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UTILITY APPROACH TO THE ANALYSIS AND EVALUATION OF SCIENTIFIC AND TECHNICAL ACTIVITIES

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Abstract

The scientific research is devoted to the application of the utility approach to the study of socio-economic processes occurring in the scientific and technical sphere. It is shown that one of the reasons for the inconsistency of scientific and technical progress is the cost (cost) method of assessing its effectiveness, which consists in identifying costs with results and ignoring the usefulness of its achievements. The target (useful) result of the functioning of the scientific and technical sphere should be considered not the maximization of R & D costs and not even the scientific and technical information obtained as a result of them, but a change (improvement) in the structure (quality) of GDP. At the same time, for the quantitative assessment of the GDP structure, the indicator of the level of technological effectiveness of the economic system is proposed for use, and as another useful criterion for the efficiency of the above-mentioned sphere – an increase in the utility coefficient of R & D costs and the procedure for its calculation is determined. The dynamics of the utility coefficient of R & D costs is also shown both in the Republic of Belarus and in the Russian Federation. Based on the analysis of statistical information available in the public domain on the development of the scientific and technical sphere in a number of technologically advanced European countries, it was proven that the useful characteristics of its functioning are as significant as traditional cost indicators, such as the science intensity of GDP and others. Based on this, appropriate recommendations were given on the development and implementation of a strategy for technological catch-up as a tool not only for strengthening the technological security of the state, but also for overcoming global contradictions generated by scientific and technical progress.

Keywords: scientific and technique progress, scientific and technical sphere, scientific and technical activity, scientific and technical information, level of processability, R & D costs, utility, R & D costs utility ratio, technological safety.

ПОЛЕЗНОСТНЫЙ ПОДХОД К АНАЛИЗУ И ОЦЕНКЕ НАУЧНО-ТЕХНИЧЕСКОЙ ДЕЯТЕЛЬНОСТИ

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Реферат

Научное исследование посвящено применению полезностного подхода к исследованию социально-экономических процессов, происходящих в научно-технической сфере. Показано, что одной из причин противоречивости научно-технического прогресса является затратный (стоимостной) метод оценки его эффективности, заключающийся в отождествлении затрат с результатами и игнорировании полезности его достижений. Целевым (полезным) результатом функционирования научно-технической сферы должна считаться не максимизация затрат на НИОКР и даже не полученная в их результате научно-техническая информация, а изменение (улучшение) структуры (качества) ВВП. При этом для количественной оценки структуры ВВП предложен к использованию показатель уровня технологичности экономической системы, а в качестве еще одного полезностного критерия эффективности функционирования вышеуказанной сферы – увеличение коэффициента полезности затрат на НИОКР и определен порядок его расчета. А также показана динамика коэффициента полезности затрат на НИОКР как в Республике Беларусь, так и в Российской Федерации. На основе анализа статистической информации, размещенной в открытом доступе, о развитии научно-технической сферы ряда технологически развитых европейских стран было доказано, что полезностные характеристики ее функционирования столь же значимы, что и традиционные затратные показатели, такие как наукоемкость ВВП и другие. Исходя из этого, даны соответствующие рекомендации по разработке и реализации стратегии технологического наверстывания в качестве инструмента не только укрепления технологической безопасности государства, но и преодоления порожденных научно-техническим прогрессом глобальных противоречий.

Ключевые слова: научно-технический прогресс, научно-техническая сфера, научно-техническая деятельность, научно-техническая информация, уровень технологичности, затраты на НИОКР, полезность, коэффициент полезности затрат на НИОКР, технологическая безопасность.

Introduction

Modern global economic processes have a specific impact on scientific and technological progress in different countries of the world, including Belarus and friendly countries, which is significantly different from what it was 2–3 years ago. Among the main features of the current stage of development of the earth's civilization, the following should be mentioned first of all:

1) digital transformation of the economy and society as a modern phase of industrialization – a permanent process of equipping them with modern technical devices (in this case, with digital software control) [1, 2, 3];

2) an unprecedented aggravation of global contradictions in the development of the earth's civilization caused by scientific and technological progress, including raw materials, energy, environmental, food, demographic, migration, military and other similar problems in their scale [4, 5, 6];

3) a sharp complication of the geopolitical situation on the planet, including the introduction of political and economic sanctions by some countries against others, including the unleashing of a technological war by Western countries against Belarus, Russia and other powers defending their sovereignty as a process of excommunicating them from access to Western high-tech products and technologies for their production [7, 8, 9];

4) an objective need to modernize the domestic economy and implement an active industrial policy in Belarus and other friendly states [10, 11, 12].

