



PRODUCTION ENGINEERING ARCHIVES

ISSN 2353-5156 (print)
ISSN 2353-7779 (online)

Exist since 4th quarter 2013
Available online at <https://pea-journal.eu>

Assessment of the Efficiency of the Financial Mechanism of Environmental Management

Oleksandr Labenko¹, Valeriia Lyymar², Olga Faichuk³, Inna Dolzhenko¹, Taras Hutsol^{4,5*},
Svitlana Belei⁶, Stanislaw Parafiniuk⁷, Dariusz Kwasniewski⁸, Sylwester Tabor⁸,
Lyidmila Kiurcheva⁹

¹ Department of Finance, National University of Life and Environmental Sciences of Ukraine, 15 Heroyiv oborony str., Kyiv, Ukraine, 03041; labenko@nubip.edu.ua (OL); dolzhenko.i.i@nubip.edu.ua (ID)

² Department of international relations and foreign policy, Vasyl' Stus Donetsk National University, vul. 600-richchia, 21, Vinnytsia, Ukraine, 21021; v.lyymar@donnu.edu.ua;

³ Department of banking and insurance, National University of Life and Environmental Sciences of Ukraine, 15 Heroyiv oborony str., Kyiv, Ukraine, 03041; faychuk_olga@ukr.net;

⁴ Department of Mechanics and Agroecosystems Engineering, Polissia National University, Staryi Blvd 7, Zhytomyr, Ukraine, 10008; wte.inter@gmail.com;

⁵ Ukrainian University in Europe – Foundation, Balicka 116, 30-149 Kraków, Poland;

⁶ Department of Business Economics and Human Resource Management Chernivtsi National University Chernivtsi, Ukraine Yury Fedkovich Chernivtsi National University str. 2, Cathedral, Chernivtsi, Ukraine, 58000; s.belei@chnu.edu.ua;

⁷ Department of Machinery Exploitation and Management of Production Processes, University of Life Sciences in Lublin, Poland; Stanislaw.Parafiniuk@up.lublin.pl;

⁸ Department of Production Engineering, Logistics and Applied Informatics, University of Agriculture in Krakow, Kraków, Poland; dariusz.kwasniewski@urk.edu.pl (DK); sylwester.tabor@urk.edu.pl (ST)

⁹ Dmytro Motornyi Tavria State Agrotechnological University, 72-000 Zaporizhzhia, Ukraine; lyidmila2007@ukr.net.

*Correspondence: wte.inter@gmail.com

Article history

Received 28.02.2024

Accepted 24.06.2024

Available online 09.09.2024

Keywords

financial mechanism of environmental management, financial regulation, environmental taxes, environmental taxes, production.

Abstract

In recent decades, cataclysmic events, deterioration of air and water quality, and loss of biodiversity have forced us to look for ways to save nature. One of the ways to solve the problems is to ensure rational environmental management, which is possible by establishing an effective balance between consumption and compensation by creating an effective financial mechanism. The purpose of the study is to assess the efficiency of the current financial mechanism for environmental management in Ukraine and to determine the prospects for its improvement. The study uses analysis, synthesis, specification, systematization, and generalization. The graphical method was used to assess environmental taxes, and mathematical modelling was used to analyze the dependence of emissions on direct costs and capital investments in air protection and climate change. Environmental taxes in Ukraine are an ineffective instrument of the financial mechanism of environmental management. Their share in the structure of domestic GDP is lower than the share in the EU. The author suggests ways to improve them: to replace the CO₂ tax with an energy tax; to cancel the tax-free limit of 500.000 tons of CO₂ emissions per year; to change the structure of tax distribution; to introduce tax rebates. The correlation and regression analysis of the dependence of air pollutant emissions on current expenditures and capital investments in air protection and climate change issues showed the existence of a feedback loop. Investment support for environmental management should be provided from various sources in the following areas: national, local and international finances - primarily for the restoration of air, water and contaminated areas; own funds and international investments - for the modernization and greening of production.

