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MODELING THE IMPACT OF ENVIRONMENTAL INVESTMENTS ON THE ENVIRONMENT STATE

The object of research is the level of environmental pollution by the example of Ukraine. The paper investigates the relationship between the volume of capital investment and a decrease in the level of environmental pollution. The methodological basis of the study is the fundamental foundations of economic theory, environmental protection, environmental economics, statistics and econometrics. To develop a statistical model of the relationship between environmental investment and environmental pollution, a correlation analysis is carried out using the paired regression equation, where a hypothesis is put forward that the relationship between all possible values of factorial and effective indicators is linear. The parameters of the constructed models are estimated by the least squares method and the statistical significance of the models is checked.

The research results indicate the presence of a close inverse relationship between the volumes of capital investments for the protection of atmospheric air on the volume of emissions of pollutants into the air. This is due to the fact that the linear correlation coefficient is -0.826 , and the value of the coefficient of determination (0.6818) shows the decisive influence of capital investments on emissions. Checking the statistical significance of the model makes it possible to recognize the constructed econometric model of the effect on the volume of emissions of pollutants into the air as statistically reliable. The resulting model can be used to predict the volume of emissions of pollutants into the air and provides an opportunity to address issues of optimizing investment and environmental policies.

On the other hand, an econometric model is obtained for the effect on the amount of recycled waste, which is characterized by a noticeable direct relationship (linear correlation coefficient -0.595) and shows that only 35.44% of recycled waste is directly related to the volume of capital investments. Checking the statistical significance shows the unreliability of the model of influence on the amount of disposed waste. Although the resulting model can't be used for forecasting, it can be used in further studies to identify other factors influencing waste disposal.

Keywords: capital investments for environmental protection, correlation analysis, pair regression equations.

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1. Introduction

Environmental protection requires adequate financial support for the implementation of appropriate environmental programs and resource and energy saving projects. In terms of content, financial support of a legally defined set of measures aimed at creating a basis for achieving certain goals, and the goals in the field of environmental protection are to reduce the level of environmental pollution and rationalize the use of natural resources.

A number of scientific works are devoted to the study of the influence of investment on the intensity of environmental pollution. So, in [1], a technique is described for the quantitative determination of the quality of the environment by determining the integral index. The study [2] developed a simulation model for assessing the impact of environmental investments on the quality of the environment. Some researchers carry out a comparative analysis of the environmental impact of various portfolios of investment funds [3]. The likelihood that foreign direct investment reduces the intensity of environmental pollution is confirmed in studies [4–6], which indicate

that investment allows the use of advanced technologies that are more favorable for the environment. The methodology for assessing the effectiveness of municipalities' current expenditures on environmental protection is described in [7–9]. Considered developments of scientists are the basis for further research, namely, modeling the impact of environmental investment on the state of the environment.

The above mentioned actualizes the problem of studying the influence of the volume of ecological investment on the state of the natural environment. Therefore, *the object of this research* is environmental pollution by the example of Ukraine. And *the aim of research* is to determine the impact of environmental investment on the state of environmental pollution.

2. Methods of research

To achieve this aim, a generalization of scientific publications was used to study the impact of financing of environmental protection measures on the state of the environment. The paper uses the method of correlation

analysis to build models of the relationship between the phenomena under study. The dependencies were obtained on the basis of actual statistical data on the volume and structure of expenditures for environmental protection, emissions of pollutants into the air and waste generation [10]. A graphical method was used in the processing of statistical data to visualize the studied indicators and display the results of the study.

According to a literature review, the relationship between indicators characterizing the state of environmental pollution and environmental investments can be significant and insignificant, as well as positive and negative.

In the course of the study, a correlation analysis was carried out using the paired regression equation, where a hypothesis was put forward that the relationship between all possible values of factorial and effective indicators is linear. This allows to develop a model of the impact of environmental investments on the state of environmental pollution. The parameters of the constructed models are estimated by the least squares method. The statistical significance of the models was tested using the coefficient of determination and Fisher's test.