The above and some other circumstances dictate the need to accelerate the technological development of the Belarusian and Union (meaning the Union State of Belarus and Russia) economy. Unfortunately, there are a number of serious obstacles along this path, the main one of which is, perhaps, the cost-based, inherently expensive approach to assessing socio-economic processes, including the analysis of the functioning of the scientific and technical sphere [13].

In the most general sense, the term "cost approach" implies the fact, which generally lies on the surface, that due to the insufficient theoretical development of the category of "utility" and, most importantly, the objective difficulties of its quantitative measurement, economists prefer to

focus their attention on the cost characteristics of economic goods associated with cost analysis. At the same time, their utility parameters are not considered in detail, since it is believed that this function is carried out in practice by free markets instead of economists, "trained" to deprive those who produce less useful goods of profit and to reward those whose products better satisfy consumer demands [13]. At the same time, however, it should be understood that even profit, which the absolute majority of modern economists perceive as a result exceeding costs, from the standpoint of classical political economy represents only a part of the costs of surplus labor of hired workers. Thus, it turns out that the competitive-market capitalist doctrine of development, which places the maximization of profit and its derivatives at the forefront, in reality orients the economy and society as a whole toward an endless increase in costs, which in fact leads humanity to a global conflict with nature and a general environmental catastrophe.

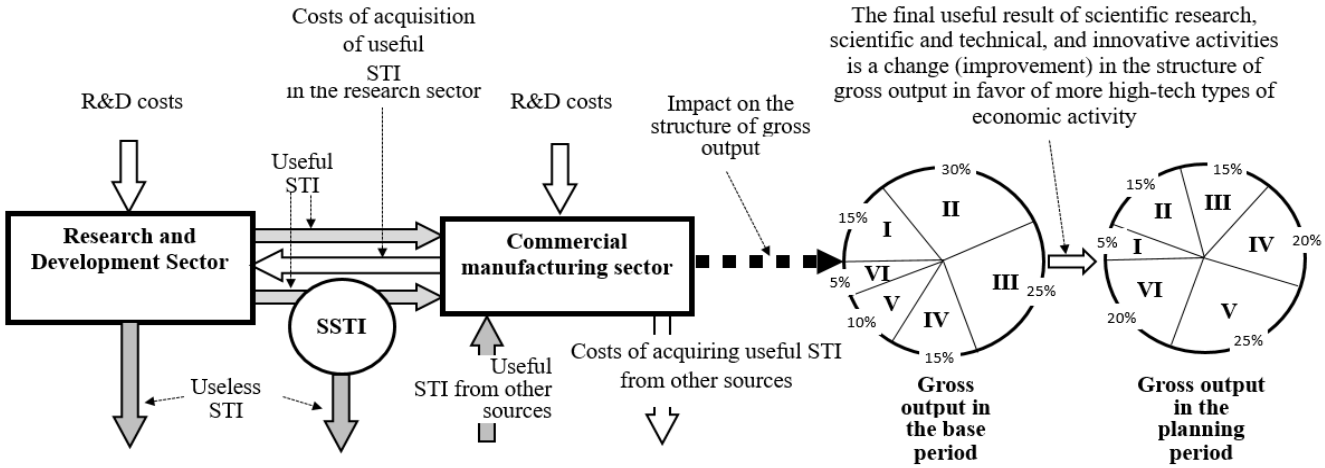
The above circumstances at the planetary level make it urgent to search for (develop) a new anti-crisis (anti-cost, useful in its meaning) economic scientific and educational paradigm capable of leveling and even overcoming the complex of the above-mentioned global contradictions of human development caused by the conflict of its insatiable needs and the possibility of their satisfaction by nature. Since many researchers, not without reason, believe that the complex of the above problems is caused by scientific and technological progress, it seems that the use of a useful approach to assessing the functioning of the scientific and technical sphere is the path that can finally lead humanity to a trajectory of truly sustainable development. In this regard, we are deeply convinced that a useful, anti-cost in its essence approach to the analysis of socio-economic processes and, above all, the scientific and technical sphere should become the main direction of further development of economic theory in the 21st century and the third millennium.

