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Approach to assessing efficiency of public expenditures on applied research in condition of digital economy

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Abstract: The article is addressing the problem of evaluating the efficiency of public expenditures on applied R&D being a tool to improve "transparency" of financial flows in scientific and technical sphere, implemented in digital environment. Economic effect of is construed as sum of economic effects expressed in GVA created by the company with utilization of R&D findings, and in sales-generated income tax payments. The article presents a model for assessing the overall economic effect of applied R&D findings utilization with the use of tool identified as "cash flow discounting". The rule of estimation of efficiency of budget expenditures for applied R&D is formulated. It is concluded that the presented model can become a part of management decision-making tools in scientific and technical sphere in terms of selection of directions of state financing of applied R&D. The proposed approach to assessing the efficiency of budget investments in applied R&D can be implemented as one of the services of the digital economy platform.

1. Introduction

Digital technologies are becoming particularly relevant at the present stage of economic development. They can be successfully applied in solving such a strategic task as improvement of efficiency of public expenditures in the scientific and technical sphere. Improvement of public expenditures efficiency, especially in the field of S&T, can be achieved by changing the approaches to management decision-making which should be based on correlation between funds spent and findings obtained. This approach cannot be implemented without ensuring transparency of financial flows. In his address to the Federal Assembly, Vladimir Putin noted that “... active involvement of digital technologies and platforms will make it possible to consistently increase transparency and whitewash the economy” [1]. Approach proposed by the authors to assess the efficiency of public expenditures on applied research can become a service for one of digital economy platforms. Implementation of proposed approach is achievable in digital environment provided that a single platform will become the basis for accumulation of data about indicators (used to assess efficiency of budget spending on research and development) like R&D financing scope and structure, data regarding information about findings of intellectual activity produced in the process of research and development (hereafter “IP assets”), volume of products manufactured with the use of IP assets, amount of tax revenues obtained from industrial enterprises manufacturing goods on the basis of R&D results.
2. Purpose of research
Purpose of the study presented in the article is to find approaches to assessing efficiency of budget spending on R&D suitable for digital environment. One of adequate approaches to solving the problem is the use of financial management tools based on evaluation R&D findings obtained in the course of research and development, by discounting the cash flow for the subsequent correlation with public expenditures incurred for the implementation of research projects. Sources of data needed for the assessment can be accumulated online in a single database on digital economy platform.

3. Research methods
Theoretical basis of the study is laid by works of domestic and foreign scientists dedicated to the problem of R&D costs efficiency assessment. To achieve the goal - general theoretical research methods (such as analysis, synthesis, analogy, modeling) were used. Goal of this paper is to adapt the well-known “cash flow discounting” method used in financial management (and detailed in works dedicated to assessment problems) to the problem of assessment of efficiency of public expenditures for R&D. The paper proposes a model of evaluation of finding obtained in the course of applied research as an economic effect of its use. The proposed model can become the basis for development of service enabling assessment of R&D costs efficiency on digital economy platform.

4. Literature review
Approaches to assessment of efficiency of state financing of science (both fundamental and applied research) are not well established and remain the subject of heated debate [2]. In the theory and practice of public administration there has long been a vogue for two major approaches to measuring the efficiency: tactical result (“output”) and strategic result (“outcome”). “Output” is understood as immediate effect of state-backed activities that are measurable and transparent while “outcome” is understood as broader anticipated social and economic effects to which outputs should lead and which are usually very difficult for precise measurement [3].

With spread of “performance management” approach pursued by public policy in different countries, emphasis in assessment of findings in the field of public science was inevitably made on measurement of formal indicators of output – mainly on number of publications and citations. But now a whole new genre of literature has taken shape, typified by expressed skepticism as to whether there is any correspondence between the output and the expected outcome. Researchers sharing this view put an emphasis on such problems as the devaluation of scientific publications [4]; a decrease in the quality of peer review of scientific publications [5]; criticism of scientometric approaches [6]; propensity to ‘risk-free’ research [7, 8]; and the productivity paradox in science [9, 10], etc.

The critical works on the subject generally have two common features. First they state that in any branch of science, regardless of its specific subject matter, an introduction of evaluation systems based on a formalized output sooner or later inevitably findings in an imitation of scientific research rather than bona fide scholarly activities. This hypothesis could be epitomized by the following paradox: the more public policy is focused on formal output-indicators of the S&T complex the worse the findings the latter produces outcome-wise [9, 10].

