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Slavyanov A. Mathematical model for decision-making on economic protection of an innovative project

Математическая модель принятия решений по экономической защите инновационного проекта

Slavyanov A.S.
Candidate of Economics, Associate Professor of the Department –
Moscow State Technical University N.E. Bauman

Abstract. *The creation of fundamentally new technical facilities is associated with a high level of uncertainty, in connection with which, at the initial stage of research, it is difficult to determine the completion date and assess the need for resources. When implementing innovative projects, the investor is forced to solve the problem of choosing the option of economic protection of investments (insurance, creation of a reserve Fund, creation of a reserve technical facility). It is shown that project insurance does not always provide rapid recovery of project characteristics. The creation of a pool may seem to be private companies rather expensive method of protection. A dynamic economic and mathematical model based on the net present value (NPV) method is developed, which allows the investor to determine the limit value of the insurance rate. In case of exceeding the limit value, the investor should focus on other methods of protection-the creation of a financial or material reserve. The model allows you to make the best decision on the protection of the project. The use of the model will reduce the project implementation time, increase the efficiency of resource use.*
Keywords: *investment, project, innovation, insurance, reservation, decision making.*

Introduction Creating fundamentally new types of equipment and technologies requires a significant amount of experimental, research and design work, which, in turn, requires scarce materials, special equipment, testing ranges and the work of highly qualified scientists and specialists [1-2]. As noted in previous studies, the implementation of projects using the results of fundamental and applied research is associated with the so-called innovative risks [3-6], which can be implemented, at all stages of the project life cycle [7-8]. Various types of accidents that occurred during experiments, during the manufacturing process, during transportation, storage, etc., can cause substantial material damage to the investor. In addition to direct damage to the enterprise's infrastructure, losses associated with delaying the project's implementation deadline, contract disruption, and reputational costs, which may lead to a market loss, are of particular danger.

Methods of economic protection Insurance, as the most common method of protection, as a rule, does not take into account these risks, which leads to severe consequences for the investor if they are implemented [9]. It should be noted that commercial insurance companies, the purpose of which is to maximize profits, are trying, as a rule, by all possible means to delay payments on insured events, which causes serious damage to the project indicators [10]. An enterprise that does not receive timely compensation cannot sustain the terms of the project and incurs losses.

An alternative method of economic protection is redundancy. here, an enterprise creates its own funds from its own funds, from which all damage from an accident or other negative event is instantly compensated. Funds are immediately directed to compensation for damage, while the insurance organization needs time to collect documents, examinations, conduct an investigation, raise funds, etc. As a rule, large payments are delayed for several months, accompanied by lawsuits and litigation, which greatly complicates the distribution of insurance as a method of protection. In conditions of dynamically developing markets, the loss of time spent in such proceedings may lead to the failure of previously concluded contracts with all the ensuing negative consequences.

Making decisions To make a decision when choosing methods of economic protection, a dynamic model was developed that takes into account all the time spent on the innovation process.

The model is based on a comparison of the NPV project [11], protected by insurance and reservation.

For insurance:

$$NPV_{ins} \geq NPV_{r}, \tag{1}$$

NPV_{ins} net present value of a project protected by insurance, NPV_{r} - net present value of a project protected by reservation.

Compliance with condition (1) provides the basis for choosing insurance as a method of economic protection. The *NPV* of the protected insurance project will include, in addition to investments and insurance payments, which are sent to the insurer under the terms of the contract:

$$NPV_{ins} = \sum_{i=m}^{n} CFi/(1+r)^{i} - \sum_{i=k}^{n} T/(1+r)^{i} - IC, \tag{2}$$

CFi is the net cash flow [12 -13] generated by the project, *r* is the discount rate, n is the number of periods of economic protection planning, *m* is the moment the technical object began to operate, *T* is the insurance premium paid to the insurer, *IC* is the invested capital [14].

NPV of a project protected by redundancy takes into account funds allocated to the reserve fund:

$$NPV_{r} = \sum_{i=m}^{n} CFi/(1+r)^{i} - (IC + ICr), \tag{3}$$

ICr – capital allocated to create a reserve.

The model allows us to determine not only the most effective method of economic protection, but also the limit value of the insurance tariff for this project. To obtain the result in a simplified form, we accept the following assumptions:

- financial resources come at a time and are spent all at once, although in practice various financing options are possible;
- the invested capital in the main and reserve objects in the model are considered the same, although the resources for creating a reserve apparatus will require less by the amount of earlier design work (*IC = ICr*).

