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Research Article

Exploring the Impact of Government Venture Capital (GVC) on Private Venture Capital (PVC) Investment Choices in China's Semiconductor Industry

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Abstract

Can government venture capital (GVC) change the investment choice of private venture capital (PVC) to fulfill its political mission? Most of the previous literatures on GVC and PVC focus on the post venture capital (VC), while there are few studies on the impact of GVC on PVC before venture capital investment. This phenomenon is more obvious in previous studies with China as the research background. Based on the background of China's semiconductor industry, which is strongly supported by the Chinese government, this paper studies whether GVC can affect the investment niche and venture capital investment mode of PVC. Through empirical analysis of the VC data of semiconductor industry in Anhui, Beijing, Jiangsu and Guangdong provinces from 2012 to 2022, I found that in the semiconductor venture capital market of the above four provinces and cities, GVC effectively played a role of leverage and effectively attracted PVC to invest in the semiconductor industry. And as the number of semiconductor GVC data as a percentage of all semiconductor VC data continues to decline year after year, PVC is more inclined to invest in semiconductor R&D firms, and more inclined to invest the firms whose location has served as a target region for government semiconductor related guided funds, and the investment form of PVC is more inclined to syndicate investment with government venture capitalists. It can be said that GVC has effectively influenced the investment decisions of PVC and fulfilled its political mission of promoting the independence of technology and production in China's semiconductor industry.

Keywords

Government Venture Capital, Private Venture Capital, China Semiconductor Industry

1. Research Background

The development of high-end information technology is inseparable from the continuous development of the semiconductor industry. In the semiconductor industry, the most important product is the electronic chip. Due to the wide range of electronic chip applications, it has become the core of economic development and scientific and technological development of countries around the world, and with the rapid development of advanced technologies,

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countries have been prompted to put forward higher requirements for their national production of electronic chips, the speed of innovation and replacement of electronic chips [24, 28]. As semiconductor industry is crucial to the country's economic growth, it has inevitably become a focal point of the China-U.S. trade war, with United States government enacting a series of measures to ban semiconductor imports from China since 2018 [35, 54]. The U.S. impedes the development of China's semiconductor manufacturing industry and semiconductor applications industry by restricting Chinese semiconductor manufacturers from importing more advanced production machinery, technology, and components [35]. In other words, although China's semiconductor industry is developing rapidly, China has not grasped the core innovative semiconductor technologies, including IC design and electronic chip design [35, 54]. Therefore, it is crucial to realize the independence of semiconductor technology R&D and production. The growth of the semiconductor industry is highly valued by the Chinese government and has formulated a series of supportive policies and measures, including listing semiconductor technology as a major technology program in China and setting up subsidies for R&D companies [24]. Entrepreneurs have found new business opportunities, and have opened companies to participate in the development of semiconductor technology in China.

But Startups cannot survive, grow and expand without the help of financing. Venture capital (VC) is one of the market-based financing instruments that, in addition to injecting capital into a company, in the case of high investments, is responsible for providing management, including human resource practices and organizational behavior, such as helping to establish and deepen the company's culture, helping the company to come up with a future strategy, and finding partners for growth [1, 2, 5, 38]. Venture capital has also been shown to help firms gain more flexibility and help firms significantly improve their innovation performance [27, 39]. Moreover, it can improve the specialization of investee firms, laying the foundation for future growth and sustainable development [15, 19, 55]. In other words, the development and upgrading of China's semiconductor core technology cannot be achieved without the innovation brought about by entrepreneurship, and the development of startups cannot be achieved without the capital, resources, and corporate management and strategy support brought about by venture capital (VC). It is therefore crucial for the Chinese government to leverage GVC to attract PVC capital to invest in China's semiconductor industry. China's venture capital market was formed in 1985, and now it has passed the period of rapid development and entered the stage of stable growth, the industry management and laws and regulations have become perfect and the bubble of venture capital market has not yet appeared [26, 30, 55]. As of 2015, the number of China's venture capital companies has surpassed that of Europe and the United States, and the amount of venture capital investment as a percentage of the country's GDP has been on the rise, making China a major venture capital country. Consistent with the international VC market, PVC as well as GVC are the two main categories of VC in China, as there is a potential gap between private VC in terms of helping startups and possible market failures in financing, while government VC is a key government intervention in the VC market, either by providing funding to VCs or through the government's independent operation and management of the venture capital firms [3, 4, 38]. Chinese government guided funds are also a characteristic way of operating in the Chinese venture capital market, which is highly marketized and focuses on investing in high-tech firms in seed and growth stages [7, 55, 56]. The starting point and objective of the government guided funds is the same as that of GVC, i.e., to play a demonstration role in investing in advanced technology startups, with the goal of utilizing the fund as a lever to attract more PVCs and to expand the amount of private capital available in the VC market while controlling market failures [51].

