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The venture capital entry model on game options with jump-diffusion process

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ABSTRACT

This paper aims to apply game options to construct the optimal decision-making and management tool for venture capital (VC) firms. This model emphasizes the inferences with game options on the market structures formed by different competition and investment strategies of the two VC firms to reflect the investment returns. These market structures are classified into an entry-deterred game (specific monopoly), a leader's dominated strategies (duopoly), and simultaneous investment. It is considered how to select investment timing to avoid any potential competitive threats in order to provide the optimal expected threshold values for the investment decisions of VC firms.

1. Introduction

Venture capital (VC) firms pursue the highly risky and profitable investment models that anticipate the appreciation of capital in the long term. They invest in the companies with the potential for rapid growth. As the status of the fledgling companies in which venture capitalists invest is highly uncertain, their earnings may drop as a result of the existence of potential competitors that grab the market share.

The paper applies the real options approach (ROA) to evaluate the feasibility of the projects taken by these companies. Assume that a start-up company's unit contribution margin (that is, sales price minus variable cost of production) follows both the geometric Brownian motion (continuous process) and Poisson process (discrete process) in their jump-diffusion processes,[1] and the paper applies the game theory to examine the investment behavior of two VC firms. The different competitive strategies adopted by these two VC firms reflect the additional sales to obtain extra (potential investment returns), which are assumed to be a hyperbolic function. The paper further constructs an investment strategy model based on the market structures of an entry-deterred game (specific monopoly), a leader's dominating strategies (duopoly), and simultaneous investment entries formed by the competitive behavior of the two VC firms in order to derive the optimal threshold value for investment decisions.

The paper will discuss that when the start-up company enters the market, it will attempt to make use of the established VC investment companies. When the unit contribution margin under uncertain profitability is the decision variable, the paper considers the previous investment and deferred investment behavior in the start-up company by VC firms and conducts a numerical analysis of entry decision threshold, relevant sensitivity analysis, and numerical example explanation.

2. Literature review

VC firms put funds into the start-up company with potential growth, as bearing high risks. To identify an appropriate level of risk treatment has become a key strategy to make profits in today's economy. Many researches regarding corporate optimum risk management have been done. Wu and Olson (2008) studied a variety of risk evaluation models within supply chains: chance constrained programming, data envelopment analysis, and multi-objective programming models. Wu et al. (2010) considered a three-dimensional early warning approach for product development risk management, which was proposed by integrating graphical evaluation and review technique with failure modes and effect analysis. Wu and Olson (2009a) discussed various risks modeling to optimize risk management. Risk management has become a key point to corporate development. Several risk evaluation methods even focus on measuring the risk value. The research has shown that the synthetic approaches to manage the risks facing an organization and the most effective ways to

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[1] A number of papers have addressed the stochastic differential equations includes Shimko (1992), Dixit and Pindyck (1994), and Smit and Trigeorgis (2004).

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take risk include new business philosophies such as corporate risk management (Wu et al., 2006; Wu and Olson, 2009b, 2010a,b). Moreover, real options analysis is one of the most appropriate methods for assessing the investments in VC firms involving uncertainty. When assessing the value of an investment project, apart from the expected future net cash inflow, the evaluation should include the management flexibility value implied by the uncertainty of investment environments. This includes the probability that managers will receive new information, high room for managerial flexibility, and the ability of decision-makers to respond to new information, etc. (Copeland and Antikarov, 2001).

Several authors have evaluated VC investment strategies. Lin and Huang (2004) noted that a start-up company raises funds from different types of VC firms and the most suitable VC entry mode is established with the reflection of investment profitability under the special effectiveness function. Under risk aversion, the proposed model conducts the most suitable VC establishment aimed at the project investment support standard generated by VC firms. Lin et al. (2007) applied the ROA in which the entire model assumed that the expected discounted factor and the jump-diffusion process were incorporated into the ROA to assess the value of a start-up company and determine the threshold of the exit timing of liquidation or convertibility when establishing the optimal disinvestment pricing model for VC firms. Kanniainen and Keuschnigg (2003) mentioned that a VC firm not only had to provide capital support to the start-up company, but also had to increase the firm value. In a VC investment project, the most appropriate amount of investment in the start-up company should be determined based on the stringent management problem. Concerning the volume of investment combination and the transaction condition between management consultants, it is especially important to reduce the management consultant fee of the combined investment company and the management cost of the VC investment expert. Rosenberg (2003) explained that the VC investment expert not only invests capital in the start-up company, but also invests professional knowledge, management technique, time, and business negotiation so as to help nurture the start-up company into becoming an enterprise of high profitability. Takezawa et al. (2007) applied an option framework to quantify the underlying risk and proposed an optimization problem to select the optimal ownership structure and supply contract for maximizing the total shareholders' value of the parent.

