УДК 330.42
DOI: 10.26140/anie-2019-0803-0067

УПРАВЛЕНИЕ ВЕНЧУРНЫМ КАПИТАЛОМ: КОМПЛЕКСНАЯ ОЦЕНКА ИННОВАЦИОННЫХ ПРОЕКТОВ И ФОРМИРОВАНИЕ ПОРТФЕЛЯ

Орлова Кристина Юрьевна, ассистент кафедры
математических методов в экономике
Самарский национальный исследовательский университет им. академика С.П. Королева
(443086, Россия, Самара, Московское шоссе, 34, e-mail: orlova.ssau@gmail.com)

Аннотация. В статье описывается механизм управления венчурным капиталом. Представленный механизм включает три этапа. Первый этап заключается в оценке ожидания прибыли инновационного проекта с учетом риска на основании модели, использующей метод реальных опционов для многостадийных проектов. Значения венчурного риска были рассчитаны на основании статистических данных о количестве проектов, проходящих каждую стадию инновационного процесса. На втором этапе применения механизма происходит интегральная оценка проекта, учитывающая ожидание прибыльности, временной лаг, а также экспертные оценки качественных критериев, характеризующих возможность реализации проекта: квалификация команды проекта и востребованность разрабатываемого инновационного продукта на рынке. Комплексная оценка использует метод анализа иерархий. Результатом оценки являются приоритеты проектов. Третьим шагом механизма является последовательное распределение инвестиций между проектами в соответствии с их приоритетами. Распределение инвестиций представлено в виде алгоритма. Предложенный механизм позволяет инвестору сформировать портфель потенциально прибыльных проектов, характеристики которых свидетельствуют о высокой вероятности успеха н рынке.

Ключевые слова: инновационный проект, инновационный процесс, реальные опционы, комплексная оценка, метод анализа иерархий, инвестиционный портфель, формирование портфеля

VENTURE CAPITAL MANAGEMENT: INTEGRATED ASSESSMENT OF THE INNOVATION PROJECTS AND PORTFOLIO BUILDING

Orlova Kristina Yurievna, assistant lecturer, Department
of Mathematical methods in economics
Samara National Research University
(443086, Russia, Samara, Moskovskoe shosse. 34, e-mail: orlova.ssau@gmail.com)

Abstract. The article describes a mechanism of the venture capital management. The introduced mechanism includes three steps. First step is estimation of the innovative project expected profitability with allowance for risk using the model based of the real options method for multi-stage projects. Values of venture risk are calculated from the statistics about average outcome of the projects at different stages of innovative process. Second step is integrated assessment of the project that accounts expectation of the profitability, time lag and expert judgements about qualitative criteria that characterize ability of the project to succeed: qualification of the project team and the market attractiveness of the future innovation product. Complex evaluation is based on the analytic hierarchy process. The result of evaluation is set of priorities of the projects. Third step of the mechanism is successive investments allocation between the projects in accordance with their priorities. The allocation technique is represented as an algorithm. The offered mechanism allow investor to build portfolio of potentially profitable innovation projects which characteristics indicate a higher probability of the market success.

Keywords: innovation project, innovation process, real options, integrated assessment, analytic hierarchy process, investment portfolio, portfolio building.

Implementing of innovations is a key factor in competitiveness on the modern markets. Innovation development demands venture investments, which are highly risky, but potentially highly remunerative. Therefore, venture investor needs to build innovation projects portfolio, which would commit a higher profit with lower risks.

Suggested mechanism of the innovation projects portfolio management includes three steps.

I. Assessment of the projects expected profitability using real options method.

II. Complex evaluation of the considered projects and further determining of the innovation projects priorities.

III. Building the portfolio of the projects according to their priorities and considering financial constraints.

Assessment of the projects expected profitability using real options method

At the first stage we evaluate potential profit of the innovation project with allowance for risk[1, 9].

Estimation of the venture investment risk was presented in the article «3000 Raw Ideas = 1 Commercial Success» by G. Stevens and J. Burley. The scientists described stable trend, which was observed during 40-years research: only one from 3000 raw innovation ideas leads to successful sales of the product. At that, risk of the project declines from stage to stage: according to this statistic, probability of the investments recoupment at the pre-seed stage is less than tenth of the percent, but at the expansion stage this value is more than 50 percent [6].

The results of this research are arranged in the table 1, where p_i – probability of the transition to the next stage, P_i – probability of success of the whole project.

Table 1 – Statistics of the innovation projects realization [1, 6, 8].

