Contracting and its Valuation Implications in Staged Venture Capital

BEIBEI LIU

636441

DDIM Program

LUISS University

Table of Contents

Table of figures and tables

Abstract

This paper lies at the crossroad of the venture capital and the real options literatures, breaking a new ground by bring them together in a way not attempted before. Its purpose is to theoretically combine the venture capital financial contracts and the real options valuation method in a combined financial systems engineering framework. Based on this framework, a venture backed company case is investigated.

Firstly, the literatures of venture capital financial contract theory and real options theory are reviewed. Secondly, the characteristics of venture capital investment and the information asymmetry problem between venture capitalists and entrepreneurs are researched. Thirdly, the important contract clauses including using convertible preferred stock and staged investment are introduced. Fourthly, option pricing methods and real option theory are reviewed. Then the combined financial framework of contracting theory and real option theory is designed. Because of the contract design in venture capital and the use of staged investment as well as the convertible preferred stock, venture capitalists can get some rights like continue investment rights, liquidity rights and other control rights, in fact, the contingent allocation of these rights could be considered as different types of real options, such as the expansion options, the delaying investment options or the abandoning options. Furthermore, in the whole process, the enterprise value and the risk premium that the investors require will change. Finally, the NT Pharma Company case is studied based on the combined framework.

Key words: Venture capital, contracting theory, staged investment, real option

1. Introduction

The current literature on venture capital can be subdivided into three main classes, depending on whether it addresses the theoretical optimality of contracts, empirically analyses the existing contracts used in practice or values the venture-capital backed company. A rich, mostly game-theoretic literature addresses the agency and moral hazard problems arising in a multi-stage financial contracting environment with information asymmetries. The second class of research includes empirical studies that analyze the specificities of venture backed projects. The third class is about how to value those venture capital backed companies.

However, few paper research venture capital contract and valuation of the venture capital backed company together. This paper lies at the crossroad of the venture capital and the real options literatures, breaking a new ground by bring them together in a way not attempted before. Its purpose is to theoretically combine the venture capital financial contracts and the real options analysis in a financial systems engineering framework. Based on this framework, I investigate a venture backed company.

This paper is an interdisciplinary research project, integrated use of the finance and venture capital knowledge, and combines theory and empirical research together. Specifically: this paper uses theory research method to research venture capital and real option theory; this paper uses comparative approach to study financial option and real option, traditional net present value evaluation method and real option evaluation method; and use case study method to apply the combined theory framework to real condition.

The structure of this thesis proceeds as follows. In section 2 I review the literature of venture capital financial contract theory and real options theory. In section 3 I introduce the characteristics of venture capital, the structure of venture capital firm, and the operating process of venture capital. Section 4 researches the information asymmetry problem between venture capitalists and entrepreneurs and contract design to mitigate this problem. The most important contract clauses include staged venture capital investment and using convertible preferred stock. Section 5 first introduces the traditional net present value method in valuing a project and discusses the limitations of this method in valuing a venture capital backed project. Then the option valuation method is introduced, including the meaning and types of option, the theory

foundations of option pricing models, binomial option pricing model, Black-Scholes option pricing model and real option. Section 6 theoretically combines the venture capital financial contracts and the real options analysis in a framework. Because of the contract design in venture capital and the use of staged investment as well as the convertible preferred stock, venture capitalists can get some rights like cash flow rights, board rights, voting rights, liquidity rights and other control rights. Compared with the characteristics of options, the contingent allocation of these rights could be considered as different types of real options, such as the expansion options, the delaying investment options or the abandoning options. Furthermore, in the whole process, the enterprise value and the risk premium that the investors require will change. After that, NT Pharma Company case is studied. Section 7 concludes this paper by summarizing and proposing directions for further research.

2. Literature review

2.1 Literatures on contracting in venture capital

Michael C. Jensen (1976) defines the concept of agency costs, shows its relationship to the "separation and control" issue, investigates the nature of the agency costs generated by the existence of debt and outside equity, demonstrates who bears costs and why, and investigates the Pareto optimality of their existence. He also provides a new definition of the firm, and shows how his analysis of the factors influencing the creation and issuance of debt and equity claims is a special case of the supply side of the completeness of markets problem.

Sahlman (1990) describes and analyzes the structure of venture capital organizations, focusing on the relationship between investors and venture capitalists and between venture capital firms and the ventures in which they invest. He emphasizes the agency problems in these organizations and to the contracts and operating procedures that have evolved in response. Venture capital organizations are contrasted with large, publicly traded corporations and with leveraged buyout organizations. The author uses data from Venture Economics, the leading information source on the venture capital industry. He finds that venture capital environment is characterized by substantial uncertainty about payoffs on individual investments and a high degree of information

asymmetry between principals and agents. To cope with the challenges posed by such an environment, certain standard operating procedures and contracts have evolved, including staging the commitment of capital, basing compensation on value created, and preserving mechanisms to force agents to distribute capital and profits.

Jeffrey (1994) addresses the role asymmetric information plays in determining why venture capitalists use equity, and preferred equity in particular, rather than debt, to finance entrepreneurial projects. He suggests that the risk of the entrepreneur observing information about the project type before the venture capitalist may play a role in the contract type selection, as well as the project quality uncertainty itself. The author develops a multi period framework in which optimal contract choice is driven by considerations of monitoring difficulty in an environment of potentially asymmetric information with moral hazard. Conditions of asymmetric information may arise between the venture capitalist and the entrepreneur. That is, at various stages of firm development there is a positive probability of a condition of asymmetric information. As a result, it is shown that the foreclosure option embedded in a debt contract may actually create an incentive for the entrepreneur to "behave opportunistically", taking whatever project payoffs are available and defaulting on the debt. As a result, for sufficiently high probabilities of asymmetric information, debt contracting may be neither feasible nor desirable. Under these circumstances, equity contracting may be a feasible alternative precisely because of the lack of foreclosure rights. In particular, preferred or convertible preferred stock may be the dominating contract; because this contract eliminates the foreclosure option while preserving some seniority in the event of bankruptcy due to current liabilities and let information turn out to be symmetric. It is argued that this asymmetric information mechanism may be responsible for the predominance of preferred stock in venture capital contracting. That predominance is demonstrated in an empirical study which extends the previous empirical literature.

Gompers (1995) examines the structure of staged venture capital investments when agency and monitoring costs exist. He finds that expected agency costs increase as assets become less tangible, growth options increase, and asset specificity rises. Data from a random sample of 794 venture capital backed firms support the predictions. Venture capitalists concentrate investments on early stage and high technology companies where informational asymmetries are highest.

Decreases in industry ratios of tangible assets to total assets, higher market-to-book ratios, and greater R&D intensities lead to more frequent monitoring. Venture capitalists periodically gather information and maintain the option to discontinue funding projects with little probability of going public.

Bergemann (1998) proposes a simple model to analyze the optimal financing of venture projects when learning and moral hazard interact. He investigates the provision of venture capital when the investment flow controls the speed at which the project is developed. As the binary outcome of the project is uncertain, the speed of development influences the (random) time at which the project yields success and the information which is acquired by the investment flow. The role of the entrepreneur is to control the application of the funds which are provided by the venture capitalist. The author provides a rationale for long-term contracting as these contracts achieve best the goal of distributing the entrepreneur's return over time in a way which maximizes the research horizon. It is further shown that the compensation of the entrepreneur is similar to an option contract, and as such depends on the length of the contract and the volatility of the information induced through her actions. The option expresses the value of the incentive constraint. As the value of the option may become exceedingly large, relationship financing may become necessary. In consequence, the optimal timing of monitoring and replacement of the entrepreneur are analyzed.

Kaplan (2002) focuses on the relationship between the monitoring activities of venture capitalists and the contracts they structure with entrepreneurs. Venture capitalists utilize contracts to mitigate risk. Risks might be internal to the firm (e.g., management team quality), where the investor is less informed ex ante than the entrepreneur, or external to the firm (e.g., market size or customer adoption rates), where both parties are equally uninformed, and risks might involve some element of complexity (e.g., product or technology innovation). Internal and external risk can be managed through greater investor control and ownership, as well as greater contingent compensation for the entrepreneur. Complexity risk can be mitigated through less contingent compensation, and more vesting overtime. The extent of investor's monitoring activities is correspondingly associated with the type of contract written: for example, as control increases, investors are more likely strengthen management teams, and as cash flow rights increase,

investors are more likely to provide value-added services.

Wang (2002) offers a formal model for staged financing in controlling risks and moral hazard in venture capital. He finds a closed-form solution, by which analysis of the complementary roles of staged financing and contracting can be made. He focuses on the problems of moral hazard and uncertainty involved in financing new startups. Specifically, he considers a financially constrained entrepreneur and a venture capitalist who is interested in investing in the entrepreneur's project. The project is risky and the entrepreneur's effort is unverifiable. The entrepreneur faces an imperfect capital market and the venture capitalist is the only potential investor who understands the project (i.e., the venture capitalist knows the distribution function of the output). The venture capitalist offers a sharing contract and finances the project strategically in stages. Using parametric functions, the author is able to derive some interesting properties of staged financing. The results clearly show that, in addition to contracting, staged financing is an effective mechanism for venture capitalists to reduce agency costs and to control risks. Staged financing can achieve high efficiency, especially for highly promising ventures. Besides the benefit of reducing risks through late investment, as a complementary mechanism to contracting, staged financing plays a crucial role in controlling moral hazard. In particular, staged financing induces a higher effort from the entrepreneur.

Didier (2002) investigates four common features of venture capital investment contracts from a real option perspective, using both analytical solutions and numerical analysis to draw inferences for a better understanding of contract features. The impact of the concept for pricing issues, valuation negotiation and contract design are considered. It is shown for example how "contingent pre-contracting" for follow-up rounds is theoretically a better proposition than the simple "rights of first refusal" commonly found in many contracts. He also provides for results (such as timing of investments, length of rounds, choices of liquidation levels, conversion levels) that take into account full interaction of the different features considered. The author documents some complex facts, such as the concavity of the venture capital contract value depending on the amount invested at the different stages, the actual share impact of the most common anti-dilution feature, some endogenous motivation for early venture capital exits from otherwise performing companies, and stresses overall the importance of a full analysis for efficient contract negotiation

and understanding.