The second feature of this particular breed of critical works is that they focus their criticism predominantly on the output indicators in fundamental science where, indeed, bibliometric methodology is least likely to yield satisfactory results. With respect to the measurement of output and outcome in applied research the authors’ attention is mainly focused on the commercialization of public scientific organizations, the effects of which are critically examined at various levels, for example, nationally, at university management level [11] or individual scientists [12]. However, unlike bibliometric indicators, the effects of the outputs in applied science (the number of patents, licenses, spin-offs, etc.) have not received the same close attention of the scientific community. Nevertheless, a number of studies on this subject exist. For example, there are authors that propose to measure the relative efficiency of R&D costs, using the method of data array analysis, where the relative efficiency is defined as a deviation from a certain efficiency boundary characterized by the maximum achievable values of the resulting
indicators (maximum output/outcome) [13]. Research is also being conducted to improve efficiency of R&D costs management, which is measured through the value of patents granted to large companies [14]. To assess efficiency of public investment in the R&D sector, a program-project approach is proposed which is based on correlation of actual and planned values of performance indicators of the research project (program) [15].

Although increase in the number of patents, involvement of private financing and commercial activity of universities may seem like objective proof of successful commercialization of the public sector of science, it cannot be excluded that there may arise the same unwanted side-effects of the overreliance on formal output indicators as in case of publication process in fundamental science. It is more difficult to identify such effects in applied research than in the case of open publication activity. At the same time, in the field of applied research the outcome of public policy is easier to quantify – since it is expressed in specific products and intangible assets based on research findings entering the economic turnover.

In view of this, financial management methodology which is becoming a more popular tool to ensure achievement of the set goals is commanding great attention [16]. There are proposals for employing cash flow discounting tool in assessment of integral effect brought about by R&D findings utilization in some publications [17]. There is however still much to explore in the field. This article introduces a model for assessment of efficiency of public expenditures on applied research and development which will help to verify relevance of “output” indicators (according to which actual assessment of performance of state finance receivers in R&D sphere is made) with “outcome” findings which represent ultimate goal of public policy pursued in scientific-and-technical sphere. Calculations in the proposed model can be carried out on the basis of digital platform which is accumulating all the necessary data.

5. Findings
The proposed model for evaluating the efficiency of public expenditures on applied research is presented below.

From the point of view of a state, efficiency of its investments in applied R&D can be reduced to the following parameters. The first one is economic effect produced by the use of a IT assets obtained in course of an applied R&D project and expressed through the GVA created by the enterprise (enterprises) using the said finding. Second parameter is the amount of tax revenue on income tax arising from the sale of products manufactured with the use of IT assets in question. Therefore, cumulative economic effect of specifically applied R&D project can be expressed as follows:

\[ EE_{R&D} = EE_1 + EE_2, \]

where \( EE_{R&D} \) equals the economic effect of using the j-th IT assets created in the course of applied R&D project;

\( EE_1 \) – economic effect expressed through a GVA created by the enterprise using the j-th RIA;

\( EE_2 \) – economic effect expressed through the amount of tax revenue on income tax arising from the sale of products manufactured with the use of the j-th IT assets.

It is worth noting that \( EE_1 \) does not directly compensate budgetary expenses for financing research and development. An indirect compensation occurs later in the future being reflected in the GDP growth. On the other hand \( EE_2 \), provides direct return of funds to the budget of the country in the form of income tax.

The following contains the procedure to determine the cumulative economic effect \( EE_{R&D} \), consisting of a sequential definition of \( EE_1 \) and \( EE_2 \), their summation and comparison with amount of budget funds spent for applied R&D project \( BF_{R&D} \).
The first component of the economic effect resulting from the use of the j-th RIA can be presented in form:

\[ EE_j^1 = \sum_{t=1}^{T} \frac{GAV_j^t}{(1+r)^k}, \quad (2) \]

where is \( GAV_j^t \) (income from new product sales minus cost of production materials) related to the use of j-th RIA during the period of time t, where \( t=(1,...,T) \);

\( r \) – discount rate;

\( k = t - 0.5 \) to calculate the discount factor by the middle of a period of time \( t \).

It should be noted that other endogenous and exogenous factors may influence the growth of company's gross income after it started to use new IT assets, for example, improvement of marketing strategy or change of external economic environment (inflation, growth in demand for enterprise products due to general increase of national consumption etc.). To evaluate influence of various factors on enterprise gross income growth it is recommended to use methods of expert assessments, scenario analysis etc. [18].

The above formula (2) takes into account time lag that can arise between R&D project completion and the moment when enterprise (enterprises) receives income resulting from the use of the relevant IT assets.

