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The criterion for managing the sustainable use of natural resources

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***Abstract*—The increasing consumption of natural resources in the world economy in the twenty-first century can lead to a global environmental crisis, so, effective management of their sustainable use is necessary to increase resource productivity. To this end, a variety of key indicators are proposed, mainly at the national level, but they are not, firstly, associated with the lower levels of the hierarchy in management of economic production systems. Secondly, they do not reflect the need for business to introduce technological innovation that can reduce the material intensity of production. The aim of the work is to identify the ways to address these shortcomings and develop a new criterion indicator. To coordinate the economic interests of the main subjects of management in the market economy, a methodological approach is proposed, which consists in distributing outcomes and costs in using production factors at all hierarchy levels of economic management. A proportional relationship between material intensity and capital intensity of production, determining the impact of technological progress on the efficiency of economic resources has been established. As a result, the analytical relationship between the efficiency of natural resources use and the efficiency of individual firms introducing technological innovation in their activity has been revealed. It is shown that the economic efficiency of technological innovation should be calculated on the basis of the proposed new type of economic analysis, namely, the investment and innovation analysis.**

Keywords—natural resources, sustainable use, productivity, efficiency, effective management, technological innovation, criterion indicator, factors of production.

I. INTRODUCTION

The basis of the sustainable economic development is the effective management of natural resources, which is now becoming increasingly important, as, on the one hand, since the second half of the XX century, the amount of all the types of natural resources used has increased dramatically (from 22 billion tons in 1970 to 70 billion tons in 2010 [1]). At the same time, from 1970 to 2008 mining has doubled and in the decades to come this growth will continue [2] mainly due to the intensive development of South-East Asia countries, which will be facilitated by the emerging trend for prices for these resources to increase [3]. On the other hand, material and energy productivity is increasing in developed countries. Thus, according to [4], in the European Union (EU-15) material productivity increased by 94 %, and energy productivity – by 73 % from 1970 to 2007. As a result, in these and other EU countries (EU-28) domestic consumption of materials tends to decrease (except Romania) [5]. On average, it decreased by 9.7% in all EU-28 countries from 2000 to 2017. At the same time, within the framework of the EU development strategy called "Europe-2020", the important "Resource-Efficient Europe" initiative to further improve the level of material productivity has been developed [6]. In general, however, the material use efficiency has been reducing since 2000 [1], although not only do the leaders in the policy of increasing the efficiency of natural resource use (Germany and Japan), but also China set a decrease in the per capita level of material use as strategic goals for their further economic development [7]. Unfortunately, in Russia, according to UNEP [8], there is a tendency to increase this level.

Thus, in order to prevent the global environmental crisis associated with the increase in the use of natural resources in the future, since, on average, more than 96% of all extracted resources do return to the natural environment as production and consumption wastes [9], it is necessary for all countries to have targets for reducing the per capita consumption of natural resources by accelerating the increase in the efficiency of their use. However, there are two interrelated problems to be solved. Firstly, such quantitative targets should be determined on the basis of the use of relevant indicators, taken as a basis by the world community as a whole, or at least at the level of individual countries for domestic use. Secondly, these indicators should aim governments and the business community at the need to improve technologies for the use of natural resources and stimulate the introduction of new technologies, as it is the only way to significantly improve resource utilization performance. Unfortunately, these problems are solved by different groups of scientists and specialists, so there is no obvious connection between them. The purpose of this paper is to study this relationship and find the ways to solve the second problem.

II. MATERIALS AND METHODS

The first task is being solved - more or less successfully - over the past two decades in the EU countries and in Japan, where at the national level material flows are taken into account and indicators of domestic material consumption (Germany and other EU-28 countries) or extraction of raw materials and their further use are determined (Japan) [10,11]. This is then used to determine the productivity of materials or resources as the ratio of gross domestic product (GDP) to domestic material consumption (DMC) or to the volume of raw materials produced and used (RMI). The

amounts of materials and resources are calculated in physical units. Such indicators are useful for analyzing the dynamics in material resource productivity at the national level and for cross-country comparisons of such dynamics to identify relevant trends, although the objective calculation of these and similar indicators is still hampered by some methodological barriers. However, this requires multi-level management of sustainable use of natural resources within countries, with sustainability criteria being used in accord with other levels at each level of the management hierarchy [7]. Accordingly, there is a great variety of such criteria and it is necessary to classify them [6], which is also still an unsolved problem.

