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The Assessment of Effectiveness of R&D within the Framework of Federal Target Programs

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Abstract: ***The purpose of this study is to develop approaches to assessing the effectiveness of R&D of civilian use carried out within the framework of federal target programs based on integrated accounting of performance indicators and the cost of projects. Methods of comparative analysis as well as the methods of expert estimations were used. The developed methodology is tested on the example of the most knowledge-intensive program — the Federal Targeted Program "Research and development on priority directions of scientific and technological complex of Russia for 2014-2020" showing its practical applicability. It confirmed the hypothesis about the existence of significant differentiation of projects containing R&D according to the quantitative structure as well as scientific and technical potential of the established objects of intellectual property in comparison with the costs of R&D. The existing system for assessing the effectiveness of R&D conducted within the framework of targeted programs is carried out with aggregate output parameters and does not pay attention to the specific contribution of each project in improving the indicators of the entire program. The authors proposed to use the concepts of "weighted effectiveness" and "innovative efficiency" of projects. The quantitative evaluation of projects based on these parameters made it possible for us to perform the ranking of projects, to identify groups of projects with varying degrees of innovative efficiency, and to distribute the most effective, low efficiency and expensive projects according to thematic areas of research.***

Keywords: ***effectiveness, efficiency, federal target programs, financing of contracts, objects of intellectual property, research and development.***

I. INTRODUCTION

The modern scientific activity has an interdisciplinary nature. It is distinguished by the scale and global scope of research. The projects are focused on solving the key tasks of social and economic development, the strengthening of national competitive advantages, the development of innovative technologies. The priority areas of development of science and technology, which are formed at the level of individual states, are the basis for the development of international cooperation [20].

A. R&D implementation in European countries

In 2014 the eighth pan European framework program "Horizon-2020" was adopted, which combined the EU framework programs in priority areas of research and development (R&D), innovation and competitiveness [8, 9]. The program is aimed at developing high-performance technologies (eco-, nano-, bio- and information technologies) in the field of "green" energy, transport, climate management, gerontology.

The mechanisms of selection and implementation of national priorities in science and technology are constantly improved. In many European countries, the formation of the list of scientific and technological areas is based on the results of foresight research, which allows to determine the prospects for the world scientific and technological development and one's own potential. The review of scientific publications analyzing approaches to the implementation of priorities for the development of science and technology in some EU countries showed that appropriate programs for research are formed and funded at the state level. For example, in Germany the main instrument for implementing the scientific thematic and innovation policy is thematic programs (the thematic R&D programs), the majority of which are controlled by the Federal Ministry of Education and Scientific Research. In the UK research and development programs are formed by research councils. In Finland the sphere of implementation and financing of state programs is coordinated by the Academy of Finland and the technological agency "Tekes" [47].

B. R&D implementation in Russia

In Russia, as part of realization of the program-based approach to the management of public finances for the implementation of major scientific, technical and socioeconomic projects in priority areas of scientific knowledge the main tool is state programs, which include federal target programs that are a complex of thematically interrelated activities structured according to the areas of implementation provided with executors and resources for the period of their implementation. The federal targeted programs remain one of the most important mechanisms for implementing the state's structural, scientific, technical and innovation policies actively influencing its socioeconomic development. A significant component of federal targeted programs is a complex of research and development as well as design and experimental works, which plays an important role in the in-novation process.

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The implementation of R&D includes two main stages of work: research and development as well as design and experimental. At the stage of R&D one performs fundamental and applied works of theoretical and experimental nature in order to determine, in principle, the technical possibility of creating a new technology in a certain time. The design and experimental works at the final stage of scientific research and the transition to industrial production include the development of design and technological documentation for proto-types, the design and creation of a pilot plant, the production of a pilot batch of products. The main source of funding for research and development under the Federal Target Program is the federal budget, which in the last 10 years accounts for about 80% of the financing structure.

The relevance of this study is justified by the need to monitor the effective use of budgetary funds and to increase the effectiveness of scientific projects, which in com-bination forms the innovative characteristics of the country. In this study we consider the effectiveness of implementation of certain civilian R&D activities within the framework of the federal target programs.

The object of this study is civilian R&D carried out within the framework of federal target programs. A special place among the federal target programs belongs to the Federal Target Program “Research and Development in Priority Areas of Development of the Russian Scientific and Technological Complex for 2014–2020”, the goal of which is the formation of a competitive and efficiently functioning research and development sector in the field of applied research. This is one of the most science-intensive federal target programs, in which the share of spending on R&D in the planned expenditures exceeds 70%. According to the departmental reports [29-31], the number of contracts in the Federal Target Program for the implementation of civilian R&D (rolling contracts and contracts concluded in 2017) amounted to 841 with a total value of 13 450 4 million rubles. Of these, 473 contracts (56.2%), created objects of intellectual property (OIP). The range of financing of these contracts is from 8.55 million to 452.0 million rubles. In terms of the total number of the protected objects of intellectual property (OIP) and applications to federal target programs the highest level of efficiency among other federal target programs was reached — 993 for the entire period of contracts performance (as of January 1, 2018). The specific structure of objects of intellectual property (OIP) is shown in Fig. 1.

