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Real Option Approach to Evaluate Strategic Flexibility for Startup Projects

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Abstract

This article is devoted to investigation and evaluation of a startup project strategic flexibility depending on its available development options using real option approach. This approach combines ideas of corporate finance, real options and game theory and concludes to the Risk-Neutral Probability measure and the value of a Call Option that comes from Black-Scholes-Merton model. The findings enable us to estimate the value of managerial decisions, project flexibility and help entrepreneurs and investors to select the best choice of project strategic development.

Keywords: strategic real options, binomial method, strategic planning, strategic development, strategy valuation, venture capital, startup project

Introduction

A state of having limited knowledge where it is impossible to exactly estimate a future outcome is commonly called uncertainty and is measured as a set of possible states or outcomes where probabilities are assigned to each possible state or outcome. A measured state of uncertainty is called risk that can be both negative and positive, though it tends to be the negative side that companies commonly focus on. Sometimes, a company may have uncertainty without risk, but not risk without uncertainty. Generally, uncertainty is allied to scientific term "information" and emerges mostly in its incompleteness. Meanwhile, incompleteness of information is an integral part of any business process and project whether it is launching or developing.

Venture capital, that deals with the highest level of risk and uncertainty, is financial capital provided to early-stage, high-potential, growth startup companies or startups that are generally newly created and are in a phase of development and research for markets. A critical task in setting up a startup is to conduct research in order to validate, assess and develop the ideas or business concepts in addition to opportunities to establish further and deeper understanding on the ideas or business concepts as well as their commercial potential. Venture capitalists, startup entrepreneurs and executives struggle every day in making decisions under conditions of incomplete information and uncertainty. The decision may be whether to invest in a new project now or wait a while, or it may be whether to contract, expand, or abandon an ongoing project. Therefore, the dilemma of better choice between available options exists.

A particular decision has a consequent effect on the project eventual cash flow or the project payoff and thus can be valued and compared. In traditional corporate finance discounted cash flow (DCF) method is used to be applied to this end. Although, the universal use of it has certain limitations. First, DCF analysis accounts for only the downside of the risk without considering the rewards. Second, DCF is based on a set of fixed assumptions related to the project payoff, whereas the payoff is uncertain and probabilistic. Such a deterministic approach does not take into consideration the contingent decisions available and the managerial flexibility to act on those decisions. Though, the latter is solved using decision tree analysis (DTA) that is an extension of the DCF method and is a more sophisticated tool which offers value when a project is multistage and contingent decisions are involved. DTA differs from DCF in the sense that it uses probabilities of outcomes rather than risk-adjusted discount rates.

Corporate or strategic real option models synthesize the newest developments in corporate finance and real options and game theory to help bridge the gap between traditional corporate finance and strategic planning. Based on real option models a real option analysis (ROA) is a supplement to DCF and DTA and fills the gaps that both cannot address. ROA enables to estimate the value of managerial decisions, timing it depending on key variables and market conditions and thus is suitable to valuing strategy and its flexibility.

Theory

DCF Analysis

DCF analysis is a commonly used method which accounts for the market uncertainty with a risk-adjusted discount rate (the higher the uncertainty, the higher the discount rate) to calculate the present value (1) of the project payoff.

$$PV = \frac{FV}{(1+r)^n} \tag{1}$$

where PV is the present value of a future cash flow, FV is the value of a future cash flow or simply the future value, r is a risk-adjusted interest rate or a discount rate, and n is a number of the time period.

There are many DCF models exist, whereas they are all based on the same foundation that involves calculation of the net present value (NPV) (2) of a project over its life cycle, accounting for free cash flows (FCF) and the investment costs.

$$NPV = \sum \frac{FCF - InvestmentCosts}{\left(1+r\right)^n} \tag{2}$$

In other words NPV of a project is simply PV of its free cash flows less PV of all investments done.

While DCF approach focuses on the downside, the reward side is ignored. DCF approach also assumes a fixed path or one set of conditions in calculating the project payoff, therefore management is constrained to make the investment decision based on the analysis of these fixed conditions. This inherent bias leads to rejection of highly promising projects because of their uncertainty, whereas in today's constantly changing environment managers have the flexibility to alter the project outcome in order to maximize the payoff or minimize the loss.