The solution of the second problem is associated with the practical implementation of the theory of endogenous economic growth and the definition of the contribution of technological progress to the development of economic production systems within the state at the macro, meso and micro levels [12]. Unfortunately, no significant progress has been achieved in this direction, because, firstly, in the theory itself there are various scientific directions that evaluate this contribution in different ways and mainly at the national level [13]. Secondly, there are no key indicators that can be used consistently at all levels of the management hierarchy. As a result, for example, to assess the effectiveness of innovation, especially technological, in foreign countries several dozen different indicators are used [14,15], including the number of patents obtained and used, the amount of costs for technological development and the like. However, it is technological innovation that is the link between the need and the desire of states to increase the productivity of resources used in the economy and the ability to do this by businesses in introducing material- and energy-saving technologies. Unfortunately, in practice, these desires and opportunities often diverge, as the economic interests of the state and business in a market economy are contradictory. The state is interested in the sustainable use of natural resources to prevent the environmental crisis and other possible unpleasant consequences for the entire national economy, and business is interested in strengthening competitiveness and making a profit. However, there is a point of conjugation of these interests, since with the introduction of material- and energy-saving technologies by firms - that is, a decrease in the material intensity of production - the share of profit in each ruble of sales of business products can increase (ceteris paribus). Accordingly, firms increase their contribution to the GDP of the state, as the share of gross value added increases in the value structure of sales. As a result, the state moves on an intensive type of economic growth while reducing the pressure on the natural environment, as, firstly, with a decrease in the material intensity of production, business will need less material resources to be used. Secondly, the overall amount of waste due to the reduction of consumption rates of material resources will reduce too. Thirdly, the new technologies will allow production and consumption waste already accumulated and stored in the environment to be processed in a cost-effective way.

To combine the above interests of the state and business we have developed an appropriate methodological approach, the essence of which is as follows. If we consider all groups of economic resources as factors of production and include human activity in costs or outcomes, it turns out that all factors, except for natural resources, when used, are included in the outcomes, since the cost of hired labor, the cost of capital and the cost of entrepreneurial ability directly form the cost of final goods - gross domestic product (GDP), that is, they are its components. Included in GDP is also the cost of intellectual capital through the amortization of intangible assets. At the same time, land as a factor of production, that is, natural resources as raw materials, fuel and energy forms the value of the intermediate product (IP) which is necessary for the production of the final product. Accordingly, in our opinion, the criterion of the effectiveness in managing sustainable use of natural resources at the national level can be the expression:

$$E = ГДП / ИП, \quad (1)$$

which is for the level of a manufacturing firm, an industry or the type of production activity represented as:

$$E = \varsigma A / MX, \quad (2)$$

where VA is the amount of value added in the sales value of the company;

MC is material costs for raw materials, fuel and energy in the cost of sales.

When calculating per ruble cost of sales of firms' products, this formula is converted into the following form:

$$E = \Sigma\eta\varsigma A / MI = (1 - MI) / MI = MП \square 1, \quad (3)$$

where ShVA is the share of value added in cost of sales of firms' products

MI is material intensity of product,

MP is material productivity.

The maximization of the value of such a criterion indicator for the management of sustainable economic development, firstly, allows the coordination of the economic interests of the main subjects of management – the state, the population of the country, including employees of firms and owners of firms, as they will all be interested in increasing the outcomes of economic activity. At the same time, it becomes possible to control the specific distribution of the outcomes from the activities of individual microeconomic systems among the state budget, employees' wages and the profits of the firms' owners.