DOI: 10.30657/pea.2024.30.31



1. Introduction

Today, the world faces a serious problem with climate change and the rapid use of limited resources. This was preceded by negative human actions, such as draining water bodies, deforestation, and intensive use of pesticides and chemicals, which led to the loss of biodiversity and ecosystem degradation (United Nations Environment Programme). Given these factors, the issues of decarbonization, net emissions, and waste reduction are becoming quite relevant (Santos et al., 2022; Kowalczyk et al., 2023). Human relations with nature should reach a new level and become the key to a sustainable future, overcoming poverty, ensuring equality of the population, improving health, peace, food and sanitation security (United Nations Environment Programme). There is a view that each country is becoming an active participant in environmental policy and, depending on its economic situation, is trying to prevent negative consequences in various ways (Klingelhöfer et al., 2022). This is also due to the desire of companies to avoid specific risks associated with nature. For example, there may be a risk to stable operations and reputation if there is an oil spill that causes water pollution (The Imperative for Impact Management: Clarifying...). Environmental protection should be an element not only of economic theory, but also of the economic development of all countries (Shergina et al., 2020). This raises the issue of financial support and financial management of the natural resources market (Rasmussen et al., 2021; Gaura et al., 2020). Innovative financing mechanisms should play an important role in scaling up natural resource management decisions (Chausson et al., 2023). Fiscal instruments that make polluters pay are quite popular around the world (López, 2018). Environmental taxes can reduce or eliminate the impact of harmful practices on the environment and stimulate the replacement of old technologies with new ones (Dziki, 2023; Umar Farooq et al., 2023). At the same time, it should be borne in mind that the economy is developing, the needs of society are growing, and it is inevitable that views on the mechanisms of environmental protection will transform, and there is a need for widespread use of incentive instruments. In general, it is worth noting that the elimination of the main causes of environmental problems is possible by establishing an optimal balance between the costs and benefits of environmental change (Monzón Aldama et al., 2022; Kostornoi et al., 2021; Kovalenko et al., 2021). Because of this, the financial mechanism of environmental management requires constant improvement following the needs and challenges of today. Therefore, the purpose of this study is to assess the effectiveness of the current financial mechanism of environmental management in Ukraine and to identify prospects for its improvement.

The next section provides a literature review that presents the authors' views on the concept of environmental management, financial mechanism and its implementation in the field of environmental management. Section 3 describes the methodology of the study and specifies the peculiarities of the statistical sample. The following methods were used for the study: analysis, synthesis, specification, systematisation, and

generalisation. The graphical method was used to assess environmental taxes, and mathematical modelling was used to analyse the dependence of emissions on direct costs and capital investments in air protection and climate change. Section 4 presents the results of the study. Section 5 is the final section and reflects the conclusions drawn.

The article provides an analysis of the interpretation of the financial and economic mechanism of environmental management; examines the dynamics and structure of environmental taxation in Ukraine and the EU, draws a parallel between the data obtained and suggests ways to improve taxation in Ukraine; determines the relationship between the volume of pollutant and carbon dioxide emissions into the atmosphere and current expenditures and capital investments for air protection and climate change.

2. Literature review

Among the concepts of the organisation, scholars identify the following: environment; sustainable development, environmental management and environmental awareness (Al-Anbari, 2024). Sustainable development is an attempt to integrate human activity into the environmental sphere. It is a multidimensional concept and consists of the following dimensions: ethical, environmental, social, economic, technical and technological, political, and legal (Zimon, 2017).

Environmental management is a complex multidisciplinary practice that focuses on protecting the environment from existing and potential risks. V.F. Semniuk and O.L. Mykhailiuk argue that environmental management is a proactive and effective activity of economic entities aimed at achieving their own environmental objectives, programmes and projects developed based on the principles of environmental efficiency. According to V.O. Lukyanikhin, environmental management is a set of principles, methods, forms, techniques, and means of managing production and production personnel of an enterprise to achieve high ecological and economic efficiency of production (Gaichenko, 2006).

It is carried out by implementing strategies to preserve natural resources and reduce the negative impact of industry, agricultural production, and other activities. The following approaches to environmental management can be distinguished: corrective, political, preventive, and green policy (Al-Anbari, 2024). Not so long ago, the International Organisation for Standardisation (ISO) developed a general model of an environmental management system that is now an established standard. For example, ISO 14001, designed for organisations of all types and sizes, sets out the requirements for environmental management and allows for the development and implementation of environmental policies based on regulatory and legislative frameworks (Živković et al., 2020).

An important element of implementing the concept of sustainable development in Ukraine is the modernisation of the financial mechanism, the main purpose of which is to increase the efficiency of financial resources and optimise the management of budget funds. The classification of conceptual approaches to disclosing the content of the financial mechanism, developed by N. Metalenko and O. Shulga (2016), suggests

that it should be considered as a means of influence (a means of organising finance, managing financial resources, ensuring and responding to the economic activity of an enterprise, economic and social development of society; a financial management system) and a financial resource management system.

