СТОПАНСКА АКАДЕМИЯ „Д. А. ЦЕНОВ“ – СВИЩОВ

КАТЕДРА „СТАТИСТИКА И ПРИЛОЖНА МАТЕМАТИКА“

КРЪГЛА МАСА
С МЕЖДУНАРОДНО УЧАСТИЕ

СТАТИСТИЧЕСКИ ИЗМЕРЕНИЯ НА РЕГИОНАЛНИТЕ РАЗЛИЧИЯ И НЕРАВЕНСТВА МЕЖДУ СЕВЕРНА И ЮЖНА БЪЛГАРИЯ

Свищов, 16 октомври 2020 г.

Сборник с доклади

Кръглата маса е организирана в изпълнение на научноизследователски проект №13-2020 „Статистически измерения на регионалните различия и неравенства между Северна и Южна България“, финансиран със средства по Наредба на МОН за насърчаване на научно-изследователската дейност

Академично издателство „Ценов“
Свищов
2020

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ISBN 978-954-23-1892-7

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КРЪГЛА МАСА
С МЕЖДУНАРОДНО УЧАСТИЕ

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Свищов, 16 октомври 2020 г.

Сборник с доклади

Кръглата маса е организирана в изпълнение на научноизследователски проект №13-2020 „Статистически измерения на регионалните различия и неравенства между Северна и Южна България“, финансиран със средства по Наредба на МОН за насърчаване на научно-изследователската дейност

ISBN 978-954-23-1892-7

Издателство и печат: Академично издателство „Ценов”
Свищов, ул. Градево № 24

ASSESSMENT OF THE ECONOMIC EFFICIENCY OF THE ENVIRONMENTAL COSTS

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Abstract: *The effectiveness of the environmental costs based on statistical modelling of the dependence between the air pollution level and the current costs and capital investments on environmental measures is evaluated in the article. This method was chosen because at the macro level, the current performance indicators (cost-effectiveness ratio) are not indicative. The cost efficiency can be estimated using the parameter a_1 in the power model as the coefficient of elasticity and shows how the amount of air pollution changes with an increase of 1% of the amount of environmental costs.*
Taking into account the obtained results, there are generalized the directions of the financing system improvement of the ecological measures that will allow to provide balanced ecological and economic development at various levels of economic activity.

Key words: *economic efficiency, environmental costs, statistical modelling, air pollution.*

JEL: *C 10; C 15; C 81.*

Introduction: Against the background of the economic crisis in Ukraine, the financing of the state targeted programs is constrained by significant restrictions on the size of the country's expenditures and changes in the priorities of economic development. As a result, only half of the planned funds are allocated from the budget for the implementation of environmental programs at best. In addition, the situation is complicated when financial resources are allocated at the end of the budget year. This leads to the impossibility of effective implementation of tasks and postponement of their implementation. The program-targeted method of managing the expenditure part of the state budget, which provides for the possibility of attracting alternative sources of funding, could help to partially solve the problem. However, to date there is no clear mechanism for activating investors. It should be noted that the effectiveness of financing directly targeted

environmental programs depends on achieving high economic and social results through the optimal use of resources from all sources of funding.

The essence and basic approaches to assessing the effectiveness in general, as well as in particular the effectiveness of financing environmental measures at the macro level have been studied in the works of many domestic and foreign scientists R. Coase, E. Moren, G. Haken, M. Petrushenko, V. Karamushka, L.Yeliseeva , O. Kharlamova, M. Khilko, S. Khlobistov, L. Sheludchenko, V.Shmandiy, L.Yatsenko and others.

At the same time, the statistical evaluation issue of the environmental costs effectiveness remains open for the scientific discussion and requires further research in this direction.

In the context of the economic efficiency of sustainable development, taking into account the environmental safety concept, these issues are fully disclosed in the monograph [1]. Also it is well known that efficiency essentially reflects the ratio of effect or result to resources or costs. That is, there is a major problem of the impact assessing of a particular factor and responsibility for creating an environmental threat to a particular person, enterprise, region and the state as a whole.

