increase their return on the investment, GVCs can interested in invention and innovation per se. GVCs thus might be more willing to devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000).

H3: There exist an influencing channel of innovation promoting*, that is, syndication investment helps firm to obtain higher innovation capability, and significantly increases the success likelihood of NEEQ firms.*

The alternative channel may have information sharing mechanism. Previous research shows that VC firms tend to locate in cities where venture capital investment have been previously successful and where innovation activities are prosperous (Chen et al., 2010). The effect from information sharing and more investment opportunities will affect the performance of VC firms positively and, therefore, also that of their portfolio companies (Zhang and Mayes, 2018).

One such factor is the density of GVCs in the province where a company's headquarter is located, as venture capitalists tend to invest in local companies (Cumming and Dai, 2011). Moreover, this factor is unlikely to affect the probability of obtaining IPO approval except via GVC backing.11 Hence, we use GVC Density, which is the number of politically-connected VCs in a company's headquarters province divided by the total number of GVCs in that province, to classify our sample into two subsamples.

H4: There exist an influencing channel of information sharing*, that is, syndication investment helps firm significantly increases the success likelihood of NEEQ firms if based in a city with high information sharing density.*

2.4. A quasi natural experiment

On May 20, 2016, the Central Committee of Chinese Communist Party and the State Council jointly issued the *Outline of the National Innovation-driven Development*

Strategy. It identified a "3-stage" target, namely to be an innovative country by 2020, a forefront of innovation-oriented country by 2030, and a world-leading scientific and technological innovation power by 2050. The outline is a top-level design and systemic plan for the implementation of the innovation-driven development in China for the next 30 years, and is of great relevance and profound historic significance. A key point of the outline is to accelerate the construction of a modern industrial technology system in China, nine strategic sectors, including information, intelligent manufacturing, modern agriculture, modern energy, ecological environmental protection, ocean and space, new urbanization, population health, modern service industry, etc., are going to be more important in China's innovation system. More resources will be allocated to these 9 strategic high-tech industries to speed up innovative development.

The 2016 national development strategy represents an exogenous policy shift towards promoting a specific group of innovative companies (treatment group), making it an attractive natural experiment to assess GVC' reaction towards national industrial and innovation policies, as well as the consequent impact on firm performance in the NEEQ market. Guided by this strategy, Chinese government will take many measures to facilitate the market to invest more in the creation, use and protection of intellectual property, and to promote the benefit-sharing and value creation of intellectual property and innovative system. Those innovative firms in the treatment group are expected to benefit more from this policy shift, while those in the control group are expected receive relatively less government support and investor attention.

3. Data, Variables, and Methods

3.1. Data descriptions and sample characteristics

We compile all firms floated on China's over-the-counter equities market, namely the National Equity Exchange and Quotation (NEEQ) market, from WIND, which consists of 14,975 firms by the end of 2020. NEEQ was established to provide equity financing support and trading for small and medium size enterprises (SMEs) in China. Especially, NEEQ focuses on SMEs with significant innovation activities. In comparison with other equity markets in China, the NEEQ does not have any profit threshold requirements, and thus is the ideal starting point for high technology companies in the domestic capital market. There were only 356 companies listed on NEEQ at the end of 2013, but the number had grown to 5,186 by the end of 2015 and the market value grew more than five times to reach 4591.42 million. Above mentioned basic characteristics of NEEQ made it ideal targeted market of micro-enterprise, SMEs and innovative firms, which are exactly what we want to research on.

We hand collect data on venture capital investments from annual reports and legal opinions of listed firms at the NEEQ system during the period of 2005 to 2015 as no specific database has published information about VC investments on NEEQ-listed firms systematically. We find that 1,876 firms were invested by venture capital; in particular, 493 firms were invested by government venture capital. Therefore, our sample consists of 5,186 firms which listed on NEEQ by the end of 2015. 1,876 firms were invested by venture capital; in particular, firms were invested by government venture capital. Sample period spans from 2005 to 2020.

We obtain information on NEEQ firms' patenting activity from the China national intellectual property administration (CNIPA) Patent Database, which provides complete information on all granted patent from 1985 to 2019 on patent assignee names, the application and publication number of patents, application and grant year, IPC classification number, type of the patent, and the number of citations received by each patent, family size and the number of citing of each patent.

Due to the missing or abnormal financial data of firms listed on NEEQ, an emerging over the counter (OTC) market, we select data based on the following steps. First, we screen out the sample with negative total asset and negative R&D expenditures. Second, we drop the sample with leverage higher than 1 or lower than 0. Finally, to minimize the effect of outliers, we winsorized all variables at the top and bottom 1% of each variable's distribution.

3.2. Variables and summary statistics

We hand collect data on venture capital investments from annual reports and legal opinion of listed firms at the NEEQ system during the period of 2005 to 2015 as no specific database has published information about VC investments on NEEQ-listed firms systematically. For each VC-backed firm, we document detailed information about investment events of VC companies and portfolio firms. Data on VCs consist of name, ownership structure, nationality, location, establishment time, and reputation ranking. Data on portfolio firms constitute of investment timing, industry, the number of employees, location, the amount of VC investment fund, investment round, investment stage, currency, investment approach such as syndication and staging, and so on. Follow the previous studies (Grilli and Murtinu, 2014, Bertoni and Tykvová, 2015, Guerini and Quas, 2016), we construct GVC DUMMY, a dummy variable which is equal to one if the firm is backed by GVC (including GVC standalone and GVC syndicates with GVC or PVC), otherwise, equal to zero. GVC STANDALONE, a dummy variable which is equal to one if the firm is backed by purely GVC (including GVC standalone and GVC syndicates with GVC), otherwise, equal to zero. SYNDICATION, a dummy variable, which is equal to one if the firm is backed by syndication investment between GVC and PVC, equal to zero. BOARD, a dummy variable, which is equal to one when GVC becomes a board member in portfolio companies, otherwise, equal to zero.

