International Business Management 10 (22): 5286-5290, 2016
ISSN: 1993-5250

Venture Capital Management Technique Based on Real Options

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Abstract: The study describes innovative process stages, provides statistics of innovative projects realization, develops a model of the innovative project evaluating by real options method.

Key words: Innovation project, innovation process, real options, venture capital, model, decision making

INTRODUCTION

In today's fast growing economy situation, development and implementation of innovative projects became a key factor in improving the competitiveness and efficiency of an enterprise or even of a state as a whole. Therefore, the problem of evaluation of innovative projects is important.

An innovative process can be represented as a sequence of the real options. The option value means expectation of a probable result and characterizes advisability of project investment continuation.

Every stage of innovative process has two scenarios: optimistic or pessimistic. A calculation of the option value uses statistics of probability of these results. Pessimistic case means fail and optimistic means continuing of the project. Interpretation of the optimistic case depends on the stage of the innovative process. On the last stage, i.e., expansion stage, possible gain is sum of NPV of the project and cash flow from early sales. On the early growth stage gain can be found as a sum of cash flow from early sales and option value of expansion stage minus investments on the same stage. For other stages optimistic gain prediction is found as the difference between option value and investments (both on the next stage).

The analysis starts from the last stage. If real option value on this stage is positive number, last investment is profitable and it's necessary to make similar operations until the stage of decision making or until the stage with negative option value. So, the option value on the stage of decision making shows advisability of the project investment.

Being quite a simple, this model allows making a decision about innovative project investment based on average probabilities of success.

MATERIALS AND METHODS

Theory: An innovative process is a process of innovative ideas' successive transformation into product (Hashi and Stojcic, 2013). It includes the following steps:

- Environment creation
- Fundamental science
- Applied science
- Pre-seed stage
- Seed stage
- Early venture capital investment
- Early growth
- Production expansion (scalability)

Figure 1 illustrates cash flow and set of the innovative project participants at each stage. This scheme illustrates ideal innovative process; in reality, some participants may be missing and their functions can be performed by other structures (Ajupov *et al*., 2015). For example, venture capital funds can assume the functions of a business angel.

We would like to consider a simplified model of the innovation process, shown in Fig. 2. The numbers of analyzed stages are shown in the figure in Roman numerals. For each stage probability of success of a project as a whole (P_i) and probability of failure ($Q_i = 1 - P_i$) are specified. The first two stages of the innovative process (i.e., the stages of environment creating and fundamental science), that result to generation of new ideas are not considered in the model, since it is impossible to determine the probability of occurrence of their final result innovative ideas. A project being at the ith stage ($i = 1, ..., 6$) has two scenarios. Optimistic: that

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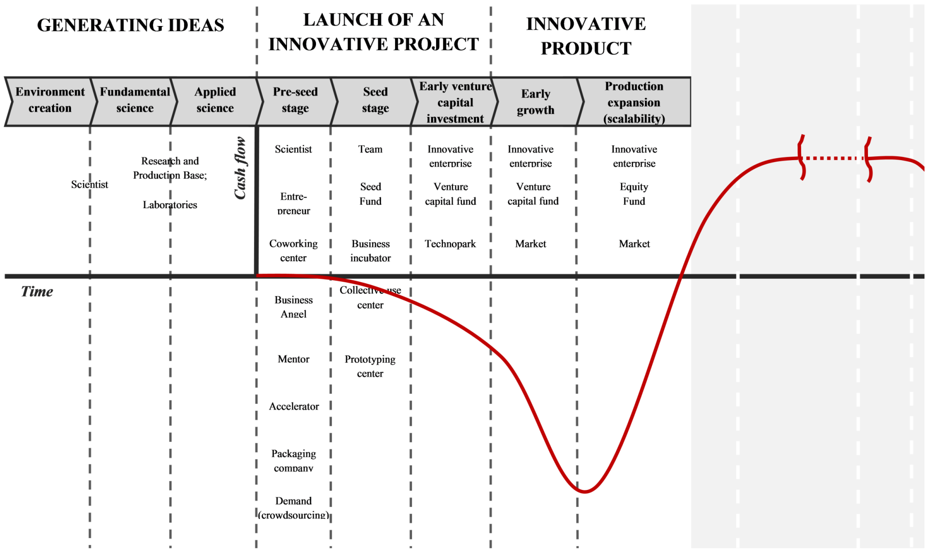