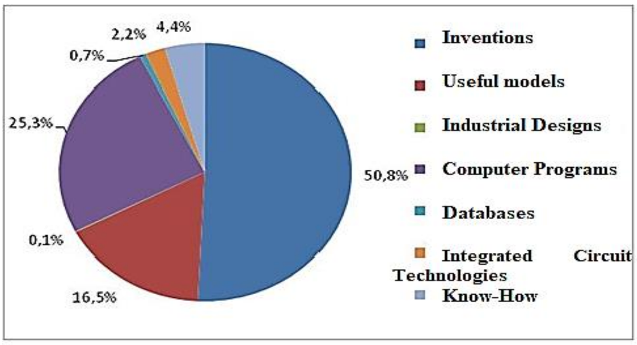

Figure 1. The structure of objects of intellectual property (OIP) received in the period 2014-2017 within the framework of the federal target program [28, 38]

The subject of this study is the effectiveness of civilian R&D carried out within the framework of the federal target program. The purpose of the study is to develop approaches to assessing the effectiveness of civilian R&D within the federal target program. The paper shows that when evaluating the effectiveness of R&D of civil usage implemented within the framework of the federal target program it is necessary to consider the effectiveness of executed contracts (considering the specific structure of objects of intellectual property (OIP) in comparison with the costs for their creation.

II. MATERIALS AND METHODS

A. Methodological approach to assessing the effectiveness of federal target programs

The fundamentals of methodological approach to assessing the effectiveness of federal target programs in the system of public administration of the country's economic development are laid out in the provisions of regulatory legal documents, the development of which dates back to 1995 [46]. Currently, in the context of integration of federal target programs into larger state programs (SP) the parameters of evaluation of the effectiveness of federal target programs are interrelated with the system for assessing the effectiveness of state programs. The methodology for evaluating the effectiveness of pro-grams, which is carried out on a bottom-up basis, the initial assessment of the degree of implementation of individual activities, subprograms and the program as a whole [44, 45]. The analysis shows that the existing system for assessing the effective-ness of federal target programs as well as target programs in general, has a number of objective shortcomings [6, 7]. The main one is that the evaluation is conducted with aggregate output parameters.

B. Definition of objects of intellectual property

The most complete definition of objects of intellectual property is given by the World Intellectual Property Organization: “... the term “intellectual property” means any property recognized by common consent as intellectual in character and deserving of protection including, but not limited to, scientific and technical inventions, literary or artistic works, trademarks of business enterprises, industrial designs and geographical indications [50]. In Russia, the objects of intellectual property include the results of intellectual activity, which may be granted legal protection in accordance with the Civil Code of the Russian Federation, Part 4 “Intellectual Rights and Means of Individualization” [43].

The effectiveness of civilian R&D is traditionally determined by the number of the created intellectual property objects. But at the same time, in our opinion, it is also necessary to consider the specific structure of intellectual property objects (OIP). In this aspect we determine differences between individual types according to their scientific and technical potential, their impact on technological development, legal protection,

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and the significance (or weight) of each type of OIP in comparison with other types. Certain aspects of this problem were considered by us in previous studies [49].

C. Types of intellectual property objects (OIP)

The highest level of technical creativity is inventive activity; therefore, the hierarchy of the most important types of intellectual property objects (OIP) in industrial property is as follows: invention, useful model, industrial design. The creation of these property objects testifies to the development of new solutions to technical problems, the improvement (modernization) of the overall design of products contributing to raising the technological level of production. Inventions, being the embodiment of new technical ideas, determine the competitiveness of technologies and patents help protect new technological processes. The main difference between useful models and inventions is that the first do not have to confirm the inventive level. A useful model is a technical solution that relates exclusively to the device (changes and improvements made in the design of machines, production equipment or products as well as the configuration of products and their parts, electrical circuits, etc.). This definition cannot be applied to methods, substances, strains of microorganisms, etc. The industrial design refers to artistic and engineering solutions regarding the design and appearance of the product [33, 36]. In the recent decades new objects of industrial property have been qualified, which are protected by copyright: the topology of integrated microcircuits, the secrets of production (know-how), computer programs and databases.

