Evaluation of Synergy Efficiency of Investment Projects Based on an Analytical Hierarchical Procedure

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Abstract. The article is devoted to definition of synergy efficiency of investment projects and a method of their estimation on the basis of analytical hierarchical procedure. Synergy effects are based on space and time coordinated actions of heterogeneous factors, mechanisms that lead to qualitative changes in the system. The model for determining the synergy efficiency of the project is total ratio received as a result of activities for project implementation and their effects in various spheres, such as economic, social, technological, environmental, regional, to to the costs of their obtaining and implementation, weighted by priority of each sphere of obtaining the effect in an overall index. To identify the priorities, the objectives of the project are identified, a hierarchy of synergistic project efficiency is developed and the priorities are calculated based on an analytical hierarchical procedure.

1. Introduction

The conditions of modern economic development, characterized by the prevalence of processes of uncertainty, nonlinearity, nonequilibrium, multivariance require that companies seek for opportunities to increase the synergy efficiency of investment activity, since it is these effects that are the basis for using of non-obvious reserves to achieve an economic breakthrough.

The issue of evaluation of synergy effects in the economy is discussed in the works of such foreign authors as I. Ansoff, P. Druker, V.-B. Zanga. In Russian literature a synergetic approach to assessing the efficiency of projects is presented in the works of D.S. Chernavsky, V.P. Milovanov, O.M. Belotserkovsky, B.L. Kuznetsov, M.S. Kuznetsov and other authors.

Synergy (from Greek synergós - acting together) is an increase in the efficiency of activities as a result of integration, combination, merging of separate parts into a single system due to the so-called systemic impact, emergence [4,10].

From law of synergy, the sum of the properties of an organized whole shall be greater than the sum of properties of all the elements it is composed of. In this case, the properties of the elements and the whole are understood as the change in various parametric characteristics (for example, for social and economic systems this is labor productivity, production volume, profit, profitability, etc.), their interdependence and variation over time. The organizational total effect obtained in this case is called synergies.

The analysis of publications allows us to drive to a conclusion that synergy effects are the effects caused by a space and time coordinated actions of heterogeneous factors, mechanisms, that lead to qualitative changes in the system [4,10]. The synergy effect can be estimated by a complex indicator

of synergy efficiency, generated as a system sum of specific performance indicators, reflecting the evaluation of the results classified as the costs of obtaining these results.

In official methodological recommendations on the evaluation of the efficiency of investment projects approved by the Ministry of Economy of the Russian Federation, the Ministry of Finance of the Russian Federation, the project's efficiency is defined as a category reflecting the project's conformity to the objectives and participants of the project, herewith several types of project efficiency are identified, such as public, commercial, budget, social, etc., and it is specified that in the final project efficiency indicator in quantitative terms all project externalities should be taken into account, and if this is not possible, a qualitative assessment of their impact should be carried out [3].

2. Methodology

Having summarized the definitions of synergy efficiency and investment project efficiency, we can conclude that synergy efficiency of the project (E_s) should reflect the ratio of the effect obtained as a result of an project implementation activity to the costs of its implementation [5]. Herewith the project efficiency should cover several areas of obtaining the effect from the project realization [3]. Thus, it is possible to present the indicator of synergy efficiency in the following model: $E_s = \sum_{i=}^{N}$ (1) where Se_i – is a the effect obtained in one of the areas (subsystems) of the project implementation is defined as the change in the state of this subsystem as a result of the project implementation, monetary units;

A_i – priority of each sphere of obtaining the effect in the generalized efficiency index;

Z_i - amount of costs for the implementation of the project in a particular area i, monetary units;

N – the number of spheres in which an effect is expected.

Since in practice the costs of project implementation are quite difficult to divide by the spheres of obtaining the effect, the formula can appear as follows:

$$E_s = \sum_{i=1}^{N} \frac{Se_i \times A_i}{Z} \quad (2)$$

where Z – is a total amount of costs for project implementation, monetary units.

Thus, the task of determining the synergy efficiency of the project is to determine particular efficiency indicators for different subsystems of the project, to determine the priority of these indicators and synthesis of the results obtained.

3. Main part

It is necessary to determine various spheres of obtaining effects for each project, for example, economic, social, technological, environmental, regional, etc., herewith it is necessary to make a quantitative assessment of the change of these subsystems as a result of the project implementation, the following indicators presented in Table 1 can be used for carrying out this analysis.

The main principle of generating of particular indicators is that they should cover all possible areas for obtaining effects from the project, satisfy the condition of comparability and they shall be based on the principle of positive feedback, that is, an increase in the particular indicator should contribute to an increase in the composite indicator of synergy efficiency.

One can use the analytical hierarchical procedure method to determine the priorities of effects in different subsystems in the overall efficiency index. This method allows to decompose the indicator of synergy efficiency in the form of a hierarchy on the particular indicators of project efficiency, and then to compare and evaluate the importance of each indicator of particular efficiency in a generalized criterion. In this respect the important fact is that using the method of hierarchies analyzing, one can take into account both quantitative (cost) and qualitative effects of the project [1,7].

