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CASE STUDY OF FINANCING OF INNOVATIVE PROJECTS AND EXOGENOUS SHOCKS

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Abstract
One of the main problem of innovative projects in Russian Federation is the need to assess the impact of exogenous shocks on their financing and development. The impact of this type of shock in the period of globalization is sharply increasing. In order to assess the impact of exogenous shocks on innovative projects we create a model with two stages using the innovate project of production of water purification plants. The first stage of it is the construction of a simple model of financial risk, stipulating the conditions when investors will invest in this firm in the absence of negative shocks, their expectations will depend on their own confidence in continuing investment at the next stages. This model shows a positive result. At the second stage we take into account the impact of the negative exogenous shocks on the project, and try to trace a reaction of companies involved in financing innovative projects. The results of the project were negative. The investor in this case as a rule can stop financing and has the risk of losses. In order to prevent this situation we propose to use a real option for a possible refusal to implement an innovative project in the event that the net present value after one year of financing will be negative or very small. To our opinion it is one of the best ways to reduce financial risks during the implementation of innovative projects for investors.

Keywords
exogenous shocks, innovative projects, real option, financial risks, financing projects, to reduce risks of investment projects,venture investors.

Introduction

In recent years, more and more entrepreneurs are beginning to launch innovative projects in the sphere of scientific developments and nanotechnologies. Innovative projects are attractive not only because of short investment payback period (on average from 2 to 4 years), but also because of their high profitability(which is always connected with risks), efficiency and, growth potential (caused by the need to introduce new technologies on the global market). All these qualities are inherent in the latest projects that arise on the basis of a unique business idea or technology.

Most projects need to attract financing tools which depend on the development of financial instruments and financial markets in the country. These tools can not only reduce the risks of financing new projects, but they also play a more important role in diffusion and commercialization of new technologies by creating favorable conditions for project financing.

However, there are some problems and contradictions regarding innovative projects and investments:

1. Nowadays, innovative project show a high degree of uncertainty. They are unstable in their development. There is a growing competition and high copying capabilities of the business model, which incurs additional costs, necessitates a deeper study of the customers preferences, the search for additional sources of financing, etc.

2. There is a lack of technological development on the territory of the Russian Federation, the populations is not ready to acquire and use innovative technologies, and entrepreneurs cannot conduct innovative business.
3. There is an absence in Russia of an established innovation-venture ecosystem, including a regulatory and legislative framework, unified requirements for projects and a system of effective selection of objects for investment.

For the above reasons, Russia still lags far behind the leading countries (the United States, Germany, China, Japan, France, India, etc.), both at the maturity of the institutional environment, the effectiveness of implementing innovative projects, and in terms of attracting investment.

Innovative projects are risky because of their exposure to external shocks, which in macroeconomics are traditionally understood as the impact of factors outside the national economy (that is related to the world economy) on macroeconomic indicators (primarily through aggregate demand, or aggregate supply), which is both positive (positive shocks) and negative (negative shocks).

The impact of this type of shock in the period of globalization is sharply increasing, as the boundaries between national economies are gradually eroding. For example, the increase in oil prices during 2002-2008 was a positive shock for Russian economy. Positive impact was also provided by the improvement of financing conditions in the world financial markets in 2003–2007. The extreme form of negative external shocks is the crisis phenomena. It is spreading from the outside to the national economy.

The influence of globalization and external various types of shocks is very strong.Traditionally, there are two channels of external shock transmission between economies: trade and investments. In modern conditions, financing of innovative projects is influenced by the financial channel, so as a significant part of investment inflows is a movement of financial capital without the acquisition of real assets. It is determined by specific factors, including the expectations of investors.

The investment channel is connected with the dynamics of direct investments. The impact of a negative external shock through innovative projects can be twofold: the outflow of direct investment as a result of the worsening economic situation in the country, or the desire of foreign investors to buy temporarily impoverished assets (in case of their expectations of improving the economic situation). That is why a shock can be transmitted almost instantaneously that has a negative impact on the implementation of an innovative project. When describing the impact of the crisis on the economy of the country through various external shocks, it is also necessary to take into account the economic policy of the country in the pre-crisis period, as well as its reaction to external shocks.

The main problem of this study is the justification of the need to assess the impact of shocks on the development of innovative projects [1, 2]. It may reduce uncertainty, ie, avoid inefficient use of financial resources and improve their survival and attractiveness for investors [3, 4]. It will address issues related to the behavior of investors in the event that they finance innovative projects taking into account possible shocks in accordance with their preferences and expectations.