Fluck (2005) develops a model to study how entrepreneurs and venture capital investors deal with moral hazard, effort provision, asymmetric information and hold-up problems. How severe the underinvestment problem start-up firms are facing is, how much value lost in the entrepreneur-venture capital relationship relative to the first-best is, whether venture capital financing is generally more efficient for high-variance firms, whether there are significant efficiency gains from syndication of later stage financing. The author explores several financing scenarios, including first-best, monopolistic, and syndicate financing and solves numerically for the optimal contract, the entrepreneur's effort and the option values of the project. Relative to the first-best, he finds significant value losses due to under-provision of effort and hold-up problems. The underinvestment problem is severe: many start-ups with positive net present value projects cannot get financed. A commitment to syndicate financing in later stages reduces the entrepreneur's under-provision of effort and the hold-up problem, increasing overall efficiency.

Bienz (2005) analyzes the degree of contract completeness with respect to staging of venture capital investments using a hand-collected German data set of contract data from 464 rounds into 290 entrepreneurial firms. He distinguishes three forms of staging (pure milestone financing, pure round financing and mixes). Thereby, contract completeness reduces when going from pure milestone financing via mixes to pure round financing. He shows that the decision for a specific form of staging is determined by the expected distribution of bargaining power between the contracting parties when new funding becomes necessary and the predictability of the development process. To be more precise, parties choose the more complete contracts the lower the entrepreneurs expected bargaining power- the maximum level depending on the predictability of the development process.

Tian (2011) examines the causes and consequences of venture capital stage financing. Using information about the physical location of an entrepreneurial firm and the geographic distance between the venture capital investor and the firm, the author shows that venture capital investors located farther away from an entrepreneurial firm tend to finance the firm using a larger number of financing rounds, shorter durations between successive rounds, and investing a smaller amount in each round. However, venture capital investors' propensity to stage is independent of

whether the firm is located in a close-knit community. He also finds that venture capital staging positively affects the entrepreneurial firm's propensity to go public, operating performance in the initial public offering (IPO) year, and post-IPO survival rate, but only if the firm is located far away from the venture capital investor. However, the effect of venture capital staging on entrepreneurial firm's performance is independent of whether it is located in a close-knit community.

2.2 Literatures on options in venture capital

Black and Scholes (1973) develop the Black-Scholes option pricing model by using No-arbitrage principle. John C. COX, Stephen A. ROSS and Mark RUBINSTEIN (1979) develop a simple discrete-time model for valuing options. Its development requires only elementary mathematics, yet it contains as a special limiting case the celebrated Black-Scholes model, which has been derived only by much more difficult methods. By its very construction, it gives rise to a simple and efficient numerical procedure for valuing options for which premature exercise may be optimal.

Timothy (1998) bridges the gap between the practicalities of real world capital projects and the higher mathematics associated with formal option-pricing theory. The framework produces quantitative output, can be used repeatedly on many projects and is compatible with the ubiquitous discounting cash flow (DCF) spreadsheets that are at the heart of most corporate capital-budgeting systems. The author begins by examining a generic investment opportunity- a capital budgeting project- to see what makes it similar to a call option, and then compares DCF with the option-pricing approach to evaluate the project. Instead of looking only at the differences between the two approaches, the author also looks for points of commonality. Most of the data the framework uses come from the DCF spreadsheets that managers routinely prepare to evaluate investment proposals. And for option values, the framework uses the Black-Scholes option-pricing table instead of complex equations. Finally, the framework is used in a typical capital-investment decision.

Mark (2002) interprets the staged finance in venture capital as s multiple stage compound

option, which is also known as an installment option. The author derives bounds on how much a venture capitalist should initially invest in a start-up firm. Under suitable assumptions, such bounds rely solely upon no arbitrage arguments. Upper and lower bounds can be enforced by constructing portfolios of European options on firms in the same industry. In this research, the author considers venture capital projects that are in strong sense imitators of existing firms in some industry. Under the assumption that European options are traded for the existing firms, the venture capitalist can use this information to decide whether or not to fund a new project. This is achieved by comparison of the expected cash flows and future investment payments of the venture project to that of an installment option on an existing firm in the same industry. He shows that the venture capital investor can realize an arbitrage profit by funding the venture capital project and at the same time selling a portfolio of European options. This will occur if the required initial payment for the venture project is lower than the cost of the European option strategy. This provides a lower boundary on the amount that the venture capital investor would be willing to pay initially. If the venture capital investor is a profit-maximizing rational agent, the upper boundary for initial project funding must be the upper boundary of the installment option on the related firm.

Yong (2007) takes a real options perspective towards venture capital staging and views the staging decision as a choice between holding the current option to invest and investing now to obtain the option to invest subsequently. He proposes that this staging decision depends on the factors that influence the value of these two options, such as competition and various sources of uncertainty. The empirical results suggests that market uncertainty encourages venture capital firms to delay investing at each round of financing, whereas competition, project-specific uncertainty and agency concerns prompt venture capital firms to invest sooner.

Sofia (2007) prices the options of both the entrepreneur and the venture capitalist to participate in venture capital investment. She concentrates on the strategic aspect of the relationship between the parties as regards their optimal choice of effort in order to maximize their option values, applying an adjusted Black and Scholes formula. The association of effort and option value is demonstrated through implementation of the model numerically. The results, restricted by the model's assumptions (required return, constant effort, liquidation value,

financing), provide some guidance on contract negotiations and on the designing of the optimal contract for both parties; for the entrepreneur non-zero effort exerted improves his option value and prefers the venture capitalist exerting full effort; for the venture capitalist zero effort level is optimal if his share of profits and the liquidation value are very high, diminishing the robustness of the entrepreneur's advantage, while at the same time, he prefers the entrepreneur exerting low effort.

Ma (2008) theoretically analyses the dynamic allocation of rights between the investing and financing sides of the venture capital contract under a real options framework. Based on this systems framework, he further investigates and examines the venture capital investment of a high-tech corporation in China. In this case, the clauses of the venture capital financial contracts are interpreted from a principal-agent perspective. The stage financing clauses provide the nodes for carrying out the real options evaluation by the risk-neutral valuation method and explaining the decision path by dynamic rights allocation analysis.

Yao (2008) uses contingent claims analysis to investigate the staging decision of venture capitalist in a principal-agent framework. Venture capital investment opportunities are modeled as real options with multiple volatilities, and the entrepreneur's incentive is assumed to maximize the probability of getting funded in the next financing round. Two celebrated formulae in the option pricing literature are generalized to evaluate these real options. He finds that staging not only gives the venture capitalist a waiting option but also mitigates the agency problem of the entrepreneur undertaking too conservative activities. Moreover, he finds that the venture capitalist tends to stage her investment when the expected growth rate of the venture's market value is lower. However, the risk-free interest rate is not an important factor in the staging decision. His model also provides a good explanation for existing empirical evidence on the staging of venture capital investment.

3. Venture capital

3.1 The history of venture capital

Paul Gompers (2001) reviewed the history of venture capital in his paper "The Venture Capital

Revolution". The first true venture capital firm was American Research and Development (ARD), established in 1946 by MIT President Karl Compton, who was a professor at Harvard Business School, and local business leaders. This small group made high-risk investments in emerging companies that were based on technology developed for World War Two. The success of the investments ranged widely: almost half of ARD's profits during its 26-year existence as an independent entity came from its $70,000 investments in Digital Equipment Company in 1957, which grew in value to $355 million. ARD was structured as a publicly traded closed-end fund. A closed-end fund is a mutual fund whose shares trade from investor to investor on an exchange like an individual stock.

Activity in the venture industry increased dramatically in late 1970s and early 1980s. In 1979, the U.S. Department of Labor clarified its "prudent man" rule in a way that explicitly allowed pension fund managers to invest in high-risk assets, including venture capital. Eight years later, when more than $4 billion was invested, pension funds accounted for more than half of all contributions. Venture capitalists backed many of the most successful high-technology companies during the 1980s and 1990s, including Apple Computer, Cisco Systems, Genentech, Microsoft, Netscape, and Sun Microsystems.

Venture capital develops very fast in emerging countries recently. For example, venture capital in China begins in 1980s and grows fast these recent years. In fact in the year 2010, venture capital fund has increased by 11 billion us dollars in China. And 817 investment cases happened, the investment amount were more than 6 billion us dollars. And last year in China 388 cases exit, 85 percent of them are in IPO form. Last year China government has made decision to improve some strategic emerging industries, these industries include energy saving, new energy, new energy vehicles, new materials, new generation of information technology, biotechnology, and high-end equipment manufacturing. Now China is in an important period of the transformation of economic growth model and upgrading of industrial structure, and these strategic emerging industries will have great growth potential in China. But In the current situation, these industries need a lot of money to develop, so there will be a lot of opportunities for venture capitalists to invest in these industries.

3.2 The implication of venture capital

Venture capital has developed as an important intermediary in financial markets, providing capital to firms that might otherwise have difficulty attracting financing. These firms are typically small and young, plagued by high levels of uncertainty and large differences between what entrepreneurs and investors know. Moreover, these firms typically possess few tangible assets and operate in markets that change very rapidly. Venture capital organizations finance these high-risk, potentially high-reward projects, purchasing equity or equity-linked stakes while the firms are still privately held. The typical venture capital investment occurs after the seed funding round as growth funding round in the interest of generating a return through an eventual realization event, such as an IPO or trade sale of the company. The venture capital industry has developed a variety of mechanisms to overcome the problems that emerge at each stage of the investment process. At the same time, the venture capital process is also subject to various pathologies from time to time, which can create problems for investors and entrepreneurs.

Venture capitalist is a person or investment firm that makes venture investments, and these venture capitalists are expected to bring managerial and technical expertise as well as capital to their investments. A venture capital fund refers to a pooled investment vehicle that primarily invests the financial capital of third-party investors in enterprises that are too risky for the standard capital markets or bank loans. Venture capital firms typically comprise small teams with technology backgrounds (scientists, researchers) or those with business training or deep industry experience.