In terms of the form of VC investment, the Chinese VC market is consistent with the mainstream VC market in the world, firstly, it is categorized according to the number of times the investee firms have received VC investment, which can be classified as multiple financing and one-time financing, and secondly, it can be classified as non-syndicated and syndicated according to whether the investee firms are invested by a single investor or a combination of multiple investors. [37].

So what is the relationship between GVC and PVC and can GVC change PVC's investment decisions? Previous scholarly research on the venture capital market has focused more on the development of investee firms after venture capital investment and less on investment decisions before venture capital investment occurs. The link between GVC and PVC is uncertain, and the reasons for this may depend on 1. country. For example, Bertoni, Colombo, and Quas in 2019 used an organizational ecology perspective to conduct an empirical study of GVC empirical study on how it affects PVC, considering GVC and PVC as two different organizational species with different ecological niches, and the authors analyze data on PVC investments from Europe and conclude that there is a reciprocal relationship between GVC and PVC, i.e., the higher the density of GVCs in the same year, the more likely PVCs are to invest in the types of firms that GVCs typically invest in [3]. In addition, GVC is able to exert a certification effect by screening the market, selecting potential startups and certifying them to private venture capitalists, and as a result, firms that receive GVC investments receive more PVC investments [11]. However, Cumming and Macintosh found that GVC in Canada had a negative impact on PVC investment in their country and was detrimental to the growth of the local Canadian VC market [8]. Thus, there is no conclusive evidence on

whether the presence of GVCs positively contributes to PVC investment, and such differences may vary from country to country. 2. Selection of industries for research. As stated by Bertoni, Colombo and Quas, future research needs to continue to utilize data from other countries to examine the investment niche where PVC chooses to follow GVCs, and further research is needed to examine the reasons for changes in PVC investor decisions [3]. In addition, scholars have conducted fewer studies on the Chinese venture capital market, focusing more on the aftermath of VC investment, such as the relationship between VC investment and the exit success of invested startups and the ability of VC investment to promote subsequent innovation and development of invested firms [20, 38]. Moreover, the positive correlation between PVC and GVC remains understudied in the past literature [18, 20, 32, 36, 53]. There are even fewer studies on pre-VC in the Chinese context, especially on the impact of GVC on PVC investment decisions. Studies in China have focused on the impact of the Chinese market on the reputation of investment firms and on the reasons for the importance of relational networks on the willingness of venture capitalists to invest and the use of forms of VC by venture capitalists in the context of the immature development of the Chinese securities market and the liberalized investment regime in terms of investment ownership [9, 12, 21, 29]. As well as the impact of geographic distance, weather, media and other broader environments on GVC in China [10, 17, 31]. Due to the uncertainty of the relationship between GVC and PVC, the reasons why PVC chooses to follow the investment niche of GVC and why PVC chooses to follow the investment niche of GVC need further research, and there is a lack of research on pre-VC in China. This paper will further investigate the interaction between government venture capital (GVC) and private venture capital (PVC) in the context of China's semiconductor industry and how effective GVC has been in China's semiconductor market from the perspectives of investment niches and venture capital approaches, as well as to explore whether and why it can change PVC investment niches and investment approaches. This study can help the government analyze how effective GVC is in China's semiconductor industry, as well as help entrepreneurs better understand the state of venture capital in China's semiconductor industry and complement previous studies.

