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Real Options Literature Review*

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ABSTRACT

After 30 *years of discussion and research, the academic community has established a complete theoretical system of real options and provided an excellent framework for the use of real options theory in the investment appraisal of high-tech projects. An option is an entitlement without any obligation and it has been used to describe a variety of management decisions in business investment. The description of management is effective and proper. Due to the introduction of real options theory, there has been a major breakthrough in the investment area. Project evaluation is the core content of bank credit risk assessment and business evaluation. The core content never changes from the investment evaluation framework to the credit risk evaluation framework. The project evaluation meets various needs of subject s in different ways. In this paper, the importance of real options is analyzed and the literature is reviewed.*

Keywords: *Real Options, Literature Review, Enterprises*

1. Introduction

A knowledge economy speeds the development of science and technology enterprises. There were 55 National Level High-Tech Industrial Development Districtsestablished by 2008, with a total output value break zone GDP of 1.5 trillion Yuan RMB (REN MING BI) in these districts. In China, this accounted for 5%. This is greater than 11 percentage points over the same period of the GDP. These districts created 80% of the scientific and technological achievements of the country. Zhongguancun Science and Technology Park Zone in China, for example, are the most active areas of innovation and entrepreneurship in China. There have been more than 3,000 high-tech enterprises founded and 100 or more of them produce an annual 100 million in sales revenue. A large number of the scientific and technological achievements made by these enterprises have effectively promoted technological advances and market competition. They play an important role in product innovation, industrial restructuring, employment opportunities and the rise of the regional economy.

Scientific and technological enterprises develop rapidly, but financing bottlenecks become the primary obstacle restricting their development. On October 30, 2009, 28 companies were officially listed on the GEM. Relative to China's vast scientific and technological enterprises, there is a long way to go to get their economic power to the open market and financing directly at this stage. Currently, bank loans are still the main channel of finance for technical enterprises.

Large fluctuations will occur in short-run operating activities because of the great risk and uncertainty of the high-tech enterprises, so it is difficult to make a reasonable forecast of a company's future by means of its information and project data items. These problems lead to the banks having great difficulties in making correct judgments when high-tech enterprises and high-tech projects need bank loans.

It is an internal control issue in credit risk when a bank decides to accept high-risk technology companies and accept scientific and technological projects. The bank must set up a strong credit risk identification, supervision and management mechanism. Since the People's Bank provides a floating rate for a loan, banks can not offset high risk by demanding high interest rates. If banks take the high risk, they cannot obtain corresponding income subsidies to cushion against losses. Because of this, most banks often refuse to lend to high-tech projects whose risks are high. It is not easy to get loans for high-risk companies and this problem is the bottleneck that restricts the development of high-tech companies.

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Real options evolve from the financial option. Its original intention was to deal with future uncertainties of a project's implementation, so real option, bank credit risk and purpose of the evaluation are the same by virtue of the fundamental nature of an option. After the introduction of option evaluation methods, many investment decisions which previously needed intuitive decision-making can now be illustrated with a quantitative description. Corporate management decisions can also be guided by applying a scientific calculation and estimation. Therefore, applying real options to risk assessment of bank's credit has a very important practical significance.

2. Western Literature Review

After many decades of development, real options theory has become an important branch of finance, it is also a current hot topic in academic finance. Both theoretical and applied researches about real options are definitely in the ascendant and have achieved remarkable results. The descriptions in this section make a comprehensive analysis of three aspects of the current literature: the real options theory, the differences between the real options theory and the traditional theory in decision-making and the application of real options.

2.1. Introduction of Real Options

Myers (1977) [1] first proposed the "real options" concept, and pointed out the similarities between the financial options and real options. The company can obtain a right after it has made an investment decision. It can use the right to buy or sell a physical asset or investment plan in the future. When the investment project has a highly uncertain characteristic the project's value should be equal to the Net Present Value (NPV) of the project plus the value of the future option.

Ross (1978) [2] made an analysis of risky projects. He found the inherent potential investment opportunities, he considered such an investment opportunity as real options, and then discussed the theory of real option valuation.

Trigeorgis (1993) [3] divided the real options into seven categories according to the differences in flexibility : Option to Defer, Staged Investment option, Option to Alter Operating Scale, Option to Abandon, Option to Switch, Growth Option, and Interacting Option.

Amran and Kulatilaka (1999) [4] applied option pricing theory and the financial market rules to the evaluation of non-trading assets, helping managers make use of their own option right to make management decisions in option areas such as strategic investment, R&D project selection and so on.