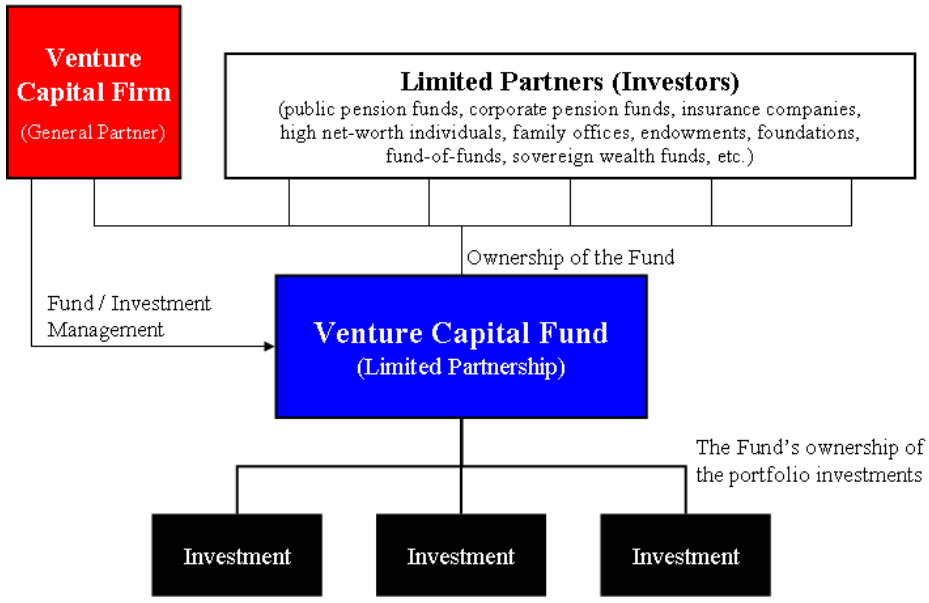
A core skill within venture capitalist is the ability to identify novel technologies that have the potential to generate high commercial returns at an early stage. By definition, venture capitalists also take roles in managing entrepreneurial companies at an early stage, thus adding skills as well as capital (thereby differentiating venture capitalist from buy-out private equity, which typically invest in companies with proven revenue), and thereby potentially realizing much higher rates of returns. Inherent in realizing abnormally high rates of returns is the risk of losing all of one’s investment in a given start-up company. As a consequence, most venture capital investments are done in a pool format, where several investors combine their investments into one large fund that invests in many different start-up companies. By investing in the pool format, the investors are spreading out their risk to many different investments versus taking the chance

of putting all of their money in one start-up firm.

3.3 The structure of venture capital firm

Venture capital firms are typically structured as partnerships, the general partners of which serve as the managers of the firm and will serve as investment advisors to the venture capital funds raised. Venture capital firms in the United States may also be structured as limited liability companies, in which case the firm's managers are known as managing members. Investors in venture capital funds are known as limited partners. This constituency comprises both high net worth individuals and institutions with large amounts of available capital, such as state and private pension funds, university financial endowments, foundations, insurance companies, and pooled investment vehicles, called fund of fund.

Figure 1: The structure of venture capital firm



Venture partnerships have predetermined finite life spans. The limited partnership agreement explicitly specifies the terms that govern the venture capitalists' compensation over the entire ten-to-thirteen-year life of the fund. It is extremely rare that these terms are renegotiated. The specified compensation has a simple form. The venture capitalist typically receives an annual fixed fee, plus variable compensation that is a specified fraction of the fund's profits. The fixed

portion of the specified compensation is usually between 1.5 and 3 percent of the committed capital or net asset value, and the variable portion is usually 20 percent of fund profits.

3.4 Characteristics of venture capital

The three primary characteristics of venture capital fund which make it eminently suitable as a source of risk finance are: equity or quasi equity investment, long-term investment and active form of investment.

First, venture capital is equity or quasi equity investment because the investor assumes risk. Investors of venture capital have no liquidity for a period of time. Venture capitalists hope that the company they are backing will thrive and after five or seven years from making the investment it will be large and profitable enough to sell its shares in the stock market. Second, venture capital is a long-term investment and generally requires five to seven years to harvest. This long-term investment always accompanies by high uncertainty and risk. Finally, venture capital investment involves participation in the management of the invested company. Venture capitalists participate in the Board and guide the firm on strategic and policy matter, they help the invested company in the fields of marketing, human resource, and public relation.

3.5 The operating of venture capital

Paul Gompers (2004) described the venture capital cycle in his book “The Venture Capital Cycle”. The venture capital cycle starts with raising a venture fund; proceeds through the investment in, monitoring of, and adding value to firms; continues as the venture capital firm exits successful deals and returns capital to its investors; and renews itself with the venture capitalist raising additional funds.

The first stage is to raise a venture fund. There are many resources of venture fund, like government investment, big company fund, bank fund and pension fund. The main resource is from institutional investors and wealthy individuals, and only a small part is from government, since venture capital investment is a kind of business activity and the government only acts as a

guide. Venture capitalists typically raise their capital not on a continual basis, but rather through periodic funds. These funds, which are often in the form of limited partnerships, typically have a ten-year life, though extensions of several years are often possible. Eventually, however, the funds must be returned to the investors, and a new fund raised. A venture organization usually will raise a fund every two to five years.

The second stage is to screen and evaluate proper project. The typical venture organization receives many dozens of business plans for each one it funds. Although most proposals are swiftly discarded, serious candidates are extensively scrutinized through both formal studies of the technology and market strategy and informal assessment of the management team. It is not unusual for a venture team to complete 100 or more reference checks before deciding to invest in a firm. The decision to invest is frequently made conditional on the identification of a syndication partner who agrees that this is an attractive investment. Venture capital usually invests in those industries with a novel technology, like communication, electronics, new materials, new energy, mobile internet, biotechnology and so on. Venture capital will also choose the investment scale; generally one project is 10% of the total amount of the fund. Different venture capital prefers different investment stage, some prefer to invest in seed or start-up stage, and others prefer late stages. Geography is another factor to be considered when choosing the proper invested project; generally speaking venture capitalists prefer those projects which are near their working offices. There is always a careful due diligence before investing, to find more detail information about the entrepreneur company, including the condition of the management team, the patent ownership, the financial and accounting data and market prospects. If the venture capital decides to invest, then the two parties will start to negotiate about the price and investment scale and sign the contract. The contents of the contract include the number of investment periods, the duration of each period and the amount to be invested in each period.

Third, venture capital will monitor and add value to the entrepreneur company. Managers of these venture-backed firms are forced to return repeatedly to their financiers for additional capital to ensure that the money is not squandered on unprofitable projects. In addition venture capitalists intensively monitor managers. These investors demand preferred stock with numerous restrictive covenants and representation on the board of directors. Venture capital not only

monitors the entrepreneur company but also participates in the strategic decision and organizational restructuring. They will help the entrepreneur company to find proper talents, choose proper industry and market, and find important customers and suppliers. Venture capital monitors and influences the entrepreneur company by participating in Board of Directors and reviewing the financial reports.

Finally, when the entrepreneur company is success enough to raise money from the public market, venture capital exits and earns profit. Typically, venture capitalists seek to take public the most successful firms in their portfolios. While a relatively modest fraction of portfolio firms are taken public, they account for the bulk of the venture returns. Even among these offerings, often a small number of firms account for the bulk of the returns; the distribution is highly skewed. Other, less successful firms are liquidated, sold to corporate acquirers, or less remain operational at a modest level of activity.

4. Problems in venture capital and contract design

4.1 Problems in venture capital

The most serious problem in venture capital investment is the principle-agent problem between venture capitalists and entrepreneurs.

Michael C. Jensen (1976) first researched the principle-agent problem in his paper “Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure”. The principal-agent problem or agency dilemma treats the difficulties that arise under conditions of incomplete and asymmetric information when a principal hires an agent, such as the problem of potential moral hazard and conflict of interest. The principal-agent problem arises when a principal compensates an agent for performing certain acts that are useful to the principal and costly to the agent, and where there are elements of the performance that are costly to observe. This is the case to some extent for all contracts that are written in a world of information asymmetry, uncertainty and risk.

William A. Sahlman (1990) researched the principle-agent problem in venture capital industry in his paper “The structure and governance of venture-capital organizations”. The venture capital

environment is characterized by substantial uncertainty about payoffs on individual investments and a high degree of information asymmetry between principals and agents. The entrepreneur controls the allocation of the funds and the investment effort is unobservable to the investor. The control over the funds implies that the entrepreneur also controls the flow of information about the project.

If asymmetric information and agency costs do not exist, the structure of financing is irrelevant. If entrepreneurs pursue shareholder value maximizing strategies, financing is simple. Venture capitalists would give entrepreneurs all the money they need and entrepreneurs would decide whether to continue the project based on their information. The private benefits from managing the firms the entrepreneurs create, however, may not always be perfectly correlated with shareholders' monetary returns. Entrepreneurs may have incentives to continue running projects they know have negative net present value. Similarly, entrepreneurs may invest in projects that have high personal benefits but low monetary returns for investors.

Two related types of agency costs exist in entrepreneurial firms. First, entrepreneurs might invest in strategies, researches, or projects that have high personal returns but low expected monetary payoffs to shareholders. For example, a biotechnology company founder may choose to invest in a certain type of research that bring him/her great recognition in the scientific community but provides less return for the venture capitalist than other projects. Similarly, because entrepreneurs' equity stakes are essentially call options—the entrepreneurs' equity stakes are almost always junior to the preferred equity position of venture capital investors—they have incentives to pursue high-variance strategies like rushing a product to market when further testing may be warranted.

Second, if the entrepreneur possesses private information and chooses to continue investing in a negative net present value project, the entrepreneur is undertaking inefficient continuation. For example, managers may receive initial results from market trials indicating little demand for a new project, but entrepreneurs may want to keep the company going because they receive significant private benefits from managing their own firm.

In addition, the information asymmetry caused by the principle-agent problem is particularly obvious in the high-tech venture capital financing. In the financial system, the information

asymmetry can be divided into the following three types. Firstly, the ex ante information asymmetry is caused by the intangible assets with high technological specialty, entailing immense difficulty for the investors to evaluate. Besides, because most of the entrepreneurs are technological background researchers engaging in high-tech domain, it is hard for the investors to examine the business knowledge and the management experience of the entrepreneurial team. Secondly, the ex post information asymmetry comes from the insider position of the entrepreneurs who are more familiar with the operation and performance of their own enterprises. It is possible that they deliberately conceal the announcement of some important information, or even make up false information to cheat the investors, in order to increase their private interests. Furthermore, since it is arduous to carry out complex tasks in high-tech enterprises, the human capital of the entrepreneurs is extremely important. This makes some traditional theories and empirical analysis ineffective when being applied to the venture capital investment (Kaplan and Stromberg, 2003, 2004).

Another problem is the “hold-up” problem. In the world of incomplete contracting, the theory of Hart and Moore (1994) on the inalienability of human capital suggests that an entrepreneur cannot contractually commit to staying with a firm in which the entrepreneur’s unique human capital is critical to achieving the venture’s full potential. Close-knit communities where entrepreneurial firms are clustered provide entrepreneurs with good opportunities for purchasing better careers if they leave the firm in which they are initially employed. This allows the entrepreneur to hold up venture capital investor.

4.2 Contract design in venture capital

The fundamental problem that financial contract intends to solve is that, how the entrepreneurs with urgent need of capital and the investors with surplus capital should negotiate and sign the contract clauses, so as to balance the interests of both sides and make the progress efficient.