2. Empirical Analysis

2.1. Hypothesis Development

Due to international pressures and internal corporate demands, the Chinese government realizes the significance of autonomy in the production of semiconductor-related technologies. But the realization of technology and production independence cannot be achieved without the continuous innovation of semiconductor companies. Therefore, the Chinese government will definitely use a variety of measures to support China's semiconductor startups, especially semiconductor-related R&D startups, which are in dire need of financial and managerial support from venture capitalists, so as to enable China's semiconductor industry to master the industry's core technologies by relying on the technological innovations of semiconductor industry enterprises. Since GVC is a policy tool of the government, the GVC should play a leveraging role in supporting the growth of China's semiconductor industry and enterprises, that is, the government takes the lead in investing funds into the semiconductor industry, which pries private capital into investing in the semiconductor industry [55]. Therefore, when the government venture capital performs well in the semiconductor industry or can play a leveraging role, the GVC density (number of GVC investment data in China's semiconductor industry/number of total VC investment data in China's semiconductor industry) should be gradually decreased.

Tao argues that for China, policy making is closely related to national milestones and that VC investment decisions are also influenced by government policies [40]. Kong, Zhang and Ramu argue that a number of policy incentives, including R&D incentives, are the basis for the stable and rapid growth of Chinese semiconductor industry [23]. Since the founding of China, the government has been implementing national economic and social development plans on a five-year basis to provide strategic planning for the growth of various industries in China [13]. From the 8th to the 14th Five-Year Plan, strategies for the growth of the semiconductor industry have been proposed, with one goal always at the forefront of China's policy and strategic planning, which is to continuously support the research and development of products, technologies and raw materials related to the semiconductor industry. So It must be one of the niches for GVC to invest in companies with semiconductor-related R&D to promote the development of core technology. Therefore, hypothesis 1 is proposed: as the density of GVC in China's semiconductor market decreases, PVC is more inclined to invest in companies with semiconductor-related products and technology R&D in their labels. The number of patents held by a technology firm is an effective measure of its innovation capability [34]. The fact that a company has its own patents at the startup stage should be a proof of its innovative capacity. And GVC needs to play a role in certification, screening companies with good prospects for PVC investment, and companies with innovative capacity should have a certain good prospect for growth [55]. Therefore, I believe that firms with patents are also one of the investment niches for GVC to invest in China's semiconductor industry. Thus there is Hypothesis 2: As the density of GVC in the Chinese semiconductor market decreases, PVC is more inclined to invest in startups with patents. In addition, this paper argues that the stage of development a firm is in is also a key

niche for GVC investment selection. Research on the life cycle of Chinese firms tends to categorize firms into four stages: seed stage, startup stage, growth stage and maturity stage [14]. Seed stage technology enterprises are the first stage of the enterprise life cycle, due to the company's simple organizational structure and fewer personnel, so there is a higher demand for technological innovation from the founders of the company, and there is the risk of failure of the enterprise incubation [25]. The startup stage enterprises are the second stage of the enterprise life cycle, when science and technology enterprises already have some new products and enter the market, but not yet get the high attention of the market and complete the product commercialization, so they need investment support to realize commercialization [25]. Moreover, they also need management support to expand their business channels [25]. However, given the urgency of the semiconductor industry, I believe that startup stage firms are more suitable for GVC than seed stage firms because they can be selected for investment based on the technological advancement of their products, and can help the industry's cutting-edge products to be launched in the market quickly, thus completing the iteration of the entire industry as soon as possible to stimulate further innovation. In addition, as the startup enterprise already has a product, also further proves that this enterprise has the ability to develop its patent into a molded product, which in line with the government needs to carry out the need for certification [55]. Thus, Hypothesis 3 of this paper is: as the density of GVC in the Chinese semiconductor market decreases, PVC is more inclined to invest in startup stage semiconductor firms. As mentioned above, China's securities market is still characterized by immature development, the uncertainty of successful exit of startups is high, and the syndicated investment approach has a positive impact on the successful launch of startups, and the performance and innovation ability of GVC firms can be increased when private capital is co-invested with GVC [21, 29, 37]. Therefore in order to further help and support the successful exit of semiconductor industry startups and enhance the innovation ability of the invested companies, as well as to improve GVC's investment performance and introduce private capital into the semiconductor industry, facilitate syndicated investments by PVC investors in conjunction with GVC investors must also be one of the objectives of the government, and the Chinese government has also used fiscal measures for the support of syndicated investment. Therefore, hypothesis 4 is proposed: as the density of GVC in China's semiconductor market decreases, PVC is more inclined to make syndicated venture capital investments in conjunction with government venture capital. As argued above, both government guided funds and GVC possess the role of bringing private capital into specific industries or regions [52]. When I compiling data on government guided funds in China's semiconductor industry from 2012-2022, it was found that the administrative level of the governments that issued semiconductor related government guided funds was higher than that of the governments that issued GVC investments, and government venture capitalists would invest in semiconductor firms in the areas targeted by government guided funds to respond to the call of high level governments. Therefore, attracting private capital to the regions targeted by government guided funds should also be another political goal of GVC. Hypothesis 5 thus follows that as the density of GVC in China's semiconductor market decreases, PVC is more inclined to invest in firms which in government guided fund targeted regions.