The above-mentioned objects of intellectual property (OIP) have different legal protection regimes. For example, inventions, useful models and industrial designs are protected by patent law. The regime of exclusive rights applies to the means of individualization of entrepreneurs and products (firm name, trademark, service mark, name of the place of origin of goods), according to which only the owner of the registered object determines the mode of its use. The third group of objects of intellectual property (OIP) (topology of integrated microcircuits, etc.) is protected by copyright. Therefore, the characteristic features inherent in each type of OIP form their role and significance in the scientific, technical and production spheres.

D. The new concept "weighted effectiveness of contracts"

The analysis shows that the contracts for R&D within federal target programs have different effectiveness both in terms of the total number of created objects of intellectual property (OIP) and in terms of their profile (type structure). The quantitative and species composition of OIP in terms of contracts differs in a fairly wide range. Accordingly, the contribution of each contract to the performance indicators of the whole federal target program is different.

In our study, by involving other experts we offer to determine weighting coefficients of the significance of types of intellectual property objects and, considering the quantitative-specific structure of the OIP, to evaluate the weighted effectiveness of each contract as its contribution to the overall R&D performance in federal target programs.

The new concept "weighted effectiveness of contracts" proposed in this paper is an aggregate indicator characterizing the quantitative-specific structure of OIPs created in the course of R&D of a separate contract, obtained by summing the number of OIPs for each type of intellectual property multiplied by the corresponding weighting coefficients. According to the results of expert work, the evaluation of importance of different types of OIPs will allow us to assess the weighted effectiveness of each contract.

The analysis of financial provision for R&D showed that the parameters of financing in the context of contracts differ in an even a bigger range. In order to obtain a full and objective assessment of the effectiveness of contracts it is necessary to compare their effectiveness with the costs of establishing objects of intellectual property (OIP). The comparison of data on the ratio of the weighted effectiveness of contracts with the amount of financing (implementation costs) will give the value of "innovative effectiveness" of each contract.

Under the innovation efficiency of a contract we understand a characteristic of correlation between the results achieved in creating an OIP and the costs of research and development. The proposed concept represents the weighted effectiveness of contracts for the period of their implementation attributed to the estimated costs of R&D (creation of OIP) for the same period. This indicator will help determine the value of projects (contracts), their contribution to the implementation of activities of federal target programs considering the effectiveness of R&D and the costs of creating an OIP. On the basis of these data the ranking of contracts is carried out determining the most effective of them and thematic areas of prospective studies.

The procedure (algorithm) for implementing the proposed methodical approach includes the following steps:

1. determination of weight coefficients for the significance of objects of intellectual property (OIP);
2. determination of the weighted effectiveness of contracts and the overall effectiveness of R&D in federal target programs;
3. determination of estimated costs (the average annual amount of funding for each contract multiplied by the number of years of the contract's performance, including 2017) for performing R&D for the period of contract execution;
4. determination of innovative effectiveness of contracts (The quotient obtained from dividing the weighted effectiveness of contracts for the period of their implementation by the amount of estimated costs for the implementation of R&D (creation of OIP) for the same period);
5. ranking of contracts according to the indicator of innovation efficiency.

E. The model of ranking of projects (contracts) implemented as part of federal target programs

For practical implementation of the proposed approach we developed a model for ranking projects (contracts) implemented as part of federal target programs in terms of innovation efficiency. The calculations are based on existing developments in this area [5, 48].

In this model for assessing the weighted performance we determine the criteria that characterize the number of objects of intellectual property that are the result of R&D within the framework of a project (contract) for which protection documents have been received or applications have been submitted.

The following types of objects of intellectual property (OIP) are defined as performance criteria: Inventions, Useful models, Industrial Designs, Computer Programs, Databases, Integrated Circuit Technologies, Know-How.

When scoring according to performance criteria a scoring scale is used, where 1 point corresponds to 1 OIP, for which a protection document has been received or applied for. In this case, one project (contract) can be evaluated according to several performance criteria simultaneously.

For each criterion a weight is determined, which reflects the importance of the criteria for each other. The weights are determined expertly through the distribution of scores from 1 to 10 with the subsequent rationing by 1.

The score of the performance criteria for the project (contract) will determine the weighted effectiveness of contracts and is calculated with the following formula:

$$V = \sum_{i=1}^{I} (a_i * X_i) \quad (1)$$

where: ai – the weight of the i-th performance criterion; Xi – evaluation of the i-th performance criterion, score; i = 1, 2, … I – the number of performance criteria;

In order to take into account the assessment of financial costs for the implementation of the project (contract), the rating of projects (contracts) determines the budget score of the project budget (BP) calculated as a share of the project (contract) budget in the total amount of funding of projects (contracts) by the following formula:

$$BP = \left(\frac{BP_p}{BP_s} \right) \times 100 \quad (2)$$

where: BPp – budget of the project (contract); BPs – the total amount of funding for all projects (contracts) in the sample.