In order to calculate the discount rate (\( r \)) used in the discounted cash flow model, the cumulative construction method or the weighted average cost of capital are usually used [19]. However, in order to assess efficiency of budget funds invested in R&D it is advisable to use as a discount rate \( r \) the so-called social discount rate, that is, the discount rate used for the state and society. In Russia the refinancing rate or the key rate of the Central Bank of Russia (CBR) on the date assessment adjusted for inflation can be used as the social discount rate [20]. In the evaluation process a decision to account for the cash flow of the post-forecast period using, for example, the Gordon model [21] is also made.

Assessment of the second component of economic effect – the amount of tax revenue from the profit tax (\( EE_2^1 \)) is to be assessed according to the following formula:

\[ EE_2^1 = \sum_{t=1}^{T} \frac{H_j^t}{(1+r)^k}, \quad (3) \]

where \( H_j^t \) is the amount of taxes on revenues related to the use of the j-th RIA paid during the time period \( t \), where \( t=(1,...,T) \);

\( r \) – discount rate at the level of the refinancing rate established by RF Central Bank;

\( k = t - 0.5 \) to calculate the discount factor by the middle of a period of time \( t \).

Further, to assess the efficiency of budget expenditures on applied research and development, the actual costs and the finding are compared. Efficiency is positive if the following condition inequality is true:

\[ BF_{R&D} < EE_{R&D}, \quad (4) \]

where \( BF_{R&D} \) equals an amount of budgetary funds spent on financing an applied R&D project including costs for remuneration of research staff, equipment costs, purchase of inventory, additional costs associated with the R&D costs for general needs, other expenses.

It should be noted that a significant share of the amount of public funds spent on financing the applied R&D is the cost of labor of scientists who participated in its conduct. According to the Form № 2-Science "Information on the implementation of research and development" in 2017, the share (in the
internal current costs) of research and development attributable to the cost of remuneration of scientists in the public sector ranged from 41% in the medical sciences to 57% in the humanities. Scientists belong to the category of highly qualified specialists, therefore, increase in their wage level is high on the agenda of both the President and the Government of the Russian Federation. Yet the wages of Russian scientists and engineers are on average still significantly lower than is common in leading technologically developed countries. This, in turn, results in downslide of popularity that scholarly career currently experiences in Russia. In this regard, when making management decisions to reduce government spending on a particular area of research, it is necessary to be guided by the principle of maintaining sufficient level of labor costs for researchers in the public sector. It is advisable to determine the calculated threshold value of the amount of expenses for R&D for decision-making about its efficiency, given the reduction factor $\lambda$ (provided that $\lambda < 1$), in terms of expenditures on labor remuneration in the left part of inequality (4). Then the inequality takes the form:

$$\lambda \times S_R + R_{R&D} < EE_{R&D},$$

where $S_R$ – costs of remuneration of scientists;

$\lambda$ – reduction factor, that adjusts costs for R&D in the part of costs of remuneration of scientists;

$R_{R&D}$ – other R&D expenses, including equipment costs, purchase of inventory, additional costs associated with the implementation of the R&D, costs for general needs, other expenses.

A decision as to the amount of the reduction factor $\lambda$ is made by experts on the efficiency of budget expenditures for R&D on the basis of the use of the presented assessment model.

The entire set of calculations in accordance with the presented model can be made in the digital environment using data on government spending on each specific R&D, as well as data on the subsequent use of R&D findings in the real sector of the economy.

6. Conclusions
Methods of financial analysis & management have every reason to become an integral part of a decision-making toolkit in the S&T realm.

The suggested methodological recommendations for assessing efficiency of budget expenditures for applied R&D that rely on financial management tools will allow to quantify economic efficiency of public investment in specific applied research. The proposed method in its present form has certain limitations. In particular, it is not optimized for the evaluation of scientific projects the objective function of which is mainly social and non-commercial in nature as well as studies that are more fundamental or exploratory in nature. Thus the methodology presented here not only enables the user to assess (with a higher degree of precision) efficiency of budget expenditures on applied R&D projects – especially when framed as public-private partnership – but also to develop a basis for a more ambitious all-encompassing integrated way to assess economic value of scientific research regardless of its type. It is important to note that methods of financial analysis in general, and the proposed method of evaluating the efficiency of budget expenditures on applied research and development, in particular, are potentially well adapted (algorithmized) for digital environment which allows them to be used in the framework of digital economy platform.

7. Directions for further research
Directions for further research are: proposed model testing in capacity of tool enabling assessment of efficiency of budget expenditures for applied research and development and development of proposals for development of information system that would: accumulate all necessary data for such assessment and act as one of digital economy platform services.

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