Jeffrey J. Trester (1993) researched the contract design in venture capital in his paper “Venture Capital Contracting under Asymmetric Information”. The venture capital industry has evolved operating procedures and contracting practices that are well adapted to environments

characterized by uncertainty and information asymmetries between principals and agents. A key feature of the contracts and operating procedures is that risk is shifted from the venture capitalists to the entrepreneur.

Venture capitalists are actively involved in the management of the ventures they fund, typically becoming members of the board of directors and retaining important economic rights in addition to their ownership rights.

Venture capital partnerships enter into contracts with both the outside investors who supply their funds and the entrepreneurial ventures in which they invest. The contracts share certain characteristics, notably: staging the commitment of capital and preserving the option to abandon; using compensation systems directly linked to value creation; preserving ways to force management to distribute investment proceeds; using convertible preferred stock to get some protection and flexibility. These elements of the contracts address three fundamental problems: the sorting problem, how to select the best entrepreneur ventures; the agency problem, how to minimize the present value of agency costs; the operating-cost problem, how to minimize the present value of operating costs, including taxes.

4.3 Staged investment

4.3.1 Introduction of staged investment

Paul A. Gompers (1995) researched the staged investment in his paper “Optimal Investment, Monitoring, and the Staging of Venture Capital”. Staged capital infusions are the most potent control mechanism a venture capitalist can employ. Prospects for the firm are periodically reevaluated. The shorter the duration of an individual round of financing, the more frequently the venture capitalist monitors the entrepreneur’s progress and the greater the need to gather information. The role of staged capital infusion is analogous to that of debt in highly leveraged transactions, keeping the owner/manager on a “tight leash” and reducing potential losses from bad decisions.

This part examines the staging of capital infusions by venture capitalists. It explores not only

how these investments are structured but also why this approach is employed. The evidence indicates that the staging of capital infusions allows venture capitalists to gather information and monitor the progress of firms, maintaining the option to abandon projects periodically.

4.3.2 Agency and monitoring costs that affecting the staged investment

Venture capitalists claim that the information they generate and the services they provide for portfolio companies are as important as the capital infused. Many entrepreneurs believe that venture capitalists provide little more than money. If the monitoring provided by venture capitalists is valuable, certain predictions can be made about the structure of staged capital infusions.

If monitoring and information gathering are important, venture capitalists should invest in firms in which asymmetric information is likely to be a problem. The value of oversight will be greater for these firms. Early-stage companies have short or no histories to examine and are difficult to evaluate. Similarly firms in industries with significant growth opportunities and high R&D intensities are likely to require close monitoring. A significant fraction of venture investment should therefore be directed toward early-stage and high-technology companies.

Total venture financing and the number of financing rounds should also be higher for successful projects than for failures if venture capitalists utilize information in investment decisions. Venture capitalists monitor a firm’s progress and discontinue funding the project if they learn negative information about future prospects. Firms going public should thus receive greater total funding and more rounds of financing than firms that are acquired or liquidated.

The positive relationship between going public and level of investment is not obvious unless venture capitalists use information during the investment process. If venture capitalists only provide capital, firms that go public might quickly turn profitable and would need less venture capital financing and fewer rounds than companies that are acquired or liquidated.

If asymmetric information and agency costs do not exist, the structure of financing is irrelevant. As Hart (1993) points out, if entrepreneurs pursue shareholder value-maximizing strategies, financing is simple. Venture capitalists would give entrepreneurs all the money they

need and entrepreneurs would decide whether to continue the project based on their information. In the case of start-ups, entrepreneurs would derive stopping rules that maximized shareholder value. Based on their private information, they would decide whether to continue the project or not.

The private benefits from managing the firms they create, however, may not always be perfectly correlated with shareholders' monetary returns. Entrepreneurs may have incentives to continue running projects they know have negative net present value. Similarly, entrepreneurs may invest in projects that have high personal benefits but low monetary returns for investors. If venture capitalists could costless monitor the firm, they would monitor and infuse cash continuously. If the firm's expected net present value fell below the stopping point, the venture capitalist would halt funding the project.

In practice, venture capitalists incur costs when they monitor and infuse capital. Monitoring costs include the opportunity cost of generating reports for both the venture capitalist and the entrepreneur. If venture capitalists need to 'kick the tires" of the plant, read repots, and take time away from other activities, these costs can be substantial. Contracting costs and the lost time and resources of the entrepreneur must be imputed as well. Each time capital is infused; contracts are written and negotiated; lawyers are paid; and other associated costs are incurred. These costs mean that funding will occur in discrete stages.

Two well-known companies illustrate how venture capitalists use staged investment to periodically evaluate a firm's progress. Apple computer received three rounds of venture capital financing. In the first round, venture capitalists invested $518,000 in January 1978 at a price of $0.09 per share. The company was doing well by the second round of venture financing in September 1978. Venture investors committed an additional $704,000 at a price of $0.28 per share, reflecting the progress the firm had made. A final venture capital infusion of $2.331 million was made in December 1980 at $0.97 per share. At each stage the increasing price per share and the growing investment reflected resolution of uncertainty concerning Apple's prospects.

Federal Express represents a second example of how venture capitalists use staged capital infusions to monitor the firm. Federal Express also received three rounds of venture capital

financing, but the firm's prospects developed in a much different manner. The first venture financing round occurred in September 1973 when $12.25 million was invested at a price of $204.17 per share. The firm's performance was well below expectations and a second venture financing round was necessary in March 1974. $6.4 million was invested at $7.34 per share and reflected the poor performance of the company. Performance continued to deteriorate and a third round of financing was needed in 1974. At this stage, the venture capital investors intervened extensively in the strategy of the company. The $3.88 million investment was priced at $0.63 per share. Ultimately, performance improved and Federal Express went public in 1978 at $6 per share, but staged investment of the venture capitalist allowed the venture investors to intervene and price subsequent rounds so they could earn a fair rate of return.

The nature of the firm's assets may have important implications for expected agency costs and the structure of staged venture capital investments. The capital structure literature motivates a search for those factors. Much of this literature (see Harris 1991) has emphasized the role of agency costs in determining leverage. Asset characteristics that increase expected agency costs of debt reduce leverage and make monitoring more valuable. Therefore factors reducing leverage should shorten funding duration in venture capital transactions.

Williamson (1988) argues that leverage should be positively related to the liquidation value of assets. Higher liquidation values imply that default is less costly. Liquidation value is positively related to the tangibility of assets because tangible assets (e.g., machines and plants) are, on average, easier to sell and receive a higher fraction of their book value than are intangible assets like patents or copyrights. In empirical research on capital structure, many researchers, including Titman and Wessels (1988), Friend and Lang (1988) and Rajan and Zingales (1995), use the ratio of tangible assets to total assets as a measure of liquidation value. All find that use of debt increases with asset tangibility.

In the context of staged venture capital investments, intangible assets would be associated with greater agency costs. As assets become more tangible, venture capitalists can recover more of their investment in liquidation, and expected losses due to inefficient continuation are reduced. This reduces the need to monitor tightly and should increase funding duration.

Shleifer and Vishny (1992) extend Williamson's model by examining how asset specificity

might affect liquidation value and debt levels. They show that firms with assets that are highly industry and firm specific would use less debt because asset specificity significantly reduces liquidation value. Firms that have high R&D intensities are likely to generate assets that are strictly firm and industry specific. Smith (1995) utilizes the ratio of R&D to firm value to explore debt maturity.

Asset specificity would also influence the structure of staged venture capital investments. Industries with high levels of R&D intensity would be subject to greater discretionary investment by the entrepreneur and increase risks associated with firm and industry specific assets. These factors increase expected agency costs and shorten funding durations.

Finally, Myers (1977) argues that firms whose value largely depends on investment in future growth options would make less of debt because the owner/manager can undertake investment strategies that are particularly detrimental to bondholders. Myers suggests that a firm's market-to-book ratio may be related to the fraction of firm value that is comprised of future growth opportunities. Empirical results support this prediction. Rajan and Zingales (1995) find a negative relationship between firm market-to-book ratios and leverage. Similarly Barclay and Smith (1995) find that debt maturity declines with a firm's market-to-book ratio.

Entrepreneurs have more discretion to invest in personally beneficial strategies at shareholders' expense in industries where firm value largely depends on future growth opportunities. Firms with high market-to-book ratios are more susceptible to these agency costs, thus increasing the value of monitoring and reducing funding duration.

4.3.3 Other factors that affecting the staged investment

The growth of inflows to new venture capital funds may also have effects on the structure of investment. The venture capital industry has gone through several fund-raising cycles. During periods of low fund raising, venture capitalists might be liquidity constrained. Venture capitalists would like to make more and bigger investments (which are positive NPV), but they are unable to raise enough money to invest in all of these projects. If constraints restrict investment, greater commitments to new funds lead venture capitalists to invest more money per round and to invest

more often.

Free cash flow theory (Jensen 1986) also predicts that increases in commitments to venture capital funds would lead to larger investments and shorter time between investments. Venture capitalists would try to put the increased level of commitments to use. Free cash-flow agency costs have been documented by Blanchard and Shleifer (1994), who provide evidence that cash windfalls adversely affect companies' investment behavior. Lawsuit winners appear to invest in bad projects rather than give cash to shareholders. If free cash-flow problems affect venture capitalists, more frequent and larger investment implies venture capitalists may be overinvesting.

Similarly growth of the venture capital pool may measure entry by inexperienced venture capitalists. These new entrants may overinvest and may not monitor companies as effectively as experienced venture capitalists. As in the case of free cash-flow agency costs, the increase in investment is excessive.

4.4 The use of convertible preferred stock in venture capital investment

Both venture capitalists and entrepreneurs want eventually to convert their illiquid holdings into cash or cash equivalents, but they can disagree on the timing or the method. The standard stock-purchase agreement has a number of features that control the process by which the venture capitalists and the entrepreneurs achieve their goals. Chief among these is the decision to invest in the form of a convertible preferred stock. Preferred or convertible preferred stock may be the dominating contract because this contract eliminates the foreclosure option while preserving some seniority in the event of bankruptcy due to current liabilities should information turn out to be symmetric.

The preferred stock investment format provides the venture capitalist with preferences in liquidation, a feature reinforced by the accruing dividends. The latter are not meant to be paid unless the exit mechanism is not rich enough to provide adequate returns to the investors. In such circumstances, for example liquidation, accruing dividends (often 10-20% per annum) guarantee a disproportionate share of the assets to the venture capital investors. The net effect of the preferred equity format with accruing dividend is to skew the payoff distribution in case of

liquidation in favor of the venture capitalist.

