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A Study on the Effectiveness of the Venture Capital Market Intervention Policy: The Case of the South Korean Government*

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Abstract

This study aims to empirically examine the role of government intervention in the venture capital environment in South Korea. The study conducted a literature review on government interventions in the venture capital ecosystem. For empirical analysis, annual data from the Korea Venture Capital Association and the Korea Fund of Funds from 2004 to 2021 were analyzed using time-series statistical methods and macroeconomic analysis. The literature indicates that government policy intervention in the venture capital ecosystem can be divided into direct, indirect, and temporal approaches. The direct approach includes both direct and indirect government investments. The case study shows that the Korean government primarily engages in indirect investment in private venture capital funds. The time-series analysis found that early-stage investments increased with a higher proportion of early-stage investment funds and preferred stock investments, whereas an increase in total venture fund formation led to a decrease in early-stage investments. Based on the findings from the case studies and empirical analysis, policy recommendations for indirect government intervention were proposed.

Keywords: Venture capital, Government Policy Intervention, Early-stage investment

Ⅰ. Introduction

Entrepreneurs play a pivotal role in introducing new technologies that give rise to numerous industries, create jobs, and enhance the socio-economic conditions of nations, thereby improving overall quality of life(Audretsch et al., 2006; Baumol et al., 2007). While many ventures rely on personal and informal sources of finance, bank loans, and overdrafts(Owen, 2022), these sources often prove inadequate for some firms, necessitating the need for venture capital(Svetek, 2022). The significance of venture capital is evident in its impact on innovation, the formation and commercialization of new industries (Parhankangas 2012), and the development of technology clusters (Mason & Harrison, 2002). Venture capital-backed firms not only grow faster than their non-venture capital-backed counterparts(Gompers & Lerner, 2001) but also contribute substantially to productivity growth(HM Treasury, 2003). The government's policy for promoting entrepreneurship also highlights the importance of venture capital(Del-Palacio et al., 2012).

However, the development policies for venture companies face two major concerns. First, there is the question of whether national markets can efficiently allocate resources to the venture sector (Gilson, 2002). Over the past decade, the Korean government has aimed to create a venture-related financial market to support the start-up and growth of technology-intensive SMEs (Black & Gilson, 1998). Second, even with an established venture capital market, there is a need for greater resource allocation. New companies utilizing venture capital often fail to account for economic externalities due to a focus on private profits. To maximize these externalities, the government must intervene by providing subsidies, incentives, and tax benefits to ensure sufficient resource allocation to the venture sector(Brown & Jackson, 1993).

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Given these issues, government intervention in the venture capital market is essential for revitalizing venture startups through early-stage investments(Choi et al., 2021). This study aims to classify the stages of government venture capital evolution and examine the Korean government's interventions in the venture capital market. By reviewing existing literature on the effectiveness of government venture capital, the study seeks to empirically demonstrate how government policies have stimulated early-stage investment in venture capital over the past 15 years. The findings will provide empirical analysis on the effectiveness of the Korean government's venture capital initiatives and offer policy implications for future government interventions in the venture capital market.

Ⅱ. Literature Review

We try to review existing explanations of governments' roles in venture capital market development, and the categorizations of Lerner & Tag(2013) and Murray(2021) would provide a foundation for reviewing the related literature. First, the direct approach highlights government intervention in capital production(Avnimelech et al., 2010; Wang, 2023). This approach appears to aid policymakers in addressing the 'capital gaps' to facilitate the venture capital market(Sohl, 1999). There are two direct approaches to this. One is government venture capital funds(GVCs), which are entirely financed and managed by government officials to compensate for the shortage of venture capitalists(Lerner, 2009). For GVCs, one of major concerns is that government officers are unfamiliar with the venture capital market; this may lead to distortions(Bottazzi et al., 2004). Owing to the continuing uncertainty of investment, some GVCs may not recognize market changes as fundamental to the venture capital process when rearranging investments in their original direction(Lerner, 1995; Murray et al., 2012; Lerner, 2009). The second is the government-sponsored venture capital fund(GSVF), which is a hybrid fund. While the GVC allocates the role of venture capitalists to government officials, the GSVF eliminates government intervention in venture selection and management by delegating it to private venture capitalists(Engberg et al., 2021). GSVFs are typically financed by matching funds from both public and private sources. And the government plays as a limited partner in venture capital funds operated by private venture capital funds, to overcome the competency gap(Murray et al., 2012). The general partners of these funds have operational autonomy under the established model of venture capital funds(Lerner, 2009). GSV assumes that the market is in its early stages of development. Unlike GVC, GSVFs seek to develop a market(Avnimelech & Teubal, 2006; Lerner, 2009; 2002; Del-Palacio et al., 2012; Murray et al., 2012).

Indirect approaches involve governments creating conditions for venture capital to thrive(Murray et al., 2012; Devarakonda & Liu, 2024). Venture capital market development is influenced by favorable economic conditions. A strong legal environment is also critical for the venture capital cycle. Venture capital needs a legal framework to protect owners' ability to value appropriately because of the dominant logic of maintaining a higher control rate relative to equity investment(Armour & Cumming, 2006). According to McMullen et al.(2008), entrepreneurs who possess robust intellectual property rights tend to be more innovative than those without. Higher investor pay and downward protection differentiate the legal environment for venture capital(Lerner & Tåg, 2013) and promote the capacity of effective contracts to accommodate ambiguity, information asymmetry, low opportunism, and the transaction fees inherent in startups(Guler & Guilen, 2010; McMullen et al., 2008). The contract's incentives are designed to encourage investment and extra support to help startups develop the competencies they require(Bottazzi et al., 2004).

