Investigation and explanation of mathematical tooling for accounting non-economic characteristics during the investment project effectiveness' assessing process

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Abstract. In this work we briefly present the study results of the issue of accounting and implementation of specific mathematical tooling for non-economic characteristics in evaluating of projects' effectiveness. There is established classification of events in which using of one or another mathematical apparatus during solving the question of accounting for non-economic characteristics can be observed. It is proposed to study the classification of non-economic characteristics easily formalized and difficult to formalize (parameters) that are used when assessing the effectiveness of projects. There is explained and recommended a certain mathematical tooling for the process of accounting for non-economic characteristics in the assessment on the basis of classification under description.

1. Introduction
As part of the implementation of the research project of the Russian Foundation for Basic Research (RFBR) No. 18-010-00018, we developed a study of foreign and domestic experience on this issue for developing recommendations on the use of mathematical methods and the elaboration of original models for recording non-economic characteristics in the process of evaluating the effectiveness of investment projects. The collection and analysis of material for the period from 1975 to March 2018 based on the Web of Science Core Collection database allowed us to select 168 sources out of them. Among them, 57 sources were selected which directly reflect the subject of the study - the consideration of non-economic characteristics (externalities) in evaluating the effectiveness of investment projects. Originally, to study the domestic experience in this matter, 139 sources from the Russian Science Citation Index (RSCI) database were selected by search queries. After a detailed study of abstracts (annotations), 48 sources remained. The specific results of these studies are presented in articles and submitted to certain publishers for consideration about the possibility of publication. In the frames of this work, 105 analyzed sources were subjected to detailed consideration in the aspect of applying the mathematical method, a tool for recording non-economic externalities in the process of evaluating the effectiveness of investment projects. As a result, 45 cases of application of mathematical tools in evaluating the effectiveness of 41 sources were studied.

2. Aim of research
Developing of recommendations for the use and elaboration of specific mathematical tooling to account for non-economic characteristics in the process of evaluating the effectiveness of investment projects.

3. Research method
Analysis of the existing mathematical tooling in assessing the feasibility and effectiveness of investment projects (based on the Web of Science Core Collection and RSCI).

4. Results and discussion
The study of the sources of literature of the foreign Web of Science Core Collection database and the RSCI database on the subject of research allows us to single out the following mathematical methods and their application frequency in evaluating the effectiveness of investment projects (see table).

Table 1. Frequency and percentage of application of certain mathematical tooling to take into account non-economic characteristics when evaluating the effectiveness of investment projects

| № № | Mathematical methods and tools | Total cases | Percentage, % |
|-----|--------------------------------|-------------|---------------|
| 1   | Method of valuation of changes in macroeconomic indicators (“Cash flow” and cost-benefit analysis methods (CBA)). | 22 | 49 |
| 2   | Method of multi-criteria optimization based on the use of the Monte Carlo method and data matching | 1 | 2.2 |
| 3   | Energy balance calculation method | 1 | 2.2 |
| 4   | Methods for assessing risk and uncertainty: | 8 | 17.9 |
| 4.1 | Scenario method (theory of games with "nature") | 4 | 9 |
| 4.2 | Risk adjustment in the discount rate | 1 | 2.2 |
| 4.3 | Risk assessment matrix method | 3 | 6.7 |
| 5   | Methods of fuzzy (vague) sets | 4 | 8.8 |
| 5.1 | Efficiency criteria in the scales of fuzzy sets theory in the form of linguistic variable | 1 | 2.2 |
| 5.2 | AHP- fuzzy comprehensive evaluation method | 1 | 2.2 |
| 5.3 | TOPSIS method in combination with linguistic neutrosophic numbers (LNN) | 1 | 2.2 |
| 5.4 | TFIEOWA operator's method | 1 | 2.2 |
| 6   | Methods of the aggregation theory (generalization) | 9 | 19.9 |
| 6.1 | Desirability function method by Harrington | 3 | 6.7 |
| 6.2 | The method of valuation and the integral indicator (except for the function of desirability) | 2 | 4.4 |
| 6.3 | Weighted scoring method (ranking) | 2 | 4.4 |
| 6.4 | Indicator evaluation method | 2 | 4.4 |
| 7   | Cases in total | 45 | 100 |

The research base contains both foreign sources [1-5] and domestic [6-9], [10]. These links do not list all sources. A complete list of the database under investigation is presented in a separate file of the Internet source [11].

The results of the study suggest the idea of classifying the considered non-economic characteristics (parameters, indicators) into two groups: easily formalizable and difficult to formalize. Easily formalized characteristics are understood as various parameters of a noneconomic nature, the impact of which on the project environment can be assessed in the value scale (monetary units) with a high degree of probability. This will allow to take into account their impact when evaluating the
effectiveness of projects directly in the stream of payments. Difficultly formalized characteristics are understood as various parameters of a noneconomic nature, whose impact on the project environment cannot be assessed with a high degree of probability in the value scale (monetary units). To take into account such characteristics, it is necessary to translate the parameters of a different physical nature into another unified normalized rating scale, which will allow evaluating projects based on a generalized criterion and unambiguously choosing the best project. In this case, the category of "effectiveness" and the category of "optimality" become synonymous.

It is fundamentally recommended to use the indicator reflecting the “yield” from the potential as a criterion for determining the effectiveness of a project. I.e. an indicator that would reflect the proportion of the project’s compliance with the conditions and restrictions of the decision maker from a potential condition at the time of the assessment. At the same time, the presence of uncertainty in the assessment requires the use of fuzzy sets in the representation of quantitative values of the estimated parameters.

So, economic and easily formalized non-economic parameters are estimated in the value (monetary) scale. In this case, it is possible to take them together in a consolidated stream of payments. Difficultly formalized non-economic parameters (quantitative and qualitative) must be reduced to one single normalized scale, having the limitations set by the decision maker. As far as possible, quantitative parameters should be specified in the form of linguistic variables, each term of which should be represented as a fuzzy set of values. This will allow to take into account at least two parameter estimates with different degrees of membership. It is also proposed to translate economic and easily formalized characteristics into the same normalized scale, having limitations on them (together with difficult to formalize characteristics). The obtained integral final value (as a geometric mean and (or) weighted average) will act as a generalizing quantitatively oriented evaluation criterion, which will have a fraction of the potential value of this criterion. For example, the value of the desirability function is from 0 (the worst) to 1 (optimal, the best) or the radar area fraction, which is a “reflection” of potential probable effectiveness.

An extended article on the subject of the study is under consideration for publication in a journal indexed in the Web of Science Core Collection and Scopus database.

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