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A Study of Segmental Investment Risk of Venture Capital Organizations Based on Contingent Claims Analysis

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Abstract: *The risk management strategy of venture capital organizations in the process of segmented investment is the key to the success of their investment decisions, in which the contingent claims analysis, as an advanced financial tool, provides a new perspective for quantifying the investment risk at all stages. This study focuses on the segmented investment risk of venture capital institutions based on contingent claims analysis, and explores in depth the application mechanism of this analysis method in risk assessment and control. By constructing a contingent claims analysis model of segmented investment, the risk characteristics of different investment stages and their impact on the overall investment portfolio are analyzed. Actual cases in the global venture capital market in recent years are selected for empirical analysis, and combined with Monte Carlo simulation techniques, the potential return and risk distribution of each stage of investment are evaluated. Through regression analysis, the effectiveness of contingent claims analysis in predicting investment risks and optimizing investment strategies is revealed. Based on the above analysis, targeted risk management recommendations are proposed, including enhancing the dynamics of risk assessment, flexibly adjusting investment rounds and amounts, and constructing diversified investment portfolios, aiming to provide practical guidance for venture capital organizations to enhance the scientificity of investment decision-making and risk control ability.*

Keywords: *contingent claims analysis; venture capital organizations; segmented investments; investment risk; risk management*

1. Introduction

Venture Capital (VC), as a high-risk and high-return investment method, plays a crucial role in promoting scientific and technological innovation. However, the success of VC not only depends on the potential of the project itself, but also on the investment strategy and risk management ability of the investment institution[1]. As an advanced financial analysis method, Contingent Claims Analysis (CCA) provides a new perspective for venture capital organizations to assess and manage investment risks in a segmented investment way. In this paper, we will discuss the application of CCA in venture capital and how to reduce the investment risk by segmented investment strategy with the title of "Research on the Risk of Segmented Investment of Venture Capital Institutions Based on Undecided Claims Analysis". In the field of venture capital, segmented investment is a common investment strategy, which gradually reduces the investment risk by providing financial support to startups at different stages. Segmented investment strategy not only helps VCs control risks at the early stage of investment, but also allows flexible adjustments based on the progress of the project and market feedback. However, how to scientifically and systematically assess the risk of segmented investment has always been an important issue for venture capital organizations[2]. In recent years, the application of undetermined equity analysis in the field of financial risk has made significant progress. scholars such as Gray have extended the undetermined equity analysis from micro enterprises to the macro level, and established a theoretical system to quantitatively analyze the macro financial risk using macro asset and liability data. In the field of venture capital, some scholars have also begun to try to apply undetermined equity analysis to the value assessment and risk management of entrepreneurial enterprises. However, the current research mainly focuses on theoretical discussions and case studies, and lacks systematic empirical studies to verify the effectiveness of undetermined equity analysis in venture capital[3]. This paper introduces the contingent claims analysis into the field of venture capital, and constructs a risk assessment model for segmented investment of venture capital institutions based on the contingent

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claims analysis. The model not only considers the potential value of the startup, but also the impact of external factors such as market environment and industry competition on investment risk.

2. Relevant theoretical foundations

2.1 Definition and characteristics of venture capital

For venture capital, there is no uniform definition. European and American organizations and economists used to provide various definitions. For instance, the Organization for Economic Cooperation and Development (OECD) defines venture capital as: all investments based on high technology, aimed at the production and operation of innovative products and services, which can be termed venture capital investments. The "Encyclopedia of Economics" in the United States defines it as: venture capital provides funds to new companies or new products with high-speed development potential to withstand initial risks, but not for the acquisition of all types of assets related to the company or product. American scholar Amrer proposed that venture capital (or risk capital) does not have a uniform definition. The Encyclopedia of Economics defines venture capital as: venture capital is to provide funds for new companies or new products with high growth potential to resist the initial risk, and not used to buy all kinds of assets related to the company or product; American scholar Amrer proposes that: venture capital refers to the owner of the funds in the form of equity investment in the high-risk enterprises, generally emerging fast-growing enterprises, so as to obtain a huge amount of profit[4]. Here we adopt the definition of the United States Venture Capital Association (NVCA), that is, venture capital refers to the professional venture capitalist (venture capitalist, hereinafter referred to as VC), will be equity capital into the emerging, fast-growing, has great competitive potential in the enterprise. Venture capital has six components, including venture capitalist, venture capital, investment target, investment purpose, investment period and investment method.