Fig. 1: Innovation process stages

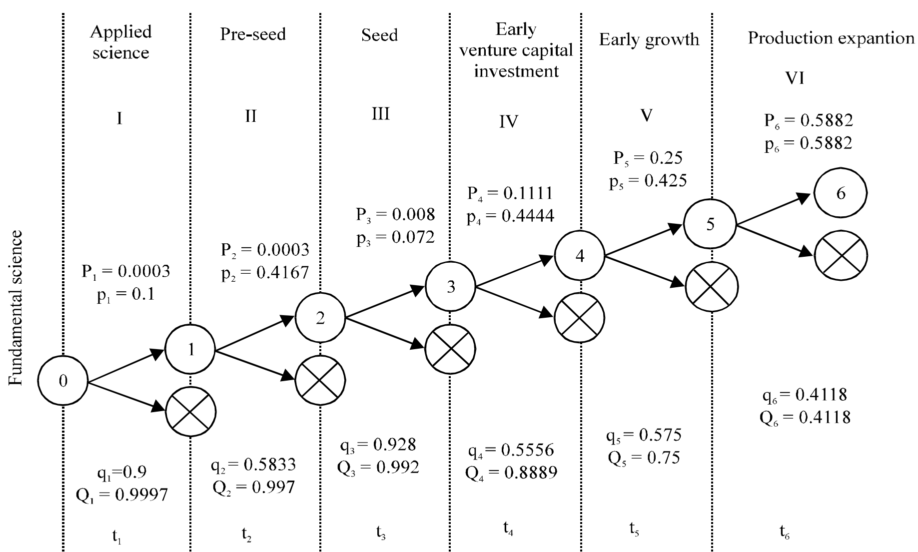

Fig. 2: Stages of innovative project realization

mean successful stage completion and transition to next, (i+1)th, stage. The probability of this scenario is p_i. Pessimistic: that mean failure of the stage and, consequently, of the whole project. The probability of this scenario is $q_i = 1-p_i$. As the assumptions of the model, we assume that both potential outcomes (success or failure) are expected simultaneously, at the same time, after an interval t_i from the start of the stage.

We decide to take the statistical probability of the project continuation as indicators $p_i \prod q_i$. Statistics of innovative projects realization was presented by Stevens and Burley (1997) in the article "3000 Raw Ideas = 1 Commercial Success" based on the analysis of the 40 years period data. Title of the work characterizes stably observed for the studied period proportion: one of 3000 scientific ideas is implemented in the form of a commercially successful project (Stevens and Burley, 1997). Statistics is summarized in Table 1.

An investor can invest in the project being at the ith stage the capital in the amount of I_{i-1} and in the case of success of the project has an opportunity to continue investing in the later stages. Successful completion of the project will mean gaining profit (or share of profit) from the sale of innovative product (in discounted form).

Table 1: Performance indicators of innovative project stages

Stage	Stage result	Quantity	p_i (%)	P_i (%)
Fundamental science	Raw idea	3000.0	-	-
Applied science	Submitted Idea	300.0	10.00	0.03
Pre-seed	Small project/patent submission	125.0	41.67	0.33
Seed	Early stage development	9.0	7.20	0.80
Early venture capital investment	Major development	4.0	44.44	11.11
Early growth	Launches	1.7	42.50	25.00
Production expansion	Commercial success	1.0	58.82	58.82

The proposed model of the innovative process is a series of consecutive real call options (Cobb and Charnes, 2007), i.e., options to buy. At the same time, investing in an innovative project on the stage of production expansion is a real option to the ability of taking profit from the sales of innovative products and investments on the previous stages mean option to the next option. For example, investing on the stage of early growth is a real call option to the option to production expansion. At the beginning of each stage option premium will be determined as the discounted expectation of benefits:

$$C_{i-1} = \frac{p_i G_i + q_i L_i}{(1+r)^{t_i}} \tag{1}$$

Where:

G_i = Gain in the end of the stage in optimistic case

L_i = Gain in the end of the stage in pessimistic case

r = Discount rate

t_i = ith stage duration; $\forall i = \overline{1...6}$

In pessimistic case, i.e., in case of the project failure, it is no point for investor to exercise the option, so his gain equals zero, i.e., $L_i = 0$. In terms of financial market this option is called "out of the money". Consequently:

$$C_{i-1} = \frac{p_i G_i}{(1+r)^{t_i}} \tag{2}$$

Generally, in optimistic outcome benefit of exercising the option is the difference between the market price of the asset at the time of the option exercise and the strike (exercise) price X_i:

$$G_i = S_i - X_i$$

Reciprocally, if exercising the option gives benefit, this option is "in the money". Interpretation S_i and X_i of and indicators in the context of the innovative project will vary on different stages. The analysis of the project starts from the last stage, i.e., product expansion stage. As noted above, the expansion stage is considered as an option to the sale of innovative products. For the scalability stage the optimistic case gain will equal NPV of the project. At the same time, initial investment is not taken into account because it is carried out regardless of the success of the project (Bertoni *et al*., 2015). We consider zero period as the time of completion of the conditional stage of the production expansion. Also, it is possible to obtain a positive cash flow after this stage from the sales initiated on early growth stage. Thus:

$$G_6 = NPV + CF_6 = \sum_{j=1}^{6} \frac{CF_j^+ - CF_j^-}{(1+r)^j} + CF_6 \tag{3}$$

Further, the option premium C_5 is calculated by the Eq. 2 and compared with the investments at the beginning I_5 of the stage:

$$C_5 = \frac{p_6 G_6}{(1+r)^{t_6}}$$

If $C_5 \geq I_5$, i.e., if the investment is recouped by the following cash flows, investing at the production expansion stage will make sense provided (certainly, in case of success of the previous stages). Else investing at this stage considered inappropriate. As an innovative project is not a liquid asset and it is difficult to consider the possibility of its sale, the investment in the project as a whole will also be considered as having no meaning. Further calculations in this case break.