Results and their discussion

One of the areas of implementation of the research work at BSU "Development of the high-tech sector of the economy as a factor in ensuring scientific and technological security of the Republic of Belarus" (task of the State Program of Scientific Research "Economy and Humanitarian Security of the Belarusian State" for 2021–2025) is the development of a utility method for studying scientific and technological progress. Unfortunately, it must be admitted that the analysis and assessment of its achievements is still dominated by the cost approach characteristic of economists, which boils down to identifying the costs and results of economic (in this case, scientific and technical) activities. A typical example of the manifestation of the cost approach to the study of the scientific and technical sphere is, for example, the tradition that has developed among economists and officials to consider (define, assign) the science intensity of gross output (GDP, GRP, etc.) as the main integral criterion for its development [14]. For example, in the Program of Socioeconomic Development of the Republic of Belarus for 2021–2025, one of the most pressing tasks is identified as "achieving the level of innovative development of the leading countries of Eastern Europe based on the implementation of the intellectual potential of the Belarusian nation by improving the conditions for the implementation and stimulation of scientific, technical and innovative activities, and the accelerated development of innovative infrastructure. This task involves increasing the science intensity of GDP to a level of at least 1 percent" [15].

The results of our studies show that the GDP science intensity indicator, being a typical cost parameter of the scientific and technical sphere, does not always adequately reflect the actual level of its development. The fact is that in practice, costs are never fully transformed into the final useful result, for example, due to their excessively large useless losses. It is no coincidence that in engineering sciences, the criteria for the efficiency of technical systems are the efficiency coefficients (EC) and useful use coefficients (UUC), since with low values of these clearly useful characteristics, any increase in the consumption of energy consumed by equipment will be equivalent to its banal waste. In order to exclude similar "waste" in the scientific and technical sphere, we propose to replace (or even better in addition to) the traditional cost criteria for its assessment using utility parameters that focus attention not on costs, but on the final useful result. Of course, the most difficult scientific problem is the definition and quantitative measurement of this very useful result, which was already discussed above.

In the process of solving the set tasks, we managed to develop a methodology and technique for quantitative determination of the final result of scientific and technical activity. In our opinion, its final useful result is not the costs of R & D or even the scientific and technical (including useful) information obtained in the process of their implementation, but a change (improvement) in the structure of gross output in favor of the products of more high-tech types of economic activity (Figure 1).



Designations:

STI – scientific and technical information; SSTI – (national, state) system of scientific and technical information; R & D – research and development work; I, II, III, IV, V, VI – contributions to gross output of types of economic activity related to the first through sixth technological waves, respectively

Figure 1 – Illustration for determining the final useful result of scientific and technical activity

Source: own development of S. V. Makarevich under the scientific supervision of Professor V. F. Bainev

For an objective quantitative measurement of this improvement, we proposed a special indicator of the level of technological readiness of an economic system (enterprise, industry, region, country) TL ("technological level"), which characterizes the average weighted contribution of specific types of economic activity to its gross output, taking into account their typification by the level of applied technologies based on the European Classification of Types of Economic Activity. This indicator is a real number from the range from 1 to 6 (distinguished technological structures), reflecting the average weighted technological structure of the economic system. The methodology and techniques for determining this indicator are described in detail in [16, p. 213–226], and the results of his calculations for Belarus, Russia, China and the assessment for the G7 countries are presented in Figure 2.

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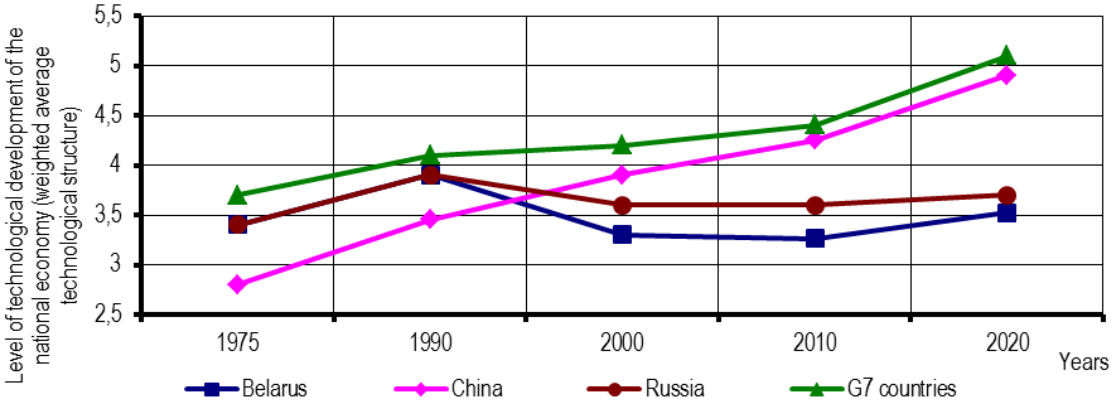

