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Interfaces with Other Disciplines

Venture capital, staged financing and optimal funding policies under uncertainty

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ABSTRACT

Our paper presents a dynamic model of entrepreneurial venture financing under uncertainty based on option exercise games between an entrepreneur and a venture capitalist (VC). In particular, we analyze the impact of multi-staged financing and both economic and technological uncertainty on optimal contracting in the context of VC-financing. Our novel approach combines compound option pricing with sequential non-cooperative contracting, allowing us to determine whether renegotiation will improve the probability of coming to an agreement and proceed with the venture. It is shown that both sources of uncertainty positively impact the VC-investor's optimal equity share. Specifically, higher uncertainty leads to a larger stake in the venture, and renegotiation may result in a dramatic shift of control rights in the venture, preventing the venture from failure. Moreover, given ventures with low volatility, situations might occur where the VC-investor loses his first-mover advantage. Based on a comparative-static analysis, new testable hypotheses for further empirical studies are derived from the model.

1. Introduction

Venture capital (VC) is a significant source of financing for entrepreneurs seeking to implement innovative investment projects as well as for the development of start-up businesses (e.g. Cassar, 2004). For example, the amount of capital invested by VC-investors in start-up companies totaled $87 billion in 2014, over 58% more than the capital invested in 2013.[1] This aggregated value, which is due to only 6.507 VC-financings, is as high as the gross domestic product (GDP) of countries like the Slovak Republic, Ecuador or even the sum of the three Baltic states, indicating the importance of VC-financing and successful venturing for sustainable economic growth on a global scale.

Determining how to make successful decisions in VC-projects, however, is still one of the most complex investment problems because of the specific characteristics of these ventures (e.g. Miltersen & Schwartz, 2002). On the one hand, VC-projects imply a sequence of investment decisions that have to be made at certain points in time. At these "milestones" the VC-investor (and respectively the entrepreneur) has to decide whether to further invest in the project or to abandon it. This implied characteristic gives these ventures a specific time pattern ("phase financing") the economic consequences of which must be adequately captured in the calculus (e.g. Cossin, Leleux, & Saliasi, 2002; Gompers, 1995; Kaplan & Strömberg, 2003, 2004; Sahlman, 1990). On the other hand, the process of VC-financing is influenced by multiple sources of idiosyncratic uncertainties. The activities of an entrepreneur, as well as the investment of the VC-investor, are not only exposed to severe market risks as soon as the developed product is sold, but also to technical uncertainties typical for any venturous process before commercialization (e.g. Davis, Schachermayer, & Tompkins, 2004; Li, 2008; Pennings & Lint, 1997; Wang & Zhou, 2004).

Some of the financial literature dealing with the decision-making process in VC-projects pleads for the application of the real option-approach (e.g. Dixit & Pindyck, 1994; Sick, 1995) since VC-activities (almost) exclusively portray future options for the firm involved (e.g. Cossin, Leleux, & Saliasi, 2005; Li, 2008). The scope of the existing real option-based models is, however, limited as those approaches commonly rely on games against nature and do not properly account for the (inter-)actions and managerial flexibilities of the parties involved (e.g. Bergemann, Hege, & Peng, 2008; Berk, Green, & Naik, 2004; Childs & Triantis, 1999; Dixit & Pindyck, 1994; Hsu, 2002; Miltersen & Schwartz, 2002; Pennings & Lint, 1997). The assumption

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[1] Cf. Ernst & Young Venture Capital Insights 4Q14.

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of a “central planner” is not appropriate for VC-projects which typically involve options that can only be exercised if the parties agree on relevant economic parameters, i.e. negotiate about a continuation and financing of stages respectively. In order to better capture these actions and flexibilities some articles explicitly consider contract design problems in dynamic settings and thus analyze non-cooperative bargaining processes in staged investments for an array of different VC-related aspects (e.g. Cornelli & Yosha, 2003; Cuny & Talmor, 2005; Dessi, 2011; Fluck, Garrison, & Myers, 2006; Hellmann, 2002; Neher, 1999; Repullo & Suarez, 2004). While those approaches commonly address the important question of how the surplus generated by the VC-project can be shared between the VC-investor and the entrepreneur, the presumed settings do not allow for the analysis of the specific characteristics of staged investments.

This article contributes to the existing branches of research as we provide a sequential decision model for staged VC-projects under uncertainty and in this framework analyze the outcomes of a non-cooperative bargaining process between the VC-investor and the entrepreneur. The starting point of the model is based on the consideration that the vision of a plan focused on diverse "milestones" or "stages" respectively should regularly form the basis for decision-making about the financing of ventures. Correspondingly, it seems to be conducive to consider the sequence of decisions concerning the allocation of VC as a consequence of diversely significant options (flexibilities) that can only be exercised at certain points in time, i.e. require investment decisions of the parties involved at certain stages (cf. Cuny & Talmor, 2005). With regard to these joint decisions, we focus on the optimal funding policies in VC-projects, with particular emphasis on the determinants of both parties' choice of equity as the investment is exposed to technological and market uncertainty. Closely linked to this area of focus, we investigate the circumstances under which the funding of such a staged project will occur and finally how the surplus generated is shared between the parties involved.