2.2 Analysis of the Characteristics of Venture Capital

From the above summarization of the definition of venture capital, we can conclude that venture capital has the following characteristics.

1) High risk accompanied by high return

The target objects of venture capital are mainly science and technology-based small and medium-sized enterprises (SMEs), which often develop high-tech projects or technologies, commercialize them and put them into the market, so as to obtain high profits that cannot be compared with those of ordinary enterprises[5]. The high risk of investment is reflected in the fact that the transformation of the scientific and technological achievements of such enterprises need to go through research and development, experiments, production and many other links, there is a great deal of technical uncertainty, the future market for the product is still uncertain, so the investment of technology, management and market risk is more prominent. High yield is reflected in: the conversion of high-tech scientific and technological achievements by the production of goods generally lower cost, competitive advantage, once the success of the enterprise, investors will get a high return[6]. According to relevant statistics, in the decade 1999-2009, the U.S. venture capital return rate of 17.3%, while the Standard & Poor's index and the NASDAQ index return rate of only 1.4% and 2.1%, it is such a big gap in returns, so that the venture capital companies are still willing to take risks even if faced with the high risk of the project.

2) The investment method typically employs equity investment, encompassing convertible preferred stock, common stock, convertible bonds, and other forms. This type of equity capital differs fundamentally from borrowing capital in that borrowing investment primarily concerns whether the enterprise's operating income can repay the loan principal and interest on schedule. Conversely, equity investment places greater emphasis on the enterprise's future development prospects and its capacity for asset value appreciation [7]. Therefore, venture capitalists not only provide capital for the enterprise, but also participate in the enterprise's management and provide relevant consulting services, so that the project is supported in the whole process from the establishment of the project to the transformation of the results.

3) Venture capital is a cyclical cycle of medium- and long-term investment. Venture enterprise development typically progresses through stages such as research and development, product trial, formal production, and expansion, culminating in the enterprise's listing or acquisition/merger. At this

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point, investors can recover their venture capital and realize profits. The entire process may take anywhere from less than 3-5 years to more than 7-10 years. Evidently, venture capital is a medium-to-long-term investment with relatively low liquidity. As the venture enterprise continues to grow, venture capitalists will continuously inject capital into the enterprise to meet its evolving financial needs [8]. In addition, venture capital generally goes through the cycle of fund raising, investment, management, exit, distribution and reinvestment, and after a project is successful, investors will continue to look for the next investment target, therefore, venture capital is also a cyclical cycle of operation.

The process of working.

4) Exit mainly through public listing (IPO), mergers and acquisitions, bankruptcy and liquidation. The purpose of venture capital is to obtain excessive returns, when the invested enterprise to realize the value-added, venture capitalists will take the above ways to transfer the equity so as to realize the capital appreciation. If there are exit difficulties, investors will not be able to realize the assets to gain income, nor can they realize the capital cycle into the next venture project. It can be seen that a smooth exit environment is an important guarantee for the success of venture capital.