Using preferred stock with a dividend creates a mechanism for deriving some income from an investment if the company is only marginally successful. Most deals defer payment of the dividend until the board allows it, but because venture capitalists often control the board, they can make the decision. Since the dividends are not tax-deductible, the burden of paying dividends is often onerous, which often leads the entrepreneurs to try to buy out the preferred.

Many agreements also give the venture capitalists the right to force redemption of a preferred stock or the right to put the stock to the company, to achieve liquidity. This option may be exercised if the company is financially viable but too small to go public. Some contracts give entrepreneurs the right to sell stock back to the venture capitalist, as might happen if the venture capitalists terminate the entrepreneur's employment without cause.

Venture capitalists are concerned about situations where the entrepreneurs have an opportunity to sell their shares before the venture capitalists sell theirs. Therefore, the contract typically specifies that the venture capitalists can sell their shares at the same time and on the same terms as the entrepreneur.

Using a convertible preferred also provides flexibility in setting the conversion terms. The venture capitalist often can base the conversion ratio for the preferred stock on the company's performance. If the company does well, the conversion price might be higher, with lower dilution for the management team. A similar tool is the 'ratchet' which ensures that the effective price per share paid by the venture capitalist is at least as low as any price paid in the future.

Flexible conversion terms alter the risk-and-reward-sharing scheme. The intent is to discourage entrepreneurs from overstating their projections to increase the initial valuation and to encourage them to build value. Incorporating these provisions into contracts also serves as a negotiating tool to account for differences of opinion about future prospects.

One final consequence of having preferred stock in the capital structure relates to taxation: using a preferred creates two kinds of securities, one with superior rights. A security that is senior in rights to common stock in effect lowers the economic value of the common. Members of the management team can therefore buy the common stock at low prices without incurring taxable income. Common-stock value is frequently set at 10% of the conversion price of the

preferred. If the common stock had the same rights as the preferred, the managers would have to report taxable income on the difference between the price they paid and the price paid by the venture capitalists. There is no immediate tax disadvantage to using preferred stock, however, because the dividend is deferred and many of the ultimate recipients are tax exempt.

5. Valuation methods in venture capital

5.1 Net present value method

Richard A. Brealey (2006) described the net present value method in his book “Principles of Corporate Finance”. In finance the net present value (NPV) of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values (PVs) of the individual cash flows. In the case when all future cash flows are incoming (such as coupons and principal of a bond) and the only outflow of cash is the purchase price, the NPV is simply the present value of future cash flows minus the purchase price (which is its own PV). NPV is a central tool in discounted cash flow (DCF) analysis, and is a standard method for using the time value of money to appraise long-term projects. The formula is:

$$\mathrm{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1+r_1)(1+r_2)\dots(1+r_t)} - \sum_{t=1}^{T} \frac{I_t}{(1+r_1)(1+r_2)\dots(1+r_t)}$$

In this formula, C_t means cash inflow in year t, I_t means cash outflow in year t, r_t is the interest rate in year t. There are several assumptions in net present value method. First, the cash flow in each year of the project can be precisely predicted and the interest rate adjusted by the risk can be identified. Second, in the whole life of the project, the investment environment doesn’t change a lot. Third, the investor can only use the strategy of “do now or never”, that’s to say, the investor can only choose to invest in the whole life of the project or abandon the project. Forth, in the process of the project, the investor cannot do anything in the condition of the environment change.

However, lots of conditions in venture capital investment are not consistent with the assumptions in net present value method. There are lots of uncertainties in venture capital environment, and the mutual influences of the competitors make the environment more uncertain. Also most venture capital investments are in stages, not only in one time. So NPV method is not very accurate to value venture capital backed companies.

5.2 Option method

5.2.1 The meaning and types of option

John C. Hull (2009) introduced option in his classic book “Options, Futures, and other Derivatives”. In finance, an option is a derivative financial instrument that establishes a contract between two parties concerning the buying or selling of an asset at a reference price. There are two basic types of options. A call option gives the holder of the option the right to buy an asset by a certain date for a certain price. A put option gives the holder the right to sell an asset by a certain date for a certain price. The date specified in the contract is known as the expiration date or the maturity date. The price specified in the contract is known as the exercise price or the strike price. Options can be either American or European. American options can be exercised at any time up to the expiration date, whereas European options can be exercised only on the expiration date itself.

According to different underlying assets, there are financial option and real option. In financial option the underlying assets are financial assets, like stocks, currencies, stock indices and futures. A real option itself is the right- but not the obligation- to undertake some business decisions; typically the options to make, abandon, expand, or contract a capital investment; for example, the opportunity to invest in the expansion of a firm's factory, or alternatively to sell the factory.

5.2.2 The theory foundation of option pricing models

Before talking about the option pricing model, there are several principles should be

considered, including the no-arbitrage equilibrium principle, risk-neutral valuation principle and efficient markets hypothesis.

No-arbitrage equilibrium means that arbitrage opportunities do not exist. Arbitrage is the practice of taking advantage of a price difference between two or more markets. If the market prices do not allow for profitable arbitrage, the prices are said to constitute a no-arbitrage equilibrium or arbitrage-free market. No-arbitrage equilibrium is a precondition for a general economic equilibrium. The assumption that there is no arbitrage is used in quantitative finance to calculate a unique risk neutral price for derivatives.

In a risk-neutral world all individuals are indifferent to risk. In such a world investors require no compensation for risk, and the expected return on all assets is the risk-free interest rate. Cox and Ross derived the option valuation formula in a risk-neutral investment world. A risk neutral world is characterized as a place where the investors require no risk premium for their investments (i.e., the investors always demand only the risk free rate of interest as the average expected return on investment). In such an investment environment, investors are neutral towards risk because on an average there is no risk.

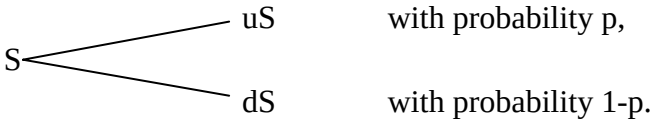
The efficient-market hypothesis (EMH) asserts that financial markets are “informational efficient”. That is, one cannot consistently achieve returns in excess of average market returns on a risk-adjusted basis, given the information publicly available at the time the investment is made.

5.2.3 Binomial option pricing model

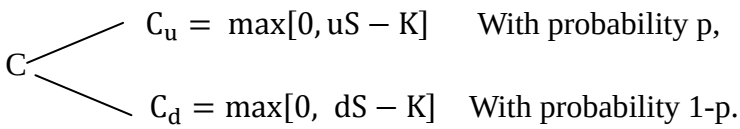
Cox, Ross and Rubinstein (1979) introduced the binomial option pricing model in a paper called “option pricing: a simplified approach”. There are several assumptions in the model: the interest rate is constant and the individuals may borrow or lend as much as they wish at this rate; there are no taxes, transaction costs, or margin requirements.

Suppose that the stock price follows a multiplicative binomial process over discrete periods. The rate of return on the stock over each period can have two possible values: u-1 (where $u>1$) with probability p, or d-1 (where $d<1$) with probability 1-p. Thus, if the current stock price is S, the stock at the end of the period will be either uS or dS. We can represent this movement with

the following diagram:



To see how to value a call on this stock, we start with the situation that the expiration date is just Δt away. Let C be the current value of the call, C_u be its value at the end of the period if the stock price goes to uS, and C_d be its value at the end of the period if the stock price goes to dS. The striking price is K. Since there is only one period remaining in the life of the call, we know that the terms of its contract and a rational exercise policy implies that $C_u = \max[0, uS - K]$ and $C_d = \max[0,\ dS - K]$. Therefore,



We imagine a portfolio consisting of a long position in δ shares and a short position in one option. We calculate the value of δ that makes the portfolio riskless. If there is an up movement in the stock price, the value of the portfolio at the end of the life of the option is $uS\delta - C_u$. If there is a down movement in the stock price, the value becomes $dS\delta - C_d$. The two are equal when:

$$uS\delta - C_u = dS\delta - C_d, \text{ or } \delta = \frac{C_u - C_d}{uS - dS},$$

That's to say, δ is the ratio of the change in the option value to the change in the stock price. In this case, the portfolio is riskless and, for there to be no arbitrage opportunities, it must earn the risk-free interest rate.

If we denote the risk-free interest rate by r, then the present value of the portfolio is $(uS\delta - C_u)e^{-r\Delta t}$, and the cost of setting up the portfolio is $S\delta - C$. It follows that:

$$S\delta - C = (uS\delta - C_u)e^{-r\Delta t}, \text{ or } C = S\delta(1 - ue^{-r\Delta t}) + C_u e^{-r\Delta t}.$$

Since$\delta = \frac{C_u - C_d}{uS - dS}$, we finally get:

$$C = e^{-r\Delta t}[pC_u + (1-p)C_d], \text{ where } p = \frac{e^{r\Delta t} - d}{u - d}$$

In a risk-neutral world, we can get $u = e^{\sigma\sqrt{\Delta t}}$ (σ is volatility of stock price), $d = 1/u$.

American options can also be valued by binomial option pricing model. The procedure is to work back though the tree from the end to the beginning, testing at each node to see whether early exercise is optimal. The value of the option at the final nodes is the same as for the European option. At earlier nodes the value of the option is the greater of: the value given by the formula $C = e^{-r\Delta t}[pC_u + (1-p)C_d]$ or the payoff from early exercise.

5.2.4 Black-Scholes option pricing model

Black and Scholes (1973) introduced the Black-Scholes option pricing model in a paper called "The pricing of options and corporate liabilities". In deriving the model for the value of an option in terms of the price of the stock, some ideal conditions in the market for the stock are assumed, including:

The short-term interest rate, r, is known and is constant through time;

The stock price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus the distribution of possible stock prices at the end of any finite interval is log-normal. The variance rate of the return on the stock is constant. The stock price follows the Wiener process:

$$dS = \mu S\, dt + \sigma S\, dZ,$$

S is the price of the stock, μ is the expected return on stock per year, σ is the volatility of the stock price per year, and Z also follows a Wiener process;

The stock pays no dividends or other distributions;

The option is “European”, that is it can only be exercised at maturity;

There are no transaction costs in buying or selling the stock or the option;

It is possible to borrow any fraction of the price of a security to buy it or to hold it, at the short-term interest rate;

There are no penalties to short selling. A seller who does not own a security will simply accept the price of the security from a buyer, and will agree to settle with the buyer on some future date by paying him an amount equal to the price of the security on that date.

