IOP Conf. Series: Materials Science and Engineering **240** (2017) 012056 doi:10.1088/1757-899X/240/1/012056

Alternative evaluation of innovations' effectiveness in mechanical engineering

A S Puryaev[1]

[1]Naberezhnye Chelny Institute, Kazan Federal University, 18 Kremlyovskaya street, Kazan, 420008, Russia Federation

aidarp@mail.ru

Abstract. The aim of present work is approbation of the developed technique for assessing innovations' effectiveness. We demonstrate an alternative assessment of innovations' effectiveness (innovation projects) in mechanical engineering on illustrative example. It is proposed as an alternative to the traditional method technique based on the value concept and the method of "*Cash flow*".

1. Introduction

Along with the necessity to implement the innovation in all areas of human activity, including and in the manufacture of cars, vehicles and other equipment there appears an important question of evaluating the effectiveness of innovative projects. People who think only in economic terms may object and claim about the absence of relevance of such a question as any innovation, in their view, brings a huge effect in expression of monetary terms; innovation is the creation of the new technology, which today will allow to change the lives of consumers and only positively; this is the creation of a new product, which allows to satisfy the tastes and preferences of consumers at the current period of time. But the other side of the coin is left without due attention - the consequences of this innovation in the long term perspective, mainly in non-economic systems of society (national security, ecological sphere, the social system, science and technology, culture and traditions of the country). Notably the consequences of this innovation may be far from positive. Therefore, we have repeatedly raised the question of assessing the effectiveness of investment projects, including innovation projects (innovations) as a relevant and alternative to traditional economic evaluation efficiency of investments. Alternative assessment methodology, based on the author's concept of "*Compramultifactor*", allows taking into account during the process of assessment non-monetary, quantitative and qualitative parameters of the project, especially innovative and aimed at changing the quality of work and life in general.

In the article named *Evaluating of innovative projects' effectiveness at industrial enterprises*, published in conference information package ICIE-2016 ("Industrial Engineering", South Ural State University, 2016) we introduce the general assessment methodology of innovative projects for industrial enterprises. This article is supposed to show its work on hypothetical example of assessing innovative engineering projects.

2. Goal

Applying the concept and methodology of "*Compramultifactor*" [2,3,4] to assess the effectiveness of innovative projects presented above (InP) and choose the optimal (efficient) version of the innovative project by the criterion *D→max*.

Decision maker (DM) is necessary to evaluate the effectiveness of three investment projects to introduce innovation (three innovative projects). DM has restrictions on evaluated private evaluation parameters (PEP), as well as their status (strict - strict; the desired level - desirable). Each project has its own meaning for each PEP, i.e. all projects are comparable and identical. Table 1 shows the basic data.

Table 1. Meanings of PEP of evaluated innovative projects and restrictions (desired levels) of them

№№	**Group of critical parameters of effectiveness evaluation**	**Innovative projects**			**Restrictions (desired levels)**	
		InP1	**InP2**	**InP3**		
The subgroup of high-quality options						
1	Compliance with the priority areas of science and technology (8 directions), the list of critical technologies of the Russian Federation (27 technologies) [1]	yes	yes	yes	yes	strict min
2	The fact of import and (or) uniqueness	yes	yes	yes	yes	strict min
3	Parameter of uncertainty and risk (UR) in the implementation of the project, points	2,1	2,25	2,6	2,5	desirable min
4	Parameter of project's performance functions' quality (PFQ), points	2,7	3,1	3,5	3	desirable min
The subgroup of quantitative parameters		**InP1**	**InP2**	**InP3**	**Restrictions (desired levels)**	
5	Parameter of the National Security (resource security, RS), % (linguistic variable)	40	45	50	40	strict min
6	Parameter of reducing the risk of manmade disasters and man-made impact (units of reduction of greenhouse gas emissions), CO_2e/ year (linguistic variable)	50000	55000	75000	50000	strict min
7	Parameter of GDP growth acceleration (accession rate of added value, ARAV), % (linguistic variable)	25	22,5	20	20	strict min
	Group of economic parameters to effectiveness evaluation	**InP1**	**InP2**	**InP3**	**Restrictions (desired levels)**	
8	Net Present Value (NPV), thous. of rub.	1279	1554	2260	1000	strict min
9	Internal rate of return (IRR), %	40	32	34	25	strict min
10	Discounted payback period (DPP), years	3,25	4	4,5	5	strict max
11	Investments in the project (IP), thous. of rub.	5560	6240	8500	10000	strict max

3. Decision

Table 2 shows the calculated meanings of the partial functions of desirability (d) for all the parameters evaluated, as well as generalized optimization parameters (D_j) of evaluated of innovative projects according to the group of critical parameters effectiveness evaluation.

For solving this optimization problem it is offered to use the method of desirability function by Harrington [5], which has the form:

$$d_{ij} = e^{-e^{-y'_{ij}}} \tag{1}$$

where d_{ij} – private desirability function of one-way restriction for i-parameter of j-innovative project;

y'_{ij} – coded (normalized) meaning of i-parameter of j-innovative project, transferred into the desirability scale.