The identified task poses the scientific problem of the study, related to the assessment of the impact of shocks and financial risks on the decision to continue financing the innovation project [5, 6].

Financing of innovative projects depends directly on the impact of exogenous shocks and the development of financial instruments in financial markets. It may not only reduce the risks of financing new projects but also plays a much more important role in the diffusion and commercialization of new technologies, by creating favorable conditions for investors to continue financing projects.

Literature review

The degree of commercialization of new ideas in any industry depends on the state of development of the financial market. More and more scientific studies are devoted to the role of finance in the innovative process [7–11].

Most researchers believe that all transactions are primarily aimed at generating income, but in their studies they do not take into account the state of the external environment, the so-called exogenous conditions that affect the project [12]. For example, many scientists consider the low return on investment during the recovery period as evidence of poor investment quality. However, in some cases, the low return on investment is not due to the low quality of investment, but to the state of the external environment and its uncertainty. A similar statement was made for the first time in work by Nanda and Rhodes-Kropf [13]: they suggested that investments made during the economic recovery are the most risky and can cause losses, but, on the other hand, they can bring a big income.

Moreover, the desire of investors for the experiment, which can be an important part of the technological revolution, leads to the process of creative o destruction [14]. According to the theory of creative destruction, the market economy is constantly being improved by natural displacement of the obsolete and unprofitable business and redistribution of resources in favor of new, more productive companies.

Most of the research currently focuses on the success of breakthrough technologies throughout the study period, while similar success is always accompanied by the failure of other venture projects [15].

The technological revolution is always associated with the periods of experiments and a small number of successful venture projects, a large number of failures of innovative projects. While the work of the previous period suggested a correlation between innovation and the boom in the financial market they could provoke, the authors suggest that low financial risk makes investors to take experiments and thus to seek and implement the most innovative ideas in the economy [12, 16, 17].

This assumption suggests a more positive interpretation of the peaks of financial activity. It may be explained through the historical link between the initial diffusion of new technologies and the high activity of the financial market, while other assumptions stemming from this relationship can demonstrate how financial markets influence innovation. To describe these interdependencies, we propose a model based on the description of the impact of exogenous shocks and financial risk on investment decisions. At the same time, financial risk can be defined as the risk of investors' refusal from financing the project at the next stage of the development if the first stage of the project is completed and has no positive changes. In this case, financial risk is a part of the rational equilibrium where innovative projects are at risk of their failure.

The process of creating a model consists of two stages. The first stage is the construction of a simple model of financial risk, stipulating the conditions when investors will invest in this firm, their expectations will depend on their own confidence in continuing investment at the next stages of the company's development. At the second stage, a reaction to the potential exogenous shock and financial risk for companies involved in financing innovative projects is traced.

Research methodology

There is an innovative project for the production of drinking water purification plants, environmentally friendly and energy-saving. The plants have no direct counterparts at the moment.

In accordance with the proposed innovative project, it is planned to install and put into operation a workshop for the production of water purification plants with a design capacity of 12 000 units per year, starting costs for a business will be – 2000 thousand rubles, loan capital – 1812 thousand rubles. Initially, it can be assumed that there is not enough money to implement this project, and the project needs an inflow of money. Investments in this project in the early stage can have a positive effect, a negative effect or achieve inconclusive results. The project in the latter stages needs an investment inflow. For example, it may be necessary to conduct additional studies or experiments. After these researches investor takes a decision to continue or to close the project.

It is supposed that this project overcomes difficulties and achieves potential success and income, which is a way out of investment. These difficulties can continue for a long time during several rounds of financing. There may be a technological uncertainty or a risk of finding a buyer, etc. For the simplicity, we will consider a firm with one round of financing. So, the firm needs to attract investments to eliminate financial problems. However, the investor wants to finance the project in the event that the net present value (NPV) is positive. The indicator of net present value before the beginning of investment, we will denote as NPV_t, where the exponent t denotes the investment period. With probability y_l, the result is negative and the project is unprofitable, any investment in the project is unprofitable, despite the state of the financial environment. This may be the case if the technology does not work at all or does not work efficiently, or the capacity of the potential market is low.

With the probability of y_a a company implementing a project, has the opportunity to find a potential buyer or has the opportunity to negotiate a sale. With probability y_w, the project can be profitable and provides payments to investors. With probability $1 - y_l - y_a - y_w$ the project needs to attract investments, in order to exceed the break-even point.