The traditional approach is to make investment decisions based on net present value. This assumes the existence of a static investment environment and takes only net cash flows into consideration. However, it is very important to analyze a dynamic investment environment in order to devise a flexible investment strategy to cope with future uncertainties in the investment environment. For that reason, the ROA has rapidly gained popularity as an investment decision method. The investment decisions based on the ROA emphasize the value of flexible management and options (Myers, 1987; Dixit and Pindyck, 1994). In the recent years, scholars have stressed that the influence of decisions from competitors is also an important factor affecting the value of flexible management. Smit and Trigeorgis (2006) pointed out that strategic investment projects should be based on an expanded (or strategic) net present value (NPV) criterion that incorporated not only the passive (or direct) NPV of expected cash flows from investing immediately and the flexibility value from active management (real options), but also the strategic (game theory) value from competitive interactions. Smit and Ankum (1993) applied the game options principle as an analytical tool to evaluate a project's value and support the overall operating and investment strategy. Smit (2003) showed that the game options approach could make a more complete assessment of a strategic option value in an interactive competitive setting. Miller and Waller (2003) pointed out that project planning was an important decision management tool and encouraged managers to utilize real options to process investment evaluation under future uncertain conditions and to explore how to use the opportunity to evade potential threats. Yeo and Qiu (2003) suggested utilizing the ROA to allow for a more feasible judgment in making investment decisions.

Aloysius (2002) introduced the concept that the most suitable investment decision for investors involved cooperation via symmetrical information in the duopoly market. The advantage for competitor is that cooperation will not be the most appropriate approach. Kong and Kwok (2007) applied real options and game theory to analyze the oligopoly market. Assuming that there are two competing firms and they have incurred asymmetric sunk costs, there will be a leading investor in the market. The firm with a competitive edge will make the first investment, or the two firms will invest at the same time. If a firm is more competitive, it will enter the market by setting up an optimal investment threshold value for the market leader and follower. When the preemptive thresholds of both firms happen to coincide, the two firms will enter the market simultaneously. Smit and Trigeorgis (2006) applied real options and game theory to the investment planning of strategic alliances. Pawlina and Kort (2006) noted that in an oligopoly, the investment costs are asymmetric and there is an optimal investment strategy. The study's result shows that a marginal increase in the investment cost of the firm with a cost disadvantage can enhance that firm's own value within a certain range of the asymmetry level. Jin et al. (2009) used a financial tool "option-based" mathematical model for the joint production and the maintenance system provided useful maintenance decisions in the environment of uncertain demand.

De Giovanni et al. (2008) analyzed the dynamic structure of a return process using subordinated laws and showed how subordinated models can be used to price contingent claims. The subordinated asset price models will consider the hyperbolic model. Kalashnikov et al. (2009) justified the concept of conjectural variations equilibrium applied to the mixed duopoly model by demonstrating the concavity of the expected profit function. Huang and Hsu (2008) enhanced the capability of explaining intemporal decision-making behavior and proposed an anticipative hyperbolic discounted utility model that revised the conventional hyperbolic discounted utility model by introducing anticipative parameters under the consideration of the anticipation of future gains or losses. Therefore, the paper assumes that the investment additional sales to obtain extra (the investment returns) from the competition between two competing VC firms form a hyperbolic function.

3. Proposed model

The paper adopts real options combining game theory, it evaluates theoretical models to figure out the threshold for unit contribution margin based on following the geometric Brownian motion (GBM) involved in a Poisson jump-process. Assuming that there are only two VC firms in the newly created market, when they are interested in investing in the start-up company, the investment scale is equal, which means the same investment input. Based on the investment of two VC firms, the start-up company can gain more additional sales to obtain extra and added values. Furthermore, eternal factors impact the market. Different strategies verify the additional sales to obtain extra. The two VC firms have different competitive advantages; although their investment inputs are the same, contributions and sharing are different.