Under these assumptions, the value of the option will depend only on the price of the stock and time and on variables that are taken to be known constants. The Black-Scholes formula for the prices at time 0 if a European call option on a non-dividend-paying stock and a European put option on a non-dividend-paying stock are:

$$C = S_0 N(d_1) - Ke^{-rT} N(d_2),$$

And

$$P = Ke^{-rT} N(-d_2) - S_0 N(-d_1),$$

Where

$$d_1 = \frac{\ln(S_0/K) + (r + \sigma^2/2)T}{\sigma\sqrt{T}},$$

$$d_2 = \frac{\ln(S_0/K) + (r - \sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}.$$

The function $N(x)$ is the cumulative probability distribution function for a standardized normal distribution. In other words, it is the probability that a variable with a standard normal distribution, $\emptyset(0,1)$, will be less than x. The variable C and P are the European call and European put price, S_0 is the stock price at time zero, K is the strike price, r is the continuously compounded risk-free rate, σ is the stock price volatility, and T is the time to maturity of the option.

5.2.5 Real option

A real option is the right to undertake some business decision. There is a growing gap between how the market is pricing some businesses- especially those fraught with uncertainty- and the values generated by traditional valuation models such as discounted cash flow (DCF). Managers and investors instinctively understand that selected market valuations reflect a combination of known businesses plus a value for opportunities that are to come. Real options- a relatively new analytical tool- bridge this gap between hard numbers and intuition.

The real options approach applies financial option theory- the best known for is the Black-Scholes model- to real investments, such as manufacturing plants line extensions, and R&D investments. This approach provides important insights about businesses and strategic investments. These insights are more vital than ever, given the rapid pace of economic change.

Real options are particularly important for businesses with a few key characteristics. The first is smart and reputable management with access to capital. Managers must understand options, identify and create them, and appropriately exercise them. This contrasts with business leaders focused on maintaining the status quo or maximizing near-term accounting earnings. Businesses that are market leaders are also attractive, as they often have the best information flow and richest opportunities- often linked to economies of scale and scope. Finally real options are most applicable precisely where change is most evident.

There are several kinds of real options, including abandonment option, expansion option, contraction option, option to defer and option to extend.

Abandonment option is an option to sell or close down a project. It is an American put option on the project's value. The strike price of the option is the liquidation (or resale) value of the project less any closing-down costs. When the liquidation value is low, the strike price can be negative. Abandonment options mitigate the impact of very poor investment outcomes and increase the initial valuation of a project.

Expansion option is an option to make further investments and increase the output if conditions are favorable. It is an American call option on the value of additional capacity. The strike price of the call option is the cost of creating this additional capacity discounted to the time

of option exercise. The strike price often depends on the initial investment. If management initially chooses to build capacity in excess of the expected level of output, the strike price can be relatively small.

Contraction option is the option to reduce the scale of a project's operation. It is an American put option on the value of the lost capacity. The strike price is the present value of the future expenditures saved as seen at the time of exercise of the option.

Option to defer means that kind of option to defer a project. This is an American call option on the value of the project. Option to extend means the option to extend the life of an asset by paying a fixed amount. This is a European call option on the asset's future value.

Timothy A. Luehrman (1998) introduced the link between a financial option and a real option in his paper "Investment Opportunities as Real Options: Getting Started on the Numbers". The following table shows this.

Table 1: Real options: The link between real investments and Black-Scholes inputs

Investment opportunity	Variable	Call option
Present value of project's free cash flow	S	Stock price
Expenditure required to acquire project assets	X	Exercise price
Length of time the decision may be deferred	t	Time to expiration
Time value of money	R_f	Risk-free rate
Riskiness of project assets	σ^2	Variance of returns

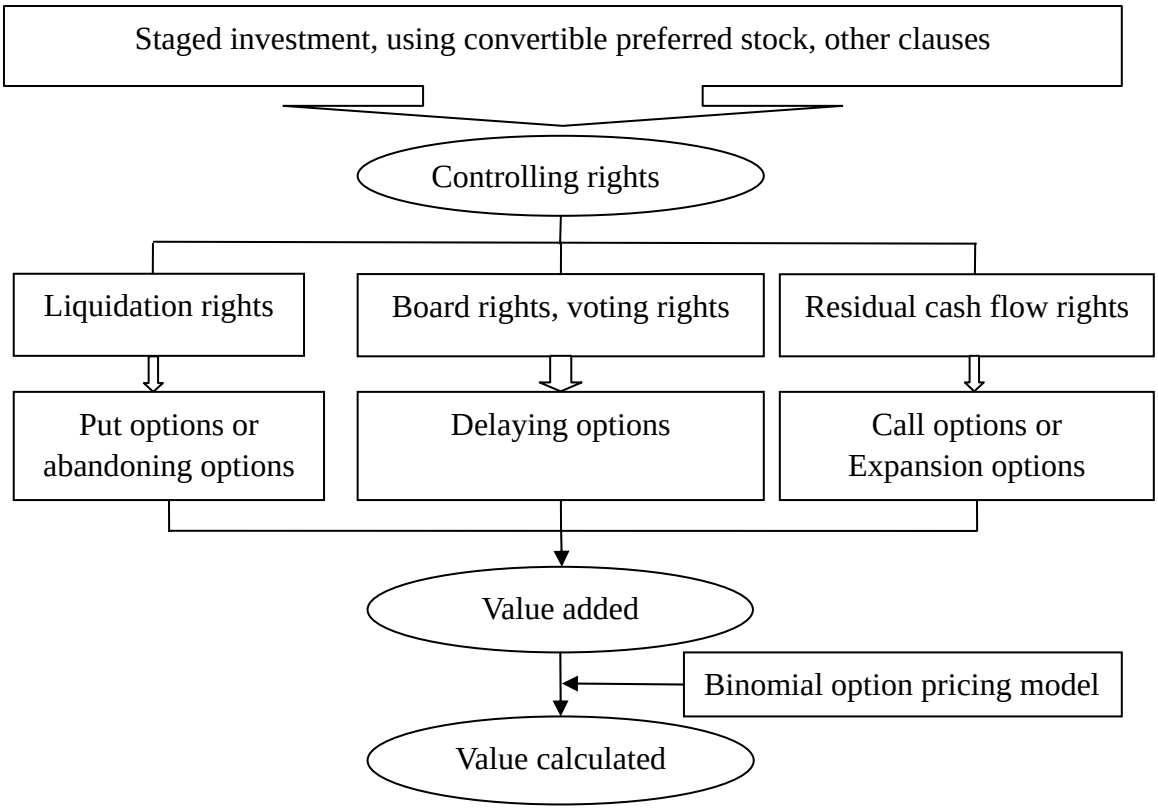
6. The combined theoretical framework and case study

6.1 The combined theoretical framework

Although there has been abundant literature on both venture capital financial contract and real options, the theoretical and empirical research that combines the venture capital contract and real options approach has been scarce. What I contribute to the existing literature is that I theoretically combine the venture capital financial contracts and the real options analysis in a framework.

Because of the contract design in venture capital and the use of staged investment as well as the convertible preferred stock, venture capitalists can get some rights like cash flow rights, board rights, voting rights, liquidity rights and other control rights. Compared with the characteristics of options, the contingent allocation of these rights could be considered as different types of real options, such as the expansion options, the delaying investment options or the abandoning options. Furthermore, in the whole process, the enterprise value and the risk premium that the investors require will change. The dynamic interaction of these aspects is illustrated in Figure 2.

Figure 2: The combined framework of contracting theory and option theory



On the one hand, the venture capitalists have the right to choose the time and stage of investment. This implies that they own a kind of real options like an US call option, with the total investment as the strike price and the present value of the project as the underlying stock price. On the other hand, the venture capitalists have the right to withdraw from the project according to the signals of development. This kind of real option can be considered as an US put option which takes the residual value of the project as the strike price and the present value of the project as the underlying stock price.

In such a financial system, the cash flow rights and the control rights will be allocated between the venture capitalists and the entrepreneur in a dynamic way. When there is a contingent event or the need of next round financing, in most cases we have:

If the enterprise value is very low, even lower than the cost of the investors and the possibility of value increase is slim, venture capitalists might get all the control rights. The form of cash flow rights becomes liquidity rights. They intend to exercise the abandoning option, liquidating the enterprise. It is the venture capitalists who are the decision makers in this circumstance.

If the enterprise value is at the intermediate level and the technology risk has been greatly reduced, when there is negative accounting signal, the venture capitalists will also intervene by gaining more control rights and participating in the board voting of strategic decision making of the enterprise. This is similar to the delayed investment, or the contracting investment option in the real options theory. It is the venture capitalists and the entrepreneurs who are both the decision makers in this circumstance.

If the enterprise value is high and the risk of technology is at a low level, the venture capitalists will require return on their investment and withdraw from the investment cycle. At this stage, the investors will give up a part of the control rights to the entrepreneurs. The form of cash flow rights is residual cash flow rights, similar to call options or expansion investment options, which is exactly the contract mechanism for motivating entrepreneurs to increase the enterprise value. It is the entrepreneurs who become the important decision makers in this circumstance.

In a word, the financial contract design between venture capitalists and the entrepreneurs will play a critical and significant role in determining the enterprise performance and the allocation of

these interests among each side. The function of these incomplete contracts is to dynamically solve the principal-agent problem caused by information asymmetry. At the nodes of staged investment, the execution of real options of the decision makers will create value for the enterprise, also causing change in the allocation of rights.

6.2 The introduction of NT Pharma Company case

6.2.1 Background information

NT Pharma Company is the largest fully integrated supply chain and promotion and sales services provider of vaccines as well as the second largest third party promotion and sales services provider for pharmaceutical products in China. Its supply chain services consist of customs clearance, warehousing, delivery, invoicing, receivables collection and other value added services. Its promotion and sales services include educating health care practitioners on the clinical uses, benefits, side effects and other characteristics of its product portfolio (i.e., medical detailing), organizing clinical seminars, sponsoring industry conferences and other promotional activities, and ancillary supply chain services. Its promotion services differentiate it from other supply chain service providers in China who do not provide such services.

The company is also the second largest third party promotion and sales services provider of pharmaceutical products in China. It provides promotion and sales services primarily for products manufactured by leading global pharmaceutical manufacturers, focusing on anti-infective and CNS medicines. Its promotion team regularly makes sales calls to over 26,500 doctors and 3,500 hospitals, including over 900 class-three (i.e. the highest ranked regional hospitals by the Ministry of Health) (over70% of the total class-three hospitals) and over 1,250 class-two hospitals (approximately 20% of the total class-two hospitals) as of December31,2010, giving the company an extensive promotion network in China. The company also offers pharmaceutical supply chain services, which primarily distribute the pharmaceutical products it promotes throughout China.