Ⅲ. Research Context and Hypotheses Development

3.1. The Korean context of venture capital ecology

Venture companies, venture capitalists, and exit markets are major components of the venture industry(Robbins-Roth, 2001). The Korean government did not achieve satisfactory results until the early 1980s because venture development was promoted as an extension of the technology development policy(Park, & Park, 2019). However, the Korean government began to establish government venture capital, as its perception of the industry changed. The Korean government established three state-owned venture capital companies in the 1980s. The VCs are the Korea Technology Development Corporation(KTDC), Korea Development Investment Corporation(KDIC), and Korea Technology Guarantee Fund(KTFC). In the early 1980s, venture capital witnessed very low investment activity because of a lack of social awareness of its functioning. Investment in the venture capital market was not attractive without an exit mechanism for return on investment. After this stalemate, in 1986, the Congress passed a bill to foster small and medium-sized enterprises, and fund innovative technology-based ventures to increase the supply of venture

capital. Both laws have contributed to the formation of new venture capital companies. The government launched the 'over-the-counter' market in April 1987 after announcing a 'market organization plan to revitalize stock trading for SMEs' in December 1986. The market did not act as a major source of funding for venture support companies. As the venture capital market worsened until the mid-1990s, large companies(chaebols) were allowed to establish venture capital in 1994. Beginning in the mid-1990s, entrepreneurship began to emerge and grow actively in the telecommunications, computer hardware, and software industries, thereby increasing the interest of venture capitalists. In 1996, the Korean government implemented a policy aimed at supporting the venture industry. As growing companies had to form a new stock market, the KOSDAQ was launched 25 years ago for them. Since the opening of the KOSDAQ, the government expected capital flows and investment cycles to promote new ventures, as it is easier for technology-based companies to be listed on the KOSDAQ. Since the KOSDAQ market opened in 1996, it took only four years for it to exceed the market capitalization of the local general exchange, even if there was an Internet bubble. The government has selected new technology- and knowledge-based industries as strategic targets to further develop promising companies. For this, the 'Special Act for Supporting Venture Companies'(hereinafter referred to as the 'Special Act on Ventures') was drafted. Immediately after the 1997 financial crisis, Korea's venture industry faced a completely new economic environment. Extreme economic restructuring provided unexpected opportunities for venture companies to access new businesses, workers, and capital markets. Large companies collapsed and reorganized, and venture companies grew rapidly. Finally, the capital market grew exponentially from 1999 to 2000. It is often said that 1999 was a leap forward in the Korean venture industry. The venture capital market experienced rapid growth due to factors such as the restructuring of the banking industry, the low-interest financial environment post-economic crisis, and the role of the KOSDAQ. Generally, the growth of the KOSDAQ contributed to the growth of venture companies by accelerating the inflow of capital.

The fall of the NASDAQ market, from 5,000 to 1,500 points, in the spring of 2000 triggered a massive shake in the Korean venture industry. As a result, the stock index of the KOSDAQ market plunged by more than 70% from its high point in June 2001. The stricter the venture capitalists evaluated venture companies, the stricter they became. Consequently, many startups have difficulty raising adequate capital. The government developed two major measures in line with the exit of the venture industry. First, the venture company certification system and KOSDAQ registration standards were more strictly regulated. The government forced venture evaluation agencies to secure certification validity in 2002. Members of the Korea Venture Business Association declared a code of ethics on their own. The government also raised KOSDAQ registration criteria(Park & Choi, 2009).

In addition, the Korean government began to change its policy toward venture capital from direct to indirect investment, as it suffered the collapse of the Internet bubble. There was awareness that the government's direct intervention in venture policies resulted in moral hazards for venture companies. To stabilize the venture capital market by July 2004, the government adopted 'A Comprehensive Plan to Strengthen Small and Medium Enterprise Competitiveness' and 'Plan to Create and Operate 1 trillion Won in Funds'. Unlike in the late 1990s, the government began to support the private sector in forming and growing its venture ecosystem from the end of 2004. The government privatized all government venture capital in an effort to halt direct investment. Instead, it was established as the government parent fund in June 2005. The Korea Venture Investment has an operating period of 30 years (2005-2035) for objective and transparent management. The Korea Fund of Funds, the nation's largest venture fund investor, established itself as a leading institution. From 2005 to 2019, 10 government ministries invested 4.5 trillion Won in the Korean Fund of Fund. Private investors contributed 22.4 trillion Won to sub-funds operated by private venture capital, five times the budget.

Since 2000, the agricultural, forestry, fishing, and farming sectors have been complemented by new investment opportunities in green growth, high-tech agriculture, and the food industry. However, the study revealed that Korea Venture Investments, an investment management company associated with Korea Funds of Funds, was unable to successfully manage the venture capital fund. Therefore, the Agriculture, Forestry, and Fisheries Food Investment Association was launched on January 3, 2010. Accordingly, funds from the Ministry of Agriculture, Forestry, and Fisheries were established. In 2013, the government decided that conditions should be created to raise funds by utilizing various assets, such as intellectual property rights, and supporting growth at a stage where investment in existing venture capital funds is insufficient. This goal was achieved in 2013 when the government created a third parent fund based on the 'May 15 Venture and Start-up Fund Ecosystem virtuous cycle plan', called the 'Growth Ladder Fund'. Afterwards, the 'Korea Growth Investment Corporation', a joint venture between the Korea Development Bank and the private sector, started with the consignment management of the 'Growth Ladder Fund'. and continued to form parent funds mainly based on private funds rather than government resources. As a result, more funds from

private investors are allocated to venture capital funds.