Decision Tree Analysis

DTA is considered effective tool in valuation of projects that involve contingent decisions. A decision tree (Fig.1) shows a strategic road map, in the form of a branching tree, depicting alternative decisions, their costs, their possible outcomes and probability and the payoff of the outcomes. In DTA the project NPV is calculated by using the expected value (EV) approach. The EV of an event is simply the product of its probability of occurrence and its outcome commonly expressed in terms of its cash flow value.

DTA is an extension of the DCF method as the payoffs for different outcomes used in the DTA are derived based on the DCF analysis. The final project expected NPV (ENPV) is calculated based on this payoff by incorporating contingent decisions at various decision nodes in the future. This is where DTA adds value, because DCF assumes a fixed path and does not account for management's contingent decisions. The major drawbacks of decision trees lie in estimating the probabilities of the decision outcomes and selecting an appropriate discount rate inside the decision tree when the tree is extended for more than a year or so.

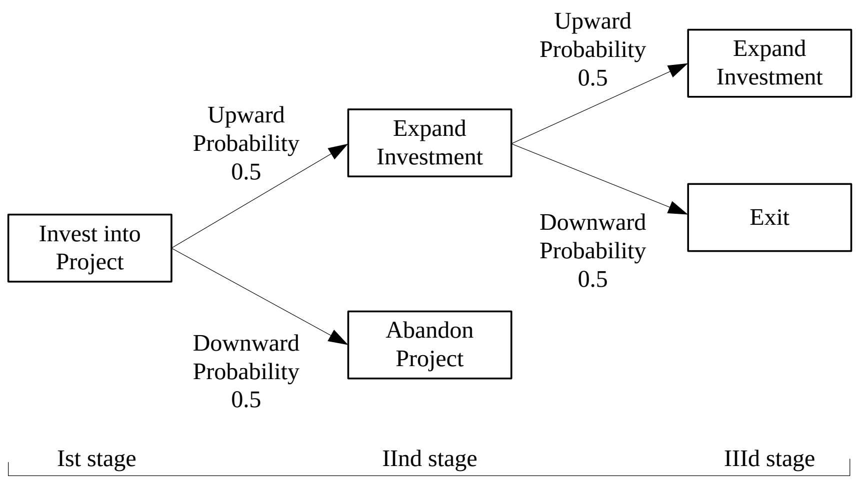

Fig. 1. Decision tree

Black-Scholes Equation

Several methods are available to calculate option values, and within each method there are alternative computational techniques to deal with the mathematics. The choice depends on simplicity desired, available input data, and the validity of the method for a given application. The Black-Scholes and binomial method are the most common ones.

Based on real option models developed by the Nobel Prize winners Fischer Black, Robert Merton, and Myron Scholes for pricing financial options real option approach concludes to the risk-neutral probability measure and the value of a call option that comes from Black-Scholes equation

$$C = N(d_1)S_0 - N(d_2)X\exp(-r_f T) \quad (3)$$

where C is value of the call option, S_0 is current value of the underlying asset or project payoff, X is the cost of investment or strike price, r_f is a risk-free interest rate, T is a time to expiration of the option, $N(d_1)$ and $N(d_2)$ are the values of the standard normal distribution at d_1 and d_2,

$$d_1 = \left[\ln(S_0 / X) + (r_f + 0.5\sigma^2)T\right] / \sigma\sqrt{T} \qquad (4)$$

$$d_2 = d_1 - \sigma\sqrt{T} \qquad (5)$$

where σ is annual volatility of future cash flows of the underlying asset.

The Black-Scholes and binomial models use continuously compounded discount rates as opposed to discretely compounded rates. The continuous discount rate can be calculated from the discretely compounded rate as follows

$$r_f = \ln(1 + r_d) \qquad (6)$$

where r_f and r_d are the continuously and discretely compounded risk-free rates, respectively.

The risk-neutral probability is the most important principle in derivative valuation and thus in pricing both financial and real options. It states that the value of a derivative is its expected future value discounted at the risk-free interest rate. This is exactly the same result that we would obtain if we assumed that the world was risk-neutral. In such a world, investors would require no compensation for risk. This means that the expected return on all securities would be the risk-free interest rate.