Control Variables

Following the innovation literature, we control for a variety of firm and industry characteristics that may affect a firm's innovation performance. The financial performance data for SMEs at the NEEQ market during 2005 to 2015 are collected from WIND dataset, which is a comprehensive database on China's financial markets. Basic introduction provided by WIND makes up with code, name, establishment time, listed time, industry according to the classification criteria of China Security Regulatory Commission (CSRC), state ownership structure, nationality, location. Variables on accounting and financial conditions include total number of employees, total assets, total liability, total equity, total sales, net profit, returns on assets (ROA), R&D expenses, and so on. The definitions of some key variables are as follows.

Total asset (ASSETS) is a key indicator that represents firm size of firms, which is measure by the total assets of a firm in calculated year divided by 1 million. HIGHTECH is a dummy variable, which is equal to one if the firm belongs to a high-tech industry, otherwise, equal to zero. Return to Assets (ROA) is a key indicator that represents the profitability of firms, which is measure by net profit divided by total assets at the calculated year. Earn per share (EPS) which refers to the market value of a film at the end of fiscal year t. LIQUIDITY refers to the current assets ratio of the company, defined as the value of current assets divided by the value of total assets measured at the end of fiscal year t TANGIBILITY refers to the ratio of tangible assets to the total assets in a sample company. R&D intensity, which is the indicator of R&D activity, is measured by R&D expenditure scaled by sales revenues.

Table 4.4 Definition of key variables.

Variable	Definition
Dependent Variables	
Graduate	Success graduate dummy, equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation.
Key explanatory variables:	
GVC_Entry	A dummy variable, equals to 0 for the period before pure GVC investment is made, and equals 1 for the period after the investment is made.
PVC_Entry	A dummy variable, equals to 0 for the period before pure PVC investment is made, and equals 1 for the period after the investment is made.
SYN_Entry	A dummy variable, equals to 0 for the period before syndication investment of GVC and PVC is made, and equals 1 for the period after the investment is made.
SYN Amount	Total amount of investment firms received so far, measured by natural logarithm of one plus the total investment amount of firms.
Control Variables	
Size	Natural logarithm of the number of employee of firms at the end of fiscal year t.
Age	Natural logarithm of the time between the year of birth of a firm and the given year t.

Leverage	Leverage refers to the leverage ratio of the company, defined as total debt divided by total assets at the end of fiscal year t.
ROA	ROA refers to the profitability of a firm at the end of fiscal year, defined as net profit divided by total assets at the calculated year.
RD intensity	RD expenditures divided by book value of total sales at year t, set to zero if missing.
Tangibility	Tangibility refers to the tangible asset ratio of the company, defined as the value of fixed assets divided by the value of total assets measured at the end of fiscal year t.
CapEx	CapEx refers to the capital investment ratio, measured by capital investment in total assets in given year t.

3.3. Methodology

To compare GVC-backed and non-GVC-backed firms in terms of innovation activities, we use propensity score matching (PSM) method to construct a control group for comparison purposes. We build the control group in several steps to ensure that our results are not driven by a specific matching method. First, we select all VC backed firms from our sample and then classify all firms into GVC backed firms and non GVC backed firms. We then match the GVC backed firms with non GVC backed firms by industry (at the three-digit SIC level), location (at the provincial level), age (operation period), size (total assets), leverage and sales. Finally, we employ the methodology of randomly drawing one-to-five matched pairs to build the control group. To ensure that our control group is representative, we repeat this random draw methodology 5 times, and the results are consistent (Guo and Jiang, 2013).

Logit model is employed in this study so as to discover the relationship between characteristic of portfolio firms and the possibility of being invested, in other word, this study aims to find out what kind of firms GVCs prefer to invest. Logit model is the most appropriate model to explain the relationship between the qualitative characteristic of dependent variable and the possibility of independent variable. Since the independent variables are not linearly related with the probability, logit regression is estimated using the Maximum Likelihood (ML) method.

We begin by specifying our baseline regression. Specifically, we use various forms of the following logit model to examine the respective impacts of GVC backing, syndication backing and on the likelihood of a company graduate to senior stock market.

$$\mathrm{P(Graduate = 1)} = \alpha + \beta_1 Syndication + \beta_2 Size_{i,t} + \beta_3 Age_{i,t} + \beta_4 ROA_{i,t}$$
$$+ \ \beta_5 R\&D_{i,t} + \beta_6 \, R\&D_{i,t} + \beta \quad Tangibility_{i,t} + \beta_7 Capex_{i,t} \ + FIRM_i + YEAR_t + \varepsilon_{i,t}$$

where the dependent variable is IPO Approval, an indicator variable for whether a company graduate to senior stock market successfully. The key explanatory variable in the above model is VC Backing, an indicator variable for whether a company is backed by GVC or syndication investment. Industry captures industry fixed effects based on CSRC industry classifications. We cluster standard errors at the company level.

Difference-in-difference estimation is the most widely used methods in estimating causal relationships after the research by Ashenfelter and Card (1985). The rationale of DID method is that observations are divided into two groups for two periods. Treatment group, one of the groups, is exposed to the treatment in one period. Control group, one another group, is not exposed to treatment during both periods. In the case where the same units within a group are observed in each time period, the average gain over time in the control group is extracted from the gain over time in the treatment group. This double differencing, the so called "difference-in-difference" methods, removes biases in the second period comparison between the treatment and control groups that could be the result from permanent differences between those groups, as well as biases from comparison over time in the treatment group that could be the result of time trends unrelated to the treatment (see Abadie, 2005; Finkelstein, 2002; Card and Krueger, 1994 for more detailed discussion).