As presented above, in Korea, the government intervenes directly in the venture capital market. More specifically, we discuss Government-Sponsored Venture Funds(GSVF), the second of the two sub-steps of the direct intervention phase. Murray et al.(2012) suggest that the Korean government should adopt an indirect government intervention approach to create a supportive environment for venture capital to flourish. Governments need to create a conducive economic and legal environment for the venture capital market to thrive. Venture capitalists need a legal framework for protection against contractual downside risks and for greater control (Armour & Cumming, 2006; Bottazzi et al., 2004). A strong legal environment for venture firms facilitates greater investor support and downward protection (Bottazzi et al., 2004; Lerner & Tag, 2013), and efficient contracts that accommodate uncertainty, low transaction costs, and information asymmetry (McMullen et al., 2008). However, the government has not yet created a legal and economic environment in which VCs can actively invest. Therefore, the government-supported venture capital fund(GSVF) is the second stage of direct intervention, whereby the government intervenes in the venture capital market.

3.2. Hypotheses development

This study aims to examine whether government intervention in domestic venture capital reduces the risk avoidance of early-stage venture companies due to high uncertainties and risks. First, government investment increases the size of funds and has an authentication effect on the market (Collewaert et al, 2010). Therefore, venture capital funds attract private funds and have a crowding-in effect. Making the strong assumption that a flow of attractive investments is available to fund managers, the key findings from a policy perspective are regarding the significance of fund size for returns to the venture capital management company(the managing partner). The return goals of both, limited and managing partners, must be met to ensure the long-term viability of this fixed-term funding structure. Management cannot be expected to bear an unreasonable risk burden because of the fixed and variable costs incurred and the uncertainty of attractive investment returns, without the prospect of adequate compensation.

Therefore, the investment surplus of venture capital funds encourages investment in high-risk early venture companies, as the fund size increases. Venture capital funds grow in size and pursue diverse investment targets to manage portfolio balances. The growth of these funds will enable venture capitalists to allocate more resources to managing investors and conducting due diligence. They can then focus on small-, medium-, and long-term early stage companies that have been neglected due to their cost-effectiveness. This will encourage venture capitalists to invest in smaller, longer-term, early-stage companies, leading to an anticipated increase in investments in these types of startups.

Hypothesis 1: An increase in the Korean government's total investment in VC funds has a positive (+) relationship with early-stage venture capital investments.

Second, so far, the research shows that there is no consensus in the scientific discourse on government intervention in venture capital markets. Proponents justify government programs due to the enhancement of venture capital supply for early-stage businesses, while opponents underline the negative aspects of activation of venture capital markets, predominantly, 'Crowding out' of private investors and generation of low returns. Many studies confirm that private venture capital funds outperform GSVC funds when comparing the performance indicators of portfolio companies(Mason & Pierrakis, 2009, In the case of an 'early-stage VC gap', the potential for entrepreneurship can be held back because of a shortage of venture capital in the earliest start-up phases (OECD 2006). It is, therefore, arguably in the early seed and start-up phases, where private alternatives are most likely to be scarce, and the motivation for GVC intervention is the strongest (OECD, 2006).

The Korea Fund of Fund expands its early-stage investment by separately selecting a venture capital fund that invests intensively in early ventures. Moreover, policy funds like the Korea Fund of Funds typically have a lower required standard return for venture capital investments compared to private investments. In addition, venture capital funds do not require preferential losses, even if they suffer losses during the liquidation process(KVIC, 2016). Thus, government-backed venture capital funds offer the benefit of lowering the capital costs of venture capital funds, thereby mitigating the tendency to avoid early-stage investments that have to deal with long-term losses and recoveries. By hiring venture capital more suitable for it, early-stage investment is advanced with policy-inducing effects.

Hypothesis 2: The increase in the Korean government's policy investment in venture capital funds has a positive (+) correlation with early-stage venture capital investments.

Third, a large body of academic work examines the problem of financial contracting, frequently within the context of an entrepreneur negotiating a financing deal with an investor(Bolton & Dewatripont, 2004). Financial contracting plays an important role at this stage, as entrepreneurs' ability to promise outcome-independent payments to venture capitalists(VCs) is affected by their limited early-stage resources and liability constraints, as well as severe information asymmetries and agency problems(Hall & Lerner, 2010). Relevant studies highlight that agency problems differ across firms and imply that entrepreneurial firms prefer different contract offers, depending on their risk/return profiles. In light of this observation, researchers note that securities can be designed within contracts to mitigate agency problems appropriately, based on the specific characteristics of the firm seeking financing (Cumming & Johan, 2009). Early finance literature characterizes convertible preferred securities as the optimal form of financing for entrepreneurial firms (Schmidt, 2003), whereas the second stream suggests that convertible securities are not uniquely optimal (Cumming & Johan, 2009).

The empirical results, using U.S. data, leave little room for doubt that convertible preferred equity is the major financing instrument chosen by the VC industry. Accordingly, the overall picture in other countries is substantially more diverse. In several studies outside the US, convertible securities ranked behind straight equity, silent partnerships, or debt-equity mixes (Bascha & Walz, 2002). Korean venture investments faced difficulties in the early 2000s due to the IT bubble, making it hard to recoup investments from the KOSDAQ market. The increase in investment losses in 2001 and 2002 led to a preference for convertible bond investments, but these failed due to debt ratio issues. Therefore, a rational investment method was needed, leading to the study of American investment methods and the consideration of introducing preferred stocks. In December 2002, the Korean Venture Capital Association hosted a seminar on the preferred stock used by VCs in USA(Korea Financial News, 2002). Compared to the preferred stocks used by VCs in USA, the preferred stock used by VCs in Korea are not effective in realistically defending against the downside risks of VC investments. However, because the preferred stock in Korea could provide more legal conditions than common stocks for protection against investment risk, Korean VCs can have an incentive to make early-stage investments.