Methods

In this paper we apply the binomial method as it offers the most flexibility compared to Black-Scholes. First, input parameters such as the strike price and volatility can be changed easily over the option life, jump factors can be accommodated without any complex changes. Second, the binomial method offers to a practitioner transparent underlying framework, making the results easy to understand by showing the project values in the future for given expected payoffs and the rational decisions one would make.

Binomial method is based on both the risk-neutral probability and binomial lattice. The basic methodology of the risk-neutral probabilities approach involves risk adjusting the cash flows throughout the lattice with risk-neutral probabilities and discounting them at the risk-free rate.

Lattices look like decision trees and basically lay out the evolution of possible values of the underlying asset during the life of the option. An optimal solution to the entire problem is obtained by optimizing the future decisions at various decision points and folding them back in a backward recursive fashion into the current decision.

The most commonly used lattices are binomial trees. The binomial model can be represented by the binomial tree shown in Fig. 2, where S_0 is the initial value of the asset. In the first time increment, it either goes up or down and from there continues to go either up or down in the following time increments.

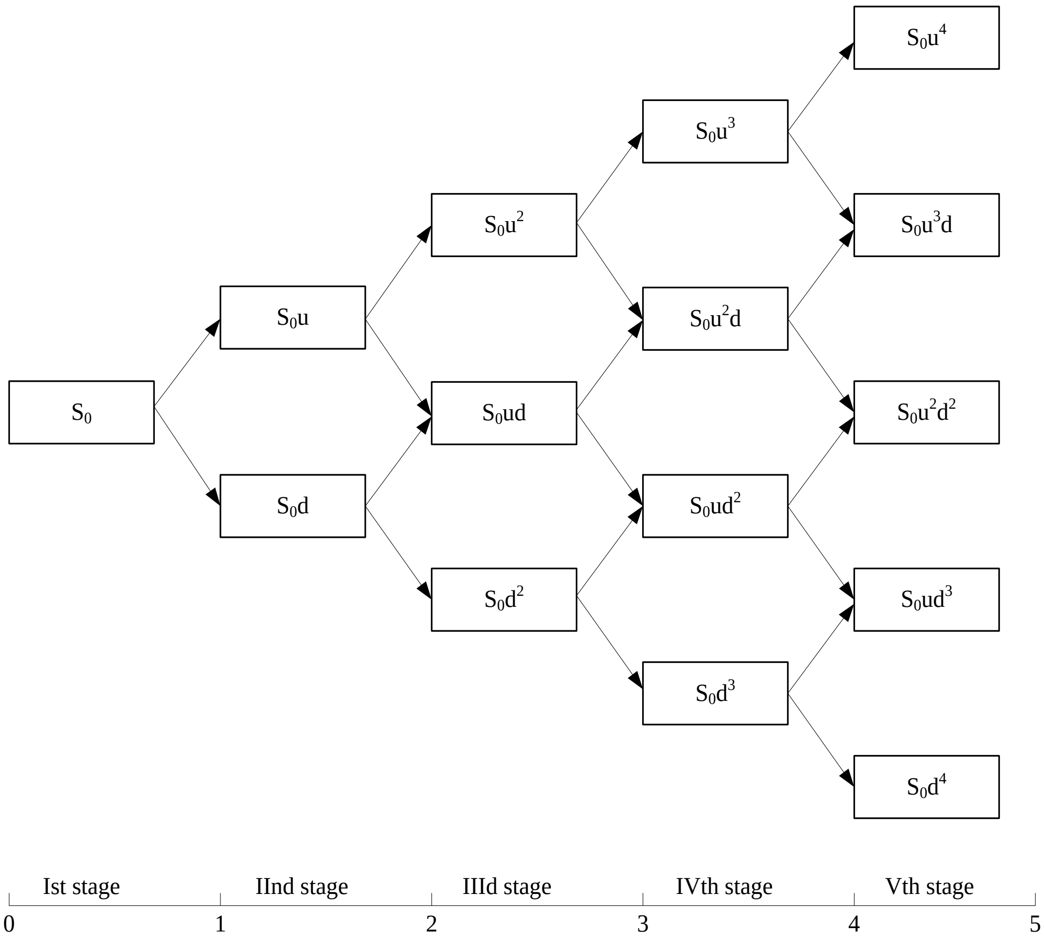

Fig. 2. Binomial tree

The first time step of the binomial tree (Fig. 2) has two nodes, showing the possible asset values (S_0u , S_0d) at the end of that time period. The second time step results in three nodes and asset values (S_0u^2 , S_0ud , S_0d^2), and so on. The last nodes at the end of the binomial tree represent the range of possible asset values at the end of the option life.