2.2. Data Sources and Data Collation

Since Jiangsu, Guangdong, and Beijing have been the more concentrated areas of VC capital in China, and Anhui province is one of the provinces where China's VC market has been growing faster in recent years, the VC data region is limited to these four provinces and cities [55]. VC data collection through Zero2IPO database, CVSource, and Wind database, it can be noted that these three data services are authoritative and complete. As mentioned earlier, the investment focus of VC is on startups, and the key issue of this paper's research is the choice of PVC's investment decision for semiconductor startups in China due to the influence of GVC. Therefore, the stage of enterprise development in the data is limited to seed stage and startup stage enterprises. By removing non-disclosed investors and non-disclosed investees, I finally obtained 2,780 pieces of venture capital investment data on Chinese semiconductor companies from 2012 to 2022, and the preliminary screening data includes the name of the investor, the investee company and its corporate label, as well as the region, the stage and the time of investment, and the number of rounds of investment. QCC was used to further supplement the data to determine whether each investor was a state owned enterprise and to select Chinese state owned investor firms as GVC investors and to position individuals, Private firms, and government-involved investor firms as PVC investors. Subsequently, the number of patents that each investee company had before being invested was obtained by using QCC. After calculating the investment density of GVC in China's semiconductor industry in the four selected provinces and cities from 2012 to 2022 each year, the GVC data were excluded from the database, resulting in a total of 2,127 PVC data from 2012 to 2022 in the four provinces and cities. In addition, the Wind database was used to further searched to find the specific amount of VC investment from 2012 to 2022 in the above four provinces and cities for the calculation of the additional independent variable VConGDP [3]. The data on the utility value of innovation capacity of the above four provinces and cities each year form 2012 to 2022 were taken from the China Regional Innovation Capacity Report published annually from 2012 to 2022, which was compiled by the China Science and Technology

Development Strategy Group, and the regional innovation utility value of individual provinces was calculated through the innovation strength, innovation potential, and efficiency of each province each year [6, 41-50].

2.3. Research Methodology

In this paper, the quantitative analysis method was chosen to test the hypotheses presented above. The quantitative analysis research model used in this paper is according to the methodology of the previous study [3], and since the dependent variables are all dummy variables, probit regression model will be used. This paper will then specifically perform descriptive statistical analyses, and analyze the results obtained from probit regression to either reject or support the five hypotheses above.

2.4. Specific Variables

The independent variable involved in the probit regression is GVC Percentage of VC in Semiconductor industry, and this independent variable is also the key to this study. The GVC density percentage of the semiconductor industry is calculated by dividing the amount of GVC investment data in the semiconductor industry within the four provinces and cities each year by the number of all VC investment data in the semiconductor industry within the four provinces and cities each year [3]. The first other independent variable is Innovation utility value, that is, the value of the innovation utility of these four provinces and cities per year, and I use innovation utility value of the four provinces and cities mentioned above in each year to control for the impact of the differences in the innovation capacity of the four provinces and cities on the model [6, 41-50]. The second additional independent variable is first round, which explores whether this VC investment is the first round of financing received by the investee firm [3], and the third additional independent variable is VConGDP, which is used to control for the development of the VC market in the four provinces, and divides the amount of VC investment in each province each year by the the total value of each province's GDP for that year [3]. In addition, this paper adds investment year dummies, and province dummies to the model, thus controlling for the impact of investment and venture market development on PVC investment behavior [3]. The specific variables are shown in the table below.