The model for a generic member of any of groups can be written as

$$\boldsymbol{y = \beta_0 + \beta_1 dB + \delta_0 d_2 + \delta_1 d_2 \cdot dB + u} \qquad \textbf{Equation 1}$$

Where y is the outcome of interest, $d2$ is a dummy variable for the second time period. The dummy variable dB captures possible differences between the treatment and control groups prior to the intervention entry. The time period dummy, $d2$, captures aggregate factors that would cause changes in y even in the absence of a policy change. The coefficient of interest, δ_1, multiplies the interaction term, $d2 \cdot dB$, which is the same as a dummy variable equal to one for those observations in the treatment group in the second period. The difference-in-differences estimate is

$$\boldsymbol{\hat{\delta}_1 = (\bar{y}_{B,2} - \bar{y}_{B,1}) - (\bar{y}_{A,2} - \bar{y}_{A,1})} \qquad \textbf{Equation 2}$$

4. Empirical result

4.1. Descriptive summary

The summary statistics are set out in Table 4.5. About one of each 125 firms could graduate from NEEQ to the main board. Syndication backed firms and pure PVC backed firms share a similar number which is nearly twice of pure GVC firms. More than 10% of NEEQ firms could graduate after a syndication or PVC investment is made while 5.8% could graduate after GVC invest. The mean amount of syndication investment is about 0.622, about three times of GVC investment and twice of PVC investment.

Table 4.5 Summary statistics

Variable	Obs	Mean	Min	Max	Std. dev.
Graduate	62457	0.008	0	1	0.089
Pure_GVC	62457	0.078	0	1	0.268
Pure_PVC	62457	0.133	0	1	0.340
SYN	62457	0.147	0	1	0.354
GVC_Entry	62457	0.058	0	1	0.234
PVC_Entry	62457	0.105	0	1	0.307
SYN_Entry	62457	0.129	0	1	0.335
GVC_Amount	62457	0.213	0	7.688	0.810
PVC_Amount	62457	0.343	0	7.588	0.994
SYN_Amount	62457	0.622	0	9.303	1.569
Size	62457	4.826	0	7.109	1.058
Age	62457	2.564	0	2.773	0.166
Leverage	62457	0.420	0	0.956	0.215
ROA	62457	0.059	-0.367	0.375	0.140
RD intensity	62457	0.305	0	3213.934	19.023
Tangibility	62457	0.160	0	0.984	0.158
CapEx	62457	0.051	0	1.044	0.073

Notes: This table reports the number of observations, mean, maximum value, minimum value, standard deviation for all the variables used in this paper. The main pooled sample consists of 13475 firms and 62457 observations from year 2009 to 2020

4.2. Baseline results

In order to test our hypotheses, we introduce a number of time-varying VC-related dummies to indicate the status of venture capital, then use a multinomial logit model to analyze the relationship between venture capital and the graduation success of entrepreneurial firms. The GVC_Entry dummy identifies GVC backed companies and it is equal to one after a company has received a financing round from a stand-alone GVC. The PVC_Entry dummy identifies PVC backed companies and it is equal to one after a company has received a financing round from a stand-alone PVC. The SYN_Entry dummy is equal to one after a company has received a financing round from a syndicate whose lead investor was an GVC or PVC.

Table 4.6 shows our results for the correlation between different kinds of venture capital backed companies and their graduation probability using the multinomial logit regressions. The first investment year dummy and company's industry dummy are both include in the test to absorb and variables that vary only by industry and year. We totally run three models. The coefficient estimates of GVC_Entry and PVC_Entry dummy in model (1) and model (2) are both insignificant at the 10% level, which suggest that we cannot find any strong evidence that GVC backed and PVC backed companies have some significant difference for their graduation success in NEEQ market. In Model (3), we further estimate the influence from syndicate whose lead investor was an GVC or PVC. We find a positive and highly statistically significant effect for syndicate backed companies.

Table 4.6 VC investment impact on the graduation success of NEEQ firms.

	(1) Graduate	(2) Graduate	(3) Graduate
GVC_Entry	-0.261		
	(-0.79)		
PVC_Entry		0.201	
		(0.67)	
SYN_Entry			0.887***
			(4.11)
Size	2.480***	2.475***	2.382***
	(19.19)	(19.17)	(17.16)
Age	7.491	7.534	7.559
	(1.23)	(1.23)	(1.32)
Leverage	-7.019***	-7.029***	-6.831***
	(-11.08)	(-11.08)	(-10.81)
ROA	3.239***	3.251***	2.938***
	(5.54)	(5.52)	(4.78)
RD intensity	-2.287	-2.355	-2.479
	(-1.46)	(-1.49)	(-1.56)
Tangibility	-3.007***	-2.984***	-2.837***
	(-4.24)	(-4.20)	(-3.91)
CapEx	3.453***	3.459***	3.296***
	(4.21)	(4.22)	(3.76)
_Cons	-35.51*	-35.62*	-35.35*
	(-2.09)	(-2.09)	(-2.22)
N	61208	61208	61208
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R^2	0.488	0.488	0.499

Notes: This table uses Logit model to examine the effects of different types of VC on the success rate of NEEQ listed firms graduating to senior stock market. The dependent variable is dummy variable of graduate success. The independent variables are dummy variables that equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1.

As we mentioned above, The SYN_Entry dummy identifies equal to one after a company has received a financing round from a syndicate whose lead investor was an GVC or PVC. Therefore, in Table 5, we spilt the SYN_Entry dummy into the GVC_led_Entry dummy, PVC_led_Entry dummy, and SYN_led_Entry dummy. We use the first financing round of companies to distinguish these three different dummies. The GVC_led_Entry dummy is equal to one after a syndicate backed company has received the first financing round from a GVC and then received financing round form PVC. The PVC_led_Entry dummy is equal to one after a syndicate backed company has received the first financing round from a PVC. The SYN_led_Entry dummy is equal to one after a syndicate backed company has received the first financing round from both GVC and PVC. Consistent with Table 4, the first two columns of Table 4.7 both show insignificant result, which indicate the positive correlation between SYN_Entry and graduation success may not come from GVC_led_Entry and PVC_led_Entry. In the model (3) of Table 5, the coefficient estimates of SYN_led_Entry dummy is positive and significant at the 1% level, suggesting that syndicate backed companies with both GVC and PVC entered in the first financing round are more likely to graduate from NEEQ market through an IPO instead of syndicate backed companies with GVC or PVC entered separately in the first financing round.