Mr. Ng, chairman of the company, founded the Group in1995. At the time of the establishment,

the company distributed prescription pharmaceutical products manufactured by Smith Kline Beecham (now GSK) in China. It started its vaccine supply chain business in 2004. Since commencing its vaccine supply chain business, it has established logistics centers in Shanghai, Beijing, Guangzhou and Suzhou to support its vaccine supply chain business. It has expanded its vaccine supply chain network and built an advanced cold chain infrastructure capable of delivering vaccines to anywhere n China (except Tibet) within 48 hours of dispatching the vaccines. The company started its vaccine promotion and sales business in 2005 to expand its vaccine portfolio and to take advantage of higher margins offered on vaccine promotion and sales services relative to vaccine supply chain services. Since the commencement of its vaccine promotion and sales business, it has rapidly expanded its nationwide vaccine promotion network.

6.2.2 Risk analysis

In order to analyze the venture capital investment and the real options in NT Pharma Company, the uncertainties it encountered should be firstly examined.

There are risks inherent in the operations and these risks can be categorized into risks relating to its business; risks relating to the industry in which the company operates and risks relating to conducting business in China.

Risks relating to the business include that: The Company may not be able to respond sufficiently and promptly to changes in government regulation in the PRC vaccine and pharmaceutical industries; Scientific and technological developments in the industries or changes in consumer preferences could materially and adversely affect its business, financial condition and results of operations; The vaccine and pharmaceutical business operations are affected by seasonality; The company operates in a highly competitive market and its business, financial condition and results of operations may be materially and adversely affected if it is not able to compete effectively and the competition could negatively affect the overall market as well.

Risks relating to the industry in which the company operates include that: the vaccine business may be adversely affected by product recalls or defects in the vaccine industry, and any other incident that negatively affects the reputation and public perception of the vaccine industry as a

whole; Changes in the regulatory framework of the PRC health care industry, including changes related to the PRC's latest healthcare reform plan, or any inability to obtain, maintain or renew the permits, licenses or certifications required to carry on the business may disrupt the business or results of operations.

Risks relating to conducting business in China include that: Exchange rate fluctuations of the RMB may affect the results of operations; Changes in political or economic policies of the PRC government, and as low down in China's economy may have an adverse impact on the operations.

6.2.3 Financial contract clauses in venture capital investment

Under the financial systems theoretical framework of venture capital contract and real options, this section will begin to focus on the financing and investing process of NT Pharma Company from a principal-agent perspective. Information asymmetry is the core issue. Due to the inconsistency of the objective functions and the different attitudes towards risk between the financing and the investing sides, there is important and necessary design of the financial contract.

The clauses of a venture capital financial contract can include the following contents, or even more under specific situations. They are the amount and saving period (the time interval between adjacent investments) of investment, the form and duration of investment, real options in the investment process, option pool, employment contract, vesting schedules and buy-back provisions of shares, information rights and the structure of the board.

The financing side and the investing side have different degrees of risk aversion and knowledge of information (information asymmetry). Hence, the utility expectation of the same project can be judged very differently by the two sides. From the financing side, the entrepreneurial team is more familiar with the application of the patent and other key technologies. Nevertheless, for the long-term development of the enterprise, the financing side should have balanced the interests of the venture capitalists and the employees when setting the clauses.

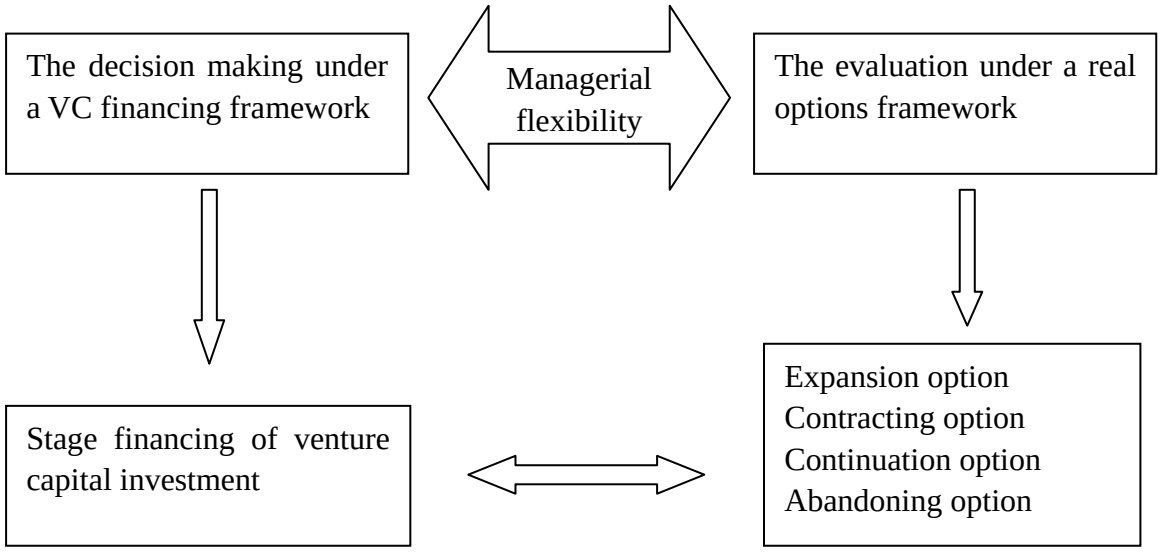
There is a plan of stage financing in the clauses, including the amount and time interval of investment, which creates the managerial flexibility at the nodes of stage financing that the decision makers can exercise real options. The contract requires that TPG capital invests $I_1 = 170{,}000$ thousands Chinese Yuan to NT Pharma Company in January of 2008, and the venture capital has the right to make a second investment of $I_2 = 68{,}000$ thousands Chinese Yuan in December of 2010 if certain financial criteria and revenue targets of NT Pharma Company can be met.

This endows me with the opportunity to carry out the real options analysis of quantitative valuation in next section. That is how I apply the theoretical framework described in Section 6.1 to examine this venture capital financing under the real options framework. The real options efficiently modeled the managerial flexibility brought up by stage financing clauses in venture capital.

6.3 Real options analysis of venture capital stage financing

Since I have analyzed the clauses in the venture capital investment in Section 6.2.3, now I turn to explain how I relate the venture capital investment and real options frameworks together in the NT Pharma Company case.

Figure 3: The transformation of venture capital decision making to real options evaluation



The important mechanism design in the case of NT Pharma Company that allows me to analyze under a real options framework is stage financing, which is a very effective approach to solve the information asymmetry. At the same time, it creates the opportunities and nodes for exercising real options. On the nodes of stage financing, the systematic dynamic rights allocation endow the decision makers with the corresponding real options, as the value and risk of the enterprise change. Along the path of stage financing, the decision makers can execute the proper real options at the nodes, which I will illustrate in the following case of NT Pharma Company. Thus, the problem of venture capital decision making can be transformed to the problem of real options evaluation.

The real options analysis method I use is actually the risk-neutral valuation method, it is the fundamental approach of modern finance in asset pricing under uncertainties, and can also be applied to the real options framework. I seek to solve the real options by adopting dynamic replicating technology based on the binomial model. The details of solution are explained below.

6.3.1 The NPV analysis of the project without managerial flexibility

By using the following formula which I have introduced in section 5.1, the net present value of this project can be calculated.

$$\mathrm{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1+r_1)(1+r_2)\dots(1+r_t)} - \sum_{t=1}^{T} \frac{I_t}{(1+r_1)(1+r_2)\dots(1+r_t)}$$

The following table shows the calculation process of the NPV of the company.

Table 2: the NPV analysis of NT Pharma Company (Unit: thousands Chinese Yuan)

investment year	01/2008	12/2008	12/2009	12/2010
time	0	1	2	3
Total sales		1,413,985	2,395,038	2,667,978
cost of sales		(1,178,904)	(1,915,167)	(2,004,775)

gross profit		235,081	479,871	663,203
other revenue		48,196	7,670	28,698
other net (loss)/income		(44,311)	(1,739)	8,148
distribution costs		(108,129)	(237,418)	(354,456)
administrative expenses		(43,147)	(55,999)	(90,056)
profit from operations		87,690	192,385	255,537
finance costs		(14,277)	(17,128)	(45,379)
profit before taxation		73,413	175,257	210,158
adjustments for interest, amortization., depreciation.		93,382	205,112	297,067
change in inventories, receivables, payables		(124,451)	(438,617)	(595,422)
cash used in operations		(31,069)	(233,505)	(298,355)
tax paid		(6,630)	(17,769)	(848,800)
net cash used in operating activities		(37,699)	(251,274)	(383,235)
net cash used in investing activities		(66,845)	(63,019)	(57,599)
net cash generated from financing activates		108,201	459,611	378,104
net increase/(decrease) in cash		3,657	145,318	(62,730)
cash at January 1		64,884	66,934	212,240
effect of foreign exchange changes		(1,607)	(12)	300
net cash flow at December 31		66,934	212,240	149,810
annual discounting rate		0.200	0.200	0.200
proper dicounting factor		1.200	1.440	1.728
PV of net cash flow		55,778	147,389	86,696
Total PV of net cash flow	289,863			
VC investment	170,000			68,000
PV of VC investment	170,000			39,352
Total PV of VC investment	209,352			
NPV	80,511			

The purpose of this table is to get the NPV of NT Pharma Company project. It is calculated by

subtracting the total present value of VC investment from the total present value of net cash flow. The annual discount rate here of 0.2 is estimated according to the risk premium of this high-tech project, which is highly above the annual risk free rate 0.06.

Therefore, without the managerial flexibility, the investment plan would be determined at the beginning. And the decision makers could not see the value brought up by stage financing clauses in the venture capital contract. I will price this increased value of managerial flexibility by real options analysis as follows.

6.3.2 Determining the volatility and establishing the present value event tree

This step will give the cash flow on each node of stage financing, which is the fundamental of the following real options analysis. In this process, the most important factor is to assume one important coefficient, the volatility of the project, σ. It directly reflects the risk of the project and is the fundamental reason of bringing value to real options. However, it is the most difficult coefficient to be properly and accurately estimated. In practice, there are the following methods to make estimation of the project volatility.

The time series method: it assumes that the distribution of the future value of the project can be reflected by the current model and adopts the time series method by using the history deviation of the project value as the volatility.