2.2. The Difference between Real Option Theory and the Traditional Decision-Making Theory

Myers (1984) [5] laid out the limitations of Discounted Cash Flow (DCF), and analyzed the importance of a company's strategy in the capital budget process. He recommended that much investment should be decided by options pricing rather than the DCF approach.

Hodder and Riggs (1985) [6] pointed out that the DCF method has been misused in practical applications. Because the project risk gradually decreases as the project becomes ongoing; and management flexibility may also reduce project risks; using only one discount rate throughout the project's assessment process is inappropriate.

Trigeorgis and Manson (1987) [7] pointed out that when the managers used traditional NPV or DCF to make decision, their theories are based on the assumption that the estimated future cash flows can be estimated on the premise of the future certainty. Therefore if uncertainty exists, the NPV or DCF can not estimate the management flexibility of changes in the investment decision-making. So in terms of investment analysis in an uncertain environment, it may produce a biased result of an investment program by the NPV.

Brealey and Myers (1992) [8] found that R&D investment will bring an option for the company within a specified time period. The company has a right to decide whether to implement the investment follow-up project. If the R & D fails, the loss is only the initial investment costs. If the projectis successfully developed, therecould be a follow-up for enterprises to create greater value. R & D investment costs can be regarded as a royalty for this option, which is very similar to a Call option. So they proposed that the Option Pricing Theory can be applied in the evaluation of R & D investment programs.

Dixit and Pindyck (1995) [9] maintain that traditional investment decision-making assumes that the strategic decision-making of corporate planners can not be deferred. If the company does not make the investment now, it will lose the opportunity forever. The company must choose a decision of whether to invest at a particular time without any change in the decision-making which ignores the value created by the delay of investment decisions, resulting in errors on the project value. Thus, this makes the entire investment a decision-making error. In fact, the investment project can wait until more information appears, then make the investment decisions.

Ross (1995) [10] points out that the NPV and other traditional methods may result in wrong investment decisions. For example, some investments which include some follow-up investment are incomplete at one-time. If the upfront investment can not be in line with the stan-

dard positive NPV, it may not be approved by the management. While the NPV method advocates "now accept" or "never accept" criteria, it obviously is not conducive to assessing the present and the future value of the uncertain investment.

2.3. Application of Real Options

Lander and Pinches (1998) [11] summarized these applications in 16 aspects: such as natural resources, competition and business strategy, production, real estate, R & D, public good, mergers and acquisitions, corporate governance, interest rates, inventory, labor, venture capital, advertising, legal, hysteretic effect and corporate behavior, environmental development and protection. We have selected the more prominent areas of research literature to be reviewed.

2.3.1. The Area of Natural Resources Investment

The product price in the area of natural resources investment has the characteristic of a high degree of random fluctuation, which also requires enterprise management capabilities to use arbitrage opportunities.

Brennan and Sehwaaz (1985) [12] studied the problem of how to estimate the value of a copper mining project with a high-risk cash-flow. In their research, they constructed a financing portfolio including short-term assets of futures contracts, and long-term assets of mineral resources, and then obtained a partial differential equation of copper values.

Trigeorgis (1990) [13] analyzed the assessments of a multinational natural resource project. The NPV of the project was negative, but the managers identified these options by the binary option pricing methodology: delay options, abandonment options and options of conversion scale during the course of the project, concluding that the NPV of the project was positive and the implementation of the project finally succeeded.

2.3.2. Land (Real Estate) Development Areas

Many investors want to retain land, waiting for a more favorable opportunity to invest.

Titman (1985) [14] adapts the option pricing methods which were first used by Fisher Black, Myron Scholes [15] and Robert Merton [16] to estimate the value of the undeveloped land where the future price of building units is uncertain. They assumed the vacant land as a Call Option, the construction costs as the strike price, and determined the vacant land's value through a combination of construction cost and government bonds.

Quigg (1993) [17] found that the price of undeveloped land is 6% higher than the average price of developed land by empirical analysis of Seattle real estate transaction data between 1976 and 1979. This figure almost equals the average premium paid by real estate developers in the process of purchasing land at the same period in Seattle. Holding the undeveloped land was the equivalent of holding an American-style call option. She also derived a land evaluation model with options.

Capozza and Sick (1994) [18] considered that agricultural land converted to urban land can be seen as an American-style call option. Their results show positive correlation between the price of the land waiting for conversion and the rent price of urban land. When urban land rental prices become more volatile, the option of agricultural land development will be more valuable.

2.3.3. The Field of Corporate Strategy

Keser (1984) [19] considered that under the traditional decision-making methods, even the negative NPV projects, so much as there is a long-term strategic value, they may be worthwhile investments. In the evaluation of such projects, the real options approach should be used. When competitors have the same options, the enterprise should implement options as soon as possible in order to prevent losses.