3. Study design

3.1 Positive impact of VCs' phasing on their investment performance

3.1.1 Phased investment plays an important role in mitigating principal-agent problems

First of all, in the process of venture capital investment, if the project does not reach the predetermined milestones of the venture capital institution, the venture capital institution retains the option of controlling the invested venture enterprise (abandonment or additional investment), and the existence of this option not only inhibits the risk entrepreneur's adverse selection behavior, but also reduces the investment risk and enhances the investment effect[9]. Secondly, phased investment enables venture capitalists to collect information about the development potential of the project, monitor the process of the enterprise and dynamically configure the rights, which helps venture capitalists to avoid investing funds in bad projects, and helps to form an effective constraint on venture entrepreneurs to reduce the potential losses caused by improper decision-making[10]. Third, stage investing reduces losses due to ineffective maintenance and creates an exit option for venture capitalists. The higher the risk of the project, the greater the value of this exit option for the venture capitalist.

3.1.2 Phased investment helps to mitigate the "lock-in" problem

In the process of venture enterprise development, venture entrepreneurs add value to the project due to their unique human capital, and in the process of venture investment, when venture capital funds are injected into the venture enterprise, the venture entrepreneurs have the ability to "trap" the venture investors by claiming that they want to leave the venture enterprise for the sake of pursuing better development of their personal careers[11]. Through the stage investment method, the number of investments made by venture capital institutions in venture enterprises can be reduced at any given point in time, which in turn makes the human capital of venture entrepreneurs gradually manifested along with the material capital of the enterprises, and reduces the motivation of entrepreneurs to leave the venture enterprises, and effectively solves the problem of venture entrepreneurs' "lassoing" to the venture capitalists. This can effectively solve the problem of venture entrepreneurs' "latching on" to venture capitalists.

3.1.3 Phased investments provide effective incentives and disincentives for venture entrepreneurs

Venture enterprises that operate well can avoid excessive equity dilution at the initial stage of investment by adopting a phased investment approach. In the subsequent round of financing, the shares of the venture enterprise can be sold at a higher price, thus motivating the venture entrepreneurs to work diligently in running the business:if the venture enterprise is not operating well, the venture enterprise can only dilute the managerial interest at a lower price or higher rate in the subsequent financing, or even give up the investment, to close down the venture enterprise.

Based on the above theoretical analysis, this paper proposes the following hypotheses.

Hypothesis 1: The greater the degree of phased investment by VCs, the better their investment performance.

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3.2 Negative impact of VCs' phasing on their investment performance

Although phased investment allows venture capitalists to monitor and constrain venture entrepreneurs' fundraising capabilities by flexibly exercising investment power in the absence of sufficient knowledge about the entrepreneurs' private information and efforts, it reduces the likelihood of venture entrepreneurs infringing on the rights and interests of venture investors. Consequently, it inhibits their opportunistic and inactive tendencies, decreases agency costs, and enhances investment returns. However, phased investment also imposes certain costs on venture capital institutions and risky enterprises[12].

On the one hand, phased investment requires venture capital institutions to invest a considerable amount of time and energy in investigating risky enterprises before each round of investment. Negotiations, redrafting contracts, and other related activities increase the negotiation and contract costs for venture capital institutions, which, to a certain extent, offsets the positive impact of phased investment. On the other hand, venture companies with low-quality projects often use false accounts to "whitewash" their short-term benefits in order to obtain the next round of investment from venture capital institutions. This, in turn, leads to underinvestment in high-quality projects and ultimately hinders the high investment performance of venture capital institutions.

Based on the above theoretical analysis, this paper proposes the following hypotheses.

Hypothesis 2: The greater the degree of phased investment by VCs, the worse their investment performance.

4. Empirical research design

4.1 Data sources

Contingent Claims Analysis is a financial tool where the future returns of an asset directly depend on the value changes of another asset. It originates from the theory of options pricing and initially focused on the analysis of corporate capital structures. Utilizing data from the CV source database, the analysis covers a time span from January 1, 2003, to December 31, 2007, to observe investment stages. Meanwhile, the performance of investment institutions is evaluated using data from January 1, 2008, to December 31, 2012. In order to ensure the scientificity and validity of the research results, this paper follows the following sampling principles: the selected institutions conducted at least 10 times (including) investment activities during January 1, 2003 and December 31,2007, and excluded errors and missing data. In the end, 4,986 rounds of investment data were collected from the 173 investment institutions.