Denote the indicator w (or $w = 0$) as an alternative output and consider the issue of a possible acquisition of a company or project. It is theoretically possible that the probability that a firm needs more cash inflows can proceed for an unlimited number of periods. However, in practice it is extremely difficult to determine the investment period. The decision to invest is made at the early stages of the innovation project by so-called venture investors. At each stage, competitive investors choose whether to invest in the project in the next stage of development or not to invest. At the same time, any venture investor is limited in funds.

Venture investors expect the rate of return from an innovative project to be equal to r. In this case, they are rational and apply a rule of positive NPV for investment. While other venture investors are also rational and similarly use the rule of a positive NPV. From the moment when venture investors begin to compete among themselves and receive a positive net present value, a venture investor investing in the first period gets a share of $x/(\text{profit}_1 + x)$. This share is then blurred in the next period, while the second investor gets a share of $x/(\text{profit}_2 + x)$. Thus, the first investor has a portion of $x/(\text{profit}_1 + x) \times (1-x)x/(\text{profit}_2 + x)$. Of course, the real rate of return of venture investors in each period of time implies payment in each future period of time. In other words, investors will continue to invest in the firm until the NPV indicator remains positive.

As a basic model for assessing the impact of exogenous shocks on innovation-driven projects, the Raman Nanda and Matthews Rhodes-Kropf model is chosen [13]. In this model the net present value (NPV), will be used as the basis of the simulation. The basis of the model will be the so-called sequential investments, which are made up to the period in which the company will begin to receive positive cash flows. The venture investor decides whether to invest it or not, depending on the decisions other investors make. It is assumed that there are external generally available signals that investors will continue to finance the project. On the basis of these signals, other venture capitalists will decide to continue financing in the next period within the time interval $s(t) \in [0; 1]$.

As noted above, there are exogenous shocks which move macroeconomic conditions from one state to another. The factors associated with increased uncertainty are examples of such shocks [19, 20]. These factors allow the company to suspend its investment activities. In the Russian Federation, different signals can be attributed to a change in the investment environment due to an improvement (deterioration) in the political situation or the abolition (adoption) of sanctions. We accept a reduced output cost, which depends on the signal of the next period as $V(s(t+1))$. The future value of the company, thus, can be designated as $V(s(t+1))$, where $V(1) > V(0)$. Signal 1 in the period $t+1$ assumes investment, and the signal 0 in the period $t+1$ implies the end of the investment. If regardless of the signal, investors will or will not invest in the project, $V(1) = V(0)$. Θ — is a probability that the signal remains in the position 1 and $(1-\Theta)$ – probability that the signal will pass from 1 to 0.

τ – represents probability that the signal will remain in the position 1, and $(1+\tau)$ – probability that the signal will be zero.

Taking into account that all venture investors are rational, they will invest in the event that the expected NPV of the project is positive (Fig. 1).

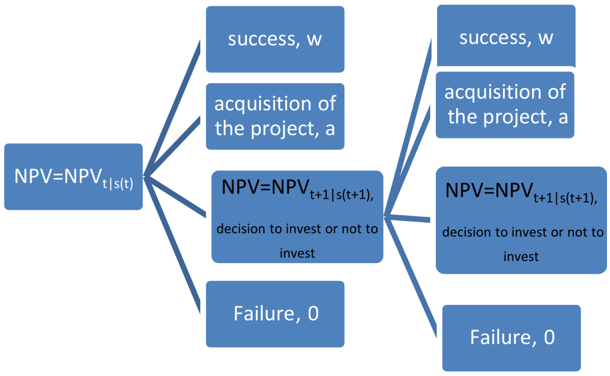

Fig. 1. Decision tree.

Let $\text{NPV}_{t|s(t)} = 1$ be an NPV project when signal is 1, and $\text{NPV}_{t|s(t)} = 0$ is the NPV of the project if the signal is 0. Assume that the venture investor has sufficient capital to maintain the project for one period and does not have the opportunity to combine capital with another investor to reduce potential financial risk. An extensive form of this situation is shown in Fig. 1. Any investor maximizes their wealth and the NPV of the project in period t can be designated as (1):

$$\text{NPV}_{t|s(t)} = \frac{1-y_1-y_a}{1+r} \cdot [X\text{NPV}_{t+1|s(t+1)=1} + Y_{\max}[\text{NPV}_{t+1|s(t+1)=0}, 0] + \frac{y_a}{1+r}[XV(s(t+1)=0) + YV(s(t+1)=0)], \tag{1}$$

where

$$X = s(t)\theta + (1-s(t))(1-\tau), \qquad Y = s(t)(1-\theta) + (1-s(t))\tau. \tag{2}$$

Provided that $\text{NPV}_t + 1|s(t+1) = 0 < 0$, venture capitalists will not invest if the signal is zero, and they will not earn anything or even lose.