Table 1. *Specific variables.*

Variable types	Variable names	Variable Valuation Methods
Dependent Variables	Start up stage	1 for startup stage investee firms and 0 for seed stage investee firms.
	R&D Company	The investee's corporate label containing semiconductor-related technologies, products, materials, application research and development is set to 1, and 0 if it does not.
	Government guided funds	whether the location of the firms invested in by private venture capital has ever been a target area for the government's semiconductor-related guided fund prior to the date of each PVC investment, with a value of 1 if yes and 0 if no.
	Syndicated	whether the venture is invested by both GVC and PVC, which is set to 1 if it is and 0 if it is not [3, 22].
	Owned patents	Whether the investee has patents prior to the date of investment, with patents, set to 1, and set to 0 if it does not.
Independent Variables	GVC Percentage of VC in Semiconductor industry	calculated by dividing the number of GVC investment data in the semiconductor industry within the four provinces and cities each year by the number of all VC investment data in the semiconductor industry within the four provinces and cities each year [3].
Additional Independent Variables	firstround	Whether this venture capital is the first round of financing received by the investee company, with a value of 1 if it is, and 0 if it is not [3].
	VConGDP	calculated by dividing the amount of GVC investment in the semiconductor industry within the four provinces and cities each year by the amount of GDP within the four provinces and cities each year [3].
	Innovation utility value	Data taken from the 2012-2022 China Regional Innovation Capacity Report, (The China Science and Technology Development Strategy Group [6, 41-50].

2.5. Descriptive Statistical Analysis

Table 2. Descriptive statistics.

VARIABLES	N	mean	sd	min	max
year	2,127	2,020	2.042	2,012	2,022
Startup stage	2,127	0.628	0.484	0	1
R&D company	2,127	0.526	0.499	0	1
syndicated	2,127	0.674	0.469	0	1
Owned patents	2,127	0.577	0.494	0	1
First round	2,127	0.363	0.481	0	1
Government Guided Funds	2,127	0.876	0.329	0	1
GVC Percentage of VC in Semiconductor industry	2,127	22.52	4.139	17.54	51.52
VConGDP	2,127	2.249	3.845	0.0228	20.09
Innovation Utility Value	2,127	54.41	8.157	28.36	65.49

Table 3. Number and percentage of GVC investment data per selected province.

Table of the number of GVC investment data per selected province and cities		
Provinces	**Number of venture capital data**	**Ratio to total sample size**
Anhui Province	93	14.2%
Beijing	152	23.2%
Guangdong Province	166	25.4%
Jiangsu Province	242	37.0%
Total	653	100%

Table 4. Number and percentage of PVC investment data per selected province.

Table of the number and percentage of PVC investment data per selected province and cities		
Provinces	**Number of venture capital data**	**Ratio to total sample size**
Anhui Province	138	6%
Beijing	470	22%
Guangdong Province	673	32%
Jiangsu Province	846	40%
Total	2127	100%

Table 5. PVC and GVC sample size over time.

Year		variation
Number of private venture capital investments data in the semiconductor industry in four provinces and cities		
2012	16	0
2013	10	-6
2014	16	6
2015	47	31
2016	63	16
2017	88	25
2018	148	60
2019	187	39
2020	279	92
2021	673	394
2022	600	-73
Number of government venture capital investments data in the semiconductor industry in four provinces and cities		
2012	10	0
2013	6	-4
2014	17	11
2015	10	-7
2016	26	16
2017	35	9
2018	39	4
2019	69	30
2020	63	-6
2021	192	129
2022	186	-6