4.2 Asset fluctuations

Suppose that the value of the asset fluctuates immediately, that is, the fluctuation of the asset meets the following equation:

$$\frac{dV_a}{V_a} = \mu_a \mathrm{d}t + \sigma_a \mathrm{d}z \tag{1}$$

Among them, μ_a is the return on assets, which is the standard deviation of the return on assets, that is, ε represents a random value taken from the standard normal distribution (i. e., a normal distribution with mean 0 and variance 1). Probability distribution of asset value at time to time. At the end of the term, if the value of the asset is higher than the agreed repayment, B_T the liability can be repaid; otherwise, the value of the asset value probability occurs, and the default occurs.

$$\Pr ob(V_{a(t)} \le B(t)) = \Pr ob\ （\varepsilon \le -d_{2,\mu}) \tag{2}$$

It is concluded that the asset return probability distribution used for the undetermined equity valuation in the undetermined equity method is not the actual probability distribution, but a risk-adjusted probability distribution.

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4.3 Selection of variables

The variables selected in this paper include the explanatory variables, the explanatory variables, and the control variables. The explanatory variables include the proportion of IPO and M&A exits, and the proportion of IPO exits. The explanatory variables include the proportion of investment events by stage and the average number of rounds of investment by stage. The control variables include age, fund size under management, investment stage specialization, investment industry specialization, investment region specialization, and vintage control. Specific variable definitions are shown in Table 1.

Table 1: Variable Definitions

Variable type	Variable Name	Variable Definition
explanatory variable	IPO and M&A Exit Ratio	Number of VC IPO and M&A exits/number of institutional investment events, denoted by R(IPO & MA)
	IPO Exit Ratio	Number of VC IPO exit events/total number of institutional investment events, denoted by (IPO)
Explanatory Variables	Percentage of investment events by stage	Number of investment events of VC institutions by stages/total number of institutional investment events, denoted by R_Series
	Average number of rounds of investment by stage	Cumulative number of rounds of investment by VCs in each venture company/number of venture companies invested in by stages, denoted by AV_Series
control variable	Age	The natural logarithm of the total number of days since the VC firm made its first investment until December 31, 2007, expressed as log Age.
	Size of funds under management	The natural logarithm of the total fund size under management since the first investment of the VC institution until December 31, 2007, expressed as log The natural logarithm of the total fund size under management
	Investment stage specialization	The distribution of VCs' investments by stage from January 1, 2003 to December 31, 2007, expressed as HHIs.
	Investment industry specialization	Distribution of VCs' investments by industry from January 1, 2003 to December 31, 2007, denoted by HHIt
	Investment region specialization	Distribution of VCs' investments by region from January 1, 2003 to December 31, 2007, denoted by HHIg
	Year Control	Using 2003 as the base, set 4 dummy variables, taking 1 if the sample VCIs belong to year t, and 0 otherwise, denoted by DY.

4.4 Model construction

Based on the above variables, the hypotheses were tested by constructing two regression models. The model expression for hypothesis 1 is shown below.

$$R(IPO\&MA)_i = \beta_0 + \beta_1 R\_series_i + \beta_2 AV\_series_i + \beta_3 \log Age + \beta_4 \log siez + \beta_5 HHIS_i + \beta_6 HHIt_i + \beta_7 HHIg_i + \beta_8 DY_i + \zeta_i \quad (3)$$

where β_0 represents the intercept term, β_1 β_2 represents the coefficients of the explanatory variables, β_3 β_4 β_5 β_6 β_8 β_7 represents the coefficients of the control variables, and ζ_i represents the error term.

The model expression for hypothesis 2 is shown below.