Taking into account the principles and limitations of the study, this paper evaluates the effectiveness of environmental payments based on statistical modelling of the dependence of the final result (effect) on current and capital expenditures on environmental protection measures in Ukraine. This method was chosen due to the fact that at the macro level, the ratio of the result to cost can not reflect the type and direction of the relationship between them and is quite indirect. Therefore, in the economic literature there are the following approaches to assessing efficiency [1, p. 73]: cost, resource and quality of activity or performance of works.

The cost approach involves comparing the outcome of activities with its costs for certain items (capital costs, labor costs, material costs, innovation costs), and so on. However, this approach is not always appropriate, as in practice the results of environmental measures are taken into account for a maximum of one year, and certain types of resources, such as fixed assets, transfer their value to products for many years, although they are constantly involved. In such cases, use the resource approach, when the result is compared with the resources involved in the production process. The approach to assessing the effectiveness of the work quality or work performance is used in case of difficulties with a clear indication of the result and costs of the process. This approach is used to assess the effectiveness of organizational and technological, technical and technological, organizational and administrative level.

It is known that capital investments in environmental protection are funds for the acquisition of new and used ones, or the manufacture of tangible and intangible assets for their own use, the cost of capital repairs and modernization, which are carried out to protect the natural environment [3].
Current costs of environmental protection are the costs incurred for the maintenance (maintenance and operation) of the object (fixed assets for environmental purposes) in working order, and are part of the costs of the current period [3].
The current costs of environmental activities include: funds to pay workers and professionals engaged in environmental activities; the cost of purchasing materials and raw materials needed for special construction, reclamation; ensuring the operation of treatment plants and other environmental equipment; fuel and electricity costs; costs for the purchase of perishable tools, equipment, etc.
In order to determine the relationship between costs and investments in appropriate measures in the environmental field in this paper the correlation and regression analysis has been used.
Dependence models allowed determining the funds effectiveness to improve the environmental condition of Ukraine. Models of dependence of pollutant and carbon dioxide emissions into the atmosphere have been constructed, as this is one of the components in current environmental costs (Fig. 1).
As it can be seen, the largest share of current costs is accounted for the waste management of hazard classes I-III (36.5%). 28.9% of current costs are spent on return water treatment. Atmospheric air pollution is also one of the most acute environmental problems; its share in costs is 16.6%. Despite a certain decline in production in Ukraine, the level of air pollution in large cities and industrial regions remains consistently high. To assess the effectiveness of current costs and capital investment in air protection measures, dynamic regression models for 2007-2019 were built. The result is emissions of pollutants into the atmosphere, as factors are used costs and capital investment for air protection.