Table 4.7 The impact of leading VC in syndication investments on the graduation success of NEEQ firms.

	(2) Graduate	(3) Graduate	(4) Graduate
GVC_Led	0.334*		
	(2.55)		
PVC_Led		0.478***	
		(4.08)	
SYN_Led			0.515**
			(3.11)
Size	2.453***	2.380***	2.227***
	(22.12)	(24.37)	(16.05)
Age	7.938***	6.725***	16.41***
	(5.43)	(5.58)	(7.09)
Leverage	-7.673***	-6.669***	-6.350***
	(-17.71)	(-17.89)	(-12.67)
ROA	3.050***	3.027***	2.115**
	(4.78)	(5.36)	(2.70)
RD intensity	-2.551	-3.056*	-1.825
	(-1.82)	(-2.23)	(-1.12)
Tangibility	-3.075***	-2.539***	-3.373***
	(-4.88)	(-4.42)	(-4.34)
CapEx	3.254*	3.318**	3.739*
	(2.55)	(2.87)	(2.35)
_cons	-36.62***	-33.26***	-58.50***
	(-8.73)	(-9.60)	(-8.85)
N	26382	37906	10494
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R^2	0.459	0.471	0.422

Notes: This table uses Logit model to examine the effects of different types of VC on the success rate of NEEQ listed firms graduating to senior stock market after propensity score matching (PSM). We employ one to five nearest neighbors with 0.05 caliper propensity score matching method. The dependent variable is dummy variable of graduate success. The independent variables are dummy variables that equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1.

5.Mechanism analysis

In our main results show a positive association between GVC investment, syndication investments and likelihood of portfolio firms graduation. In this section, we research into the mechanisms that potentially drive the impacts of GVC investments, syndication investments on portfolio firms and look for potential explanations. We explore several dimensions of heterogeneity and find three potential channels that plausibly explain the association and change. The results of the empirical tests of the mechanisms are presented in this section.

5.1 Resource Allocation Channel

Resource allocation channel argue that VCs often provide a variety of services that considerably enhances the success probability of invested firms can be provided by VCs, such as helping in making strategic decisions, fostering innovation by increasing research and develop (RD) expenses and patenting activities, bringing in broader contact networks in the product market, providing better management and employee incentives, helping in recruitment of competent management, and so on (Casamatta, 2003; Hellmann, 1998; Kortum and Lenrer, 2000; Spiegel and Tookes, 2008).

Table 4.8 reports a series of estimations results for financial performance, particularly leverage, with syndication dummy to identify the impact of syndication investments on the leverage of portfolio firms. We further disentangle that GVC investments facilitate their portfolio firms to obtain higher long-term leverage This result implies that GVC introduces more long-term financing, such as bank loan, to firms to release financial constraint and firms may allocate more resource on innovation activity.

Table 4.8 Mediating effects of long-term debt ratio on the relationship between syndication and graduates.

	(1) Graduate	(2) Long-term debt	(3) Graduate
SYN_Entry	0.887***	0.568***	0.849***
	(4.11)	(11.85)	(3.91)
Long-term debt			2.925***
			(3.91)
Size	2.382***	0.347***	2.374***
	(17.16)	(19.90)	(17.09)
Age	7.559	0.178	7.268
	(1.32)	(0.44)	(1.16)
Leverage	-6.831***	2.534***	-7.245***
	(-10.81)	(33.17)	(-11.07)
ROA	2.938***	0.516***	2.644***
	(4.78)	(4.80)	(4.24)
RD intensity	-2.479	-0.000117	-2.236
	(-1.56)	(-0.17)	(-1.42)
Tangibility	-2.837***	2.189***	-3.132***
	(-3.91)	(20.73)	(-4.30)
CapEx	3.296***	3.102***	2.343*
	(3.76)	(18.94)	(2.46)
_Cons	-35.35*	-1.079	-34.76*
	(-2.22)	(-1.39)	(-1.99)
N	61208	62448	61208
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R^2	0.498	0.137	0.505

Notes: This table uses Logit model to examine the effects of VC syndication on the success rate of NEEQ listed firms graduating to senior stock market. The dependent variable is dummy variable of graduate success. The independent variables are dummy variables that equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1

5.2 Innovation Promoting Chanel

Innovation Promoting Chanel, argues that GVCs devote more resources to their portfolio companies than do other VCs, resulting in a greater number of patents. For instance, devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000). Additionally, GVCs can offer government network, certification, government subsidy and related industry policy to portfolio firm.

Contrary to IVCs, which are independent from the fund providers and have purely financial objectives, GVCs have to respond to economic policy objectives set by the public entity that established them. Specifically, while IVCs are interested in invention and innovation only to the extent to which they increase their return on the investment, GVCs can interested in invention and innovation per se. GVCs thus might be more willing to devote resources to exploratory activities that give rise to inventions, while this activity might be too lengthy, too risky and too uncertain for IVCs (Sonnek, 2006), which would rather prefer to invest their resources in turning these inventions into commercially used products (Hellmann and Puri, 2000).

Table 4.8 reports a series of estimations results for innovation capability, particularly patent number, with syndication dummy to identify the impact of syndication investments on the innovation of portfolio firms. We disentangle that syndication investments facilitate their portfolio firms to obtain more patents. This result implies that syndication investment facilitates firms obtain more patent, therefore, achieve higher likelihood to graduate to senior stock market.

Table 4.9 Mediating effects of number of granted invention patents on the relationship between syndication and graduates.