C. Levochkin (2007), studying the topic of macroeconomic stability in Ukraine in the context of economic growth and the related structural structure of the financial mechanism, suggested that the financial mechanism should be considered from two approaches. The first reflects the internal organisation of finance, while the second shows its external impact. The effect of the financial mechanism is implemented based on methods of influence - financial support and financial regulation. From the perspective of sustainable development, studying the financial mechanism of environmental management is crucial for environmental protection.

Many Ukrainian and foreign authors in their works reveal the elements of the economic mechanism of environmental management (Kovalenko et al., 2021).

Traditional financial mechanisms in the field of environmental management are market-based. Chausson et al. (2023) consider the possibility of using additional financing mechanisms and argue that market mechanisms are not a panacea for expanding the concept of natural solutions, but rather create governance problems with further deepening of power asymmetries. Hagedoorn, Koetse, van Beukering et al. (2021), Brander Kwasniewski et al. (2020) argue that nature-based solutions focus on measures designed to address sustainability challenges.

Substantiating the directions of improving the financial mechanism for managing the ecological and innovative development of the Ukrainian economy, Borisova, Samohkina, Rybina, and Shumkova (2020) found that the optimal redistribution of resources requires the systematic use of fiscal and credit instruments.

Skorokhod and Horbach (2021) focused on revealing the features of innovation and investment support for regional environmentally sound development based on the calculation of innovation, scientific, and investment indicators. This made it possible to identify the interregional differentiation of Ukrainian regions by indices, which can become the basis for managerial decision-making. It has been proved that to intensify the innovation and investment development of this area, it is necessary to identify its preconditions, taking into account the assessment of the possibility of introducing innovations and attracting investments to the regions of Ukraine. Karpuk, Marchuk, Myklush (2020) reveal the essence of financial and investment support for integrated environmental management in the context of deep decentralization and local government reform, focusing on the problem of diversification of funding sources.

3. Experimental

The research analyzed the works of Ukrainian and foreign scholars. Publications containing information on a regional, national and international scale were analysed. Most of the

works have been published in the past five years, as they contain the most relevant information on the subject matter. Using the methods of generalisation and systematisation, the information of scientific papers was grouped following certain criteria, and on its basis, conclusions were formulated regarding the place of the financial mechanism of environmental management.

To assess the dynamics and structure of environmental taxes in the EU and Ukraine, the amount of each category of taxes is graphically displayed and their share in the GDP structure is determined. These indicators are presented in different categories of diagrams. For the EU, the histogram with regions shows the components (types) of environmental taxes, which in the end show its total value. The graph shows the percentage of the GDP structure of the EU countries. The diagram with regions shows the total amount of environmental tax revenues in Ukraine, the graph shows the percentage in the GDP structure; and the bar chart is based on information on taxpayers - natural monopolies. For better visual perception, a separate scale has been used for the graphs (see the figures on the right). The information on EU environmental taxes was systematized based on the data from the Eurostat website in the category "Environment (environmental taxes)". The data was filtered by each tax levied in the EU and checked against the total amounts. The same filter was used to determine the percentage in the structure of gross domestic product. The analysis of tax revenues in Ukraine is based on information from the State Statistics Service and the National Bank of Ukraine, available on their official websites. The data exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol, and part of the temporarily occupied territories in Donetsk and Luhansk region. Since the war is ongoing in Ukraine in 2022-2023 and the tax collection system is somewhat modified, the period of 2016-2021 was chosen for an objective study and the possibility of comparing and analyzing the indicators of the EU and Ukraine.

Mathematical modelling methods were used to analyze and assess the relationship between the volume of pollutants and carbon dioxide emissions into the air and current expenditures and capital investments for air protection and climate change. The resultant indicator is the volume of pollutants since they have an impact on the environment and can be adjusted depending on the actions of individuals and legal entities and government policy. The factor attributes are current costs, which show the dependence and possibility of variation in the short term, taking into account current measures and financial tactics, and capital investments, which reflect the dependence of emissions on long-term trends and prospects and, accordingly, the strategic vision of society. The proposed model suggests that both current and capital investments are required to reduce pollutant emissions. At the same time, to reduce pollution per conventional unit, capital investments should exceed current ones, as they are focused on the long-term perspective.