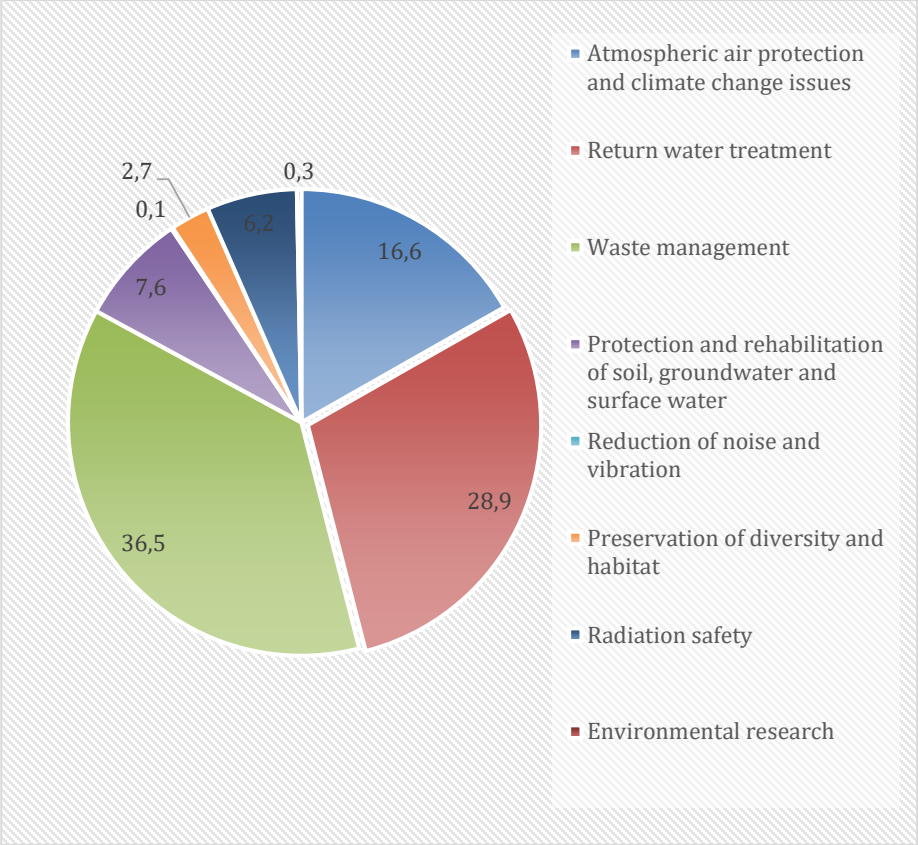

Fig. 1 The structure of the current costs for environmental protection by types of environmental measures in 2019, % [calculated by the author on the basis of 3].

The dynamics of emissions of carbon dioxide pollutants into the atmosphere and the costs and investments in air protection and climate change are given in table 1.

In the first stage, the presence of a relationship between performance and factor characteristics, as well as the presence of multicollinearity. For this purpose, even correlation coefficients were calculated, which are given in table. 2.

Table 1

Dynamics of pollutant and carbon dioxide emissions into the atmosphere and costs and investments in air protection and climate change

Years	Emissions of pollutants and carbon dioxide into the atmosphere, thousand tons y^{air}	Current costs for air protection and climate change, UAH million x_1^{air}	Capital investments in air protection and climate change, UAH millionx_2^{air}
2007	7380,0	1141,9	1379,3
2008	7210,3	1350,0	1476,3
2009	6442,9	1035,2	1273,8
2010	6678,0	1314,8	1139,9
2011	6877,3	1475,4	2535,6
2012	6821,1	1341,5	2462,7
2013	6719,8	1415,8	2411,9
2014	5346,2	1238,6	1915,1
2015	4521,3	1519,8	1422,9
2016	4686,6	1760,6	2502,8
2017	4230,6	2104,3	2608,0
2018	4121,2	2897,7	3505,9
2019	4119,0	2963,9	4276,8

Source: data from the State Statistics Service of Ukraine [3]

Table 2

Matrix of paired correlation coefficients of pollutant and carbon dioxide emissions into the atmosphere and costs and investments for air protection and climate change

	y^{air}	x_1^{air}	x_2^{air}
y^{air}	1		
x_1^{air}	-0,767	1	
x_2^{air}	-0,596	0,883	1

Source [own calculations]

The matrix of paired correlation coefficients shows that there is a strong feedback between the emissions of pollutants into the atmosphere and the current costs of air protection, which indicates the feasibility of including this factor in the correlation-regression model. There is a moderate and

inverse relationship between performance and capital investment, while there is a strong direct relationship between investment and cost. This situation indicates the possibility of multicollinearity, which can negatively affect the quality of the model, so the model must exclude the factor of capital investment in air protection.

Since both z costs and capital investments are funds directed to environmental protection only from different sources, there might be a close relationship between them (correlation coefficient 0.883). Therefore, pairwise dependences were constructed. The reliability and accuracy of the models were assessed by the formal criteria for approximating the models, which are presented in table 3.

Table 3

Regression models of dependence of pollutant and carbon dioxide emissions into the atmosphere and current costs for air protection and climate change

Regression model	Linear	Quadratic	Power
Function	$\hat{y}_x^{air} = 8395{,}4 - 1{,}576x_1^{air}$	$\hat{y}_x^{air} = 11997 - 5{,}59x_1^{air} + 0{,}001\left(x_1^{air}\right)^2$	$\hat{y}_x^{air} = 380067{,}3\left(x_1^{air}\right)^{-0{,}5}$
The correlation coefficient R	-0,767	-0,800	-0,810
Coefficient of determination R^2	0,588	0,640	0,656
Least squares sum	8208423	7172332	7677268
Fisher's calculation criterion F_p	15,67	8,87	20.94
Fisher's tabular criterion $F_т$	4,84	4,10	4,84
Relative approximation error, % ε_{rel}	13,2	11,06	12,14