Hypothesis 3: The increase in Korean VC investment in limited preferred stock has a positive (+) correlation with early-stage venture capital investments.

Ⅳ. Data and Methods

4.1. Data

The Korea Venture Capital Association publishes the 'KVCA Yearbook and Venture Capital List' annually, offering comprehensive data on the Korean venture capital market. This study used data provided by the 'KVCA Yearbook and Venture Capital List', from 2004 to 2021. The necessary variables were extracted from the data to create a dataset organized by year.

The amount of total venture capital funds formed by the government's investment: In the mid-2000s, the Korean government ended its policy of direct investment in venture companies through government-operated venture capital. Instead, the government shifted its policy to financing private venture capital funds. Therefore, all private venture capital funds in Korea received funding from three government funds, and the total amount of venture capital funds formed annually in Korea is determined by the contributions of these three funds. Consequently, this study utilized the 'total annual venture capital fund formation' data provided in the 'KVCA Yearbook and Venture Capital Directory,' an annual publication by the Korea Venture Capital Association.

The amount of early-stage venture capital funds by the government's investment: As explained above, the government uses its own funds to intervene in venture capital funds. Government funds specifically establish and invest in venture capital funds with the mandate to invest a portion of their capital in early-stage venture companies. Therefore, to measure the extent of government intervention, it is essential to ascertain the percentage of early-stage funds within the total venture capital funds. As a result, the study relied on the value calculated by dividing the annual 'early-stage fund formation total' by the 'annual venture capital fund formation total amount.'

Proportion of preferred stock investment by venture capital: In early 2000s, domestic venture capitalists were able to introduce preferred stocks, permitted by domestic commercial law, into the venture capital investment market. These preferred stocks are different from those used by foreign VCs. Preferred stocks issued by domestic venture capital thus far include only limited refixing and redemption rights, so VCs cannot realistically defend against downside risks to their investments. In other words, if the venture in which it has invested is in financial difficulty, there is no way for the VC to recover the remaining amount of its investment because it does not have exclusive rights to a particular matter. However, these limited preferred stocks involve

more legal conditions than common stocks, for protection to VCs against the downside risks of their investments. Therefore, this study used the value obtained by dividing the annual 'preferred stock investment total' by the 'annual amount of venture capital investment.'

The proportion of early-stage investment by venture capital: Korea's related laws stipulate that early-stage investment is investment in those venture companies that have been established for less than three years. Given this, the study employed the value obtained by dividing the annual 'early-stage investment total' by the 'annual amount of venture capital investment.'

4.2. Methods

In time-series research, the analysis begins with performing a unit root test to determine whether the time series data is stationary or non-stationary. Common tests for this purpose include the Augmented Dickey-Fuller(ADF) test, the Phillips-Perron(PP) test, and the Kwiatkowski-Phillips-Schmidt-Shin(KPSS) test. If the unit root test indicates that the data is stationary, the analysis proceeds with estimating a Vector Autoregression(VAR) model. The VAR model is utilized to capture the linear interdependencies among multiple time series variables. It helps in understanding how the current and past values of these variables are related.

After estimating the VAR model, the next step is to conduct an Impulse-Response Function(IRF) analysis. The IRF helps analyze how a shock to one variable in the VAR model affects other variables over time. By applying a shock, typically one standard deviation, the IRF traces the effect of this shock on the current and future values of the variables, providing insights into the dynamic behavior of the system.

Following the IRF, a Forecast Error Variance Decomposition (FEVD) analysis is performed. FEVD determines the proportion of the movements in a time series that can be attributed to its own shocks versus shocks to other variables in the system. This decomposition is crucial for understanding the relative importance of different shocks in influencing the variables.

However, if the unit root test reveals that the time series data is non-stationary, cointegration analysis is performed. Cointegration analysis determines whether a set of non-stationary time series variables are cointegrated, meaning they have a long-term equilibrium relationship despite being individually non-stationary. The Johansen cointegration test and the Engle-Granger two-step method are commonly used for this purpose. When cointegration is identified, an Error Correction Model(ECM) is employed. The ECM models the short-term dynamics of the time series while maintaining the long-term equilibrium relationship established by the cointegration analysis.

By following these methodological steps, researchers can systematically analyze time series data, identify underlying relationships, and make informed predictions about the behavior of the variables involved.

This study focuses on variables that affect the actual early-stage investment portion: the total amount of venture funds, the amount of early-stage funds, and the portion of investment in preferred stocks. First, the causal relationship between the total amount of venture funds, the amount of early-stage funds, the proportion of preferred stock investment, and the proportion of actual early-stage investments was analyzed. This process has the advantage of being able to determine the direction that each factor affects. That is, it is possible to predict the change in each variable for the actual early-stage investment proportion in the future.

