Evaluation of the Efficiency of the Implementation of Public-private Partnership Mechanisms in the High-tech Industry

To cite this article: V V Artyakov et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 476 012001

You may also like

- The dynamic index of urban environment quality as a tool for sustainable urban development
  D M Suvorov, L A Suvorova, I V Pestova et al.

- Unified informational statistical base as a tool for monitoring energy efficiency of industrial facilities
  Natalia Taskaeva, Tatiana Meshcheryakova and Natalia Shchepkina

- Sustainability in Building Construction – A Multilevel Approach
  T Lützkendorf
Evaluation of the Efficiency of the Implementation of Public-private Partnership Mechanisms in the High-tech Industry

V V Artyakov¹, A A Chursin²,³ and E S Andreeva⁴

¹ State Corporation «Rostec», Moscow 119048, Russia
² JSC Russian Space Systems, Moscow, Aviamotornaya, 53, 111250, Russia
³ Peoples’ Friendship University of Russia, Moscow 117198, Russia
⁴ Kazan National Research Technological University, Nizhnekamsk 423578, Russia

E-mail: esandreeva-nk@rambler.ru

Abstract. The article proposes a tool for assessing the efficiency of the implementation of public-private partnership mechanisms in the high-tech industry including aerospace. The paper presents a tool to assess the efficiency of public-private mechanism and the change of the efficiency estimation. Having the predicted pathway of the change in the efficiency evaluation, it is possible to monitor the real values of the indicator in the course of a project implementation, using the public-private partnership mechanism. Such monitoring will reveal significant deviations from a pathway, which can be of two types: deviations, exceeding the actual values of an indicator over the predicted values and deviations, failing to achieve the real values of the predicted indicator.

1. Introduction

The modern world economy is increasingly focused on a new type of economy - the knowledge economy. Today, the resources that determine the further development pathway of the national economy are neither raw materials and productive capacities, nor labor resources, but the unique competencies of corporations and employees. They play a crucial role both at the microeconomic and macroeconomic level.

The work [1] formulated the economic law on the interaction between the development of competences and consumer markets. Their interconnection leads to a spiral pathway and provides innovative economic growth, which suggests that the creation of unique competences increases resources in high-tech companies, leading to an abrupt occurrence of unique innovative technologies. Their use leads to the creation of fundamentally new products that form the requirements for new amenities and promote the emergence of new markets and economic growth that develops economic opportunities for creating new unique competences.

But to realize competencies in any highly competitive product or technology and bring the necessary result in the form of creating new consumer markets, it is first necessary to select the most promising projects for implementation, based on an assessment of their efficiency, and secondly, to ensure their investment attractiveness for commercial partners, since such projects are cost demanding.

Evaluation of the efficiency of projects and programs implemented in high-tech industries (including aerospace) is one of the most important components of their economic analysis. Indicators
of the efficiency of projects and programs can be both absolute (for example, profit from commercial activities) and relative (economic, political and socio-social indicators). Evaluation of the efficiency of the implementation of programs and projects may indicate the significance of the results achieved, the extent of possible risk factors development and the degree of implementation of the activities, planned for a project or a program. The process of implementation of large projects is described in [2-4].

Public-private partnerships can play an important role in the implementation of major projects in high-tech industries [5,6]. Foreign experience shows the efficiency of PPP application in such industries. In this regard, it is necessary to have methods, based on the economic and mathematical modeling that enable to assess the prospects and efficiency of implementing a project, based on public-private partnership mechanisms. Simulation model is an effective tool for such analysis, which enables to take into account various economic factors, affecting the efficiency of PPP forms in the Russian Federation. Now many PP projects deal with the development of hi-tech competences creation what makes them especially risky [7-10].

Such models can be applied to solve a number of practical economic problems.

The proposed simulation economic and mathematical model provides opportunities to analyze economic risks when implementing large-scale projects in the form of PPPs including aerospace industry. The issues of practical risk assessment for a private partner in projects, based on the mechanism of public-private partnership are considered. The notion of threshold risk for a private partner is introduced and the way this concept can be used for practical risk assessment of the whole project is shown.

It is necessary to make a simulation model of a project implementation with the help of the public-private partnership, using the data on the amount of project stages financing by a state customer and a private partner, the predicted profit values, based on the results of a project implementation and random factors of the economy. Besides, it is necessary to consider various incentives (financial) that increase the investment attractiveness of a project for a private partner. Various economic indicators can be considered as the functions of the economic effect. For example, a ROI indicator can be such an indicator, equal to the ratio of the received income to the total investment volume).