The above equations show the effect (1), (2) achieved at the current NPV level. Comparing Eq. (2), when $s(t) = 1$ with the same equation, when $s(t) = 0$, we see that NPV with zero signal can be changed in two ways. The first way is that the project does not generate revenue, but continues to work and investors believe that future investments will only be made if $s(t+1) = 1$, then $s(t) = 0$.

The second way is that investors will invest if $s(t+1)=1$, then $V(s(t+1)=1) > V(s(t+1)=0)$, while the signal affects on the value of the company when the conditions of investment change. There is also the possibility of increasing the cost of the project $V=(s(t+1)=1$.

The most important comparison comes from the analysis of the company's profitability indicator when the project is implemented and is not implemented. For example, in the case if $y_l = l$, the project is unprofitable, $y_l = 0$, the project can generate revenue.

However, if the contract is not implemented, the value of NPV will be very important. It shows the possibility of the failure or of the success of the project. The higher the indicator, the greater is the profit of the project.

Can a richer investor protect their investments from negative shocks? Let's make the assumption that the venture investor has sufficient capital to finance the project for two or more cycles. In this case, even with a negative net present value, investor can continue to implement his project (3).

$$\mathrm{NPV}|_{t|s(t)}^{n=2} = \frac{l - y_l - y_a}{1+r} \cdot [\tau \mathrm{NPV}_{t+1|s(t+1)=0} + (1-\tau)\mathrm{NPV}_{t+1|s(t+1)=1}] + \frac{y_a}{1+r}V, \tag{3}$$

where $n = 2$ is a financing period equal to two years.

In this situation, the net present value of the project can grow substantially after two years or fall sharply. Thus, large investors or their syndicates can increase the net present value of the project by giving it more funding over a long period. Sufficient cash inflows can lead to an increase in the net present value of the project, even if the financial risk is high. However, after the end of financing, the project can bring significant losses to the investor, it will significantly exceed the possible losses in the event of a timely abandonment of the project.

Now we'll try to make an assessment of influence of exogenous shocks on our innovative project. For this purpose we'll make the financial plan through modeling of production streams. We'll take into account inflation of 9%, necessary volumes of production stocks, and disregard influence of negative exogenous shocks (Table 1). The net present value (the difference between integrated income and expenses) in three years on the project will be 4831 thousand rubles, the Index of profitability will be 3.53 internal rate of return will be 149.9%.

In case of the absence of financial shocks all financial coefficients will be very high. The Return on equity in the first year will be 201.09% and it will reduce up to the end of the project.

At the first stage we take into consideration the financial performance with negative exogenous shocks. It will be worse because of their negative impact (Table 2).

Table 1
Financial performance in the absence of negative exogenous shocks.

	1 year	2 year	3 year	4 year
Current Ratio (CR), %	364.38	624.53	1216.13	1725.68
Quick Ratio (QR), %	204.14	464.44	1057.94	1563.52
Net working capital (NWC), th. rub.	753.06	1572.19	3874.33	6457.83
Inventory turnover (IT)	8.83	8.83	8.95	8.70
Working capital turnover (WCT)	13.55	6.83	3.21	2.21
Fixed assets turnover (FAT)	13.16	14.27	17.90	22.37
Total assets turnover(TAT)	5.63	4.09	2.53	1.90
Total debts to total assets(TD/TA), %	15.71	11.42	7.06	5.30
Total assets to equity (TD/EQ), %	18.64	12.89	7.60	5.60
Gross profit margin (GPM), %	60.48	60.51	60.51	60.68
Operating profit margin (OPM), %	43.04	43.12	43.40	43.52
Net profit margin (NPM), %	30.13	30.19	30.38	30.47
Return on current assets(RCA), %	296.14	173.10	89.50	63.35
Return on fixed assets(RFA), %	396.37	430.68	543.83	681.59
Return on investments (ROI), %	169.50	123.48	76.85	57.96
Return on equity (ROE), %	201.09	139.40	82.69	61.21

Table 2
Financial performance with negative exogenous shocks.