In addition, this study analyzes the detailed forms of the correlations, as well as causal relationships. Because even elements that form the same causal relationship can affect each other in different directions, quantitative analysis of the direction and size of the effect is performed, rather than concluding with a simple causal analysis. In addition, using the impulse response function, the influence of a change in one variable can be investigated by analyzing the responses of the numbers. Finally, by determining the relative importance of each variable, it is possible to determine which variables are more dependent on certain variables. Through this analysis method, the importance of each factor can be identified, and a reference point for efficient decision-making, which considers priorities, can be prepared when establishing policies. As for the analysis methodology in this study, since a stationary time-series was obtained after a difference was performed after a unit root test, a regression model(VAR), impulse-response function, and prediction error variance decomposition method were intended to be used.

In this study, the causal relationship was determined using a quantitative method for each factor. First, each element was seasonally adjusted, and the unstable data values were stabilized through the first difference, using the unit root test. The Johansen test was then performed, and the structural relationship of each element was modeled, using a vector autoregressive model. Impulse response analysis was used to analyze the dynamic effects of changes in one variable on other variables. Finally, the impact of the variables was decomposed by factor, through prediction error variance decomposition.

V. Results

5.1. Unit root test

The The basic assumption in time-series analysis is the data stability. Stability refers to the tendency of time-series variables to return to equilibrium in the long run, even when subjected to short-term shocks. Conversely, if the time series is unstable, the average value of the time series continues to change over time; in this case, a unit root is said to exist. In the case of an analysis using an unstable time series with a unit root, there is a high possibility of a spurious regression phenomenon wherein, even with no correlation between variables, they appear to be correlated. ADF(Augmented Dickey-Fuller) test, a method for determining the existence of a unit root, assumes that the given time series is unstable if the absolute value of the t-statistic is greater than the critical value(Harris, 1992). In this study, the ADF test was conducted to analyze the stability of the variables to be used, that is, to determine the presence or absence of a unit root. In the case of an unstable time series in which a unit root exists, a stabilization operation should be performed.

$$\Delta Y_t = \alpha + \beta t + (\rho - 1)Y_{t-1} + \sum_{i=1}^{p-1} \delta_i \Delta Y_{t-i} + \epsilon_t$$

<Table 1> shows the ADF test results of the variables(total amount of venture fund formation, early-stage fund formation amount, preferred stock investment portion, and actual early-stage investment portion) used in this study. However, unstable time-series data with a unit root are generally known to be stable through first-order differences(Paparoditis & Politis, 2018). Therefore, in this study, the null hypothesis that a unit root exists through the first difference is rejected. From <Table 1>, it can be confirmed that each variable with instability rejected the null hypothesis and acquired stability through the first difference.

<Table 1> ADF(Augmented Dickey-Fuller): Data by year 2004-2021

Variables	Level		1st Difference with Trend	
	ADF	P-value	ADF	P-value
The total amount of venture funds formed	-0.074	0.9934	-3.411	0.05
The total amount of early-stage funds formed	-0.248	0.9906	-4.863	0.0004
The proportion of preferred stock investment	0.376	0.6433	-4.865	0.0004
The proportion of early-stage investment	-3.501	0.0393	-4.691	0.0007

The independent variables - the total amount of venture funds, the amount of early-stage fund formation, and the proportion of preferred stock investments - were found to have a unit root, so the first difference was made. The early-stage investment proportion variable was a relatively stationary time series, but the first difference was applied to increase stability.

5.2. The optimal order of lag and the Johansen test

<Table 2> The optimal order of lag

Lag	LL	df	p	AIC	SBIC
Lag 0	-182.621	16	-	31.1035	31.2651
Lag 1	-159.764	16	0.000	29.9607*	30.7688*

*>.1, **> .05, ***>.01

<Table 3> Johansen tests for cointegration.

maximum rank	Parms	LL	Eigen value	Trace statistic	5% critical value
0	4	-196.66646		36.8199*	47.21
1	11	-187.77822	0.74524	19.0434	29.68
2	16	-182.0032	0.58871	7.4933	15.41

*>.1, **> .05, ***>.01

According to the analysis, the optimal time lag can be seen as the past value of Period 1. The Johanson cointegration test results show that the cointegration vector is zero. That is, assuming that there is no cointegration relationship between the four variables, we estimate the VAR model of equation (1). Therefore, it was analyzed using a vector autoregressive model that does not require cointegration.

5.3. Analysis results of vector autoregressive model

The vector autoregression model(VAR) analyzes the linear correlation of multivariate time-series data. Thus, the model can also be used when there is no cointegration and it is unnecessary to consider cointegration. Therefore, it consists of a structural equation that considers the current observed values of all variables in the model as dependent variables, and all lagged variables as independent variables. The purpose of vector autoregressive model analysis is long-term and short-term prediction. In particular, when an exogenous shock occurs, long- and short-term predictions can be made by analyzing the responses of endogenous variables using the shock response function. Excluding a priori models based on hypotheses and theories as much as possible, and estimating them with a

generalized model can reflect reality more appropriately(Zuhroh & Kurniawati, 2017).