	(1) Graduate	(2) Patent	(3) Graduate
SYN_Entry	0.887***	0.508***	0.784***
	(4.11)	(12.10)	(3.49)
Patent			0.261***
			(4.55)
Size	2.382***	0.358***	2.338***
	(17.16)	(22.56)	(16.84)
Age	7.559	0.0878	7.743
	(1.32)	(0.22)	(1.37)
Leverage	-6.831***	-0.293***	-7.023***
	(-10.81)	(-4.26)	(-11.14)
ROA	2.938***	0.000451	3.070***
	(4.78)	(0.00)	(4.97)
RD intensity	-2.479	0.00121*	-3.479
	(-1.56)	(2.11)	(-1.93)
Tangibility	-2.837***	-0.258**	-2.745***
	(-3.91)	(-2.61)	(-3.84)
CapEx	3.296***	0.275	3.389***
	(3.76)	(1.62)	(3.77)
_Cons	-35.35*	-5.499***	-35.38*
	(-2.22)	(-8.61)	(-2.25)
N	61208	62438	61208
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R^2	0.499	0.133	0.508

Notes: This table uses Logit model to examine the effects of different types of VC on the success rate of NEEQ listed firms graduating to senior stock market. The dependent variable is dummy variable of graduate success. The independent variables are dummy variables that equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1.

5.3 Government support Chanel

Additionally, GVCs can offer government network, certification, government subsidy and related industry policy to portfolio firm. This table uses mediating effect model to examine the effects of subsidy on the success rate of NEEQ listed firms graduating to senior stock market. In table 4.10, it is demonstrated that syndication investment can introduce government subsidy to increase the likelihood of graduation success ratio.

Table 4.10 Mediating effects of amount of subsidy on the relationship between syndication and graduates.

	(1) Graduate	(2) Subsidy	(3) Graduate
SYN_Entry	0.887***	0.228***	0.642**
	(4.05)	(3.79)	(2.88)
Subsidy			0.382***
			(5.25)
Size	2.323***	0.355***	2.210***
	(16.56)	(17.53)	(15.68)
Age	7.833	1.603***	7.167
	(1.44)	(4.04)	(1.48)
Leverage	-0.0711***	0.00361***	-0.0843***
	(-10.97)	(4.47)	(-12.00)
ROA	0.0276***	0.0103***	0.0431***
	(4.33)	(9.39)	(6.01)
RD intensity	-2.403	0.000166	-7.756**
	(-1.51)	(0.30)	(-3.11)
Tangibility	-2.762***	0.687***	-4.803***
	(-3.67)	(5.91)	(-5.99)
CapEx	2.015***	0.213	1.848**
	(3.66)	(1.03)	(3.01)
_Cons	-35.95*	-4.414***	-37.84**
	(-2.37)	(-3.98)	(-2.77)
N	61208	62436	61208
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R^2	0.505	0.417	0.561

Notes: This table uses mediating effect model to examine the effects of subsidy on the success rate of NEEQ listed firms graduating to senior stock market. The dependent variable is dummy variable of graduate success. The independent variables are dummy variables that equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

6. Robustness check and further analyses

6.1 A quasi natural experiment

To further address the endogeneity problem, we apply a difference-in-differences (DID) approach in the context of an exogenous event to identify the effect of politically-connected venture capital on the graduation success in NEEQ market. The exogenous event we examine is the Outline of the National Innovation-Driven Development Strategy the which was published and took effect on May 20, 2016. The policy emphasizes that scientific and technological innovation is the strategic support for improving social productivity and comprehensive national strength. Specifically, the Outline of the National Innovation-Driven Development Strategy points out nine technology fields for the government and the industries to focus on in the next decades, which may significantly attract the attention of different kinds of investments for the companies in these nine technology fields.

To conduct the difference-in-difference identification strategy, we construct a treatment group and a control group. The treatment group includes the companies have received a financing round from both GVC and PVC, while the control group contains the companies have received a financing round from only GVC or PVC. Before we run the difference-in-difference regressions, in Figure 2, we first perform a Parallel Trend Test on the differences between the two groups' pre-event (2016) characteristics, and the result support that two groups have similar characteristics before the policy shock.

Table 4.11 Diagnostic tests of propensity score matching

Panel A: Average treatment effect			
Variables	Treated group	Control group	Difference
	ATT	ATT	
Graduate	0.033	0.019	0.013***
Panel B: Before matching			
Variables	Treated	Control	Difference
	Mean	Mean	
Size	5.469	4.731	0.738***
Age	2.559	2.564	-0.006***
Leverage	0.377	0.426	-0.049***
ROA	0.055	0.060	-0.005***
RD intensity	0.712	0.245	0.468***
Tangibility	0.147	0.162	-0.015***
CapEx	0.052	0.051	0.001***
Panel C: After matching			
Variables	Treated	Control	Difference
	Mean	Mean	
Size	5.469	5.476	-0.007
Age	2.559	2.557	0.002
Leverage	0.377	0.379	-0.002
ROA	0.055	0.055	0.000
RD intensity	0.712	0.809	-0.096
Tangibility	0.147	0.148	-0.001
CapEx	0.053	0.053	0.000

Notes: This table reports the data summary of treatment group and control groups after one to five propensity score matching method. Difference of ATT with respect to success between the two groups equals 0.013 and is significant at 1% level. Panel B and C present the comparison between treatment and control group using propensity score matched sample, respectively. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Next, we perform the difference-in-difference analysis in a regression framework and the results are in Table 9. It reports that the coefficients on Treat x Post are statistically significant and positive, indicating the syndicate backed companies experience much more increase after policy shock than control group, and it is consistent with our main findings.

Table 4.12 A quasi natural experiment analysis for NEEQ graduates.

	(1) Graduate
Treat x Post	0.730**
	(2.11)
Treat	0.182
	(0.55)
Size	2.378***
	(25.87)
Age	6.289***
	(5.64)
Leverage	-6.890***
	(-19.10)
ROA	2.906***
	(5.26)
RD intensity	-2.410*
	(-1.96)
Tangibility	-3.066***
	(-5.54)
CapEx	3.523***
	(3.17)
_Cons	-31.75***
	(-9.92)
N	49923
Year FE	Yes
Industry FE	Yes
R^2	0.4921

Notes: For the regression, Treat x Post is the difference in difference coefficient from our empirical specification. It is an interaction of Syndication dummy variable x After policy dummy variable. Specifically, syndication dummy variable equal to 1 if the value of syndication is greater than 50% of the observations and 0 otherwise. Policy shock began after outline of the National Innovation-Driven Development Strategy published in 2016. The regression includes the same controls as in baseline regression and also further controlled the industry and year fixed effects.