The up and down movements are represented by u and d factors which are a function of the volatility of the underlying asset and are defined as follows

$$u = \exp(\sigma\sqrt{\delta t}) \quad (7)$$

$$d = \exp(-\sigma\sqrt{\delta t}) \text{ or } d = 1/u \quad (8)$$

where σ is standard deviation of the underlying asset or annual volatility of future cash flows, and δt is the incremental time step of the binomial tree over the option life.
The risk-neutral probability, p , is a mathematical intermediate that enable to discount the cash flows using a risk-free interest rate and is defined as follows

$$p = \frac{\exp(r_f \delta t) - d}{u - d} \quad (9)$$

Using u and d factors and p we can calculate value of the call option, C , as follows

$$C = \frac{p \times C_u + (1-p) \times C_d}{1 + r_f}$$

or $C = [p \times C_u + (1-p) \times C_d] \times \exp(-r_f \delta t)$ (10)

where C_u and C_d are the potential future up and down option values respectively.

While Black-Scholes gives you the most accurate option value, the binomial method is a close approximation to it. Because of the underlying mathematical framework of the binomial method, it always is an approximation of the Black-Scholes equation. The higher the time increments used in the binomial method, the closer you get to this value.

Results

Let us assume there is a venture capitalist who considers a possibility to launch a start-up project that has the option to expand in the future. The DCF valuation of the project free cash flows using a risk-adjusted discount rate indicates a present value of S_0 = \$500 thousand over the project life, T = 4. The volatility of the cash flows is σ = 0.5 and is expected to result in a twofold expansion of current operations, E = 2.0, at a cost of expansion of X = \$250 thousand. The continuous risk-free interest rate is r_f = 0.09 and the incremental time step of the binomial tree over the option life is δt = 1.

Using equations (7)-(9) moving factors and the risk-neutral probability are calculated in Fig. 3.

$$u = \exp\left(\sigma\sqrt{\delta t}\right) = \exp(0.5\sqrt{1)} = 1.649$$

$$d = 1/u = 1/1.65 = 0.607$$

$$p = \frac{\exp\left(r_f \delta t\right) - d}{u - d} = \frac{\exp(0.09 \times 1) - 0.607}{1.649 - 0.607} = 0.468$$

Fig. 3. Option parameters calculation

Based on calculated parameters in Fig. 3 we can build a binomial tree (Fig.4), using one-period time intervals for four years and calculate the asset values over the life of the option. Start with S_0 at the very first node on the left and multiply it by the u and d factors to obtain S_0u and S_0d respectively. Moving to the right, continue in a similar fashion for every node of the binomial tree until the last time step.