Therefore, in the vector autoregressive model, there is no subjective need to distinguish between endogenous and exogenous variables. However, all the variables considered to be correlated should be included in the model. Therefore, the analysis results are highly dependent on the variables included in the model. This can be interpreted as a disadvantage since the estimates and analysis results can show sensitive changes, depending on the selection results of the variables. The vector autoregressive model is expressed as follows:

In the vector autoregressive model, the impulse response function is a moving average derived from the model. When an unexpected shock is given to the economy, it shows how all variables in the model respond to it over time. It also has the advantage of being easy to check, just by looking at a graph. As a result, it is easy to understand the causal relationships between variables and analyze the influence of changes in them. The impulse response function analyzes how the variables in the model react over time when a standard deviation shock is applied to specific variables. Hamilton & Susmel (1994) showed that vector autoregressive models can be converted to MA models in general cases. That is, if the variable vector Yt can be expressed in the form of the following equation and the coefficient $(\mathrm{A}j,\cdots \mathrm{A}p)$satisfies the invertibility condition, Yt can be expressed as a vector moving-average model ℓt.

$$Y_t = \mu + \ell_t + \psi_1 \ell_{t-1} + \cdots = \mu + \sum_{s=0}^{\infty} \psi_s \ell_{t-s}$$

$$= \begin{bmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_N \end{bmatrix} + \sum_{s=0}^{\infty} \begin{bmatrix} \Phi_{11} & \Phi_{12} & \cdots & \Phi_{1N} \\ \Phi_{21} & \Phi_{22} & \cdots & \Phi_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \Phi_{N1} & \Phi_{N2} & \cdots & \Phi_{NN} \end{bmatrix}^{s} \begin{bmatrix} \epsilon_{1,t-s} \\ \epsilon_{2,t-s} \\ \vdots \\ \epsilon_{N,t-s} \end{bmatrix}$$

This is expressed as follows, using the post operator.

$$X_t = \mu + \Psi(B)\varepsilon_t$$

Here, the coefficient $\psi(\mathrm{B})$ is a function of time s, and represents the effect of X1the impact εt. This is known as an impulse response function(Inoue & Kilian, 2013). In this study, we use the impulse response function to analyze how much, and for how long, the total amount of venture funds, amount of early-stage fund formation, and proportion of preferred stock investments, affect the actual early-stage investment proportion.

With the vector autoregressive model, it is difficult to analyze the extent to which the effect of the shock lasts, other than the positive and negative relationships of each variable. Therefore, a reference was made to the direction of the correlation between each variable, and the sustainability of the shock was reviewed mainly through shock response analysis.

<Table 4> Analysis results of vector autoregressive model

Classification	Standard	Lag 1	Lag 2	Lag 3	Lag 4
Actual	AIC	30.0272	-83.2072	-232.19*	-231.972
	SBIC	30.6324	-82.1179	-230.98*	-230.762

In this study, the AIC(Akaike Information Criteria) and SBIC(Schwarz-Bayesian Information Criterion) were used to determine the appropriate lag of the vector autoregressive model. In general, AIC tends to overidentify the number of parameters, compared to SBIC, so it is better to set it according to the SBIC information standard. In this case, both the AIC and SBIC were found to have minimum values at lag 3. That is, as a result of the optimal disparity analysis, it was found that 3 disparity is appropriate. If the lag is wide, the serial correlation of the error term can be reduced, but it has a tradeoff that is somewhat less efficient. Therefore, lag 3 was applied as an appropriate lag for the VAR model.

<Table 5> Vector autoregression

	Actual	Venture	Early-stage	Stock
Actual (-1)	0	0	0	0
Actual (-2)	.4187366 [1.7e+14]***	-73207.18 [-1.1e+14]***	3937.602 [3.9e+13]***	1.102259 [1.6e+14]***
Actual (-3)	-.4241993 [-1.8e+14]***	141054.3 [2.2e+14]***	-10194.47 [-1.0e+14]***	-.9371927 [-1.4e+14]***
Venture (-1)	-1.66e-06 [-1.2e+14]***	-.9081006 [-2.5e+14]***	-.1408162 [-2.6e+14]***	4.98e-06 [1.3e+14]***
Venture(-2)	-4.22e-06 [-2.3e+14]***	-.0622941 [-1.2e+13]***	-.1194138 [-1.6e+14]***	-5.27e-06 [-1.0e+14]***
Venture(-3)	-5.93e-07 [-4.8e+13]***	-.1165845 [-3.5e+13]***	.0689147 [1.4e+14]***	1.57e-06 [4.6e+13]***
Early-stage(-1)	-.0000121 [-1.0e+14]***	5.074932 [1.5e+14]***	-.3095773 [-6.3e+13]***	-.0000486 [-1.4e+14]***
Early-stage(-2)	.000036 [5.0e+14]***	4.424236 [2.3e+14]***	1.47772 [5.0e+14]***	.0000326 [1.6e+14]***
Early-stage(-3)	.0000426 [3.0e+14]***	4.15043 [1.1e+14]***	1.508053 [2.6e+14]***	.0000342 [8.5e+13]***
Stock(-1)	0	0	0	0
Stock(-2)	-.6290039 [-4.0e+14]***	7626.528 [1.8e+13]***	12238.01 [1.9e+14]***	-.3808089 [-.3808089]***
Stock(-3)	.3672127 [1.2e+14]***	-97039.14 [-1.2e+14]***	10716.41 [8.5e+13]***	1.30816 [1.30816]***
R^2	0.5955	0.8742	0.8685	0.6549
Chi^2	16.19529	76.43546	72.62457	29.87796