Generalized desirability function by Harrington (optimization criterion) of j-innovative project (D_j) is defined as geometric mean of private desirability's according to formulae:

$$D_j = \sqrt[n]{d_{1j} \cdot d_{2j} \cdot d_{3j} \cdot \ldots \cdot d_{ij} \cdot \ldots \cdot d_{nj}} \tag{2}$$

Table 2. Private desirability parameters (d_{ij}) and generalized optimization parameters (D_j) of evaluated innovative projects according to group of critical parameters of effectiveness evaluation

№ №	Group of critical parameters of effectiveness evaluation	Innovative projects		
		InP1	**InP2**	**InP3**
	The subgroup of high-quality options			
1	Compliance with the priority areas of science and technology (8 directions), the list of critical technologies of the Russian Federation (27 technologies) [1]	0,37	0,37	0,37
2	The fact of import and (or) uniqueness	0,37	0,37	0,37
3	Parameter of uncertainty and risk (UR) in the implementation of the project, points	0,309	0,331	0,383
4	Parameter of project's performance functions' quality (PFQ), points	0,331	0,380	0,429
	The subgroup of quantitative parameters	**InP1**	**InP2**	**InP3**
5	Parameter of the National Security (resource security, RS), % (linguistic variable)	0,37	0,403	0,435
6	Parameter of reducing the risk of manmade disasters and man-made impact (units of reduction of greenhouse gas emissions), CO_2e/ year (linguistic variable)	0,37	0,403	0,5
7	Parameter of GDP growth acceleration (accession rate of added value, ARAV), % (linguistic variable)	0,435	0,403	0,37
	Generalized parameter of optimization ($D_{1\text{-}7j}$)	**0,363**	**0,379**	**0,406**
	Rating of innovative project	**3**	**2**	**1**

Next, it's needed to evaluate the desirability of PEP economic group for all innovative projects. The calculation results are presented in Table 3.

Table 3. Private desirability function parameters of economic groups and generalized parameter of optimization projects on them

	Group of economic parameters to effectiveness evaluation	**InP1**	**InP2**	**InP3**
8	Net Present Value (NPV), thous. of rub.	0,469	0,563	0,753
9	Internal rate of return (IRR), %	0,578	0,470	0,498
10	Discounted payback per*iod* (DPP), years	0,494	0,441	0,405
11	Investments in the project (IP), thous. of rub.	0,527	0,503	0,423
	Generalized parameter of optimization ($D_{Эj}$)	**0,515**	**0,492**	**0,503**
	Rating of innovative project	**1**	**3**	**2**

It is obvious from calculations, that the first project (InP1) can be considered as prior in using the traditional economic effectiveness' assessment (without restrictions and desired levels of critical parameters' group). It would be correctly to combine the evaluation of critical group and economic as follows. We define a generalized criterion of optimization of innovative projects by the formula (3) and summarize the results in Table 4:

$$D_j = \sqrt[5]{D_{1-7j} \cdot d_{8j} \cdot d_{9j} \cdot d_{10j} \cdot d_{11j}} \quad (3)$$

where D_{1-7j} – is generalized desirability (parameter) of *j*-innovative project according to group of critical assessment parameters (according to 7 parameters);

d_{8i}, d_{9i}, d_{10i}, d_{11i} – private desirability of economic parameters' group.

Table 4

	Group of economic parameters to effectiveness evaluation *and* D_{1-7j}	**InP1**	**InP2**	**InP3**
8	Net Present Value (NPV), thous. of rub.	0,469	0,563	0,753
9	Internal rate of return (IRR), %	0,578	0,470	0,498
10	Discounted payback per*iod* (DPP), years	0,494	0,441	0,405
11	Investments in the project (IP), thous. of rub.	0,527	0,503	0,423
	Generalized parameter of optimization (D_{1-7j})	**0,363**	**0,379**	**0,406**
	Generalized parameter of optimization (D_j)	**0,481**	**0,467**	**0,482**
	Rating of innovative project	**2**	**3**	**1**

4. Conclusion

So, using an alternative technique to the traditional assessment of projects' effectiveness, we were able to take into account the constraints and desired levels by predetermined parameters of critical group (group of important and necessary at some point on exact period of time the private parameters' evaluation of diverse physical entity); we managed to combine the assessment of non-economic and economic parameters, presented in a variety of scales (quantitative: clear and fuzzy sets, high-quality, expertly measured) and, as a result get optimum (effective) innovative solution from the set of existing ones..

References

[1] The list of critical technologies of the Russian Federation 2011 (Retrieved December 1, 2016 from http://kremlin.ru/supplement/988)

[2] Puryaev A S 2015 Private Valuation Parameters of Efficiency the Investment Projects in the Concept "Compramultifactor" *Modern Applied Science* vol 9(11) pp 263-275

[3] Puryaev A S 2015 The Mathematical Apparatus of Compromise of Efficiency Estimation of

Investment Projects *International Business Management* vol 9 pp 856-861
[4] Kharisova A R and Puryaev A S 2014 Competitiveness assessment of engineering products *Source of the Document IOP Conference Series: Materials Science and Engineering* vol 69 issue 1 (article number 012020)
[5] Harrington E C 1965 The desirable function. *Industrial Quality Control* vol 21 no 10 pp 494–498