ASSESSMENT THE EFFICIENCY OF ECO-ORIENTED INNOVATION PROJECTS IN INDUSTRIAL ENTERPRISES

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Abstract: The appearance of special kind of innovation in the practice, namely, ecological innovation, led to the emergence of a new type of investment projects in industries – eco-oriented innovative investment projects. The relevance of the study is driven by the imperfection of the existing approach to evaluating the effectiveness of these projects in the Russian legislation. A complex of private parameters' performance evaluation is worked out. We offer a mathematical apparatus and the method of evaluating the effectiveness of eco-oriented innovation projects in industrial enterprises. This methodology is offered as an alternative to the traditional method based on the value conception and on the «Cash flow» method. Article submissions are of practical importance in the selection of priority eco-oriented projects at the regional level.

Keywords: innovation, innovative project, eco-innovations, eco-oriented project, desirability function, efficiency, industrial enterprise

1 Introduction

Among the priority areas of science development, technology and engineering in 2011, the Russian President approved efficient use of natural resources and to the critical technologies were added "time-lapse technology and environment state forecasting, prevention and pollution liquidation". In 2012, there have been developed and approved strategic objectives for the first time, taking into account national and international experience in environmental protection and ecological security according to the main directions of long-term socio-economic development of the country (Prognoz dolgosrochnogo social'no-jekonomicheskogo razvitija Rossijskoj Federacii na period do 2030 goda (The forecast of long-term social and economic development of the Russian Federation for the period till 2030)," 2013; Osnovy gosudarstvennoj politiki v oblasti jekologicheskogo razvitija Rossii na period do 2030 goda (Bases of state policy in the field of ecological development of Russia for the period till 2030)," 2012). To realize these set goals, investments in the sphere of environmental innovation are needed.

Currently, the evaluation of the investment projects' effectiveness is dominated by cost-based approach. However, in investment activity practice, the specific types of projects are common, the estimation of which must be implemented with taking into account the set of specific factors. Such projects include projects of environmental innovation implementation. According to Decision N° 1639/2006/EC establishing a Competitiveness and Innovation Framework Programme ("The eco-innovation action plan," 2016) an eco-innovation is "any innovation that makes progress towards the goal of sustainable development by reducing impacts on the environment, increasing resilience to environmental pressures or using natural resources more efficiently and responsibly". Eco-innovation let make it possible to get the effect of non-economic systems, which can not be adequately valued in monetary terms, using officially adopted methods of evaluation (Kosov,2000).

Eco-innovations have some peculiar features: they are focused on the long term, aim to create ecological benefits, are social in their nature, give rise to external effects (including network effects) (Yusupova ,2016). The main reason for the implementation of eco-innovation is a need to enhance the commercial viability of environmental projects. Eco-innovations, coming to replace traditional technologies of environment protection, improve the investment attractiveness of environmental projects.

The advisability of capital investment for the development of innovation is necessary to substantiate in such a way that an innovative project can satisfy not just economic indicators, but a whole range of parameters. The specifics of eco-oriented innovation projects involve injecting special parameters of project evaluation for making the decision concerning investment. The main problem in assessing "is a disparity of particular criteria, the need for simultaneous consideration of both quantitative and qualitative indicators that is connected with the presence of uncertainties of various types» (Sosyukin,2015). Evaluation of the eco-oriented innovation projects effectiveness is a separate direction of study in the design solutions field, and its methodology goes beyond the traditional approaches to the innovation analysis.

2 Method Of Research Problems

The aim of this study is to provide a method of evaluating the effectiveness of eco-oriented innovation projects in industries, based on a single criterion, which summarizes the estimated parameters of different physical nature.

Research methods and solving the problems: analysis of parameters estimation used in the industry (literature review); application of the aggregation theory.

Results of research: the method of evaluation of the effectiveness (optimal) environmental-oriented innovation projects; a set of private parameters of evaluation; mathematical apparatus that allows to roll the quantitative and qualitative parameters, different in their physical nature.

3 Research

Firstly, for solving this problem it was necessary to develop a list of private parameters of evaluation the effectiveness of projects. To do this, we have been investigated normative documents and research in the ecological field (Shoba et al, 2013;Criteria for evaluation of ecological environment to identify areas of ecological emergency and ecological disaster zones,1992; Osipov et al, 1996 ; Kas'janenko,2008; Sklyankin et al, 1988, Vetoshkin et al, 2001).

In the result of research we developed two groups of private parameters of evaluation (non-economic and economic), different in their physical nature, both quantitative and qualitative. For the integration process or evaluation generalization in a single evaluation criterion it is proposed to apply the method of Harrington's desirability function, which is universal, accurate and appropriate to solving of set problem(Harrington, 1965; Puryaev ,2015). using generalization method (aggregation).