Kulatilaka and Marks (1988) [20] studied the strategic value of flexibility options. They constructed two companies to make comparative studies; the assumptions were that one enterprise can use only a certain technique, while another enterprise has several choices of technology. This flexibility option gives the later one a strategic value.

2.3.4. The Field of R & D Areas

Uncertainty and high risk are the main features of R & D projects. Real option theory applied to R & D project management has gradually become one of the main trends of research since 1980s.

According to the studies of Morris, Teisberg and Kolbe (1991) [21], active managements could gradually reduce the risks in the process of investment. As more value could be had by the flexibility of management, they suggest choosing the projects of which have much more risk when the expected benefits and costs of items are as near as making no difference.

Nichols (1994) [22] pointed out that the DCF method can not properly assess volatility. It often underestimates the investment value of the pharmaceutical R&D projects such as science and technology enterprise. Merck Company has been using the real options approach in project evaluation.

2.3.5. The Field of Enterprise Valuation

Chung and Charoenwong (1991) [23] considered that certain enterprises do not need to become involved in investment opportunities if they can recognize the option of future investment as the value of growth opportunities. A firm's value should include the company's existing

internal asset value and the value of the company's future growth opportunities.

Kellogg and Charles (2000) [24] found that many high-tech biotechnology companies have a high stock price despite having no product revenue because their products are in early stages of development. They use the decision-tree method and binomial-lattice method to value the high-tech company's share price and found that the real options evaluation methods reflect the high-tech company's early value more accurately.

Schwart and Moon (2000) [25] apply real options theory and capital budgeting methods to assess the value of Internet companies. They established a real options model based on the continuous-time, estimate model parameters, perform sensitivity analysis and apply the results to the valuation of technology companies.

3. Chinese Literature Review

In China, research about real options began in the late 1990's. Then the research boom of finance and management emerged: research reviews, value assessment of high-tech enterprises, natural resources, venture capital, and business strategy decision-making, financing decision-making, real estate investment and development decisions, theory research and so on took place.

In the research of Huang and Zhuang (2003) [26], the theory and the model of principal-agent have been applied to real options based on the options value model. They designed the profits model of real options, and calculated the profits of investors and operators in real options. The results are regarded as investment decision evidence in analysis of different information.

Liu and Ouyang (2003) [27] make the quantitative analysis of strategic project investment decision-making process base the theory of real options, and they build the decision-making model. According to the results of the model analysis, to acquire the option value of a strategic project, decide whether the project should be invested or not, and discuss the best investment opportunities. In the end, they test the affect of various parameters on the model results by examples.

Li, Qu and Feng (2003) [28] come up with a real option approach which is concerned with investment decision-making for the two-stage, It can be used to estimate the flexible value and the corresponding optimal investment ratio in the market risk that the company faces. And they test for the specific case. In the situation of correctly estimating relevant variables, the approach can provide great support for short-term investment decision-making.

Mu and Wang (2004) [29] set up a production project investment option pricing model according to real options theory and a variety uncertainties that cause market demand. They make a comprehensive analysis about the affect of the uncertainty factor in the flexibility, management value, and investment decision-making by numerical results.

Xia, Zeng and Tang (2004) [30] introduce the present situation of general real options and strategies real option theory research, focusing on strategies of the real options of enterprise technology innovation investment, and making a more detailed category overview, further research for these issues are given at the end.

Xia and Zeng (2005) [31] use the real options analysis method to study the new technology's optimal investment strategy of enterprises under the future multi-generation of new technology. The results can be used to predict the company's investment strategy, and provide theoretical support with the empirical analysis of new technology adoption and diffusion.

J. Gao and L. Jiang (2010) [32] discussed the method of real options to encourage R & D teams when the enterprises can not achieve the desired economic benefit in the case of high-risk projects or the immature market.

The study on how to measure the credit risk of commercial banks and build an integrated management system is little developed in China. The overwhelming majority of domestic research is on the introduction of existing results of overseas research. The results related to digestion and absorption of foreign research is still relatively small. So far, it is very rare that some of the latest approaches such as real options approach are used to make empirical analytic study about credit risk measurement and management of banks in China.

4. Conclusions

In short, economists have a wide range of research for real options. The knowledge of Real Options in various areas have been applied from the initial simple B-S option pricing formula and the binomial pricing model transition to multi-stage, compound, real options models. There is the beginning of considering the real option theory under incomplete information. The theoretical system has developed and their applications related to many economic fields.

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