The descriptive statistics are shown above. In terms of China's semiconductor industry and the four selected provinces and cities, analyzing the sample at the enterprise level, Startup stage represents whether the private venture capital invested enterprises are at startup stage or not, and the proportion of start up stage enterprises is about 62.8%, which is higher than that of seed-stage enterprises 37.2%. The average number of companies with semiconductor related R&D in their company labels is 0.526. The average value of the location of firms subject to PVC investment in areas targeted by government-guided funds is 0.876. About 57.7% of firms subject to PVC investment have patents before the investment is made. In terms of VC rounds and modes, only 36.3% of the VC data in the sample were the first round of financing for the investee enterprises, while 67.4% of the venture capital data opted for syndicated investment between GVC and PVC. In terms of the development of the VC market, the average value of the amount of VC investment in the four provinces and cities as a percentage of the GDP of the provinces and cities in the selected 11 years is 2.249%, with the largest percentage of 20.9% and the smallest percentage of 0.0228%. From the perspective of regional innovation capacity, the average value of the combined regional innovation utility of the selected four provinces and cities is 54.41, and the maximum regional innovation utility value is 65.49 and the minimum regional innovation utility value is 28.36. For GVC Percentage of VC in Semiconductor industry, the maximum value is 51.52%, the minimum value is 17.54% and the average value is 22.52%. In addition, the number and percentage of GVC investment data per selected province, the number and percentage of PVC investment

data per selected province, and the number and percentage of PVC and GVC investment data per selected province are shown in Tables 3-5.

3. Probit Analysis Results

3.1. Analysis of Probit Regression Results

Table 6. Probit results.

VARIABLES	(1) Startup stage	(2) R&D company	(3) syndicated	(4) Owned patents	(5) Government guided funds
First round	-0.9433***	-0.0747	-0.3891***	-0.3987***	-0.1245
	(0.0619)	(0.0596)	(0.0614)	(0.0598)	(0.0812)
GVC Percentage of VC in Semiconductor industry	0.0228	-0.0437*	-0.0646***	-0.0025	-0.0908***
	(0.0197)	(0.0237)	(0.0216)	(0.0189)	(0.0204)
VCon GDP	-0.0364***	-0.0366***	-0.0196*	-0.0378***	0.0482***
	(0.0122)	(0.0114)	(0.0119)	(0.0115)	(0.0144)
Innovation utility value	-0.0233	0.0521***	-0.0107	-0.0599***	0.0378**
	(0.0150)	(0.0146)	(0.0146)	(0.0146)	(0.0159)
Constant	1.8711*	-1.3476	2.9235***	3.9689***	1.0072
	(0.9995)	(0.9970)	(0.9828)	(0.9562)	(1.0398)
Pseudo R2	0.1294	0.0510	0.0735	0.0598	0.1468
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	2,127	2,127	2,127	2,127	2,127

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: Province dummies and year dummies are also included in the probit regression.

3.2. The Impact of GVC on PVC Investment Niche Selection in China's Semiconductor Industry

As shown from Table 6, the results of probit regression are significant since Prob>chi2=0.0000 for all analyses. The results of the probit regression do not support the hypothesis that private venture capitalists are more inclined to invest in firms at the startup stage and to invest in firms that already have patents when the GVC in the semiconductor industry in China performs well, so hypotheses two and three are rejected. The reason may be that since the semiconductor industry is a advanced technology industry, its products and technologies are updated and iterated at a fast pace. Private venture capitalists, when making their choices, may focus more on the quality and quantity of R&D researchers in firms, and as long as the new technology or product being researched by the venture target company is more radical and innovative than existing products or technologies on the market, and as long as the R&D can be guaranteed to be successful, it is worth to invest in. Startup stage and investments in firms that already have patents are not part of PVC's investment niche following GVC.

At the 10 percent level of significance, the ratio of the number of GVC investment data in China's semiconductor industry to the total number of VC investment data in China's semiconductor industry is negatively correlated with whether or not the firms in China's semiconductor industry that are subject to PVC investment are semiconductor-related R&D companies. At the one percent level of

significance, the ratio of the number of GVC data in China's semiconductor industry to the number of total VC investment data in China's semiconductor industry is negatively correlated with whether the firms in China's semiconductor industry that are subject to private venture capital investment are regions that have been targeted by the semiconductor industry's government guided fund, and is negatively correlated with the choice of PVC to make syndicated venture capital investments in conjunction with GVC. All of these results are consistent with the corresponding marginal utility results (In Table 7). That is, with other variables held constant, when the ratio of the number of GVC data in China's semiconductor industry to the number of total VC data in China's semiconductor industry decreases by 1%, the probability of PVC investing in a firm with a semiconductor-related R&D company in its corporate label rises by 1.64%, the probability of PVC investing in a company whose investment location was once a target region for the semiconductor industry's governmental guided fund rises by 1.57%, and the probability of PVC choosing to syndicate venture capital investments jointly with government venture capitalists increases by 2.16%. Thus, the probit regression results support hypotheses one, four and five.