The calculations of the scoring assessment of budget of the project (contract) include the volumes of financial provision (federal budget, extra-budgetary sources).

The rating of the project (RP) reflecting the level of its innovative efficiency is determined as a ratio of the sum of points obtained on the basis of evaluation of the project (contract) according to the performance criteria to its budget expressed in points and calculated by the following formula:

$$RP = \frac{V}{BP} \quad (3)$$

where: V – weighted effectiveness of contracts; BP – budget of the project (contract).

III. RESULTS AND DISCUSSION

The peculiarities of individual types of objects of intellectual property (OIP) considered above were considered in developing weight coefficients of the significance of OIPs for each type and the ranking of OIPs on their basis. The determination of weight coefficients of the significance of OIPs was carried out through the distribution of scores from 1 to 10 with subsequent rationing by 1. The results are shown in Table 1.

Table 1. The distribution of weight factors in the significance of objects of intellectual property (OIP) [30, 38]

Type of OIP	Significance	Weight
Inventions	8	0.26
Useful models	6	0.19
Industrial designs	5	0.16
Databases	4	0.13
Integrated Circuit Technologies	4	0.13
Computer Programs	3	0.10
Know-How	1	0.03
Total scores	31	1.0

The data obtained on weight coefficients of OIPs (Table 1) as well as on the quantity and structure of OIP in the context of contracts within federal target programs made it possible to determine the weighted effective-ness of contracts in the range from 0.03 to 2.14 units, which is described by a nonlinear function. Of the total number of contracts one can identify 12 of the most effective ones, the weighted performance indicators of which exceed 1.0 unit (with an average sample value of 0.41). At the same time, well ahead of the others in this group there is one contract with a value of weighted productivity of 2.14 units, which provides for the implementation of R&D in the field of metal science. Within the framework of this contract the maximum number of OIPs (10 units, including 8 inventions) was created for the whole sample. The vast majority of contracts have a weighted performance score ranging from 0.19 to 1.0, of which only 1 OIP was created, which accordingly, leads to low weighted performance (0.19–0.26). Five contracts have the minimum value of weighted performance (0.03), where the result of R&D was the creation of 1 unit of know-how.

A. Ranking of contracts regarding the values of this indicator

At the next stage, when comparing the indicators of weighted effectiveness of contracts and the costs of R&D, innovative effectiveness of contracts was determined. Based on the results of the ranking of contracts regarding the values of this indicator the following was revealed.

1. The total range of innovative effectiveness of contracts is broad – from 0.07 to 23.54 units (with an average level of 2.86). The ranking of contracts according to the value of this indicator allowed to identify a group of 50 most innovative contracts including 11 of them that have a value of this indicator exceeding 10.0 units (Figure 2).

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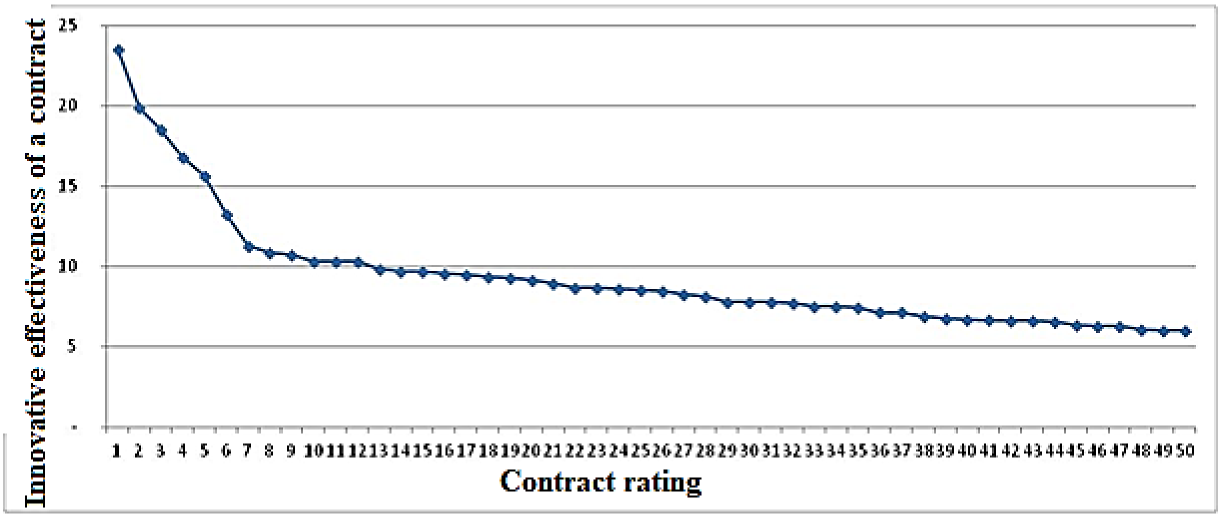