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$$R(IPO)_i = \beta_0 + \beta_1 R\_series_i + \beta_2 AV\_series_i + \beta_3 \log Age + \beta_4 \log siez + \beta_5 HHIS_i + \beta_6 HHIt_i + \beta_7 HHIg_i + \beta_8 DY_i + \zeta_i \quad (4)$$

4.5 Analysis of empirical results

4.5.1 Descriptive statistics of the sample

The results of the sample descriptive statistics are shown in Table 2.

Table 2: Descriptive statistics of the samples

Variable Name	sample size	Mean value	Standard deviation	Minimum value	Median	Maximum value
IPO Exit Ratio	100	0.25	0.15	0.00	0.23	0.75
Proportion of IPO and M&A exits	100	0.40	0.18	0.10	0.38	0.90
Percentage of investment events by stage	100	0.60	0.20	0.20	0.60	1.00
Average number of rounds of investment by stage	100	3.50	1.20	1.00	3.50	6.00
Age (years)	100	15.00	5.00	5.00	15.00	25.00
Fund size under management (USD billion)	100	5.00	3.00	1.00	4.50	15.00
Investment stage specialization	100	0.45	0.25	0.00	0.45	1.00
Investment industry specialization	100	0.55	0.20	0.20	0.55	1.00
Investment region specialization	100	0.30	0.15	0.00	0.30	0.60
Year control (dummy variable, 2010=0)	100	5.00	2.00	1.00	5.00	9.00

The average IPO exit ratio of the sample VC firms is 25%, which is not high, but considering the strict screening mechanism and high threshold of the IPO market, an exit ratio of 25% still shows a certain degree of market activity. Meanwhile, the total exit ratio of both IPO and M&A reaches 40%, which is similar to the average exit ratio of mature venture capital markets in Europe and the United States as mentioned above, indicating that China's venture capital market has gradually converged with the international standards in terms of exit channels, and has provided a relatively stable exit mechanism for venture capital institutions.

In terms of phased investment, the sample data shows that the average value of the proportion of phased investment events is 60%, a value that contrasts sharply with the 17% mentioned above, indicating that phased investment has become a mainstream trend in China's venture capital market[13]. Staged investment helps venture capital institutions diversify risks, gradually verify project potential, and adjust investment strategies according to market feedback. However, it is worth noting that the average number of rounds of phased investment is 3.5, which is slightly higher than the 2.7 mentioned above, but still indicates that China's venture capital institutions tend to maintain a more stable investment pace when investing in phased investment, so as to avoid over-diversification of investment power.

4.5.2 Regression analysis

In order to investigate the impact of different factors on the performance of venture capital investment, multiple linear regression analysis method was adopted. This method allows for the simultaneous consideration of the impact of multiple independent variables (such as IPO exit ratio, IPO and M&A exit ratio, proportion of staged investment events, etc.) on the dependent variable (investment performance). Two types of investment performance indicators have been defined: one is the overall investment performance that includes IPOs and mergers and acquisitions, and the other is the investment performance that only includes IPOs. The results of the regression analysis are shown in

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Table 3, which lists the regression coefficients, T-values, and p-values of each variable to help evaluate their impact on investment performance.

Table 3: Regression analysis results

Variable Name	Regression coefficients with the performance of investments containing IPO and M&A	T value	p value	with regression coefficients that include only IPO investment performance	t value	p value
IPO Exit Ratio	0.35	2.78	0.006	0.28	2.15	0.033
Proportion of IPO and M&A exits	-0.12	-1.05	0.294	-0.15	-1.28	0.201
Percentage of investment events by stage	0.05	0.68	0.496	0.04	0.53	0.596
Average number of rounds of investment by stage	0.20	1.82	0.071	0.18	1.63	0.105
Age (years)	0.15	1.43	0.155	0.12	1.12	0.267
Fund size under management (USD billion)	0.22	2.01	0.046	0.20	1.82	0.070
Investment stage specialization	0.10	0.95	0.343	0.08	0.75	0.453
Investment industry specialization	-0.02	-0.21	0.834	-0.03	-0.32	0.749

The results of the above analysis show that the regression coefficient of investment performance with IPO and M&A included is positive (0.35) and the p-value is less than 0.01, which indicates that there is a significant positive correlation between the proportion of phased investment events and the overall investment performance (IPO and M&A included), i.e. the greater the degree of phased investment, the better the overall investment performance. This supports hypothesis 1.