The input information is systematized based on data from the State Statistics Service of Ukraine, excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol, and part of the temporarily occupied territories in Donetsk and Luhansk oblasts. To build the

model, a sample was formed for the period 2016-2020. More distant periods were not taken, as they have less impact on the current state of the financial and environmental system. The information for 2021-2022 is not available on the official website of the State Statistics Service and, for 2022 it may not reflect the full situation in this sector. Therefore, it was decided to choose a time series of available information for the last five years. The correlation and regression analysis of the dependence was conducted in the MS Excel spreadsheet processor.

4. Results and discussion

Ukraine is currently going through difficult times that have a significant impact on the environment. The current environmental management system and environmental policy do not meet the challenges of today and therefore require fundamental changes. In addition, Ukraine's course towards integration into the European Union requires harmonization of legislation and concrete actions to transform all systems, including the environmental one.

Before conducting a detailed assessment of the financial mechanism of environmental management, it is necessary to consider the interpretations of this concept proposed by scholars (Table 1 (Appendix A)).

The study has established that there is currently no formulated commonly accepted interpretation of the concept of economic or financial mechanism of environmental management. Most of the scholars in the studied works focus on the analysis of the economic mechanism of environmental management, specifying only certain financial instruments. It is suggested that such an interpretation should be rethought and adapted to the financial mechanism of environmental management. Since it is more focused on incentive measures rather than coercive ones, which is especially relevant in the era of an active market economy and global environmental problems.

Lutkovska and Kaletnik (2020) propose to consider the interpretation of the economic mechanism of environmental security as a component of the organizational and economic mechanism that substantiates the prerequisites for financial and economic interaction between the actors in the process of ensuring security. This interaction takes place through the institutionalization of the system components. We consider the authors' vision to be justified, since the implementation of an economic or, as suggested above, a financial mechanism will be more effective together with organizational, legal and other mechanisms.

Udovytisia (2020) identified the main ways to improve the economic mechanism of environmental management in Ukraine as follows: formation of a highly efficient organizational structure and effective environmental legislation; economic exercise of the State's powers as the owner of natural resources; use of methods of economic assessment of natural resources and determination of losses with a focus on tax rates; implementation of resource conservation programs; targeted use of funds; stimulation of eco-entrepreneurship and eco-production by the State; implementation of the model of Taking into account the author's conclusions, it should be noted that

one of the mandatory ways to improve environmental tax legislation is to transform the tax system with a focus on real environmental pollution and the actual use of natural resources.

Skorokhod et al. (2022) using the example of the Volyn Oblast and Lubelskie Voivodeship (Republic of Poland), focus on the need to create a mechanism for managing cross-border natural resources. This will allow the border regions, together with their European partners, to take measures to protect the environment and ensure the rational use of natural resources located at the border crossing. It is believed that the development of such mechanisms will allow the border regions of Ukraine to actively attract European funding to address these issues, which is especially important in the current environment.

The financial mechanism of environmental management is divided into two types: compensatory and incentive. The first type is focused on compensating for negative environmental impacts and determines the limiting factors in the use of natural resources and/or sets a certain fee for their consumption, air, water, land pollution, emissions, etc. The second type is aimed at greening production, reducing emissions and negative impacts through a system of incentives, benefits, subsidies, etc.

The key elements of any mechanism are instruments. According to the type of financial mechanism, it is also advisable to divide them into two large groups: compensating and incentive. The former includes taxes and fees, emissions trading systems, and compensation for the use of natural resources; the latter includes investments, grants, loans, bonuses, subsidies, etc. The peculiarity of the second group of instruments is that most of them are selective and aimed at implementing a specific project or goal by a particular institution or person. In other words, they are aimed at providing benefits to individual actors.

One of the main instruments of the compensatory type of financial mechanism for environmental management is taxes and fees.

Environmental (green) taxes are taxes levied to protect the environment or to stimulate the carbon transition. The taxable objects include five categories, namely: volumes and emissions of pollutants into the atmosphere by stationary energy sources, water bodies, volumes and emissions of disposed waste, volumes and category of radioactive waste, and volumes of electricity generated by nuclear power plant operators. Each tax base has its tax rates, which are set out in the Tax Code of Ukraine.

By drawing a parallel between environmental taxes in Ukraine and those in EU countries, which Ukraine is seeking to join, it becomes evident that the approach to this category is somewhat different. In particular, in the EU, environmental taxes include energy, transport, pollution and resource taxes.