Figure 2. The rating of 50 most innovative and effective contracts [30, 38]

2. The analysis of distribution of 11 of the most innovative contracts on R&D thematic areas showed that about 40% of them carried out research and development in the field of medicine and biology, in a smaller volume – in energy and material science. It is interesting to compare the calculated parameters (weighted effectiveness, innovative efficiency) in the group of 11 most innovative contracts (Table 2).

Table 2. The main calculation parameters of 11 most innovative contracts* [30, 38]

Contract ranking	The field of application of OIP	Innovative efficiency	Weighted effectiveness
1	Biology	23.54	0.52
2	Materials Science	19.87	2.14
3	Oil refining	18.54	1.56
4	Medicine	16.79	0.52
5	Energy engineering	15.64	0.45
6	Medicine	13.24	0.26
7	Energy, ecology	11.29	0.38
8	Radio electronics	10.84	0.78
9	Medicine	10.71	0.71
10	Chemistry, Materials Science	10.30	0.26
11	New materials	10.30	0.26

* The ranking of contracts according to innovative efficiency

In general, in the group of the most innovative contracts there are high indicators of patent activity exceeding the average level. At the same time, four projects have a level of effectiveness below average for the sample — from 0.26 to 0.38, which suggests that their high level of innovation efficiency was achieved through lower estimated costs of R&D. Also, according to the data in Table 2, it is possible to distinguish a unique contract for the analyzed parameters. He takes the second place in the rating of innovation efficiency and the first place in the ranking of weighted performance. Within the framework of this contract R&D in the field of metal science is carried out concerning the development of compositions and the technology for manufacturing polycrystalline hexaferrites.

3. It should be noted that those contracts that have the maximum value of the indicator of the estimated cost of performing R&D (the most expensive contracts) are in lower positions according to relative effectiveness. Of the 50 most expensive contracts only one has a value of relative efficiency index (3.09) exceeding the mean level (2.86) (Figure 3).

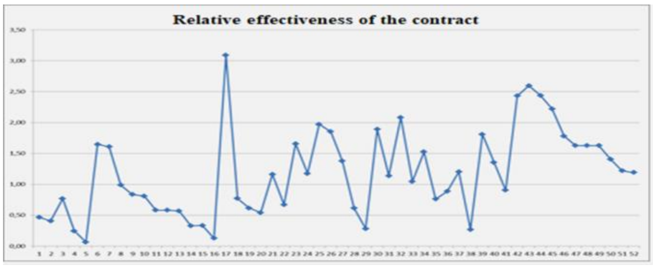

Figure 3. Indicators of innovative efficiency in the ranking of 50 most expensive contracts [30, 38]

4. The character of distribution of expensive contracts according to the values of the innovation efficiency index shows that, on the whole, the inverse dependence of innovation efficiency on the value of contracts is observed: the more expensive the contract, the lower its innovative efficiency. Similar contracts were identified in thematic areas: energy, transport, radio electronics, technological equipment (table 3).

Table 2. The rating of contracts according to estimated cost (the first 10 positions) [30, 38]

The ranking by value	The field of application of OIP	Weighted effectiveness	Innovative efficiency
1	Energy engineering	0.71	0.47
2	Transport	0.56	0.41
3	Radioelectronics	0.88	0.77
4	Radioelectronics	0.23	0.25
5	Technological equipment	0.06	0.07
6	Energy engineering	1.30	1.65
7	Radioelectronics	1.27	1.61
8	Technological equipment	0.78	0.99

9	Medicine	0.66	0.84
10	Robotics	0.64	0.81

In the rating of estimated costs, the first place is occupied by a contract that performs R&D in the energy sector, the innovative efficiency of which is only 0.47 units.

5. In comparing the data on the effectiveness and performance of expensive contracts it is revealed that, based on the weighted performance values, most of them are at a level, which is higher than average for the whole aggregate (0.41). This indicates that, based on the results of R&D, contracts have a good patent activity. Accordingly, low indicators of innovation efficiency are due to the high cost of contracts. 6. The least effective contract was identified, which carries out R&D in the field of development of technological equipment for the layered synthesis of polymetallic products occupying the 5th position in the rating of estimated costs. In the two-year period of its implementation only two know-hows were created (weighted productivity – 0.06). Due to the high estimated cost and low performance it has the value of innovative efficiency of 0.07 (the second lowest position in the general rating).