Figure 2 – Dynamics of the level of technological development of the national economy of some countries of the world [16, p. 221, 225–226]

Using and developing the utility method of assessing scientific and technical activity and, in particular, relying on its central position that its final useful result is manifested in the form of an improvement in the structure of gross output, we came to some important conclusions. First of all, we had to admit that only that part of scientific and technical information that has been tested (verified) by commercial interest should be considered useful (see Figure 1). The fact is that, firstly, it is the commercial (private and public) sector that produces material goods, provides services, performs work and thereby directly influences the structure of gross output of the national (industry, regional) economy, directly setting the level of its technology. And secondly, only commercial interest can, in our opinion, be considered a more or less reliable filter that cuts off useless expenses from useful expenditures on R & D [17, p. 30].

Analyzing the information presented in Figure 1, it is necessary to specifically characterize the role assigned to the national (state) system of scientific and technical information (SSTI). This role, in our opinion, consists of reducing transaction costs (expenses) in the transfer of scientific and technical information from generators to its consumers and, accordingly, facilitating access to it by commercial production organizations, which contributes to improving the parameters of the functioning of the scientific and technical sphere and increasing the quality of GDP as a whole.

Taking into account the above, we proposed to use several useful indicators characterizing scientific and technical activity, among which the most significant are:

– useful R & D costs, which are the sum of commercially verified (implemented in the commercial private and public sector) R & D costs and similar costs that led to a change in the structure of fixed assets in the non-profit sectors of the national economy – in the non-profit public sector, the higher education sector and the non-profit organizations sector. In our opinion, the composition of useful R & D costs should include costs for special equipment and capital costs arising in the specified non-profit sectors, since these costs also directly affect the structure of fixed assets of the national economy and its gross output [18, p. 45];

– the R & D cost utility coefficient, calculated as the ratio of useful R & D costs to the total volume of R & D costs. This coefficient, being close in its essence to the technical efficiency indicators Efficiency (KPI), reflects the share of expenditure on research and development, which contributed to the change in the structure of gross output, in their total volume [18, p. 46].

Based on the relevant statistical information for Belarus and Russia, it was possible to analyze the dynamics of the R & D cost efficiency coefficient in comparison with the science intensity of GDP for the period from 2017 to 2023 (Table 1).

Table 1 – Dynamics of some utility and cost indicators reflecting the efficiency of the scientific and technical sphere in Belarus and Russia

Indicator	Years						
	2017	2018	2019	2020	2021	2022	2023
Republic of Belarus							
R & D Cost Utility Ratio	0,730	0,728	0,713	0,696	0,681	0,668	0,713
Science intensity of GDP, %	0,58	0,61	0,58	0,54	0,46	0,47	0,58
Russian Federation							
R & D Cost Utility Ratio	0,913	0,884	0,899	0,888	0,866	0,803	0,627
Science intensity of GDP, %	1,10	0,99	1,04	1,10	0,99	0,94	1,00

Source: authors' own development based on data from [19, 20].

The data in the table show that in the last years under study, a systematic increase in R & D costs in monetary terms has been noted for both analyzed countries, but the share of useful costs in their scientific and technical sphere was shown only by the Republic of Belarus. And in the Russian Federation, a strong decrease in useful costs in the scientific and technical sphere is observed, which indicates a decreasing efficiency of using the expended resources.

Proposing the R & D expenditure utility coefficient for use as an alternative (supplement) to the traditional indicator of GDP science intensity, we carried out a correlation and regression analysis of the impact of these two significant parameters on GDP and investment activity based on statistical data from seventeen Western technologically advanced countries whose share in the global economy is relatively comparable to Belarus. Thus, the sample included Hungary, Germany, Denmark, Latvia, Lithuania, the Netherlands, Poland, Romania, Serbia, Slovakia, Slovenia, Finland, France, Croatia, the Czech Republic, Sweden and Estonia. The time range of the analysis extended from 2010 to 2021. The GDP indicator, which quantitatively characterizes gross output, and the volume of investment in fixed capital, a parameter that has a direct impact on changes in the structure (quality) of GDP, were selected as dependent parameters (regressors). Let us recall that within the framework of the utility method of research into scientific and technical activity that we are developing, it is the change in the structure of gross output that is its final useful result.