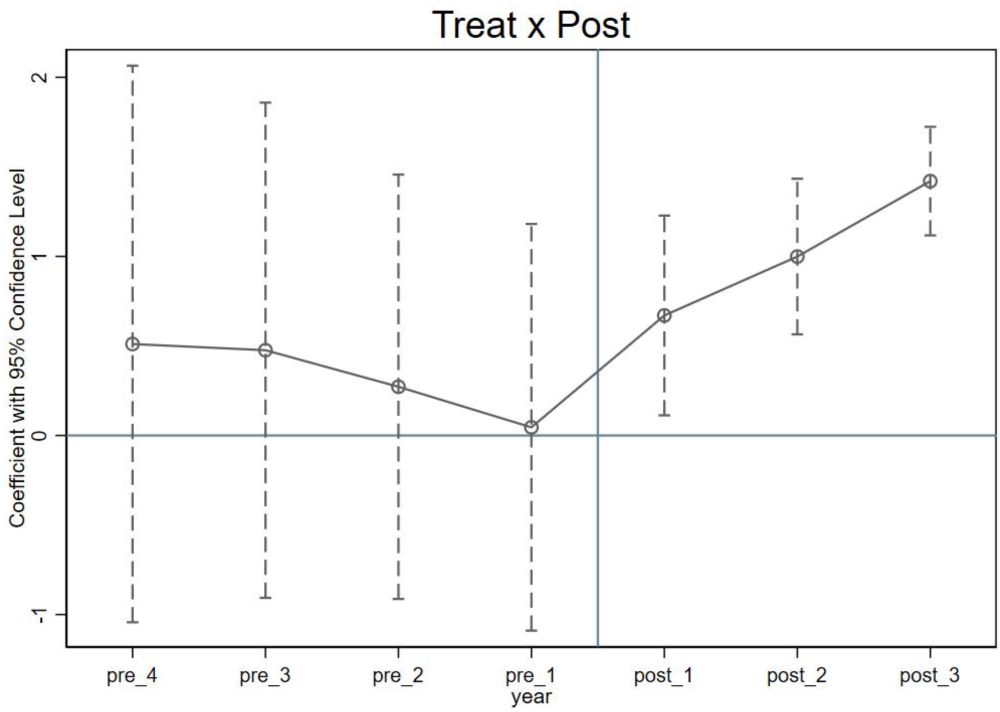

Figure 4.2 Variation of coefficient of nine technology sections and graduate.

6.2 Robustness Check

Our results are robust to a series of modifications in the econometric models. First, in Table 11, we measure the impact from difference venture capitals using the number of investment amount in financing rounds (instead of the dummy of VCs backed companies) in each industry and year. The result is consistent with our main findings in Table 4. Then, to further address the selection bias, we also employ the propensity score matching technique (PSM) proposed by Heckman et al. (1997). Although PSM may not perfectly match characteristics of VC backed companies, it generally reduces differences between different targets, which helps generate more unbiased estimations. We use three different logit models to predicting the likelihood of GVC, PVC and syndicate backed. based on propensity scores from models, we identify matches from the logit regression and replace. The results obtained after the abovementioned modifications are qualitatively similar to those illustrated in our main result.

Previous research shows that VC firms tend to locate in cities where venture capital investment have been previously successful and where innovation activities are prosperous (Chen et al., 2010). The effect from information sharing and more investment opportunities will affect the performance of VC firms positively and, therefore, also that of their portfolio companies (Zhang and Mayes, 2018).

One such factor is the density of GVCs in the province where a company's headquarter is located, as venture capitalists tend to invest in local companies (Cumming and Dai, 2011). Moreover, this factor is unlikely to affect the probability of obtaining IPO approval except via GVC backing.11 Hence, we use GVC Density, which is the number of politically-connected VCs in a company's headquarters province divided by the total number of GVCs in that province, to classify our sample into two subsamples.

In table 4.13, We notice that in subsample with high GVC density, the key dependent variable for the GVC background keeps significant in all five models' specifications at 1% level, However, syndication investment is not significant in subsample with low GVC density, which supporting information sharing theory that the information sharing can bring benefits to governmental venture capitalists and portfolio firms to improve the success rate of graduation successfully.In table 4.14, we use the amount of investments as alternative dependent variable to estimate the baseline model. The result keeps consistent with high significance.

Table 4.13 Effects of GVC density on the relationship between syndication and graduates.

Variables	GVC density	
	High	low
	Graduate	Graduate
SYN_entry	0.912***	0.717
	-3.58	-1.84
Size	2.260***	2.788***
	-14.36	-10.3
Age	6.893	15.64
	-1.52	-1.27
Leverage	-6.956***	-6.112***
	(-10.02)	(-4.56)
ROA	2.820***	3.056*
	(4.41)	(1.97)
RD intensity	-2.876	-3.353
	(-1.53)	(-1.06)
PPE	-1.697*	-6.279***
	(-2.09)	(-4.59)
Tangibility	2.209*	8.155***
	-2.22	-4.27
_Cons	-32.40*	-62.3
	(-2.55)	(-1.80)
N	38985	17727
Year FE	Yes	Yes
Industry FE	Yes	Yes
R^2	0.487	0.552

Notes: This table uses Logit model to examine the effects of different types of VC on the success rate of NEEQ listed firms graduating to senior stock market. The dependent variable is dummy variable of graduate success. The independent variables are dummy variables that equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1.

Table 4.14 Alternation definition of VC investment.