Secondly, this indicator shows the activity of economic systems at different hierarchy levels in protecting the environment , so its application will ensure the sustainable use of natural resources.

Thirdly, this indicator shows the need for the transition of economic systems to an intensive path of development and technological modernization of production to reduce material consumption and increase material productivity, which is very important for the economies of developing countries, including Russia

III. Results and Discussion

From the point of view of economic theory, the application of the criterion for managing the development of macro, meso and microeconomic (at the level of firms) systems allows, firstly, the contradictions of macro and microeconomic analysis to be overcome/. Secondly, the postulates of institutionalism turn into specific management decisions for particular regions, economies, economic activities and firms, as all the necessary data for calculating the values of this indicator are available in the accounting statements of firms and the system of national accounts.

However, to determine the prospects and opportunities of the state and business for the transition to technological modernization of production, which is extremely important for the modern economy of Russia, it is necessary to realize that not always and not every technological innovation will result in a decrease in the material consumption of products when they are used in production.

We have analyzed accounting and statistical data on the activities of several leading industrial enterprises located in the Northern regions – the subjects of the Federation as well as three types of industrial activity in all thirteen regions of the North and the Arctic of Russia for the period from 2005 to 2016. It is obvious that the development of economic production systems at any level of the hierarchy of management (macro, meso and micro) , depending on the economic efficiency of the use of production resources – material, labor and physical capital (fixed assets) can be carried out in four directions: innovative-effective, innovative-inefficient, non-innovative-effective and non-innovative and inefficient; the first and fourth direction of development can be implemented in two versions [16]. This is due to the fact that between the capital intensity (CI) and the material intensity (MI) of production there is a proportional relationship established by us, which is reflected by the coefficient of proportionality k., that is:

$$\kappa = XI / MI = MП / XП, \quad (4)$$

or

$$MП = \kappa * XП, \quad (5)$$

where CP is capital productivity of production.

The value of this coefficient can decrease or increase depending on the degree of renewal of fixed assets of firms and, above all, on the degree of renewal of their active part, that is, machines, equipment and vehicles. In the work [17], we have shown in the form of a matrix that each direction and variant of the direction of development corresponds to an increase or decrease in the values of the three indicators of firms' development : material intensity, capital productivity and coefficient k. It is clear that the best way to develop firms is innovation-effective direction, when the values of all three indicators increase simultaneously , and it is possible only by introducing new technologies into production.

Thus, increasing the efficiency of management of sustainable use of natural resources directly depends on the degree of technological modernization of production, because:

$$E = MП \square 1 = \kappa * XП - 1 \quad (6)$$

Thus, according to the trends in the values of indicator k and CP, it is possible for any production system to justify the feasibility of its technological renewal. More detailed calculations of the time when to start introducing technological innovation on the basis of comparing the lost benefits from inefficient or less efficient use of production resources and borrowing costs can be performed with the analysis of our graphical model of the life cycle of technological development of firms and using the procedures of a new direction of economic analysis: investment and innovation analysis [17].

IV. Conclusion

1. In the twenty-first century, the world economy continues to experience a quantitative increase in the use of natural resources, mainly due to the increase in economic growth in the countries of South-East Asia, while reducing efficient use of resources.. At the same time, over the past decades, a significant increase in the productivity of material resources has been achieved in developed countries of Europe and in Japan.

2. In order to prevent a global environmental crisis, it is necessary to improve the management of sustainable use of natural resources. However, it is impossible without the definition of key indicators, the target values of which could be used in the development of appropriate strategies for the economic development of countries. In addition, such criteria should ensure the coordination of the economic interests of the state and business, which is possible due to introducing new technologies for the use of natural resources by businesses.

3. It is proposed to use as such a criterion the ratio of GDP to intermediate product at the national level and the ratio of value added to material costs at the meso and micro levels, including the level of individual firms.

4. The proportional relationship established between the capital intensity and material intensity of production shows that the effective use of natural resources is possible only with the introduction of technological innovation by firms, but this requires a new type of economic analysis: investment and innovation analysis.

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