Table 1. Subsystems of the hierarchy of the project synergy efficiency assessment.

Scope of getting effects from the project	Potential quantitative indicators of evaluation
Economic effectiveness Se_1	Indicators of net cash inflows as a result of the project realization, connected with the receipt of profit from the sale of new products or increase in the volume of production
Social return Se_2	An increase in the wage fund, a decrease in payments for sick leave as a result of improved working conditions during the implementation of the project
Operational benefits Se_3	Indicators of net cash inflows as a result of the project realization, caused by cost savings as a result of improved production organization, the introduction of new equipment and technologies, the reduction of rejects in production, etc.
Ecological effect Se_4	Reduction of the amount of fines for violation of environmental legislation

To do this, it is necessary to determine the list of the most significant objectives of the project implementation, reflecting the qualitative level of the project efficiency and to conduct a pairwise comparison.

The objectives of the project implementation for each enterprise may vary depending on the specifics of the project, the industry in which the enterprise operates, the composition of the project participants [9], and the following are defined as main objectives:

P_1 – product quality improvement;

P_2 –production organization improvement;

P_3 –company image perfection;

P_4 – increase of customer loyalty to products;

P_5 – improvement of working conditions for employees;

P_6 – reduction of the production cycle;

P_7 – introduction of innovative technologies.

Thus, the hierarchy of synergy efficiency of the project will be as shown in Figure 1.

Further on it is necessary to conduct a pairwise comparison of selected indicators and calculate the value of c_{ij}. Such comparison can be made using accurate mathematical models that take into account all the factors that have impact on these criteria and all the results which they effect, or, basing on expert assessments, the comparison can be made using dimensionless indicators with a 10-point preference scale. For convenience, a matrix of priorities of the project objectives is generated, see Table 2.

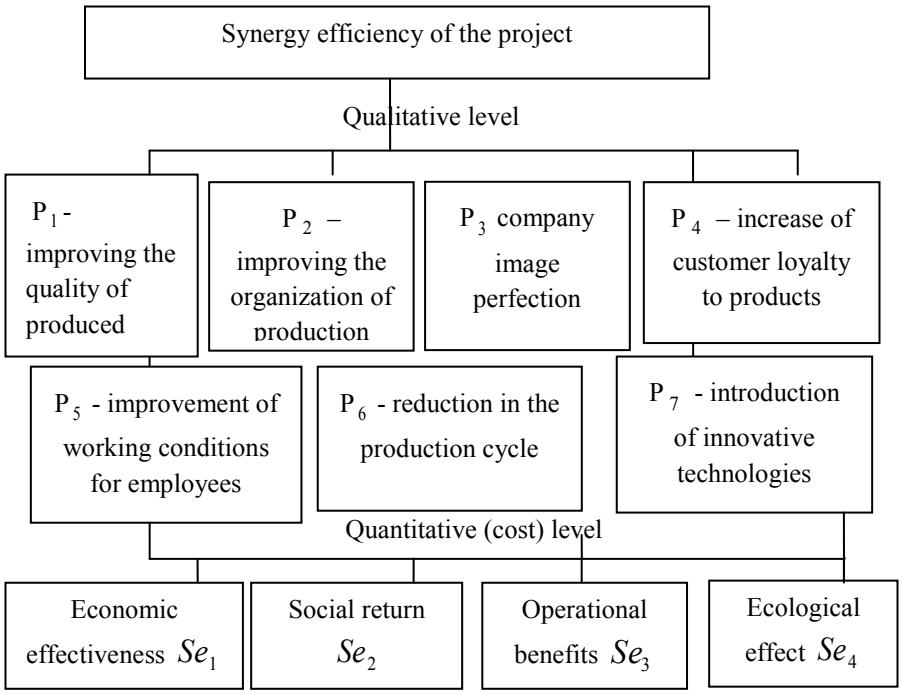

Figure 1. Hierarchy of synergy project efficiency.

Table 2. Matrix for determining the priorities of the project objectives.

Objectives	P_1	P_2	P_3	P_4	P_5	P_6	P_7
P_1	1	c12	c13	c14	c15	c16	c17
P_2	1/c12	1	c23	c24	c25	c26	c27
P_3	1/c13	1/c23	1	c34	c35	c36	c37
P_4	1/c14	1/c24	1/c34	1	c45	c46	c47
P_5	1/c15	1/c25	1/c35	1/c45	1	c56	c57
P_6	1/c16	1/c26	1/c36	1/c46	1/c56	1	c67
P_7	1/c17	1/c27	1/c37	1/c47	1/c57	1/c67	1
Sum	Sp_1	Sp_2	Sp_3	Sp_4	Sp_5	Sp_6	Sp_7

To establish the importance of elements, the following ratio scale can be used: 1- unambiguous significance, 3 - some predominance of one action over another, 5 – high degree of significance, 7 - apparent significance, 9 - absolute significance [1,7].