3. Research results and discussion

By 2019, enterprises, organizations and institutions of Ukraine spent 1692.56 million USD on environmental

protection, of which operating expenses – 1063.48 million USD and capital investments 629.09 million USD, which is 37.17 % of total spending. The largest share of capital investments in environmental protection is the cost of waste management – 35 % and the protection of atmospheric air and prevention of climate change – 26 %. This indicates the main environmental problems of the state (Fig. 1).

To achieve the set objectives, the modeling of the impact of capital investments in areas that have the largest specific weight in the total volume on the amount of recycled waste and the volume of emissions of pollutants into the air was carried out. At the same time, it was taken into account that the development of investments takes some time, therefore, data on the volume of capital investments for 2014–2018 were used. Volumes of emissions of pollutants into the air and the amount of recycled waste in 2015–2019 are shown in Table 1.

Hypothesis is put forward for data in Table 1: $H_1: r_{xy} \neq 0$, the linear relationship between variables.

The obtained results of the corresponding calculations carried out using MS Excel are given in Table 2 and Fig. 2.

The characteristics of the obtained models of the influence of capital investments on the amount of recycled waste and the volume of pollutant emissions into the air allow to accept the hypothesis $H_1: r_{xy} \neq 0$, there is a linear relationship between the variables.

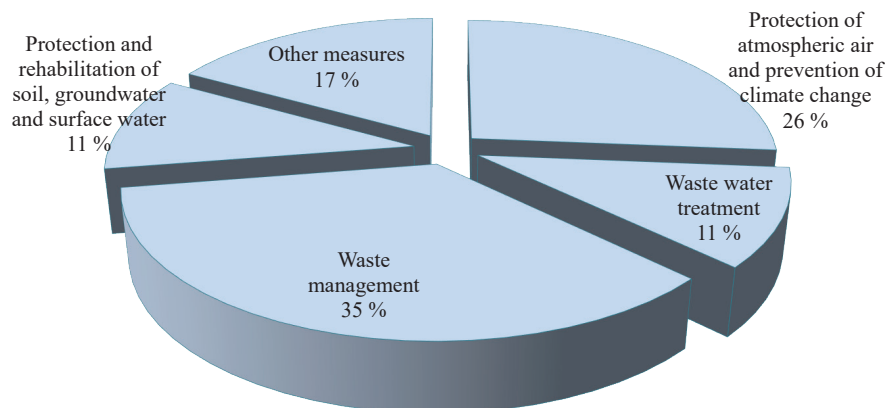


Fig. 1. Capital investments in environmental protection by type of environmental protection measures in 2019 (built by the author based on data from the State Statistics Service of Ukraine [10])

Main indicators characterizing the state of the environment and the volume of capital investments

Table 1

Year	Main indicators characterizing the state of the environment, thousand tons (y)		Year	Capital investment, million USD (x)	
	amount of disposed household and similar waste	volume of emissions of pollutants into the air		waste management	protection of atmospheric air and prevention of climate change
2015	92463.7	4521.3	2014	35.88	87.65
2016	84630.3	4686.6	2015	28.86	55.69
2017	100056.3	4230.6	2016	83.06	94.13
2018	103658.1	4121.2	2017	90.84	95.88
2019	108024.1	4119.0	2018	45.74	135.68

Note: formed by the author based on data from the State Statistics Service of Ukraine [10]

Table 2

Results and interpretation of the obtained simulation results

Indicators	For the amount of household and similar waste	For the volume of emissions of pollutants into the air
Linear model	$y = 196.0527x + 86615.808$	$y = -7.4101x + 5030.848$
Linear correlation coefficient r_{xy}	0.595 (direct noticeable relation)	-0.826 (feedback close relation)
	Accept the hypothesis – $H_1: r_{xy} \neq 0$, there is a linear relationship between the variables	
Average elasticity coefficient E	0.114	-0.16
	when x changes by 1 %. y will change by less than 1 (estimate of the strength of the connection between factor x and result y)	
Determination coefficient R^2	0.3544 (35.44 % of cases of changes in x lead to a change in y, the remaining 65.56 % of changes in in are explained by factors that are not taken into account in the model)	0.6818 (68.18 % of cases of changes in x lead to a change in y, the remaining 31.82 % of changes in are explained by factors that are not taken into account in the model)
Significance F	0.289	0.085
F -test value	1.647	6.428
	$F < F_{tabl}$, an estimate of the regression equation statistically unreliable	$F > F_{tabl}$, an estimate of the regression equation statistically reliable
Approximation coefficient	5.08 %	2.82 %
	Since the error is less than 7 %. the equation can be used as a regression	