Our paper combines multi-staging and joint contracting, which up to this point has been treated independently in the real option-literature. First, it borrows the staged investment structure from Pennings and Sereno (2011). Using a model for *N*-nested compound options the authors show that the insurance effect caused by staged investment adds considerable value, and that both technological and economic uncertainty increase the option value of staged financing. However, the staged investment project only focuses on a game against nature and reflects only an all equity-financed project. Second, our model is close to Banerjee, Gücbilmez, and Pawlina (2014) who – in line with other contributions including Lambrecht (2004), Shibata and Nishihara (2011), and Lukas, Reuer, and Welling (2012) – develop a real option-based decision-making model for jointly held options. In particular, the authors model a VC-contract between an entrepreneur and a VC-investor where the entrepreneur makes the timing decision while both parties bargain over the optimal sharing of the surplus. It is assumed that the contract can be comprised of either a cash payment, an equity stake or a combination of both. How uncertainty affects the choices of timing and equity share depends on the distribution of bargaining power. Accordingly, should the entrepreneur possess a low degree of bargaining power, an increase in volatility leads to an increase of the VC-investors equity stake and to a pronounced deferral of the investment by the entrepreneur, i.e. the optimal investment threshold increases.

Our paper, however, is different from these contributions in several ways. First, we explicitly take multiple stages into account. Consequently, the model can be interpreted as a jointly held compound option as opposed to the classical canonical real option-models by Dixit and Pindyck (1994). Second, we explicitly take technological uncertainty in the first stage into account. Finally, both parties are allowed to veto against financing the next stage, taking into account that renegotiation might serve as a proper incentive mechanism to avoid unilateral abandonment.

In Section 2, we provide a detailed outline of the decision structure of our model by characterizing the tasks the entrepreneur must accomplish in each phase, the investments necessary to enter the next phase and the risks the activities of the parties involved are opposed to. Section 3 summarizes the optimal decision-rules for the three phases assuming a non-cooperative bargaining process between the VC-investor and the entrepreneur. In Section 4, we present and discuss in detail the results of a comparative static-analysis focusing on the optimal funding policy in staged projects. In Section 5, we conclude and sketch some potential for future research.

2. The compound-option-phase-model

The starting point of the model is a temporal structure dividing VC-financing into three phases. The first phase defines the financing of the development process, which ranges from idea to prototype, including market analysis and developing a business- or project-plan. Starting at time t_0 the first phase concludes after a specified length of time, T, i.e. $t_1 - t_0$. We will refer to this phase as the *seed phase*. If no further obstacles to a product's market diffusion are present, the still preliminary *start-up phase* begins. Here, the entrepreneur prepares the product, develops a market, sets up organizational structures and production facilities. Again, we assume a fixed start-up phase that takes up the time $t_2 - t_1$. At t_2 the product may be seen as marketable and commercialization may commence. During this *commercialization phase* distribution and growth financing for market prevalence is performed.

For each of the three points in time t_0, t_1 and t_2 an investment payout is accounted for as $I_{0,VC} > 0, I_{1,VC} > 0$ and $I_{2,VC} > 0$, respectively. This payout represents the VC-financing of each assigned project phase. Likewise, at these stages the entrepreneur has to invest an amount of $I_{0,E} > 0, I_{1,E} > 0$ and $I_{2,E} > 0$. These investments also include the entrepreneur's opportunity costs of managing the project, for example missed salaries. We define $I_0 := I_{0,VC} + I_{0,E},\ I_1 := I_{1,VC} + I_{1,E}$ and $I_2 := I_{2,VC} + I_{2,E}$. A cancellation of succeeding project phase(s) within the entire process is only possible at these specific points in time. This is in line with Pennings and Lint (1997) [2] and Bienz and Walz (2010), as well as with the managerial function of VC-investors. Costs (payouts) spent at these points in time are counted as lost. At each specified point in time we assume that the value of the project $V(t)$ is uncertain[3] and follows a geometric Brownian motion[4]:

$$dV(t) = \alpha V(t)dt + \sigma V(t)dB(t), \quad V(t_0) = V_0 > 0, \tag{1}$$

where $r \in \mathbb{R}$ denotes the risk-free interest rate, $\delta := r - \alpha \in \mathbb{R}$ denotes the opportunity of waiting, $\sigma \in \mathbb{R}$ designates the variance of dV/V and $dB(t)$ indicates a Wiener increment.[5]

Because all funds provided by the VC-investor, or directly paid by the fund-seeking entrepreneur, are assumed to be sunk and that considerable uncertainty prevails, managerial flexibility becomes impor-

[2] We follow Pennings and Lint (1997) by assuming that in practice R&D resources are, to a large extent, linked to a project for a prespecified period of time. Consequently, we assume no real differences between the management of intangible resources within a firm and a venture in its respective phases.

[3] As a market-based methodology the real option-approach assumes knowledge of the market value of the underlying which is in some instances problematic (e.g. Mason and Merton, 1985). In order to circumvent this problem, we rely on the “market asset disclaimer” (MAD). In particular, following Copeland et al. (2004), we assume that the present value of the project itself serves as an underlying asset for the option rights.

[4] Samuelson's (1965) proof shows that the use of a geometric Brownian motion (gBM) is appropriate to model the evolution of the value of a project throughout time. Of course, we could also have used a different continuous stochastic process for the development of the cash-flows, e.g. arithmetic Brownian motion, mean-reverting processes or a gBM with a time-varying noise parameter.

[5] For a traditional interpretation of δ in the case of real options see e.g. McDonald and Siegel (1984).