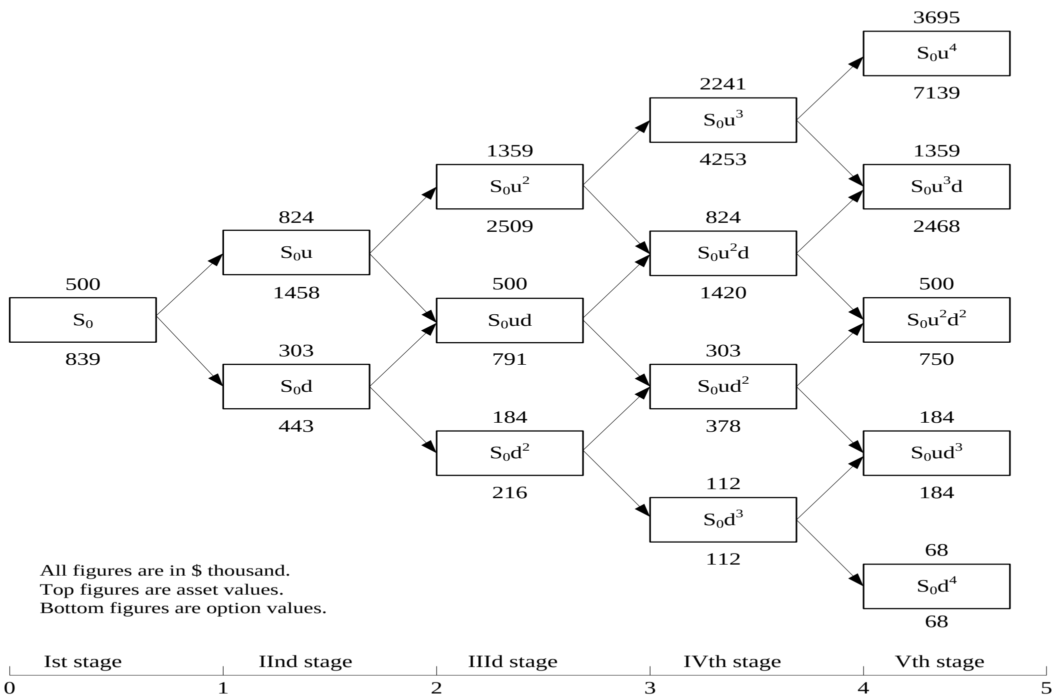

Fig. 4. Binomial tree for option to expand

Fig. 4 shows the option values at each node of the binomial tree calculated by backward induction. Each node represents the value maximization of continuation versus expansion. At every node, you have an option to either continue the operation and keep the option open for the future or expand it by two times by committing the investment for expansion.

First, start with the terminal nodes that represent the last time step. At node S_0u^4 the expected asset value is $3695 thousand, whereas if you invest X and expand the operation by E the asset value would be $7139 thousand. Evidently, to maximize return you would expand rather than continue and the option value at node S_0u^4 would become $7139 thousand. In contrast to S_0u^4, S_0u^3d and $S_0u^2d^2$, at nodes S_0ud^3 and S_0d^4 the asset value with no expansion would be bigger than with it, therefore you would continue your operations without expansion.

Second, move on to the intermediate nodes starting at node S_0u^3 and calculate the expected asset value for keeping the option open and accounting for the downstream optimal decisions. Using equation (10) that value at node S_0u^3 is $4253 thousands. Meantime, if the option is exercised to expand the expected asset value would be $\$2241 \times E - X = \$4232$ thousands. Hence, you would not exercise the expand option, and the option value at this node would be $4253 thousands. Completing the option valuation binomial tree all the way to node S_0 we get the option value of $839 thousands.

Conclusions

Let us first compare the value of the expansion option based on DCF versus ROA. The present value of the project cash flows based on the risk-adjusted DCF method is S_0 = \$500 thousand. If the operation were to be expand today by twofold, the additional value created would be \$500 thousand. Since the investment is X = \$250 thousand, the NPV of the expansion project would be NPV_I = \$250 thousand. Whereas, real option analysis using binomial method suggests that the present value of the project cash flows due to the investment cost X is \$839 thousand, that means the NPV of the expansion project is NPV_{II} = \$339 thousand after subtracting the present value of the cash flows associated with S_0.

Comparing NPV_{II} with the baseline NPV_I, the additional value provided by the expansion option is $NPV_{II} - NPV_I$ = 89 thousand. The difference is substantial and is the value added to the project because of the real options approach which management can take into consideration in decision making. Management may decide to keep the option of expansion open at this time and exercise it when the uncertainty clears and conditions become favourable. Although the option to expand is implicit in most operations, the ROA calculation helps to quantify the value of the option. If the expansion option is indeed valuable, then management can take the necessary steps to keep the option alive.

The option to expand is common in high-growth companies and startups in particular. For some projects, the initial NPV can be marginal or even negative, but when growth opportunities with high uncertainty exist, the option to expand can provide significant value. You may accept a negative or low NPV in the short term because of the high potential for growth in the future. Without considering an expansion option, great opportunities may be ignored due to a short-term outlook.

By and large, startup companies are the best candidates to be considered for expansion options as long as they have extremely high uncertainty and hence start out on a small scale, but as uncertainty clears, they can be expanded if conditions are favourable.

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