As a result of this part of the study, a system of regression equations was obtained [21, p. 23]:

$$\begin{cases} ВВП = 6\,097\,324{,}1 \cdot КПЗ_{НИОКР} + 847\,081{,}2 \cdot Н_{ВВП} - 4\,036\,471{,}6; \quad R^2=0{,}98; \quad (1) \\ \quad (p) \quad (0{,}0004398) \quad (0{,}0057439) \quad (0{,}0000021) \\ ИнвОК = 15\,789{,}0 \cdot КПЗ_{НИОКР} + 1676{,}1 \cdot Н_{ВВП} - 11\,168{,}7; \quad R^2=0{,}97, \quad (2) \\ \quad (p) \quad (0{,}00059) \quad (0{,}02581) \quad (0{,}0000018) \end{cases}$$

where *ВВП* – gross domestic product, million euros; *КПЗ*$_{НИОКР}$ – R & D cost efficiency ratio; *Н*$_{ВВП}$ – science intensity of GDP, %; *ИнвОК* – volume of investments in fixed assets, million euros.

It is obvious that the regression equations (1) and (2) obtained by us characterize the impact of the regressors – cost (science intensity of GDP) and utility (utility coefficient of R & D expenditures) characteristics of scientific and technical activities on the quantitative and qualitative parameters of GDP of the countries we analyzed. Comparison of the values of the coefficients for the regressors allows us to conclude that both science intensity of GDP and the utility coefficient of R & D expenditures affect the qualitative and quantitative parameters of gross output. At the same time, the specified impact from the utility coefficient of R & D expenditures is quite comparable with a similar impact exerted on dependent variables by science intensity of GDP. Consequently, when analyzing and planning scientific and technical activities, it is important to take into account (increase) not only the indicator of science intensity of GDP traditionally used for these purposes, but also the utility coefficient of R & D expenditures. We are convinced that the use of the new useful criteria and indicators for assessing the scientific and technical sphere that we have proposed will increase the efficiency of the resources it uses and will serve as a stimulating factor for the scientific, technical and technological development of Belarus and other friendly countries.

Conclusion

The unprecedented aggravation of global problems of civilization, the associated sharp complication of the geopolitical situation on the planet and, finally, the need to form a technetronic economy, urgently dictate the search for (development) of a fundamentally new socio-economic scientific and educational paradigm. It seems that the solution to this problem is possible through a wider use of useful criteria for assessing the achievements of scientific, technical and socio-economic progress instead of traditional cost indicators, which, alas, are oriented towards increasing costs. For Belarus and Russia, for a number of reasons, this is of vital importance. The fact is that the technological lag between our countries and their strategic competitors, against the background of tough technological and other sanctions applied to them, has designated a clear threat to their economic and national security.

To overcome this threat, we consider it necessary:

– to officially designate the strategy of accelerated technological development (strategy of technological catch-up) as the main state strategic priority of Belarus and Russia, subordinating its implementation to the monetary, budgetary, tax, scientific and educational, etc. policies of both countries;

– within the framework of the implementation of this strategy, the indicator of the level of technological development of the national economy of both our countries should be made not just statistically taken into account, but a strategically priority target parameter of their development, and we should also move to planning and strict control over the growth of this indicator in order to systematically reduce and eliminate the technological lag we have allowed. In particular, we consider it necessary to set the governments of Belarus, Russia and their Union State the task of ensuring a systematic increase in the indicator of the level of technological development of the union economy from its current value of 3.5–3.7 (see Figure 2) to, say, 4.5 by 2030 and 5.0 by 2035;

– the increase in the indicator of science intensity of GDP must be necessarily linked to the increase in the coefficient of utility of R & D expenditures, giving the utility parameter of development of the scientific and technical sphere significant importance.

It seems that a wider use of the utility approach to the study of socio-economic processes opens up great prospects not only for increasing the efficiency of the scientific and technical sphere, but also for solving global problems of earthly civilization generated by scientific and technical progress.

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