*>.1, **> .05, ***>.01

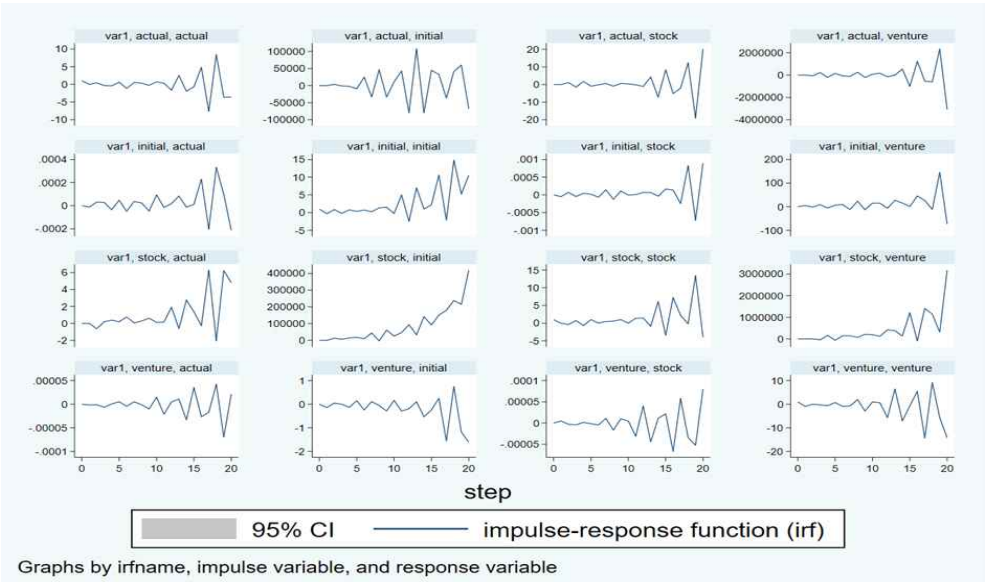
<Table 5> shows the results of estimating the dynamic relationship between the change in the actual early-stage investment portion, the total amount of venture funds, the amount of early- stage fund formation, and the change in the investment portion of preferred stocks through a vector autoregressive model. The variables that have a negative correlation with their value in the previous period, are the total amount of venture funds and early-stage fund formation. However, it was found that the actual early-stage investment proportion and preferred stock investment proportion had no relation to their value before the first period. The self-value of the previous year and the proportion of actual early stage investment had a positive correlation with a lag of two quarters, and a negative correlation with a lag of three quarters. The total amount of venture funds formed in the previous year and the final actual early-stage investment share have a negative correlation. In other words, an increase in the total amount of venture funds causes a decrease in the proportion of actual early-stage investments. It has a negative correlation with the early-stage fund formation amount in the first quarter, and a positive correlation in the second and third quarters.

The final early-stage investment portion is not related with the preferred stock investment portion in the first quarter, but has a negative correlation in the second quarter, which is more significant than that in the third quarter. The final total amount of venture fund formation has a positive correlation with the amount of early-stage fund formation in the previous year and is not related to the actual early-stage investment portion, or the preferred stock investment portion in the first quarter. Additionally, the final early-stage fund formation amount is unrelated to the actual early-stage investment portion in the previous year, while the preferred stock investment portion of the previous year and the total amount of venture funds formed in the previous year are negatively correlated. The proportion of the final preferred stock investment is not related with the proportion of actual early-stage investment in the previous year and the proportion of preferred stock investment in the previous year, but has a positive correlation with the total amount of venture funds formed in the previous year. However, the coefficient before the second quarter was found to be more significant.

5.4. Analysis result of Impulse Response Function(IRF)

If the actual early-stage investment share receives a standard deviation shock of five units from other variables, it responds in the following order: preferred stock investment, early stage fund formation, actual early stage investment, and venture fund formation. When a shock is applied to the variables, it is small until the 10th quarter, after which the change increases. The proportion of investment in preferred stocks and the total amount of venture funds showed a relatively positive (+) effect, which continued after the 20th quarter, but the other variables seemed to be negatively (-) affected afterward.

When a standard deviation shock of five units of the early stage fund formation amount is received from other variables, the impact is small until the 10th quarter, as soon as the variables are shocked, after which the actual



<Figure 1> Results of IRF analysis

early-stage investment portion and total venture fund formation show a negative pattern, whereas the amount of early-stage fund formation and the proportion of investment in preferredstocks show a positive trend. When the standard deviation shock of five units of preferred stock investment is received from other variables, as soon as the variables are shocked, the shock is small until the 10th quarter, after which the preferred stock investment proportion, shows a negative pattern, whereas the actual early-stage investment share, early-stage fund formation amount, and total venture fund formation show a positive trend. When a standard deviation shock of five units in the total amount of venture funds is received from other variables, the impact is small until the 10th quarter, as soon as the variables are shocked, after which the actual early-stage investment portion, early-stage fund formation amount, and venture fund total amount are negative. However, the impact of preferred stock investment showed a positive (+) trend.

VI. Conclusions

The study examined the stages of development of government venture capital and the Korean government's role in the venture capital market. We conducted an empirical study to assess whether the Korean government's venture capital policy effectively stimulated early-stage venture capital investment, drawing on existing literature on the effectiveness of government venture capital. From a time-series analysis of related data from 2004 to 2021, it was found that early-stage investment increased as the proportion of funds earmarked for it, and preferred stock investments increased. However, an increase in total venture fund formation was found to reduce early-stage investments. The results of this study can be interpreted as follows: First, although the preferred stocks used by Korean VCs are limited, it is noteworthy that their early-stage investment is increasing. As explained earlier, preferred stocks used by foreign VCs, such as in the US, increase active early-stage investments by VCs because they can protect against the downside risks of their investments. Since preferred stock was introduced in 2000, the use of common stock declined. However, in 2018, despite the opposition of the venture capital industry, the Korean government made the Korean Fund of Funds invest preferentially in private venture capital funds that invest in common stocks, to protect venture companies(KBS News, 2020). As a result, private venture capital has no choice but to augment investment in the form of common stocks to receive funds from the Korea Fund, and as a result, early-stage investment may shrink. Thus, in South Korea, early-stage investments can increase based on government-led policies that form the foundation of fund formation, and conversely, there is also the potential for mid-to-late-stage investments to increase.