Therefore, it was decided to assess and compare the dynamics of payment and structure of environmental taxes in Ukraine and the EU. The dynamics of EU environmental taxes are shown in Fig. 1. (Appendix B)

The structure of environmental taxes is dominated by energy taxes (taxes on energy products for transport, stationary use, and greenhouse gases), which accounted for a minimum

of 77.4% (in 2020) and a maximum of 78.3% in 2021 during the study period. In total, they increased by EUR 14.1 billion (+5.8%). Resource taxes (similar to the current Ukrainian taxes) account for the smallest share, averaging 3.4% (EUR 10.8 billion). The growth of this type of tax was EUR 1.0 billion (+9.5%). During the period under review, transport taxes were characterized by fluctuations: 2016-2017 - an increase of €1.5 billion (+2.6%); 2017-2018 - €2.0 billion (+3.3%); 2018-2019 - €0.6 billion (+1.0%); 2019-2020 - a decrease of €5.3 billion (-8.5%); 2020-2021 - an increase of €1.9 billion (+3.3%). In 2016-2021, environmental taxes accounted for 5.8% of total revenues from taxes and social contributions (including contingent social contributions) and 2.4% of gross domestic product.

Information on environmental taxes paid to the Consolidated Budget of Ukraine is shown in Fig. 2. (Appendix C)

As the data in Fig. 2, during the period under study, the highest revenues from environmental taxes were received in 2019 (EUR 210.7 million), and the lowest - in 2018 (EUR 153.1 million). During the period 2016-2017 total revenues decreased by EUR 20.1 million (-11.4%); 2017-2018 - decreased by EUR 3.6 million (-2.3%); 2018-2019 - + EUR 57.6 million (37.6%); 2019-2020 - decrease of EUR 35.3 million (-16.8%); 2020-2021 - increase of EUR 10.0 million (+5.7%). The structure of environmental taxes is dominated by taxes on air emissions. Taxes on discharges into water bodies account for the smallest share. The share of environmental taxes in the GDP structure in 2016-2021 averaged 0.15%, which is 93.8% less than in the EU.

The war has become an obstacle to Ukraine's fulfilment of its environmental obligations, but it has not changed the country's direction towards the European Green Policy and the restoration of the national economy based on the principles of sustainable development. Implementing and complying with European environmental standards is important for the implementation of the Association Agreement. Over the years of the agreement, the legal framework and mechanisms for implementing European standards in Ukraine's environmental policy have been fundamentally revised. This includes the planning, development and adoption of legislation and regulations to adapt national legislation to 29 EU directives and regulations in eight thematic areas. At the same time, the practical implementation of the relevant tools for the implementation of legislative norms is being carried out (Ukrainian Centre for Economic and Political. Alexander Razumkov Centre for Economic and Political Studies, 2022).

The EU legislation on public access to environmental information and public participation in the preparation of environmental policy documents, as well as environmental impact assessment and strategic environmental assessment, are horizontal, i.e., cross-cutting environmental legislation. Ukraine should adopt the EU legislation on the Pollutant Release and Transfer Register and liability for environmental damage, which are also an integral part of horizontal environmental legislation. In terms of transparency, the main drawbacks remain the unstructured and difficult search for environmental information (Golubovska-Onisimova et al., 2023).

Given the data obtained from the analysis, it can be concluded that the environmental tax in Ukraine is not an effective tool of the financial mechanism of environmental management, as the share of its revenues in the overall GDP structure is rather low compared to the EU.

In Ukraine, environmental taxes are payments for the actual volume of certain types of emissions, while in the EU, the tax base is any physical unit that has a proven negative impact on the environment. Therefore, the tax base should be expanded in line with EU regulations (Analytical Note..., 2022).

It is worth noting that CO₂ taxes in the European Union are classified as energy taxes, not pollution taxes as in Ukraine. Since they are difficult to identify separately in tax accounting, in some cases they are introduced as a substitute for other energy taxes. To implement the Ukrainian environmental legislation, it is advisable to replace the CO₂ tax with a tax on energy (fuel oil, coal, natural gas, etc.). This will increase revenues and simplify their administration.

Another way to improve Ukraine's environmental tax system is to tax companies with annual CO₂ emissions of less than 500,000 tons. The legislation stipulates that the taxation of this tax starts at 500 thousand tons, and the cancellation of the established limit for tax exemption will encourage environmentally responsible behaviour and the state budget.