	(2) Graduate	(3) Graduate	(4) Graduate
GVC_Amount	-0.0319		
	(-0.34)		
PVC_Amount		0.0203	
		(0.25)	
SYN_Amount			0.163^{***}
			(3.73)
Size	2.480^{***}	2.474^{***}	2.359^{***}
	(19.10)	(19.31)	(16.64)
Age	7.490	7.519	7.045
	(1.23)	(1.23)	(1.13)
Leverage	-7.020^{***}	-7.020^{***}	-6.828^{***}
	(-11.08)	(-11.03)	(-10.73)
ROA	3.251^{***}	3.256^{***}	2.932^{***}
	(5.60)	(5.52)	(4.70)
RD intensity	-2.315	-2.353	-2.203
	(-1.48)	(-1.48)	(-1.46)
Tangibility	-2.997^{***}	-2.987^{***}	-2.827^{***}
	(-4.23)	(-4.23)	(-3.86)
CapEx	3.448^{***}	3.443^{***}	3.247^{***}
	(4.19)	(4.19)	(3.74)
_Cons	-35.51^{*}	-35.56^{*}	-33.78
	(-2.09)	(-2.09)	(-1.95)
N	61208	61208	61208
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R^2	0.488	0.488	0.498

Notes: This table uses Logit model to examine the effects of different types of VC on the success rate of NEEQ listed firms graduating to senior stock market. The dependent variable is dummy variable of graduate success. The independent variables are the natural logarithm of one plus the total investment amount of firms. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1.

Table 4.15 Different types of VC impact on the graduation success of NEEQ firms (PSM).

	(2) Graduate	(3) Graduate	(4) Graduate
GVC_Entry	-0.290		
	(-0.86)		
PVC_Entry		0.319	
		(1.07)	
SYN_Entry			0.834***
			(3.89)
Size	2.489***	2.479***	2.355***
	(13.42)	(15.37)	(16.14)
Age	7.813	10.27	7.080
	(1.92)	(1.95)	(1.39)
Leverage	-6.475***	-6.462***	-6.897***
	(-8.89)	(-8.95)	(-10.59)
ROA	2.927***	2.613***	3.085***
	(4.08)	(3.89)	(4.93)
RD intensity	-2.690	-3.585	-2.646
	(-1.36)	(-1.93)	(-1.65)
Tangibility	-2.946***	-2.402**	-2.854***
	(-3.80)	(-2.65)	(-3.86)
CapEx	4.548***	4.100***	3.312***
	(4.22)	(4.11)	(3.51)
_Cons	-30.95***	-44.99**	-33.88*
	(-3.56)	(-3.04)	(-2.38)
N	17299	28157	29844
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
R^2	0.437	0.491	0.457

Notes: This table uses Logit model to examine the effects of different types of VC on the success rate of NEEQ listed firms graduating to senior stock market after propensity score matching (PSM). We employ one to five nearest neighbors with 0.05 caliper propensity score matching method. The dependent variable is dummy variable of graduate success. The independent variables are dummy variables that equals to 0 for the period before firms graduate to senior stock market successfully, and equals 1 for the period after this graduation. The fixed effects used in each specification are noted in table. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1.

7. Conclusions and future research

Our papers studies whether and how governmental venture capital firms (GVC) affect success of innovative companies in China's third-tier equity market. Using a comprehensive set of data for Chinese small and medium sized firms listed in a third-tier equity market, namely the National Equities Exchange and Quotations (NEEQ), over the time period of 2007-2020, we find, compared to insignificant impacts of standalone investments from only GVC or private venture capital firms (PVC), syndicated investing of GVC and PVC significantly enhances success chance of firm graduation (IPO) to main stock markets.

We also identify the three mechanisms through which syndications help firms graduate to main stock markets, namely resource allocation, information sharing, and innovation nurturing. Further investigation based on a quasi-natural experiment indicates that syndication impacts are more pronounced for nine key sectors that were supported by a national innovation-driven development strategy. Moreover, GVC as a later-stage investor in the syndication are more likely to enhance firm performance than those being an earlier-stage investor, which indicates that they play a facilitating rather than leading role in value creation process.

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Appendix

Table 4.16 Data summary of subsidies on NEEQ.

Industry Classification	Total Subsidies(M)	No. of Firms	Average Subsidies (M)	Percent
Manufacturing	52,498.45	6,582	7.98	0.98
Information transmission, software and information technology services	14,378.36	2,467	5.83	0.96
Scientific research and technical service industry	3,357.42	583	5.76	0.98
Leasing and business services	3,080.28	649	4.75	0.95
Wholesale and retail trade	2,572.80	580	4.44	0.93
Agriculture, forestry, animal husbandry and fishery	2,465.79	250	9.86	0.96
Construction industry	1,928.66	419	4.60	0.96
Culture, sports and entertainment industry	1,813.03	292	6.21	0.95
Transportation, warehousing and postal industry	1,701.52	224	7.60	0.98
Water conservancy, environment and public facilities management industry	1,700.85	260	6.54	0.99
Electricity, heat, gas and water production and supply industry	1,305.64	156	8.37	0.93
Real estate	529.74	116	4.57	0.97
Educate	350.37	102	3.43	0.87
Health and social work	251.98	61	4.13	0.91
Mining industry	206.97	45	4.60	0.88
Accommodation and catering	178.30	37	4.82	0.88
Residential services, repairs and other services	142.69	47	3.04	0.96
Others	1.88	1	1.88	1.00
Total	88,464.72	12,871	6.87	0.97

CHAPTER V: CONCLUSIONS AND FUTURE STUDY

Steadily rising importance of governmental venture capital firms (GVC) in many countries attracts researchers to evaluate their performance and impacts (Lerner, 1999; Gompers and Lerner, 2004; Bottazzi et al., 2008; Howell, 2014; Guerini and Quas, 2016; Zhang and Mayes, 2018; Dong et al., 2021). Despite the well-noted rationale of addressing market failures by filling in "funding gap" of entrepreneurial start-ups or innovative firms (Alperovych et al., 2020), empirical evidence on GVC performance or impact is rather mixed. Some prior studies document the successful experiences of promoting both the local venture capital markets and corporate innovation activities, such as the Small Business Investment Company (SBIC) in the US and the Yozma Program in Israel (Lerner, 1999; Gompers and Lerner, 2004; Howell, 2014). But others warn about a bunch of failures of government efforts in fostering venture capital industries and enhancing firm productivities, such as in Canada and European countries (Cumming and Macintosh, 2006; Brander et al., 2008; Cumming et al., 2017; Grilli and Murtinu, 2014). Overall evidence in this strand of studies suggests that GVC funds do not add extra value to their investees, underperform their private peers, or even crowd-out private investment (Alperovych et al., 2020).