B. The effectiveness of scientific activities

The measurement of the effectiveness of scientific activities, in particular R&D, is relevant for all countries. One distinguishes various types of efficiency: commercial, social, environmental, etc. In this paper we studied innovative effectiveness of R&D with a prevailing commercial effect conducted within the framework of national target programs. This group includes scientific developments related to the improvement of equipment, technology, man-agement and organization of production.

To assess the effectiveness of R&D implemented in targeted programs the authorized agencies of countries use the corresponding officially approved methods developed in the context of development of a program-targeted approach to the use of budgetary funds. A re-search budget is planned for the next year based on the results of the annual monitoring of implementation of program activities. It should be noted that there is no general methodology for assessing the effectiveness of R&D. The practice of using official methods reveals their certain limitations and shortcomings related both to the quality of preparation of documents and the objective process of changing economic realities, legislative base, etc. All this necessitates the improvement of approaches to assessing the effectiveness and performance of R&D. The analysis of research in this area has revealed a significant methodological diversity – in terminology, approaches to evaluation, aspects of consideration. It is advisable to consider them through the prism of projects of different levels (macro-, meso-, micro-projects).

C. Macro-level of R&D projects (national programs)

In the work of Korean scientists [18] aimed at improving the competition policy in the field of R&D they studied the conditions for the implementation of six competitive R&D programs included in the national research program. The assessment of R&D efficiency was conducted with the aim of strengthening the impact and commercialization of research results based on the analysis of the life cycle of R&D: planning-management-evaluation. As a result, proposals were developed relating to three areas of improvement: selection of projects for inclusion into the program of R&D; justification of competition models for each stage of the life cycle of R&D; formation of an institutional framework for ensuring the implementation of the new policy.

In the study dedicated to the measurement of effectiveness of large-scale state projects characterized by the complexity and dynamics of R&D, a format for such measurements is proposed [19]. It is proposed to use the matrix of indices to determine vertical (efficiency of individual elements in the industrial ecosystem) and horizontal (economic and technological results of these elements) of the category of efficiency (parameters).

The methodological problems of measuring the performance of national R&D systems to ensure cross-national comparability of R&D expenditures and publication activity were investigated in the work of Aksnes, Sivertsen, van Leeuwen, and Wendt [1]. The authors use the notion of “research productivity”, which is estimated on the basis of statistical data regarding the availability of publications in the international scientometrical databases Web of Science. To determine the effectiveness of R&D, these data are compared with the costs of work execution.

In Russia, a large-scale national assessment of scientific research of public research institutions was carried out in 2013. Based on its results an information basis for the development of scientific and technical policy, the strengthening of the role of science in the economic environment was formed. On the basis of quantitative data obtained during the national assessment, a multivariate evaluation of the results of R&D was carried out, including the publication activity and citation in scientific papers [12, 13]. The comparative analysis made it possible to perform the ranking of academic institutions according to the parameters of evaluation, to identify thematic areas with high research indicators.

D. Meso-level of R&D projects (programs of regions, sectors of economy, industries)

The regional aspect of assessing the effectiveness of R&D can be found in the works of scientists in many countries. For example, the Korean researchers study it from the static and dynamic points of view [16, 17]. At the same time, the best practices (statics) of regions were assessed as well as their dynamic perspective regarding the Malmquist performance index, which allows estimating changes in R&D performance over a period of time based on capital and labor parameters. This approach makes it possible to classify regions into three groups (deteriorating, lagging behind and improving) and to adjust the mechanisms of state scientific and technical policies. The results of R&D of universities in 30 provinces of China were proposed to be evaluated in two directions: efficiency and performance [35]. Using a network approach to the analysis of databases about the statistics of R&D in universities for the period 2004-2014 and at the same time — a multi-index integrated method of assessment, a comprehensive understanding of the dynamics of indicators and trends in R&D was obtained.

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A more representative area of work is devoted to the success of R&D in sectors and individual fields of the economy. Quite often among them there are studies of approaches to assessing the effectiveness of R&D in the public sector of the economy. For example, in the case of European countries it is proposed to assess the effectiveness of publicly funded re-search and development through the prism of their impact on the efficiency and performance of the public sector of the economy [27, 28]. The relevant composite indicators are used for this purpose.