The reasons may be diverse. (1) Policy-led reasons. The enactment of relevant support policies has been one of the ways in which the Chinese government has guided the development of China's semiconductor industry and realized the independence of semiconductor technology production. In particular, in the regions targeted by the government's semiconductor industry guided fund, governments at all levels have enacted many favorable policies for semiconductor R&D companies, such as R&D subsidies and tax exemptions, as well as many investment support policies, such as those that support the cooperation between private venture capitalists and the government venture capitalists in making syndicated investments. (2) High-level government accreditation and good role modeling. The inclusion of semiconductor technology R&D in the five-year planning program represents the government's determination to develop the semiconductor industry [52]. In organizing the data I found that, compared to the GVC, the government guided fund is generally invested by the national, provincial or municipal government, and compared to the GVC, there were few government guided fund data in China's semiconductor industry. So it can be said that government guided fund's orientation for the development of the industry and the authority is stronger that the GVC. And the government venture capitalists at all administrative levels will also follow the investment niche of the government guidance fund (e.g., region and industry), and government venture capital together with the government guided fund forms a double certification of the potential and capability of the investment region and the development of the semiconductor industry. (3) Semiconductor industry venture capital characteristics and the high reputation of government venture capitalists. Since semiconductor startups require a large amount of investment capital and time to realize profitability, the investment risk is high, and the stability of China's securities market is weak, connecting with other venture capital investments, especially with GVC, can indeed reduce the risk, and relying on the strong social network and professionalism of the government venture capital firms, they can also give the investee firms better managerial and technical support after the investment [16, 33, 57]. In addition, because Chinese government venture capitalists have good reputation and high prestige [12], investee companies are able to have access to more additional capital investment following syndicated investment by GVC and PVC.

Overall, GVC has performed well and effectively in the Chinese semiconductor market, and GVC has successfully influenced the investment niche and approach of PVC and led the investment niche to semiconductor R&D companies and companies in regions that were once the target of semiconductor government guided funds, and the investment approach of PVC has been led to syndicated investments in conjunction with the government. GVC fulfilled its the political mission of attracting private capital into the semiconductor industry and promoting the independence of technology production.

Probit marginal utility results are shown below:

Table 7. *Probit marginal regression results.*

VARIABLES	(1) R&D company	(2) Syndicated	(3) Government Guided Funds
first round	-0.0281	-0.1298***	-0.0215
	(0.0224)	(0.0199)	(0.0140)
GVC Percentage of VC in Semiconductor industry	-0.0164*	-0.0216***	-0.0157***
	(0.0089)	(0.0072)	(0.0035)
VConGDP	-0.0138***	-0.0065*	0.0083***

VARIABLES	(1) R&D company	(2) Syndicated	(3) Government Guided Funds
	(0.0043)	(0.0040)	(0.0025)
Innovationutilityvalue	0.0196***	-0.0036	0.0065**
	(0.0054)	(0.0049)	(0.0027)
Observations	2,127	2,127	2,127

3.3. Robustness Testing

To be able to verify the robustness of the probit regression, robustness was tested in two ways, first, by replacing the analytical model used and measuring robustness by regressing the data of the probit regression above again using the logit model. Second, robustness is measured by changing the way the independent and dependent variables are measured. The GVC percentage measure is changed to the number of GVC investors in China's semiconductor industry in each year/number of total venture capitalists in China's semiconductor industry in each year for the four provinces and cities selected above [3]. Second, the dependent variable Syndicated was changed, taking into account that private venture capital firms with government equity participation may involuntarily influenced by the government to make syndicated investments, so only purely private venture capital in cooperation with government venture capital investment data was set as syndicated investment, and then do probit regression again. The results from these two robustness testing methods are same with the correlation and significance results from the original probit regression in this paper. Thus the probit regression above is robust.