The market proxy method: it considers the correlated public stocks value as the proxy of the real options project value. But since the real options volatility does not equal the volatility of the corporate stocks and the stock prices can be influenced by many other exogenous factors such as the investors' psychology, this method usually brings in some irrelevant factors.

The log cash flow method: it uses the deviation of the log of future cash flow to estimate the volatility of the cash flow in real options, but if the relevant return is negative, the log of it does not exist to give a volatility of the project.

The management team assumption method: since most projects that use the real options method are new technology and new product development, there is lack of an available proxy, and the management team has to estimate the volatility of the project by their experience and

intuition.

I have analyzed the business and industry risk in previous sections and found out that the financing risk and management risk of this project are large. According to the historical data of projects in comparable industries, I estimate that the annual volatility of the asset value is 30%. Consequently, the proportion of upside value increasing in this project in one year is $u = e^{\sigma\sqrt{\Delta t}} = e^{0.3\sqrt{1}} = 1.35$, correspondingly, the ratio proportion downside value decreasing in one year is $d = {}^{1}/_{u} = {}^{1}/_{1.35} = 0.74$. Consider time 0 as the beginning node and I get the present value event tree in the following table.

Table 3: The present value event tree of NT Pharma Company (Unit: thousands Chinese Yuan)

i/j	0	1	2	3
0	289,863	391,315	528,275	713,171
1		214,498	289,573	390,923
2			158,729	214,284
3				117,459

The calculation method is (V for the value in each sell of the table, i for row, j for column), $V_{i,j}^{u} = V_{i,j-1} \times u, V_{i,j}^{d} = V_{i-1,j-1} \times d$. $V_{0,0}$ is the total net present value of cash flow, which can get from table 2, and is 289,863.

6.3.3 The real options analysis with managerial flexibility

The stage financing of VC investment endows the decision makers with real options opportunities and the nodes for implementing them. During the process of risk-neutral valuation, the method I adopt to evaluate real options, the risk free rate r will be used. I choose the one year loan interest rate of China in 2009 to represent the risk free rate, which is 0.06. I base the calculation on the original binomial model of option pricing. This requires me to work backward in this system, from the last stage to the first one, as is explained node by node below.

Whenj = 3, now the venture capitalist doesn't have to invest $I_2 = 68{,}000$ thousands Chinese Yuan, but has the option to expand investment, contract investment or continue investment. In this case, I assume that the capitalist can choose from: expansion investment of $2I_2 = 1{,}360{,}000$ thousands Chinese Yuan which will increase the project value to 2 times the original size; contracting investment of $0.5I_2 = 34{,}000$ thousands Chinese Yuan which will decrease the project scale to 0.5 times the original size; or continue to investI_2. Hence, with managerial flexibility, the value at this stage is:

$$C_{i,3} = \max\left(2V_{i,3} - 2I_2, 0.5V_{i,3} - 0.5I_2, V_{i,3} - I_2\right), i = 0,1,2,3.$$

After calculating out$C_{i,3}$, I can use the following formula which has been discussed in 5.2.3 to calculate the option value in other nodes.

$$C = e^{-r\Delta t}[pC_u + (1-p)C_d], \text{ where } p = \frac{e^{r\Delta t} - d}{u - d}$$

Table 4 shows the final result.

Table 4: The real options valuation of NT Pharma Company (Unit: thousands Chinese Yuan)

i/j	0	1	2	3
0	466,129	662,008	928,470	1,290,342
1		308,376	451,066	645,847
2			189,378	292,568
3				98,919

So by considering the value of flexibility, the real options valuation of NT Pharma Company at time 0 is 466,129 thousands Chinese Yuan, which is much higher than the value without considering the value of flexibility (which is 80,511). Thus, by these backward deducing steps of risk-neutral valuation, I have shown how to properly calculate the project value under a real options framework for the VC financed NT Pharma Company. We can obviously see the increase value of the project after applying the real options analysis. As I have emphasized several times before, it is because that the stage financing in VC clauses increases the managerial flexibility and real options framework efficiently evaluate this flexibility.

7. Conclusions

In this paper, I have introduced the characteristics of venture capital investment, which includes equity or quasi equity investment, long-term and high-risk investment and an active form of investment. In addition, there is a principal-agent relationship between the venture capitalists and the entrepreneurs, causing a lot of information asymmetry in the interaction of this financial system. I then introduce the contract design in venture capital investment to mitigate this principle-agent problem, includes using convertible preferred stock and making staged investment. After that, I investigate the valuation methods in venture capital, includes the traditional net present value method and real options method.

After reviewing the literature on financial contract theory of venture capital and on real options, respectively, I conceive that it is valuable to theoretically combine the venture capital contracting theory and the real options theory in a financial systems perspective. The combined theoretical framework is designed which states that: By using convertible preferred stock and making staged investment, venture capitalists will gain some controlling rights like liquidation rights, voting rights and residual cash flow rights. And these rights are in fact some real options like abandoning options, contracting options and expansion options. By using the option pricing model, the value of these options can be calculated.

Based on this combined theoretical framework, I further investigate and examine the venture capital investment of NT Pharma Company in China. I firstly introduce the background and risk of this company. Then, the venture capital financial contracts clauses and investment plan are interpreted. And the staged financing clauses of venture capital investment in this case provide me the opportunity to use the real options framework. Consequently, a real options analysis is carried out to evaluate the managerial flexibility using the binomial option pricing model. The result shows that the value of the case considering the real options is much higher than the value without option.

Although there has been abundant literature on the contract design in venture capital and on the analysis of applying real options to the valuation of venture-capital-backed enterprises, very little research is seen in which the real options methods and the venture capital contracting

theory go hand in hand. The thoughts and models of real options in a financial system are efficient tools to design and evaluate the venture capital contract clauses and their economic value. Therefore, the combination of venture capital contracting theory and the real options concept is the key of making breakthrough in this field.

It is also a good perspective and direction for future research in this field. In the case study of this paper, I only research the option value of staged venture capital, however, more often there are also convertible preferred stock clauses in venture capital contracts, it is a good way to value them together. Also in NT Pharma Company case, for the second investment I assume that venture capitalists can invest $2I_{2,}I_2, \text{or } 0.5I_2$, however, the real condition is much more complicated and venture capitalists not only have these three choices, further research can solve these problems.

References

[1] Paul Gompers, Josh Lerner. (2001). The Venture Capital Revolution. *The Journal of Economic Perspectives*, 15(2), 145-152.

[2] Paul Gompers, Josh Lerner. (2004). *The Venture Capital Cycle*. London: The MIT Press.

[3] Michael C. Jensen, William H. Meckling. (1976). Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure. *Journal of Financial Economics*, 3(4), 305-317.

[4] William A. Sahlman. (1990). The structure and governance of venture-capital organizations. *Journal of Financial Economics*, 27(1), 473-509.

[5] Jeffrey J. Trester. (1993). Venture Capital Contracting Under Asymmetric Information. *Working paper*, Pennsylvania: The Wharton School Financial Institutions Center.

[6] Paul A. Gompers. (1995). Optimal Investment, Monitoring, and the Staging of Venture Capital. *The Journal of Finance*, 50(5), 1461-1467.

[7] Dirk Bergemann, Ulrich Hege. (1998). Venture capital financing, moral hazard, and learning. *Journal of Banking & Finance*, 22(1), 703-707.

[8] Susheng Wang, Hailan Zhou. (2002). Staged Financing in Venture Capital: Moral Hazard and Risks. *Journal of Corporate Finance*, 10(1), 131-135.

[9] Didier COSSIN, Benoit LELEUX, Entela SALIASI. (2002). Understanding the Economic Value of Legal Covenants in Investment Contracts: A Real-Options Approach to Venture Equity Contracts. *Research paper*, Geneva: The International Center for Financial Asset Management and Engineering.

[10] Zsuzsanna Fluck, Kedran Garrison, Stewart C. Myers. (2005). Venture Capital Contracting and Syndication: An Experiment in Computational Corporate Finance. *Working paper*, Cambridge: the National Bureau of Economic Research.

[11] Carsten Bienz, Julia Hirsch. (2005). The Dynamics of Venture Capital Contracts. *Conference paper*, Copenhagen: the International Conference on Finance.

[12] Morten Sorensen. (2008). Learning by Investing: Evidence from Venture Capital. *Working paper*, Drottninggatan: Swedish Institute for Financial Research (SIFR).

[13] Guo Jue, Yan Wen-jun, Zhang Guo-xing. (2008). Stage Investment Cost and Adding

Investment Triggers in Venture Capital. Systems Engineering, 28(8), 38-40.

[14] Xuan Tian. (2011). The causes and consequences of venture capital stage financing. *Journal of Financial Economics*, 1(1), 1-5.

[15] John C. Hull. (2009). *Options, Futures, and other Derivatives*. New Jersey: Pearson Prentice Hall.

[16] Richard A. Brealey, Stewart C. Myers, Franklin Allen. (2006). *Principles of Corporate Finance*. New York : The McGraw-Hill Companies.

[17] Fischer Black, Myron Scholes. (1973). The Pricing of Options and Corporate Liabilities. *The Journal of Political Economy*, 81(3), 637-654.

[18] John C. COX, Stephen A. ROSS, Mark RUBINSTEIN. (1979). OPTION PRICING: A SIMPLIFIED APPROACH. *Journal of Financial Economics*, 7(1), 229-263.

[19] Timothy A. Luehrman. (1998). Investment Opportunities as Real Options: Getting Started on the Numbers. *Harvard Business Review*, July-August.

[20] Timothy A. Luehrman. (1998). Strategy as a Portfolio of Real Options. *Harvard Business Review*, September-October.

[21] Mark Davis, Walter Schachermayer. (2002). The Evaluation of Venture Capital As an Installment Option: Valuing Real Options Using Real Options. *Working paper*, Vienna: the Austrian Science Foundation.

[22] Yong Li. (2007). Duration analysis of venture capital staging: A real options perspective. *Journal of Business Venturing*, 23(1), 497-512.

[23] Jingyun Ma, Fengming Song. (2008). The venture capital financing under a real options framework: case of a high-tech corporation in China. *Int. J. Business and Systems Research*, 2(2), 145-163.

[24] Yao-WenHsu. (2010). Staging of venture capital investment: a real options analysis. *Small Bus Econ*, 35(1), 265-281.

[25] Anett Mehler-Bicher, Martin Ahnefeld. (2002). VALUING A PRIVATE EQUITY VENTURE INVESTMENT: THE CASE OF A B2B MARKETPLACE START-UP. *Conference paper*, Cyprus: Proceedings of the 6th International Conference on Real Options.