The insurance premium is formed as the product of the insurance rate and the value of the insured property:

$$T = t \times IC, \tag{4}$$

T – insurance premium, *t* - insurance rate, *IC* - property value equal to investments aimed at creating a complex technical facility.

After taking into account assumptions (4) in expressions (2), (3) we get:

$$NPV_{ins} = \sum_{i=m}^{n} CFi/(1+r)^{i} - IC\left(t\sum_{i=k}^{n}(1+r)^{-i} + 1\right) \tag{5}$$

$$NPV_{r} = \sum_{i=m}^{n} CFi/(1+r)^{i} - 2IC \tag{6}$$

Equate expressions (5) and (6):

$$\sum_{i=m}^{n} CFi/(1+r)^{i} - IC\left(t\sum_{i=k}^{n}(1+r)^{-i} + 1\right) = \sum_{i=m}^{n} CFi/(1+r)^{i} - 2IC \tag{7}$$

After transformations (7) we obtain the expression:

$$t\sum_{i=k}^{n}(1+r)^{-i}=1, \tag{8}$$

from which it is quite simple to calculate the marginal value of the insurance tariff:

$$t\le 1/\sum_{i=k}^{n}(1+r)^{-i} \tag{9}$$

If the insurance tariff t proposed by the insurer satisfies condition (9), then insurance protection is recommended in this project. In another case, you should focus on redundancy. The insurance contract is usually concluded for a year and then extended by agreement of the parties. If insurance is chosen as a method of economic protection, insurance payments are made from the moment the design and manufacture of the facility are completed (k), and the funds allocated to protect the technical facility are sent to the reserve fund and frozen for the duration of the project.

It should be noted that insurance coverage provides for compensation for funds lost in the event of an accident in the amount of the value of the insured property, but does not take into account losses associated with the time required to restore project characteristics. These losses are associated with the rupture of previously concluded contracts for the provision of services, delivery of products, penalties for the supply of materials and components, etc. During the time necessary for the manufacture of a new apparatus, its testing, transportation to the place of operation, installation, commissioning and other works, the income will not go to the investor's account.

Losses represent the shortfall in revenues from the sale of goods and services during the restoration of project characteristics:

$$Q=\sum_{i=m}^{2m}CFi/(1+r)^{i}, \tag{10}$$

where Q is the loss in the amount of lost profit upon the occurrence of the insured event, m is the time required for the manufacture and preparation for operation of the technical facility. When assessing insurance as a possible method of economic protection, it is necessary to take into account, along with insurance costs, possible losses, which are estimated as the product of the probability of an accident occurring on lost income (10).

Possible losses are estimated as:

$$q = p\times Q, \tag{11}$$

where q is the possible loss.

If you do not freeze the funds of a special reserve fund, but use it to build a backup technical facility that can be quickly put into operation instead of an emergency, then loss of lost profit can be avoided. We take into account possible losses in expression (5):

$$NPVins=\sum_{i=m}^{n}CFi/(1+r)^{i}-IC(t\sum_{i=k}^{n}(1+r)^{-i}+1)-\mathrm{p}\times \mathrm{Q} \tag{12}$$

Equating (6) and (12), we obtain::

$$\sum_{i=m}^{n} CFi/(1+r)^i - IC(t\sum_{i=k}^{n}(1+r)^{-i}+1) - \mathrm{p}\times\mathrm{Q} = \sum_{i=m}^{n} CFi/(1+r)^i - 2IC \qquad (13)$$

After the transformation, we get:

$$t\sum_{i=k}^{n}(1+r)^{-i} + p\cdot\left(\frac{Q}{IC}\right) = 1 \qquad (14)$$

The resulting expression allows us to more accurately assess the marginal value of the insurance tariff.

Conclusion The value of the insurance tariff depends on the discount rate, which, in turn, is determined by the level of risks in the economy as a whole. In developing economic systems, a rather high level of uncertainty in the environment in which the innovation project is being implemented, and therefore, the use of insurance as an instrument of economic protection cannot always be justified.

The production of the reserve facility, although it requires additional resources, but its application in conditions of instability practically guarantees the implementation of the project on schedule. The developed model allows to improve the quality of management decisions when choosing the method of economic protection of projects, reduce the consequences of negative events and increase the efficiency of investments.

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