4 Results And Discussion

In the result of research undertaken on problems of evaluation of ecological innovative projects' effectiveness, we received the following main results

1. We worked out the complex of private parameters evaluation, composed of the two groups:

a group of non-economic parameters of evaluating the effectiveness of eco-oriented innovation projects (Yusupova,2016). See Table 1;

a group of economic parameters of evaluating the effectiveness of eco-oriented innovation projects. See Table 2.

Developed complex of parameters' estimation allows implementing comprehensive approach to the effectiveness evaluation of eco-oriented innovation projects. The approach lets take into account not only the cost parameters of projects, but also ecological factors, innovative nature of the projects, as well as regional aspects.

Table 1- The noneconomic parameters of efficiency evaluation

№	Group of non-economic parameters	Description of parameter
1	Ecological parameters of assessment	
1.1	Impact on the atmosphere	Quantitative parameter. It is expressed as the dimension of contaminator's maximum permissible emission.
1.2	Influence on water bodies	Quantitative parameter. It is expressed as standard allowable dimension of contaminant emission.
1.3	Impact on soil	Quality parameter. It is expressed in according to the loss of soil quality.
1.4	Physical impact on the environment	Quantitative parameter. It is expressed as the dimension of maximum permissible level of noise, infrasound, ionizing radiation, vibration, magnetic and electric fields, radioactive and thermal action, an acceptable level of ultrasound.
2	The parameters of natural resources extraction	
2.1	Extraction of water resources	Quantitative parameter. It is expressed as volume value of water withdrawn from a water object.
2.2	Extraction of land resources	Quantitative parameter. It is expressed as square value of used land property.
2.3	Extraction of forest resources	Quantitative parameter. It is expressed as amount of used wood raw material.
2.4	Extraction of biological resources	Quantitative parameter. It is expressed as the amount of extracted biological material.
2.5	Extraction of subsoil resources	Quantitative parameter. It is expressed as level of processing complexity of subsoil resources.
3	Level of production disposability	Quantitative parameter. It is expressed as a coefficient of production disposability.
4	Parameter of technical risk	Quality parameter. It shows probability of man-made emergency situation. Evaluation is carried out depending on the hazard class of the object on which the project is implemented.
5	The ecological status of the implemented project area	Quality parameter. It considers regional environmental situation of the project area territory.
6	The urgency of the project realization	Quantitative parameter. The assessment is made based on the expected period of the project realization.
7	Status of the project's realization area	Quality parameter. The assessment is made according to the legal status of the project's realization area: special economic zone, one-industry town, the area of advancing social economic development, innovative regional cluster.
8	Parameter of uncertainty and risk of the project	Quality parameter. It is recommended to take into account the following parameters, which are expertly estimated: • macroeconomic risks; • risks associated with the supply of resources; • operational risks; • a risk of failure of the project deadlines; • risks associated with the uncertainty of sales; • a risk of insufficient financing of the project; • a risk of transmission of innovation among the participants of the project; • a risk of age innovation; • possibility of commerciality; • a risk of technological elaboration of innovation.

Table 2- The economic parameters of efficiency evaluation

№	Group of economic parameters of efficiency evaluation	The essence and rate setting
9	Net present value (*NPV*), rub.	Quantitative indicator of "*Cashflow*" methodology. It should be compared with the strict restriction or desirable level set by the investor and (or) the decision-maker.
10	Internal rate of return (*IRR*), %	
11	Investment payback period (discounted), T_{PP}, periods of Project.	
12	Investments in the project (*CI*), rub.	

2. The mathematical apparatus that allows to roll quantitative parameters out different in the physical essence in a single optimization criterion.

For solving this optimization problem we offer to use to apply the method of Harrington's desirability function (Harrington,1965), which is the following:

$$d_{ij} = e^{-e^{-y'ij}} \quad (1)$$

$$y'_{ij} = \frac{\left(y_{\max} - y_{ij}\right)}{y_{\max}} \quad (2)$$

$$y'_{ij} = \frac{\left(y_{ij} - y_{\min}\right)}{y_{\min}}, \quad (3)$$

where d_{ij} – private desirability function with one-side constraint for the *i*-parameter of *j*-innovation project;

y_{max}, y_{min} – upper and lower limits of unilateral restrictions on the *i*-parameter private;

y'_{ij} – coded (normalized) value of *i*-private parameter of *j*-innovation project, translated to the desirability scale.