Despite the policy interest, due to a lack of detailed data, there is relatively little well-identified empirical evidence evaluating how GVC affect innovative activities and performance of relatively young or small- and medium sized companies (hereafter, SME) in China. Only a very limited number of studies examine whether China's GVC affect portfolio firms, such as Zhang and Mayes (2018), Ke and Wang (2020) and Dong et al. (2021), and almost all of them suggest GVC underperform their private peers, or generate negative consequences on investees. Zhang and Mayes (2018) show that portfolio companies backed by GVC underperform those backed by PVC in going public. Ke and Wang (2020) find that on average GVC underperform domestic PVC in both exit and innovation performance. Dong et al. (2021) document that GVC negatively affects green innovation, which is potentially attributed to the risk aversion and adverse selection of the GVC managers.

We start the sample with 13475 companies in the China's National Equities Exchange and Quotations (NEEQ) market over the period of 2009 to 2020. Our study provides new evidence to the literature about the relationship between governmental venture capital (GVC) investments and technological innovation of SMEs listed on National Equity Exchange Quotation (NEEQ) during the period of 2005 to 2015. Empirical tests show that GVC's entry into SMEs is able to make a concerted and effective effort to fill major gaps in their innovation capacity. The bulk of venture financing supports innovative activities of SMEs at NEEQ market in the perspective of patenting numbers across industries during 2005-2015. However, GVC has no significant impacts on the proportion of novel patents, which is focusing on the patent quality. These findings are rather significant and consistent across alternative proximity measures, control variables, and econometric approaches.

We further disentangle the mechanisms of the impacts of GVC investment on portfolio firms. We investigate that GVC investments facilitate their portfolio firms to obtain higher long-term leverage but lower short term leverage, which implies that GVC introduces more long-term financing, such as bank loan, to firms to release financial constraint and firms may allocate more resource on innovation activity. And portfolio firms invest more funds in innovation activity after receiving funding. Furthermore, there is no significant evidence to show GVC draw a positive value added service to portfolio firms.

Previous literature demonstrates that different type of VC investors has a different impact on the innovation capability of their portfolio companies. Ours study provides new evidence to the literature about the relationship between governmental venture capital (GVC) investments and development of SMEs in China. Our study find that firms backed by GVC achieve a better innovation capability than their counterparties in terms of patent number, the proportion of novel patent, citing number, family size and citation number. The positive effects on innovation are even stronger for those syndicated investments and, which are consistent with the dynamic interactions between VCs and portfolio firms. The interplay of GVC and PVC play an important role in helping Chinese SMEs to improve innovation capability in this pilot over-the-counter equities market. These results are robust to a variety of estimations and specifications.

We further disentangle the mechanisms of the impacts of syndication investment on portfolio firms. We investigate that syndication investments facilitate their portfolio firms to obtain higher long-term leverage but lower short term leverage, which implies that syndication investment introduces more long-term financing, such as bank loan, to firms to release financial constraint and firms may allocate more resource on innovation activity. And portfolio firms invest more funds in innovation activity after receiving funding. In addition, we investigate additional evidence that firms backed by governmental venture capitalists spend less time to get patent granted successfully. This result indicates that syndication firms get their patent approval from patent application faster than non-GVC-backed firms and therefore achieve higher patent number.

However, no evidence is found that syndication firms can outperform PVC backed firm in terms of ROA, ROE, sale growth, and employee growth, suggesting that the increase in patents activities do not translate to better firm performance for GVC-backed firms. No evidence is found that GVC investors provide value added service to improve innovation capability of portfolio firms. This suggests that the increase in patents activities do not translate to better firm performance for GVC-backed firms.

Our papers studies whether and how governmental venture capital firms (GVC) affect success of innovative companies in China's third-tier equity market. Using a comprehensive set of data for Chinese small and medium sized firms listed in a third-tier equity market, namely the National Equities Exchange and Quotations (NEEQ), over the time period of 2007-2020, we find, compared to insignificant impacts of standalone investments from only GVC or private venture capital firms (PVC), syndicated investing of GVC and PVC significantly enhances success chance of firm graduation (IPO) to main stock markets.

We also identify the three mechanisms through which syndications help firms graduate to main stock markets, namely resource allocation, information sharing, and innovation nurturing. Further investigation based on a quasi-natural experiment indicates that syndication impacts are more pronounced for nine key sectors that were supported by a national innovation-driven development strategy. Moreover, GVC as a later-stage investor in the syndication are more likely to enhance firm performance than those being an earlier-stage investor, which indicates that they play a facilitating rather than leading role in value creation process.

Innovation and entrepreneurship are taken as the key drivers of economic growth in the China at present. Our paper confirms that GVC financing, among heterogeneous capital goods, is a key engine that drive innovation and entrepreneurship in China The straightforward finding that Chinese GVCs have released financial constraints, created values and generated innovation gains to SMEs contains strong implications for policy makers who concern with industrial upgrading and structural changes in the Chinese economy. Promoting the development of the VC industry in China's multi-layer capital market, encouraging more syndicated VC investments and letting venture capitalists with government background play a bigger role are rather important in nurturing innovation and entrepreneurship in future's China.

It is important to acknowledge, however, that our research has also some limitations. This paper only scratches the surface in studying the role and effectiveness of GVC investments in promoting innovation. In the future studies, how entrepreneurs and venture capitalists interact in China's SMEs shall also be examined through field research.