4. Conclusion

4.1. Implications and Conclusion

This paper hopes to help the government analyze the effects of GVC investment within China's semiconductor industry from the practical side. And in general, previous research on VC concentrated on the development of invested firms after VC investment, and there is insufficient research on the pre-investment period. In particular, there is insufficient research on whether and why GVC can influence the investment niche and investment methods of PVC, and the conclusion is unclear as to whether GVC can promote PVC investment [3, 8, 11], and therefore this study hopes to theoretically add to the previous studies. Since GVC should attract lots of private capital into the investment niche of GVC through a small amount of government investment, this paper argues that when GVC works in China's semiconductor industry, the ratio of the number of GVC investments data in the Chinese semiconductor industry/overall number of VC investments data in the Chinese semiconductor industry should be narrowed year by year and the investment niche of PVC should be closer to that of GVC. This paper makes hypotheses by considering the investment niche and the choice of investment method that PVC should follows the GVC to support China's semiconductor industry to realize technological and production independence and argues that the investment niche of PVC investment should be attracted by GVC to firms in China's semiconductor industry that at startup stage, contain semiconductor industry-related R&D in their firm labels, contain patents, and are located in areas that have been used for government guided funds, and that the investment approach of PVC should be guided towards syndicated investment in conjunction with GVC. The results show that when the GVC is effective in the semiconductor industry in the four provinces and cities of China, the investment niche of PVC will be more inclined to invest in Chinese semiconductor companies whose regions have been the target regions of the government's guided fund and whose labels have semiconductor related R&D. And the investment approach of PVC is more likely to be syndicated investment in conjunction with GVC.

4.2. Contribution

From a practical point of view, the results of the analysis in this paper contribute to the government's analysis of the effectiveness of GVC investment in the above four provinces and municipalities. First of all, the GVC investment is effective in attracting and incentivizing PVC investment in the semiconductor industry, and the ratio of the GVC investment data in the semiconductor industry to the total number of VC investment data is generally on a downward trend, and in 2022, it was about 14.8 percentage points lower than the ratio in 2012. Moreover, the number of PVC data in the semiconductor industry shows a general trend of increasing year by year, and the number of PVC data in the four provinces and cities in 2022 is 584 more than that in

2012, which is an extremely obvious improvement. And the GVC has successfully brought the investment niche and investment mode of PVC closer to its own. It is extremely effective in supporting the long-term development of the semiconductor industry and realizing technological independence.

From a theoretical point of view, this paper proves that GVC positively promotes private venture capital in China's semiconductor industry, which complements the inconclusive impact of GVC on PVC investment, and secondly, our study further proves that GVC can have an impact on the investment decision of PVC. In addition, this paper can complement the study of Bertoni Colombo et al., where the authors empirically analyze GVC and PVC as two species by using data from Europe, and the empirical data concludes that there is a reciprocal relationship between GVC and PVC, i.e., when the GVC% is increased, the ecological niche, also known as the investment niche of PVC should towards GVC [3]. And Bertoni, Colombo and Quas believe that future research is needed to continue to examine the investment niche of PVC choosing to follow GVC using data from other countries, and further research is needed to examine the reasons for changes in the decision making of PVC investors [3]. The findings of this paper using data from China's semiconductor industry differ from theirs in that although the investment niche of PVC shifts to GVC, the density of GVC continues to decrease over the years, which is in conflict with the theory of organizational ecology. Finally, the lack of previous research in China on the ability of GVC to change the investment decisions of private venture capital is supplemented by this paper.

4.3. Limitations and Future Directions

The limitations and future directions of this paper are as follows: 1. Due to the huge amount of data, only the semiconductor venture capital data of four provinces in China are screened for the empirical study, and future studies can use the venture capital data of all provinces in China to get more comprehensive results. 2. Causes and modalities of GVC's influence on PVC investment niches can be further investigated by using data from different countries, different industries, etc.

Abbreviations

GVC	Government Venture Capital
PVC	Private Venture Capital
VC	Venture Capital

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Author Contributions

All the authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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