Second, early-stage investments decrease when the total amount of venture funds formed increases. This can be interpreted as the fact that the effectiveness of direct government intervention through direct and indirect investment has declined over the more than 30-year history of venture capital in Korea. This study focuses on the fact that despite the government investing exponentially in government finances to increase the formation of venture capital funds since 2016, investment in the early-stages is inversely related. This could be a continuing long-term trend, even if the government withdrew from the common stock expansion introduced in 2018. Therefore, it is necessary to actively review the introduction of the preferred stocks used in USA to the domestic venture ecosystem so that the interests of founders and VCs can be reasonably adjusted in advanced venture capital countries such as the United States(Choi, 2019). Now, in order for Korea to transition to a private-sector-centered venture capital industry, the government must directly Rather than intervention through financial investment, it will be necessary to evolve to a stage where the venture ecosystem system is improved from an institutional perspective, such as advanced investment methods and tax benefits.

From an academic perspective, this study is the first to analyze the stages of government intervention in the venture capital market using the Korean context as a case study. This study interprets the Korean government's intervention in the venture capital market step-by-step, and present the next stage. In addition, this study empirically shows that early-stage investment in venture capital can be increased through indirect investment by the government. Therefore, the Korean government should strategically consider financial investment in the venture capital fund market.

This study analyzed the effects of government intervention in the Korean venture capital market and proposed practical policy measures based on these findings. The conclusions drawn from this study are as follows: First, expanding the scale and number of special purpose funds(SPFs), including mandatory initial investments, is an important measure to promote early-stage venture capital investment. By mandating a certain proportion of early-stage investment, the government can more effectively support the funding needs of startups. Second, promoting the adoption of preferred stocks plays a vital role in reducing the risks of early-stage venture investments and protecting investor rights. The government should provide tax benefits and incentives and widely disseminate the advantages of preferred stocks through educational programs. Third, strengthening the

role of policy financial institutions can further stimulate early-stage investments in the venture capital market. Policy financial institutions should support startup funding by expanding their investment and guarantee programs rather than direct investments. Finally, to enhance the effectiveness of government intervention in the venture capital market, it is essential to strengthen technical evaluation and mentoring programs to increase the success rate of early-stage startups. Collaborating with technical evaluation institutions to objectively assess the technical and market potential of startups and providing management and technical support through expert mentors are crucial. These policy measures will be significant strategies to promote early-stage investments in the Korean venture capital market and foster the growth of venture companies. Therefore, the government and related institutions should practically implement these policies to advance the venture capital market.

Despite the contributions and implications of this study, the following research limitations and future research directions are presented. First, this study conducted case studies and empirical studies on Korean cases. Therefore, the results of this study cannot be generalized. In future studies, if the results of this study are compared by analyzing the cases of Japan, where venture capital follows a development path similar to Korea's, the research framework presented in this study can be further developed. Second, in this study, time-series data for 15 years were analyzed using time-series statistical analysis. Therefore, the validity of the empirical research results is insufficient. Third, this study investigates government intervention in the behavior of venture capital. However, from the perspective of the venture ecosystem, early-stage investment in venture capital ultimately aims to revitalize venture startups. Therefore, in future studies, it is necessary to present a model taking the number of venture start-ups per year, as a dependent variable. In other words, it is necessary to present venture capital-related policy factors as factors that affect venture startups and determine whether the early-stage investment in venture capital mediates the relationship between these leading factors and dependent variables. Fourth, this study empirically demonstrated that increased investment increased investment in early-stage ventures. However, the preference for early-stage investment due to increased corporate value of later-stage companies may have had an effect. In addition, the introduction of accelerators increased early-stage investment. Therefore, future research will need to control for these factors. Finally, this study has the limitation that it can only use a vector autoregressive(VAR) model due to the size of the available data. Therefore, in future similar studies, it is necessary to secure sufficient data and clarify the causal relationship more clearly through structural equation models.

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벤처캐피탈 시장개입정책의 실효성에 관한 연구: 한국정부 사례를 중심으로*

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국 문 요 약

본 연구의 목적은 한국의 벤처캐피탈 환경에 대한 정부 개입을 실증적으로 살펴보는 것이다. 이를 위해 본 연구에서는 벤처캐피탈 생태계에 정부가 어떻게 개입했는지에 대한 관련 문헌을 검토하였다. 실증분석을 위해 한국벤처캐피탈협회와 한국모태기금에서 제공하는 2004년부터 2021년까지의 연간 자료를 시계열통계분석과 거시경제학을 이용하여 분석하였다. 문헌에 따르면, 벤처캐피탈 생태계에 대한 정부의 정책개입은 직접적 접근, 간접 접근, 일시적 접근으로 분류될 수 있다. 직접적 접근방식은 정부에 의한 직접투자와 간접투자로 더 세분화될 수 있다. 본 연구는 현재 벤처캐피탈 생태계에 대한 한국 정부의 정책개입이 민간 벤처캐피탈 펀드에 대한 간접투자로 구성되어 있음을 보여준다. 시계열 분석 결과, 초기투자자금과 우선주 투자비중이 높을수록 초기투자가 증가하는 것으로 나타났다. 그러나 전체 벤처펀드 조성이 증가하면서 초기 투자가 감소한 것으로 나타났다. 또한 사례연구 결과와 실증분석을 바탕으로 정부의 간접개입에 필요한 정책제언을 제시하였다.

핵심주제어: 벤처캐피탈, 정부정책개입, 초기투자

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