Generalized desirability function by Harrington (optimization criterion) of *j*-innovation project (D_j) is defined as the geometric average of ratio by the formula:

$$D_j = \sqrt[n]{d_{1j} \cdot d_{2j} \cdot d_{3j} \cdot \mathrm{K} \cdot d_{ij} \cdot \mathrm{K} \cdot d_{nj}} \quad (4)$$

Possibilities of extensive use of this function in the economic problems of an estimation and optimization is supported by studies of many scientists (Puryaev, 2015; Kagan, 2012; Trusova, 2014; Lyubushin et al, 2014, Barbashova et al, 2015, Myroshnyk et al, 2014; Slaschov et al, 2013; Myronchuk, 2012; Ginevicius et al, 2015).

Below there is a method of evaluating the effectiveness of eco-oriented innovation projects in industrial enterprises.

3. Method of evaluating the effectiveness of eco-oriented innovation projects consists of the following stages.

1) The mapping of estimated eco-oriented innovation projects by the presence of private valuation parameters. It is necessary to determine the possibility of assessment of alternative projects to the private parameters (see Table 1, Table 2). If all designs have values according to estimated parameters of evaluation, so they are comparable (identical), and they can be compared with each other according to the evaluation results. In the case when a single project is evaluated this evaluation phase in the procedure is missing.

2) The establishment of restrictions on the parameters' values both of the groups (Table 1, Table 2) and their status (min, max, desirable, strict). Restrictions are set by the investor (or by decision-maker) or by the supervisory authorities.

3) Transfer of parameters' values 1-3 parameter groups (Table 1) in the value of the desirability function. It is recommended to set strict limits for parameter of groups 1-3 in the form of maximum or minimum value depending on the parameter estimation. Maximum strict restrictions for parameters 1, 2 group are set and strict minimum limit on the parameter 3 is also set. The procedure of project selection process is carried out by assessing the admissibility of each parameter with a strict limitation on the criterion $d_i \geq 0{,}37$. Further it is necessary to transfer parameter settings to the values of Harrington's desirability function by formulas (1), (2), (3). If value of one of the criterion is $d_i \leq 0{,}37$, so the project is rejected.

4) Evaluation of projects eligible for parameters of 1-3 groups, the remaining parameters of the non-economic parameters of groups 4-8. For each parameter of groups 4-8 the desired or restrictive levels are set. Parameter settings are transferred into the values of the desirability function as in article 3.

5) Calculation of a generalized desirability function in groups of non-economic parameters' evaluation by the formula (4). As the result we receive an intermediate generalized criterion $D_{1\text{-}8j}$, which allows to reject options of projects at non-compliance with the limits specified in the group of non-economic parameters of evaluation, i.e. when $D_{1\text{-}8j} = 0$.

6) Transfer the values of the parameters of the economic group (Table 2) in the value of the desirability function, using the formula (1), (2), (3).

7) Calculation of generalized of desirability function (optimization criterion) D_j and by these means to implement an effectiveness assessment of the project or to establish the best option of the project. This formula looks like this:

$$D_j = \sqrt[n]{D_{1\text{–}8\,j} \cdot d_{9\,j} \cdot d_{10\,j} \cdot d_{11\,j} \cdot d_{12\,j}} \quad (5)$$

where $D_{1\text{-}8j}$ – generalized desirability (parameter) of j project based on a group of non-economic parameters of evaluation (according to 8 parameters);

d_{9i}, d_{10i}, d_{11i}, d_{12i} – private elements of the desirability of economic parameters' private group (under numbers 9- 12 from Table 2).

5 Summary

Evaluation of the effectiveness of ecologically oriented innovation projects is a complex multicriteria task. The effectiveness of these projects should be assessed not only by economic indicators, and by a whole complex of estimation parameters that takes into account ecological results of the project, as well as the regional aspects of the projects' realization. The developed method allows taking into account the most important factors from the perspective of sustainable development conception. The authors propose a specific list of qualitative and quantitative parameters, which can be supplemented and modified. The proposed methodology allows weeding out as ineffective projects that do not meet environmental and resource parameters in the evaluation process. The remaining projects that were selected by a group of ecological and resource parameters must be assessed on the other non-economic efficiency indicators and the traditional economic indicators of efficiency, also as the final selection which helps to determine the optimal project.

6 Conclusion

The proposed methodology for assessing the effectiveness of innovation projects includes assessment tools: conceptual apparatus' evaluation, the complex estimation of the two groups parameters, the mathematical apparatus of the evaluation and makes it possible to assess eco-oriented innovation projects for effectiveness (optimal) in a whole. This method serves as an alternative to the traditional economic evaluation of the innovative projects effectiveness'. Method may be improved in the future taking into account the trends in the development of industrial enterprises, territories and society in general.

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