Stage	Stage result	Proportion	p_i, %	P_i, %
Fundamental Science	Raw idea	3000	-	-
Applied Science	Submitted Idea	300	10,00	0,03
Pre-seed	Small Project / Patent Submission	125	41,67	0,33
Seed	Early stage development	9	7,20	0,80
Early venture capital investment	Major development	4	44,44	11,11
Early Growth	Launches	1,7	42,50	25,00
Production Expansion	Commercial Success	1	58,82	58,82

For evaluation of the project profitability we have chosen the real options method. According to this method, investment projects are evaluated by analogy with financial options [4].

Model of the innovation project evaluation using real options method is represented in the figure 1 [3].

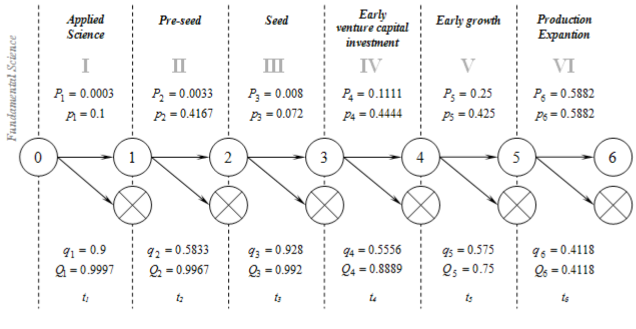

Figure 1 – Model of the innovation process

Proposed model of the innovative process represents a chain of the sequential call options. Investment at the expansion stage is a real option for selling innovative production, and investment on previous stages is option for the further option.

Investor has an ability to place the capital in amount I_{i-1} into project at the i-th stage. Success of the current stage gives ability to invest at the next stages. Success of the whole project means having income (or part of the income) from the sales of the innovative production.

Value of the i-th stage option C_{i-1} characterizes expectation of the gain G_i with allowance for risk and discount rate r:

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

Interpretation of the gain depends on stage. Gain represent value of the further option and account possible cash flows net of investments.

The analysis starts from the last stage. If option value at current stage is less than needed investments, the same analysis continues till decision stage. Else, project is not advisable.

Expectation of the innovation project profit represents a difference between value of the option and investments at the decision-making stage.

$$G_{i-1} = \tilde{N}_{i-1} - I_{i-1}.$$

The model was deeply considered in the article “Venture capital management technique based on real options” [1].

However, the estimation is based on average statistical data, thus we need to consider individual features of the project that determine probability of the project success.

Complex evaluation of the considered projects and further determining of the innovation projects priorities

Hence, we move to the second stage of the mechanism – multicriteria assessment using analytic hierarchy process.

Decision maker can select for the further analysis projects with allowable values of expected profit. The obvious critical value is zero; since we used average statistical values of risk, we may also consider projects with negative expected profit.

We propose the following criteria of the integrated assessment.

Profitability of the project.

Project *team qualification*.

Project *importance* – expert valuation of demand on the future innovative product.

Time lag of the project – average term of the investments immobilization [11].

Team qualification and importance of the project are qualitative criteria. Hence, marks with respect to these criteria would be synthesized by pairwise comparisons.

Profitability and time lag are quantitative criteria.

Profitability of the project j is calculated as a relation of the expected gain at the decision-making stage k to sum of all discounted investments.

$$\pi_j(k) = \frac{G_{k-1}}{I_{k-1} + \sum_{l=k}^{5} \frac{I_l}{(1+r)^{T_l}}}, \quad T_l = \sum_{\tau=k}^{l} t_\tau$$

For example, considered project is at the seed stage (third). Hence, $k = 3$. Thus, the expression below characterizes this particular case.

$$\pi_j(3) = \frac{\tilde{N}_2 - I_2}{I_2 + \sum_{l=3}^{5} \frac{I_l}{(1+r)^{T_l}}} = \frac{\tilde{N}_2 - I_2}{I_2 + \frac{I_3}{(1+r)^{t_3}} + \frac{I_4}{(1+r)^{t_3+t_4}} + \frac{I_5}{(1+r)^{t_3+t_4+t_5}}}$$

To dispose of negative values, we calculate modified mark o_j with the following formula:

$$o_j = \frac{\pi_j - \pi_{\min}}{\pi_{\max} - \pi_{\min}},$$

where o_j – modified mark of the j-th project profitability criterion value, π_j – profitability of the j-th project, $\pi_{\max}$ – maximal profitability value from the considered projects, $\pi_{\max}$ – minimal profitability value from the considered projects.

Thus, obtained modified mark of the project with maximal profitability will equal one, with minimal – zero. Other marks will lay in this range.