According to the calculated criteria it is possible to draw a conclusion about the reliability of models with 95% probability (Fisher's calculation criterion is greater than its tabular value), sufficient statistical accuracy of the models (relative approximation error less than 15%). The correlation coefficients indicate a strong inverse correlation, and the determination coefficients

explain that the variation in emissions of pollutants and carbon dioxide into the atmosphere is due to the variation of the factor under analysis in different models from 58.8% to 65.6%. The rest (34.4% - 41.2%) is the influence of other factors that are not included in the model. These conclusions allow us to apply in the analysis of all the calculated models.

According to the linear correlation-regression model, emissions of pollutants into the atmosphere are reduced by an average of 1,576 thousand tons with an increase in current costs for air protection and climate change by UAH 1 million. However, this interpretation of the model parameter does not fully explain how efficiently the costs are used. The cost efficiency can be estimated using the parameter a_1 in the power model, because it is the coefficient of elasticity and shows the change in the factor as a percentage. With increasing costs for air protection and climate change by 1%, emissions of pollutants into the atmosphere are reduced by 0.572%. This situation indicates the inefficient use of environmental costs, as their increase by 1% leads to a reduction in pollutant emissions, which is almost twice less than the required 1%.

The quadratic correlation-regression model makes it possible to trace to what level the costs of air protection can be increased in order to reduce pollutant emissions. This can be estimated by calculating the extremum point of the function to obtain the value of current costs, after which a further increase in costs will not increase the efficiency of their use. The extremum point is calculated by the formula:

(1.1) $x_1^{air} = 2848{,}4\ million\ UAH$

To do this, the derivative of the quadratic function must be equated to zero:

(1.2) $(\hat{y}_x^{air})' = 0$

(1.3) $(11997 - 5{,}59x_1^{air} + 0{,}001\left(x_1^{air}\right)^2)' = 0$

(1.4) $-5{,}59 + 2 * 0{,}001x_1^{air} = 0$

Thus, the extreme point of the function is the value of UAH 2,848.4 million. This means that a further increase of the air protection costs at the extreme point may change to the opposite situation and be completely inefficient, because with the obsolete technologies, pollutant emissions cannot be reduced. There is a need for mass implementation of new more efficient technologies that will change the trend of increasing air pollution to a stable equilibrium.

In this context, these calculations once again confirm the need to implement such areas to improve the system of financing environmental measures,

which is disclosed in more detail in the work of G. Kaletnik and S. Lutkovskaya [2]:
- further implementation of the market model elements in the public finance management. Currently, only the program-targeted budgeting method, medium-term budget forecasting, strategic planning of the main managers of budget funds are used;
- transition from indicative to medium-term budget planning, which will provide systematic budget financing of long-term environmental investment projects and improve the predictability of such expenditures in the field of environmental and natural and anthropogenic safety.
- balancing expenditures and revenues to the regional budgets. It provides for expenditures on environmental protection in amounts not less than the receipt of funds in regional budgets from the fee for the special use of natural resources, environmental tax and penalties for violations of environmental legislation. The main source of such expenditures should be the funds of polluting enterprises, which leads to the private capital attraction.
- environmental insurance in the field of environmental safety as one of the types of civil liability insurance of owners or users of high environmental hazards due to possible accidental pollution of the environment and causing harm to vital interests of third parties, which provides partial compensation for damage.

Such measures on optimization and expediency of financing will help to use financial resources in the ecological sphere more effectively.

Conclusions

Thus, ensuring the economic efficiency of the environmental measures financing will ensure balanced environmental and economic development at different levels of economic activity. In particular, at the enterprise level, the implementation of the methodology for assessing the effectiveness of air purification measures will allow to assess and ensure a balance between protection costs and actual pollution, in addition to assessing possible future threats. However, it should be taken into account that the analysis success of the factors impact in the financing environmental measures effectiveness depends largely on the quality and volume of information about its condition, which requires transparency and availability of information at the macro level.

Therefore, the proposed scientific approach can be used to assess the environmental costs effectiveness, which application allows more efficient

use of the financial resources in the environmental field and promote sustainable development.

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