A separate group in the research is devoted to measuring the results of R&D in high-tech manufacturing sectors. The work of Chinese scientists offers an approach to deter-mining the relative effectiveness of high-tech manufacturing sectors based on the analysis of data conversion (DEA) and some relative indicators (Malmquist performance index) by using the example of five high-tech manufacturing sectors located in 31 regions [42]. The results of the empirical study include the obtained data on the use of human resources (re-searchers) and the costs of R&D, as well as the results (revenues from the sale of new products, the number of valid patents). The nature of variability of the Malmquist performance index made it possible to characterize the competitiveness of industries.

Similar to that in many respects is the methodical approach to researching the effective-ness of R&D in high-tech industry proposed in the work of Ge and Yang [15]. The authors use the notion of "R&D productivity", which is estimated by sales revenues, the number of patent applications and the number of valid patents. The model compares the costs of R&D and their productivity. The Data Envelopment Analysis (DEA) is used to calculate the technical efficiency of input and output parameters. A projection approach is also applied in the work, which provides for projection optimization of indicators.

A paradigm shift in approaches to measuring scientific productivity is stated in the work of Kumar, Srivastava, Jeevan Kumar, and Tiwari [21]. Traditionally, scientific productivity is measured by publications or patents. The review, compiled by the authors, shows the ambiguity of this approach. For example, countries that occupy the top positions in the world ranking according to the growth in the total number of patent applications may have low rates of innovative productivity (the share of patents received). The authors project the value of the performance evaluation system in R&D by means of identification and standardization of key parameters, which will promote the motivation of researchers.

The article of employees of the Spanish Centers for Biomedical Research (CIBER) offers an approach to monitoring the effectiveness of the R&D program in this field [37] making it possible to assess the impact of research policy management on results. One aspect is the promotion of translational research through internal cooperation between different research groups. The parameter of assessment is the dynamics of citations in articles. Identification of a point at which the share of references stabilizes may indicate an effective policy in the field of R&D.

By using the example of the energy industry, a comparative analysis of the existing methods for estimating R&D (regression analysis) and the method of foresight technologies is performed [24, 25]. The evaluation of R&D projects in the context of long-term development of technologies was carried out. The limitations of the regression analysis of the efficiency of completed projects were shown on the basis of the past investments in R&D that do not allow an objective assessment of the directions of public investments. In contrast, the use of the LCOE forecast model shows that renewable energy technologies are an effective area for public investments in R&D. That is, the use of the foresight technology method makes it possible to more accurately assess the prospect of R&D in the context of long-term development of technologies.

The approaches to evaluating the results of R&D of key industries are presented in the work of Li and Wang [26]. The authors used the method of Data Envelopment Analysis (DEA), the fundamental point of which is efficiency. In the generalized form, it is a quotient of the sum of all output parameters divided by the sum of all input fac-tors. Four aspects of indicators in the system of "input-output" of R&D are considered, including: models of Data Envelopment Analysis; a system of indices for assessing the effectiveness of R&D according to the principle of "input-output" and the actual operating conditions. The problems of low efficiency of R&D of the key industries are caused by imbalances of investments in R&D among industries, unreasonable structure of input and output data, inefficient use of resources and low demand for innovations.

An interesting work is devoted to measuring the relative effectiveness of R&D of five global comparators – scientific research organizations of different countries (USA, Germany, Japan) working in similar research flows [14]. The authors use the Data Envelopment Analysis (DEA). The input parameters (the number of grants received, the number of scientific employees of the organization) and the variable results (external cash flows, the number of transferred technologies, publications and patents) were taken into ac-count in the model for assessing the relative effectiveness of organizations' activities. The study was focused on finding a balance between the local and the global efficiency, as well as the impact of scale and regional differences.

E. Micro-level of R&D projects (programs and projects of organizations)

The most representative group of studies in assessing the effectiveness of R&D is carried out at the micro-level – for the conditions of individual firms and organizations. Most of them study the projects financed from the budget. For example, the work of Serbian researchers offers a method for evaluating strategic performance indicators of R&D taking into ac-count the probabilistic nature of R&D functions [2, 3] using the example of a firm operating in the Serbian automotive industry. In the context of research of the effectiveness of R&D the Taiwanese scientists investigated the distribution of resources of research organizations using the dynamic hybrid approach DEA-ANP. The dynamic three-step network model DEA made it possible to assess the effectiveness of R&D, the efficiency of technology diffusion and the efficiency of value creation [51].

The regression analysis of panel data was used to determine the influence of the number of patents, the quality of labor resources and the possibility of service provision on the dynamic effectiveness of research organizations.

The methodological approaches of individual studies were based on the concept of dynamic capabilities of Teece with the development of a matrix of key performance indicators in the field of R&D [4]. A positive influence of the dynamic potential of research organizations on the results of R&D and innovative activity was revealed.