Time lag of the j-th project L_j is calculated as weighted average term of the diversion of the investments till the end of the production expansion stage when mass sales will start:

$$L_j = \gamma_{k-1}^j \cdot Z_k^j + \gamma_k^j \cdot Z_{k+1}^j + \ldots + \gamma_5^j \cdot Z_6^j = \sum_{i=k}^{5} \gamma_{i-1}^j \cdot Z_i^j,$$

where:

$$\gamma_{i-1}^j = \frac{I_{i-1}}{\sum_{i=k}^{6} I_{i-1}}$$ – share of the investments needed at the i-th stage;

$$Z_i^j = \sum_{\tau=i}^{6} t_\tau$$ – diversion term of the i-th stage investments.

Since integrated assessment represents maximizing criterion – the more is total mark, the better is project – we need to turn minimizing criterion of the lag into maximizing. We propose to calculate modified mark as a relation of the minimal value of lag within considered projects to the lag of the j-th project. Hence, modified mark of the “best” project will equal one, and the other marks will lie in range from zero to one. Thus,

$$o_j = \tilde{L}_j = \frac{L_{\min}}{L_j}.$$

Modified marks of the profitability and lag are normalized by the following formula:

$$x_j = \frac{o_j}{\sum_{j=1}^{m} o_j}.$$

Hence, $\sum_{j=1}^{m} x_j = 1.$

Expert judgements need to be checked for the consistency and adequacy [2-5].

The last stages of the complex assessments represent calculation of the local priorities of the alternatives (projects) and synthesis of the global priorities [2-5].

Building the portfolio of the projects according to their priorities and considering financial constraints

The last, third, stage of the mechanism is building the investment portfolio by successive resource allocation according to the projects priorities that are determined by the integrated marks of the projects. First of all investor should finance the most priority projects that have the highest integrated mark. If resource is not enough for the project, less preferable projects are to be considered.

Let us consider the statement when investor develops plan for term of Λ periods that covers term of realization of any project. Duration of the stage of the project is measured in time units that are less than period of investment planning. Thus, one planning period includes *k* units of project stage duration. For example, investor makes quarterly planning, and duration of the project stages is measured in months ($k = 3$). We will consider mentioned units further.

Investor commits capital K_λ for each quarter λ. Savings from previous quarters can be also used for investments in quarter λ. Thus, accumulations V_λ in the quarter λ would equal:

$$V_\lambda = \sum_{\varphi=1}^{\lambda-1} R_\varphi$$

Accumulations of the first quarter equal zero, $V_1 = 0$.

Investor considers *m* projects ranged by descending priorities determined after integrated assessment. Thus, mark of the *j*-th project is higher than (*j*+1)-th.

We denote I_t^j as investments needed to the *j*-th project at the moment *t*, S_λ^j as total investments needed to the project in the *λ*-th quarter:

$$S_\lambda^j = \sum_{t=3(\lambda-1)+1}^{3\lambda} I_t^j$$

Consequently, in general case:

$$S_\lambda^j = \sum_{t=(\lambda-1)k+1}^{\lambda k} I_t^j$$

Allocation of the resources shall satisfy the following conditions:

first of all, investor funds the most priority projects with higher total mark;

the following constraints shall be considered:

total investments made in each quarter can not exceed quarterly budget with savings from previous periods;

investor has two alternatives: finance in full or dispose of the project.

The constraints can be represented as a system below:

$$\begin{cases} \sum_{j=1}^{m} D_j \cdot S_\lambda^j \le K_\lambda + V_\lambda \\ I_j = D_j \cdot \sum_{\lambda=1}^{\Lambda} S_\lambda^j \end{cases}$$

Innovative projects portfolio can be built with the algorithm of the successive resource allocation in accordance with priorities.

The algorithm uses the following variables:

K_λ – budget of the λ-th quarter;

S_λ^j – total investments needed for the *j*-th project in the λ-th quarter.

D_j – decision about *j*-th project ($D_j = \{0;1\}$): 0 – overrule the project, 1 – finance the project;

F_λ – funds, that are *actually* remained in the quarterly budget after making investments to already considered projects;

R_λ – funds, that *could* remain in the quarterly budget in case of positive decision about the project;

V – current accumulated remainders;

N – sum that is lacking for the project being considered.

The considering is started from the most priority project. For each quarter decision maker conducts the analysis whether budget is enough to finance the project in the current quarter ($S_1^j \vee F_1$) or, if there is lack of funding, with account for savings from previous periods($S_\lambda^j \vee F_\lambda + V_\lambda$). Wherein savings from the later quarters, starting from (λ-1)-th, are spent first. If financing is impossible in current λ-th quarter, the decision about *j*-th project is negative, $D_j = 0$. Thus, investor considers further projects.

Flowchart of the algorithm is represented in the figure 2 [12].