2. Methods
To assess the efficiency of a project implementation, using the PPP mechanism at its various stages, let us offer an integral indicator (the ordinal number of a project implementation phase). Let us assume that the plan involves the implementation of a high-tech project or a program within a certain number of stages. Let us denote the stages in the form of a vector, which components can be represented as follows:

\[ C = \begin{pmatrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{pmatrix} \]

During the \( n \) stages of a project implementation, it is necessary to implement \( k \) activities. Let us designate them as follows:

\[ A = \begin{pmatrix} a_1 \\ a_2 \\ \vdots \\ a_k \end{pmatrix} \]

The efficiency coefficient \( M_i \) is a measure that reflects the degree of a project implementation \( V_i \) and possible risks \( R_i: M_i = M(V_i, R_i) \)
On the basis of the quantities introduced, we can formulate the following optimal control problem:

$$M_i = M(V_i, R_i) \rightarrow \max,$$

that is, the problem of maximizing the efficiency coefficient.

Let us dwell on the procedure of these coefficients construction, taking into account the degree of a project implementation and possible risks that arise as a result of a project implementation.

As previously noted, a high-tech project involves a number of planned activities, their successful implementation impacts the success of a project as a whole. These measures, as a rule, can affect the efficiency coefficient in different ways. Thus, failure to meet the deadlines of various activities implementation can have different consequences. For example, failure to meet the deadline of any activity may lead to the failure of the consequent activities performance. At the same time, the delayed implementation of an activity that does not affect the implementation of other activities significantly does not lead to such large-scale negative consequences. Let us assign the weighting factor $w_j$ to each activity $A_j$ in order to consider such effect from failure to meet the deadline of activity implementation. The economic sense of the weighting factors involves the impact of the on-time implementation of a certain activity on the further progress of a project.

Let us denote the vector of weight coefficients as follows:

$$W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_k \end{bmatrix}.$$

Weight coefficients must meet the following condition:

$$\sum_{j=1}^{k} w_j = 1.$$

The activities, carried out within the framework of a project can be implemented in stages (to recap, the calendar year is often considered as stages, but other division into stages is possible). In order to predict the changing efficiency evaluation from stage to stage, it is necessary to have the most probable estimates of the degree of implementation $q_i$ of a certain activity $A_j$ upon completion of a stage $C_i$. The law of probability distribution of the degree of a certain activity $A_j$ implementation within the project stage $C_i$ may be written as a discrete law. Let the scale of this law suggest the following reference points of the implementation degree:

- $0.00$ - no work was performed within the framework of an activity
- $0.10$ - very low degree of an activity implementation
- $0.30$ - low degree of an activity implementation
- $0.50$ - average degree of an activity implementation
- $0.70$ - high degree of an activity implementation
- $0.90$ - very high degree of an activity implementation
- $1.00$ - the activity is fully implemented

Let us combine these scale points into the following set: $l \in L = \{0.0, 0.1, 0.3, 0.5, 0.7, 0.9, 1.0\}$

The probability law of distribution of the degree of an activity $A_j$ implementation at the moment of a stage $C_i$ completion takes the form as in the table 1.

| $L(A_j)$ | 0.00 | 0.10 | 0.30 | 0.50 | 0.70 | 0.90 | 1.00 |
|----------|------|------|------|------|------|------|------|
| $q_i$    | $q_{0}$ | $q_{0.1}$ | $q_{0.3}$ | $q_{0.5}$ | $q_{0.7}$ | $q_{0.9}$ | $q_{1}$ |

Table 1 The probability law of distribution of the degree of an activity $A_j$ implementation at the moment of a stage $C_i$ completion.
The law of probability distribution of a variable \( L(A_i) \) must meet the following formula:

\[
\sum_{l \in L} q_l = 1.
\]

Taking into account our arguments and using the obtained expressions, the formula for the evaluation of the degree of a project implementation \( V_i \) at the completion of a project stage \( C_i \) will be written as follows:

\[
V_i = \frac{1}{k} \sum_{i=1}^{k} w_k \sum_{l \in L} l \cdot q_l.
\]

Thus, the presented model has:

\[
\max \left( \frac{1}{k} \sum_{i=1}^{k} w_k \sum_{l \in L} l \cdot q_l \right) = 1.
\]

It is the single value that this functional should take at the time of a whole project completion. In this case, we can say that activities within a project were implemented successfully.

The overall risk of a project (a project stage), implemented, using the mechanism of the public-private partnership, is assessed using the function \( R = R(F, G) \) of two arguments that express the impact of risk factors on the winning functions of a state customer and a private partner. We can consider the standard value - the ratio of losses during the implementation of a project stage to the overall stage budget as a quantitative risk measure. By this means,

\[
F = \frac{L_F}{S_F},
G = \frac{L_G}{S_G},
R = \max(F, G),
\]

where \( L_F \) and \( S_F \) are the losses and the budget of a stage for a state customer, \( L_G \) and \( S_G \) are the losses and the budget of a stage for a private partner.