Note: formed by the author based on the calculations

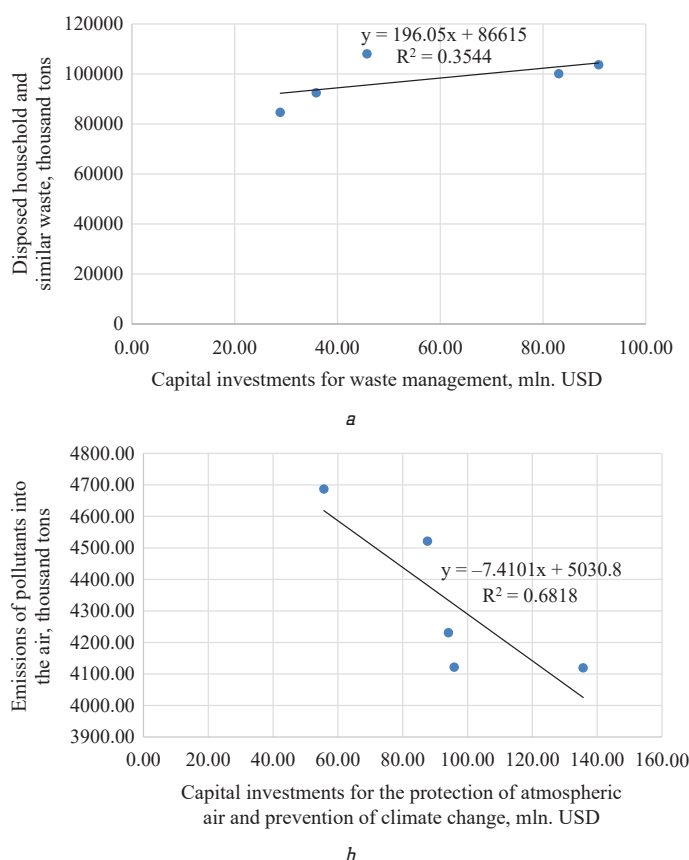


Fig. 2. Graphic representation of the results of modeling the impact of environmental investment on the state of the environment (formed by the author on the basis of the calculations): *a* – model of the impact on the amount of recycled waste; *b* – model of influence on the volume of emissions of pollutants into the air

4. Conclusions

Based on the simulation of the impact of environmental investment on the state of the environment, the following conclusions can be drawn:

- Model of the influence of capital investments on the amount of recycled waste:
 - in the situation under study, 35.44 % of the total variability of waste disposal is explained by a change in the volume of capital investments in waste management;
 - the parameters of this model are statistically significant;
 - economic interpretation of the model parameters – increase in capital investments for waste management by 1 million USD. USA leads to an increase in the amount of utilized household and similar waste by an average of 196.053 thousand tons;
 - the developed model of the influence of capital investments on the amount of recycled waste can be used for further analysis and research to identify other factors of influence on the effective indicator.
- Model of the influence of capital investments on the volume of emissions of pollutants into the air:
 - in the studied situation, 68.18 % of the total variability in the volume of emissions of pollutants into the atmospheric air is explained by changes in capital investments for the protection of atmospheric air and the prevention of climate change;
 - the parameters of the model are statistically significant;
 - economic interpretation of the parameters of the model – increase in capital investments for the protection of atmospheric air and prevention

of climate change by 1 million USD. The USA leads to a decrease in the volume of emissions of pollutants into the air by an average of 7.41 thousand tons; – the developed model of the influence of capital investments on the volume of emissions of pollutants into the air, adequate and statistically significant, can be used for further analysis and forecasting.

The constructed models of the impact of ecological investment on the state of the natural environment open up new opportunities for further research, as well as provide an opportunity to address issues of optimizing the country's investment and environmental policy.

In the future, a study will be carried out on the ways and directions of increasing the dependence of the amount of utilized household and similar waste on the volume of capital investments in waste management.

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