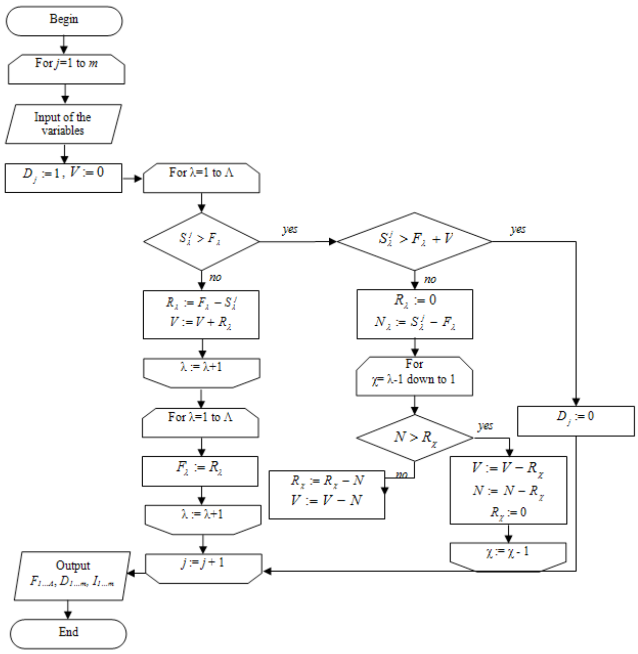

Figure 2 – Flowchart of the investments allocation algorithm

Conclusion

In summary, the offered mechanism of the venture capital management allows investor to make a well-founded decision about building the innovation projects portfolio.

The result of the applying the real option model of innovation project is estimation of the profitability with allowance for average statistical innovative risk. Complex assessment allows investor to define priorities of the projects considering, firstly, qualitative indicators of expected profitability and term of the investments diversion, and, secondly, expert judgments about key factors that determine success of the project: qualification of the team and market performance of the innovation project being developed. The allocation of the investments is processing with the algorithm according to the priorities of the projects and with allowance for budget constraints.

Complex assessment can be expanded with including "deal killer" factors that can be a reason to dispose of the project. Such factors [7] can be linked with team: for example, when founder is unwilling to step aside, if necessary, for the new CEO. Another factors illustrate weak opportunities: low market capacity or low forecasted revenue for the five years after sales started.

Besides, evaluation of the financial attractiveness of the project may account not only expectation of the profit with allowance for risk, but also potential profit in case of the project success.

СПИСОК ЛИТЕРАТУРЫ:

1. Ivanov, D.U., Orlova, C.U., Ajupov, A.A., Bogatirev, V.D. & Pavlova, E.V. 2016, «Venture capital management technique based on real options», International Business Management, vol. 10, no. 22, pp. 5286-5290.

2. Saaty, T. 1982, «How to structure and make choices in complex problems», Human Systems Management, vol. 3, no. 4, pp. 256-261.

3. Saaty, T.L. 2013, «The modern science of multicriteria decision making and its practical applications: The AHP/ANP approach», *Operations research, vol. 61, no. 5, pp. 1101-1118.*

4. Saaty, T.L. 2016, «Continuous Pairwise Comparisons», Fundamenta Informaticae, vol. 144, no. 3-4, pp. 213-221.

5. Saaty, T.L. 2016, The analytic hierarchy and analytic network processes for the measurement of intangible criteria and for decision-making.

6. Stevens, G.A. & Burley, J. 1997, «3,000 raw ideas = 1 commercial success!», Research Technology Management, vol. 40, no. 3, pp. 16-27.

7. Valuing Pre-revenue Companies. Ewing Marion Kauffman Foundation, 2007. URL: https://www.angelcapitalassociation.org/data/Documents/Resources/AngelCapitalEducation/ACEF_-_Valuing_Pre-revenue_Companies.pdf

8. Горбунов Д.В., Иванов Д.Ю. Инфраструктурная модель бюджетной поддержки реализации инновационных проектов (на примере Самарской области). //Экономические науки. 2014. № 6 (115). С. 107-115

9. Иванов Д.Ю., Орлова К.Ю. Постановка задачи оценки инновационного проекта методом реальных опционов // Вестник Самарского государственного экономического университета. 2015. №7 (129). С. 93-98

10. Лимитовский М.А. Инвестиционные проекты и реальные опционы на развивающихся рынках: Учеб.-практич. пособие. – М.: Дело, 2004. – 528 с.

11. Оглезнев Н.А. Методы определения экономической эффективности. – Куйбышев, КуАИ, 1989

12. Орлова К.Ю. Механизм управления венчурными инвестициями // Управление большими системами. УБС-2018: материалы XV Всероссийской школы-конференции молодых ученых [Электронный ресурс]. – Воронеж, 2018

Статья поступила в редакцию 02.06.2019
Статья принята к публикации 27.08.2019