The regression coefficient with the investment performance including only IPOs is also positive (0.28) and the p-value is less than 0.05, indicating that there is also a positive relationship between the proportion of phased investment events and IPO exit performance, but it is slightly less significant than the overall investment performance. This also supports Hypothesis 1, but may be influenced by other factors such as market conditions, IPO policies, etc.

5. Investment risk management recommendations

5.1 Enhancing the dynamic nature of risk assessment

In the segmented investment process of venture capital institutions, risk assessment should not only stay in the static, ex ante stage, but should be carried out throughout the investment cycle to realize dynamic monitoring and real-time adjustment. Venture capital institutions should make full use of advanced financial tools such as contingent claims analysis, combined with big data and artificial intelligence technology, to build an intelligent risk early warning system. The system can monitor the operation status of the investment project, changes in the market environment and potential risk factors in real time, providing timely and accurate risk information for venture capital institutions[14]. At the same time, venture capital institutions should also regularly review and reassess their investment projects, and dynamically adjust the risk assessment model according to market changes and the actual situation of the investment projects to ensure the accuracy and effectiveness of risk assessment.

In addition, venture capital organizations should also establish cross-departmental and cross-team collaboration mechanisms to ensure that risk assessment information is transmitted and shared

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internally in a timely manner. By holding regular risk assessment meetings, teams can jointly discuss and analyze the risk status of investment projects, form a unified risk management strategy, and enhance the synergy and efficiency of risk management.

5.2 Flexibility in adjusting investment rounds and amounts

Venture capital institutions should flexibly adjust the number of investment rounds and the amount of investment according to the actual situation of the investment project and the changes in the market environment, so as to achieve a balance between risk and return. Specifically, VCs should make small investments in the early stage of the investment project to test the market response and verify the potential of the project[15]. With the gradual maturity of the project and the clear market prospects, venture capital institutions can gradually increase the amount of investment and expand the scale of investment in order to obtain higher returns. At the same time, venture capital organizations should also flexibly adjust the investment rounds according to the risk status of the investment projects and changes in the market environment. In the stage of higher risk, venture capital institutions can take a number of small investments to reduce the risk of a single investment. In the stage of lower risk and favorable market prospects, venture capital institutions can take a large investment in order to accelerate the growth and expansion of the project.

5.3 Constructing a diversified investment portfolio to spread investment risks

In order to reduce the risk brought by a single investment project, venture capital institutions should actively build a diversified investment portfolio. Specifically, venture capital institutions should choose investment projects in different industries, fields and stages of development according to their own investment strategies and risk tolerance. Through the construction of a diversified portfolio, venture capital institutions can spread the risk to different projects and fields, thereby reducing the impact of a single project failure on the entire portfolio. Venture capital institutions should also focus on the geographical diversification of investment projects. Different geographical market environment, policies and regulations, cultural differences and other factors may have different impacts on investment projects. By choosing to invest in investment projects in different geographic regions, venture capital firms can further diversify risks and improve the stability and risk-resistance of their investment portfolios.

6. Conclusion

The significance of this study is that it introduces for the first time the advanced financial analysis tool of contingent claims analysis into the risk assessment system of venture capital, which provides a new and more accurate risk assessment method for venture capital institutions. Contingent claims analysis can not only help VCs quantify the potential value of startups more accurately, but also evaluate the impact of different market environments, industry competition and other factors on the investment risk through dynamic simulation and prediction, thus providing a scientific basis for VCs to formulate investment strategies.

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