Then we determine the weighing coefficients that reflect the relative significance of each project implementation objective for the enterprise under study. To do this, the elements of each column are summed up, then a new matrix is constructed, in which each element is obtained by dividing the element of the original matrix by the sum of the column, and then arithmetic row mean value is calculated that corresponds to the weighing coefficient of each project implementation objective for the enterprise (Table 3).

Table 3. Determining of weighing coefficients.

Objec-tives	P_1	P_2	P_3	P_4	P_5	P_6	P_7	Amount per line	Weighing coefficient
P_1	$1/Sp_1$	c_{12}/Sp_2	c_{13}/Sp_3	c_{14}/Sp_4	c_{15}/Sp_5	c_{16}/Sp_6	c_{17}/Sp_7	Cp_1	$\frac{Cp_1}{7}$
P_2	c_{21}/Sp_1	$1/Sp_2$	c_{23}/Sp_3	c_{24}/p_4	c_{25}/Sp_5	c_{26}/Sp_6	c_{27}/Sp_7	Cp_2	$\frac{Cp_2}{7}$
P_3	c_{31}/Sp_1	c_{32}/Sp_2	$1/Sp_3$	c_{34}/Sp_4	c_{35}/Sp_5	c_{36}/Sp_6	c_{37}/Sp_7	Cp_3	$\frac{Cp_3}{7}$
P_4	c_{41}/Sp_1	c_{42}/Sp_2	c_{43}/Sp_3	$1/Sp_4$	c_{45}/Sp_5	c_{46}/Sp_6	c_{47}/Sp_7	Cp_4	$\frac{Cp_4}{7}$
P_5	c_{51}/Sp_1	c_{52}/Sp_2	c_{53}/Sp_3	c_{54}/Sp_4	$1/Sp_5$	c_{56}/Sp_6	c_{57}/Sp_7	Cp_5	$\frac{Cp_5}{7}$
P_6	c_{61}/Sp_1	c_{62}/Sp_2	c_{63}/Sp_3	c_{64}/Sp_4	c_{65}/Sp_5	$1/Sp_6$	c_{67}/Sp_7	Cp_6	$\frac{Cp_6}{7}$
P_7	c_{71}/Sp_1	c_{72}/Sp_2	c_{73}/Sp_3	c_{74}/Sp_4	c_{75}/Sp_5	c_{76}/Sp_6	$1/Sp_7$	Cp_7	$\frac{Cp_7}{7}$

At the next stage of calculation, the alternatives, which represent the particular indicators of the project efficiency, are compared pairwise for each objective of the project implementation. The weighing factor is determined for each project implementation objective for each particular performance indicator using similar calculation procedure. Thus, for this example, it will be necessary to create seven more matrices and seven more tables to determine the weighing coefficients.

At the final stage of the analysis, it is necessary to perform a synthesis of priorities on the hierarchy, and to determine the priority of each alternative in the overall synergy efficiency (A_i), it is the product of the weighing coefficient of each project objective and the weighing coefficient of each particular performance indicator, taking into account the impact on each objective [1, 7].

We put the obtained values into formulas (1) or (2), and get the value of the synergy efficiency of the project.

4. Summary

Thus, the application of an analytical hierarchical procedure for assessing the synergy efficiency of the project enables to solve the complex problem accounting the joint influence of different spheres of obtaining effects from the project, to assess the significance of various factors and project indicators for the enterprise, to calculate the quantitative effect of project implementation through the prism of the project objectives, allowing to combine quantitative and qualitative effects of the project in one indicator.

5. Conclusions

In a highly competitive environment, successful operation of enterprises largely depends on how quickly they will be able to adapt to a dynamic external environment. An important role in solving of this problem is attributed to the effective implementation of investment projects.

The synergy effect can be estimated by the complex indicator of the project synergy efficiency, generated as the system sum of the particular project performance indicators that reflect the assessment of the results classified as the costs of obtaining these results. Herewith the effectiveness of the project should cover several areas for obtaining an effect from the project implementation, such as economic, social, technological, environmental, regional, etc. It is necessary to make a quantitative assessment of the changes in these subsystems as a result of the project implementation in order to determine synergetic efficiency, different indicators can be used to conduct such analysis. The main rule for the defining of particular indicators is that they should cover all possible areas of obtaining effects from the project, satisfy the condition of comparability and they shall be built on the principle of positive feedback, that is, an increase in the particular indicator shall contribute to an increase in the composite indicator of synergy efficiency.

It is also necessary to determine the list of the most significant project implementation objectives, reflecting the qualitative level of the project's effectiveness and build up a hierarchy, and then to determine the values of the indicators.

Thus, the objective of determining the synergy efficiency of the project is to determine the individual effect indicators for different subsystems of the project, determine the priority of these indicators and synthesize the results obtained on the basis of an analytical hierarchical procedure.

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