Taking into account the proposed formulas for calculating the indicator of implementation degree \( V_i \) of activities under a project (program) and the risk level \( R_i \) at a project stage \( C_i \), the formula for calculating the efficiency factor \( M_i \) for this stage of a project implementation appears as follows:

\[
M_i = M(V_i, R_i) = \left( \frac{1}{k} \sum_{i=1}^{k} w_k \sum_{l \in L} l \cdot q_l \right) \cdot (1 - R_i).
\]

In compliance with the planned deadlines for the implementation of activities and the insignificant demonstration of risk factors, the function of assessing the project implementation efficiency, using the public-private partnership mechanisms is ascendant.

The increase in the risk level has a negative effect on the growth of the efficiency evaluation, therefore

\[
\frac{\partial M_i}{\partial R_i} < 0.
\]

Values for the efficiency evaluation of a project or a program implementation are in the interval \( 0 \leq M_i \leq 1 \) and the limiting unit value should be achieved upon a project or program completion.

To monitor a project or a program implementation, it is possible to use the predictive pathways of changing estimates \( M_i \).

To do this, all the parameters: risk assessment, coefficient estimation and efficiency index, necessary for calculation indicator \( M_i \) are evaluated at the stage of a project or a program development, using the method of expert evaluation. Estimates must be made for each stage of a project or a program. Next, you need to calculate the projected values of indicator \( M_i \) at each stage of a project implementation. As a result, you will get a time series \( M_1, ..., M_N \) defining the predicted
pathway of the indicator change. The projected value of the evaluation at the end of a project should correspond to the limit value.

3. Conclusion

Having the predicted pathway of the change in the efficiency evaluation, it is possible to monitor the real values of the indicator in the course of a project implementation, using the public-private partnership mechanism. Such monitoring will reveal significant deviations from a pathway, which can be of two types: deviations, exceeding the actual values of an indicator over the predicted values and deviations, failing to achieve the real values of the predicted indicator. The first situation can refer to the excess of a project time limit over the planned one. The second situation may indicate problems and "stuttering" in the process of project implementation or the failure to implement the planned activities due to unforeseen circumstances. In this case, it is necessary to make management decisions that can return the values of the indicator to the predicted pathway or this pathway requires correction due to the changed conditions.

Acknowledgments

This paper was financially supported by the Ministry of Education and Science of the Russian Federation on the project No.26.1146.2017/4.6 «Development of mathematical methods to forecast efficiency of using space services in the national economy».

References
[1] Chursin A A, Shamin R V and Fedorova L A 2017 The mathematical model of the law on the correlation of unique competencies with the emergence of new consumer markets. European Research Studies Journal 3A 39
[2] Cooke T 2013 Can knowledge sharing mitigate the effect of construction project complexity? Construction Innovation 13 1.
[3] Dave B and Koskela L 2009 Collaborative knowledge management - a construction case study Automation in Construction 18 7.
[4] Egbu C O 2004 Managing knowledge and intellectual capital for improved organizational innovations in the construction industry: an examination of critical success factors Engineering Construction and Architectural Management 11 5
[5] Li Yaning Tang, Qiping Shen and Eddie W L 2010 Cheng A review of studies on Public-Private Partnership projects in the construction industry International Journal of Project Management 28 7
[6] van den Hurk M, Brogaard L, Lember V, Petersen O H and Witz P 2016 National Varieties of Public–Private Partnerships (PPPs): A Comparative Analysis of PPP-Supporting Units in 19 European Countries Journal of Comparative Policy Analysis: Research and Practice 18(1) 1-20 (DOI: 10.1080/13876988.2015.1006814)
[7] Chursin A and Tyulin A 2018 Competence management and competitive product development: Concept and implications for practice (Springer Intern Publ)
[8] Kashirin A, Semenov A, Ostrovskaya A and Kokuytseva T 2016 The Modern Approach to Competencies Management Based on IT Solutions JIBC-AD-Journal of Internet Banking and Commerce 01 1-12
[9] Kashirin A, Semenov A, Ostrovskaya A, Kokuytseva T and Strenaluk V 2016 The Modern Approach to Competence Management and Unique Technological Competences Quality – access to success 17(154) 105-109
[10] Shamin R, Chursin A, Kokuytseva T, Ostrovskaya A and Semenov A 2018 Modeling of Growth-Collapse Processes and Their Applications to Pricing Management International Journal of Pure and Applied Mathematics 118(18) 3741-3746