A peculiar feature of the approach to measuring the effectiveness of R&D in the work of Salimi and Rezaei is the determination of the levels of importance of indicators included in the model [39- 41]. Based on the example of 50 high-tech SMEs in the Netherlands, it was shown that the use of weighting factors provides more meaningful results in the ranking of firms and allows the development of more effective strategies for increasing R&D efficiency.

Using the resource-based view (RBV) the analysis of the impact of public financing as a financial resource on the results of R&D of German renewable energy companies was carried out [34]. With the help of regression analysis, it is determined that public funding for R&D has a significant positive impact on the number of received patents, but does not significantly affect their quality, measured by bibliometric indicators (the number of citations).

In the work of Russian scientists, the emphasis is placed on the importance of ensuring the quality of assessment of R&D projects at the initial stages of development in order to obtain a result [52, 53]. The proposed concept is based on the definition of the index of economic efficiency of R&D and, in the opinion of the authors, is applicable to the evaluation of projects of different levels (micro-, meso-, macro- projects).

A separate group is represented by studies that explore the effectiveness of R&D in joint projects. The most common approach is focused on private benefits of participants. A new look at the evaluation of success of such projects is outlined in the work of Nepelski and Piroli in which the dependence of innovative efficiency on organizational and legal diversity of participating organizations is examined [32]. A sample of the studied objects was presented by key organizations involved in the implementation of innovations and financed by the EU. An emphasis on innovative results made it possible to more accurately assess the transformation effect of the joint research. The authors found that the innovative potential of research results of homogeneous partnerships will be higher in comparison with heterogeneous partnerships. In the applied aspect this means that depending on the type of organization and the structure of consortium there are various incentives for motivating researchers, as well as additional resources and benefits.

Another approach to quantifying the success of joint R&D is proposed for projects funded by universities and industry [10, 11]. It combines retrospective (delayed) and long-term (leading) performance indicators throughout the life cycle of the pro-gram/project. The indicators include both measurable results (patents, publications) and intangible ones (social relations, motivations, organizational mechanisms).

The proposals on the revision of perspectives in the process of measuring of effective-ness of R&D are contained in the work of Laliene and Ojanen [22, 23]. The starting point is an argument about the importance of selection of the most accurate indicators for an objective evaluation of effectiveness, productivity or performance of R&D. The structure of efficiency evaluation proposed by the authors describes the entire chain of key processes of R&D: input-processing-output-transmission-result. The advantage of such a platform is that it can combine different aspects of measurement (financial, innovative, etc.).

A review of studies devoted to the measurement of effectiveness of scientific activity identified the areas for development and improvement of methodological approaches, broadening the aspects of the studied problems. The approach proposed in this paper, unlike the existing ones, makes it possible to take into account the concrete contribution of each project to improving the performance indicators of the entire target program.

IV. CONCLUSION

The conducted work confirmed the assumption about the existence of significant differentiation of projects containing R&D according to the quantitative structure as well as scientific and technical potential of the established objects of intellectual property in comparison with the costs of R&D.

The authors developed their definition of the concept of “weighted effectiveness of contracts”, which characterizes the quantitative structure of OIPs and their significance in the scientific, technical and production spheres.

The authors developed their definition of the concept of “innovative effectiveness of contracts” as a characteristic of the relationship between the results achieved in creating an OIP and the costs of research and development.

A methodology was developed for determining the effectiveness and performance of contracts (projects) for research and development (R&D) of civil use implemented within the framework of federal target programs (FTP).

The authors proposed an approach to assessing the effectiveness of civilian R&D implemented within the framework of federal target programs, which determines the weighted effectiveness and innovative efficiency of contracts making it possible to assess the value of contracts (projects) taking into account their effectiveness and cost of implementation. For practical implementation of the proposed approach a model was developed for ranking projects (contracts) implemented as part of federal target programs according to the indicator of innovation efficiency.

The developed model for the ranking of projects (contracts) according to relative efficiency was tested using the example of the federal target program “Research and development on priority directions of scientific and technological complex of Russia for 2014-2020” approved by the Government of the Russian Federation, which demonstrated its practical applicability. The use of the proposed approach to assessing the effectiveness of R&D of civilian use carried out within the framework of federal target programs makes it possible to assess innovative effectiveness of each R&D contract (project) both from the point of view of its contribution to the effectiveness of federal target programs in general and in terms of spending of budget funds.

This methodology can be used in assessing the projects participating in tenders for R&D as well as in summarizing the results of implementation of federal target programs. In addition, in the future the use of the proposed approach will allow us to assess the participation of both the entire set of contracts and the most effective ones in the development of priority are-as of scientific and technological development and critical technologies, to identify the technological points of growth as well as the most effective scientific teams of developers.

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