In case of the advisability of investing, a similar analysis is performed for other stages. Stage at which the project is located at the moment of the decision making is analyzed the last.

On the early growth stage possible benefit is calculated as the option premium at the production expansion stage, net of investment at this stage. In addition, the likely income includes a positive cash flow at the end of the early growth stage, resulting from the trial sales. In this way:

$$G_5 = C_5 + CF_5 - I_5 \tag{4}$$

Accordingly, in financial market terms for early growth stage an optimistic price$_i$ of the asset S_i will be represented as the sum of the probable profits from the sale of innovative products and the option premium of the production expansion stage. The option exercise price X_i will be represented as the amount of investments at the production expansion stage.

As in the previous step, the value of option premium is calculated according to the Eq. 2 and compared with the value of investment in the early growth stage. As a result of the comparison, decision on the advisability of investing and therefore, the continuation of calculations will be taken.

For the remaining stages there is no positive cash flows, so the probable profit is found as the difference between the option premium and the value of the investment at a later stage, i.e.:

$$G_i = C_i - I_i \ \forall i = \overline{1...4} \tag{5}$$

Thus, for the stage of applied science, pre-seed and seed stages and early venture capital investment stage indicator of the asset market price at the moment of the option exercise S_i will be interpreted as the premium for the subsequent option C_i and the strike price X_i as investments I_i required for the subsequent stage. As a result of the comparison of the option premium and the amount of investment required on the desired stage, decision of investing the required amount is taken.

RESULTS AND DISCUSSION

We would like to consider the example of this method implementation. The innovative project is in the seed stage. Data on the duration of the stage and the required investments are shown in Table 2. In the end of the early growth stage positive cash flow in the amount of 6 monetary units is expected.

Part of the investments in the scalability stage is for the continuation of trial sales and gives end-stage flow of 3 units. Upon completion of these stages following cash flow is expected (Table 3).

As a risk-free rate, we adopt short-term rate of state treasury bonds market and federal loan bonds on 06.10.2015 (data presented on the website of the Russian Central Bank). Thus, r = 0.1026 (10.26%). We give the following decision using proposed method. NPV is calculated by Eq. 3. The resulting value of NPV is 54.89 monetary units. Next the value of a real option to the sale of the product is calculated and compared with the value of investments in the scalability stage:

$$C_5 = \frac{p_6 G_6}{(1+r)^{t_6}} = \frac{0.59 \times (54.89 + 3)}{(1+0.026)^1} = 33.2 > I_5$$

Table 2: Initial data for the example

Stage	Duration (t_i), quarters	Investments (I_i), units
Seed	2	2.0
Early venture capital investments	2	3.0
Early growth	4	7.0
Production expansion	1	6.5

Table 3: Expected cash flow for the example

	Cash flow	
Terms	CF+	CF-
1	13	9
2	17	8
3	22	8
4	25	8
5	23	7

The resulting value is much greater than investments required at the stage of scalability. Therefore, investing in the expansion stage is advisable to subject (given that the successful implementation of previous phases). So, the calculation is continued. The real option value at the early growth stage is found by the following formula:

$$C_4 = \frac{p_5 G_5}{(1+r)^{t_5}} = \frac{0,43 \cdot (33.2 + 6 - 6.5)}{(1+0.026)^4} = 12.56 > I_4$$

The resulting value is more than investments required at the stage of early growth. So, next calculated is real option value on the stage of early venture capital investmen:

$$C_3 = \frac{p_4 G_4}{(1+r)^{t_4}} = \frac{0.44 \cdot (12.56 - 7)}{(1+0.026)^2} = 2.35 < I_3$$

The resulting value is less than investments required at the stage of early venture capital investment. That's why investment in this project is not practicable. Thus calculation can be finished. In this example potential result evaluated by this method (found as difference between investments and real options value on the seed stage), i.e., loss is 2.04 monetary units.

The proposed algorithm is simple and easy realizable in spreadsheet, for example in Microsoft Excel. At the same time, the presented model is quite adequate.

CONCLUSION

However, it should be noted that this model uses average probability of the project success for assessment and does not allow to take into account the inherent risks of the evaluated project and, on the contrary, the positive aspects that contribute to its implementation such as the demand for developing innovative product, the qualifications of the project team, the presence of a market for the product, the validity of the business plan. These factors can be taken into account in various ways of expert analysis. For example, it is possible to develop a comparison system of innovative projects based on the Thomas L. Saaty's analytic hierarchy process and using the results of real options valuation of the project as a profitability indicator. It is possible to take into account even the projects with negative results but not out of certain limits, for example with loss no >5% of the discounted investment amount.

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