	1 year	2 year	3 year	4 year
Current Ratio(CR), %	1.61	12.81	3.29	6.53
Quick Ratio(QR), %	1.61	12.81	0.92	0.52
Net Working Capital (NWC), th. rub.	−1052.10	−1175.77	−1325.41	−1463.51
Inventory turnover(IT)			2.90	4.01
Working capital turnover (WCT)			−0.03	−0.37
Fixed assets turnover (FAT)			0.05	0.62
Total assets turnover(TAT)			0.04	0.55
Total debts to total assets (TD/TA), %	112.13	118.13	147.67	160.17
Total assets to equity (TD/EQ), %	−924.44	−651.52	−309.78	−266.20
Gross profit margin (GPM), %	−3.64	−5.58	−12.83	−15.10
Operating profit margin (OPM), %			−126.91	29.97
Return on current assets (RCA), %			−12790.84	−1311.15
Return on fixed assets (RFA), %	−8085.45	−1438.35	−11773.40	−6899.80
Return on fixed investments (ROI), %	−148.22	−256.36	−601.25	−806.38
Return on equity (ROE), %	−145.55	−217.58	−572.03	−722.00

The results of the projects are very low. The net present value (the difference between integrated income and expenses) in three years on the project will be negative −1850 thousand rubles, the Index of profitability will be 0.75 internal rate of return will be 12%.

In this situation investors need to look for the ways to minimize possible losses.

One of the ways to reduce financial risks during the implementation of innovative projects is an option for a possible refusal to implement an innovative project in the event that the net present value after one year of financing will be negative or very small.

The use of real options is especially important for "innovative projects", as investors invest in a very risky projects. Thus, the investor acquires real options, in other words, the possibility of obtaining additional resources. Such contracts can significantly reduce financial risk. In our model, the cost of a real option depends on the likelihood that the project will cease to be viable before it is sold. In the event $y_l = 0$, the project will be viable and will not be a subject to closure. But for large values of y_1, it is necessary to reduce funding and study the project for viability in the next period. So, considering the net present value as a constant indicator, a firm with a large exponent1 has a higher option value, as the cost of rejecting the project is higher (4)

$$\mathrm{NPV}|_{t|s(t)}^{n=2} = \frac{l - y_l - y_a}{1+r} \times [Y\mathrm{NPV}_{t+1|s(t+1)=0} + X[\mathrm{NPV}_{t+1|s(t+1)=1}] \quad (4)$$

$$\frac{y_a}{1+r}V(1) - \left(1 + \frac{y_l}{1+r}\right),$$

where

$$X = s(t)\theta + (1 - s(t))(1 - \tau),$$

$$Y = s(t)(1 - \theta) + (1 - s(t))\tau.$$

The main difference between the net present value function when executing a project without an option and with an option to close represents the indicator (5).

$$\frac{y_l}{1+r}. \quad (5)$$

This indicator includes the additional costs that the firm may incur in the event of the closure of the project. Thus, using the real options model, we can significantly reduce the impact of exogenous shocks, and close the project in time. In our opinion, innovative projects should be financed step-by-step. In other words, the more expectations from the project, the more will be the cost of a real option minimizing the financial risk of its implementation. In our case, it will significantly increase the net present value after 1 year of the project. In our project the positive value will be 150 thousand rubles. It will allow the investor to compensate for the possible losses that may arise after 1 year of the project. So the value of the project will increase.

Such models can be used for other types of real options, such as an option for expansion, involving a long waiting period before receiving cash inflows. Any delay in financing can lead to significant financial losses, so the investor must balance between the possible problems and maximization of the value of the real option.

Conclusion

Certainly, the impact of exogenous shocks on the financing of an innovative project is essential.Usually continuation of project financing depends only on the sufficient funds of investors. However, this type of cash infusion increases the cost of the project. A firm with a large amount of financing can continue to implement the project even in case of disappointing forecasts for its future value. The high cost of the project affects the value of the real option of closing the firm: the larger the real closing option, the less financing the company must receive within a period. Firms that receive small cash inflows are more exposed to exogenous shocks. In this regard, there is a direct link between the reduction and the increase in the value of the option after the impact of financial shocks This dependence can be described using a real options model that has a significant impact on reducing financial risks. The use of such a model by venture investor allows to conduct a project analysis and, in the event of a negative result, it is very easy to close the project in time.

Innovative companies and projects at an early stage certainly need a developed financial infrastructure and a favorable macroeconomic environment. If they are implemented in conditions of high uncertainty, macroeconomic instability, they are more exposed to various kinds of shocks. Financing of innovative projects in Russia is currently underdeveloped; this situation is primarily related to the difficulties of attracting financing at the initial stage of the project. That is why the use of the proposed model of real options is the most appropriate way of assessing the possibility of financing innovative projects in conditions of macroeconomic instability and exogenous shocks.

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