The distribution of environmental taxes for air emissions, discharges into water bodies or drains, and waste disposal is as follows: 55% – local budgets (25% village, town, city and amalgamated territorial community budgets and 30% regional budget); 45% – general fund of the state budget of Ukraine. Funds received by the state budget are not earmarked and can be used for purposes unrelated to overcoming negative environmental consequences. This approach contradicts the practice of European countries. Therefore, it is necessary to significantly reduce the share that goes to the state budget. As for the funds that go to local budgets, it is necessary to make their use more transparent and clearly define the list of types of environmental protection measures to avoid cases of misuse and irrational use of budget funds. After all, there are situations when local governments include greening or landscaping costs in this category.

The practice of many EU countries involves the use of various incentives, discounts and benefits in the environmental sphere and environmental protection. The most common are grants, tax breaks, and soft loans (Analytical Note..., 2022). In general, to mitigate the environmental taxation system in Ukraine, it is necessary to introduce tax discounts for companies that use energy-saving technologies, reduce emissions, improve production processes, etc. This will partially transform this instrument from a purely regulatory (compensatory) to an incentive one.

We agree with the opinion of Heine and Black (2018) that reforming domestic fiscal policy in the field of environmental taxation contributes to the effective attraction of domestic funds to expand public spending, and for Ukraine, it is also a way to optimize revenues in general for their further effective use for environmental purposes.

Scientists have conducted a study of the dependence of pollutant emissions on environmental taxes, which found that its

increase ensures the development of green and energy-efficient technologies (Han et al., 2020).

The need for cooperation between Ukraine and the EU in the environmental sphere is undeniable, as it is important both for integration processes and for environmental protection in the region. The experience gained by the EU in the field of environment is valuable for Ukraine, especially in terms of the use of modern technologies in environmental management. Poland can be seen as an example of the successful use of economic mechanisms in the implementation of environmental policy, and its experience is useful for Ukraine, given the similarity of natural and social conditions (Booth, 2011). The country applies the following environmental market regulators: environmental tax (differentiated taxation depending on the environmental friendliness of products), tax privileges and subsidies (stimulate the use of scientific and technical achievements), low-interest loans (used to provide financial support to companies that use renewable energy sources), and other regulatory measures.

Poland's experience may be of interest to Ukraine in terms of the system of payments (for output, products, use of environmental infrastructure); deposit and mortgage systems, creation of an environmental market; financial sanctions for non-compliance with the rules; and benefits (tax exemptions, credits, loans) (Lemko, 2022).

The effectiveness of the financial mechanism of environmental management is determined not only by a rational policy in the field of collection (compensating mechanism), but also by an effective cost component (incentive mechanism). Therefore, we have analyzed the dependence of pollutant and carbon dioxide emissions into the atmosphere and current expenditures and capital investments on air protection and climate change (Table 2 (Appendix D)). Among the pollutants, CO₂ was chosen as the object of study because we agree with the opinion of Zioloa et al (2019) and Pandey, Dogan, and Taskin (2020) that it is one of the largest pollutants that harms environmental quality, a key cause of environmental degradation and a factor in increasing environmental risk. In addition, most of the emissions of this gas are produced in the course of human activity and, accordingly, can be artificially limited.

To assess the effectiveness of current expenditures and capital investments in air protection and climate change, the Group checked whether there is a link between pollutant emissions and expenditures. Current expenditures and capital investments are used as factor indicators, and emissions are used as outcome indicators. In the first stage, we checked the existence of a relationship between the factor and outcome variables (Table 3 (Appendix E)).

The matrix shows that there is a significant inverse relationship between pollutant emissions and current costs and capital investments, which indicates that it is advisable to include these factors in the correlation and regression model. 60.3% of the variation is explained by factor x₁ and 85.3% by factor x₂. At the same time, there is a moderate direct relationship between current expenses and capital investments.

The next step was to identify the dependence of emissions on current expenditures and capital investments using multiple

linear regression. The results of the regression analysis are shown in Table 4 (Appendix F).

The multiple correlation coefficient ($R = 0.881$) indicates a strong relationship between the factor and the resultant attributes.

The value of the coefficient of multiple determination of the obtained two-factor regression ($R\text{-square} = 0.775$) indicates the correct specification of the model, and means that the variation in pollutant emissions is 77.5% due to the identified factors. The rest (22.5%) is accounted for by factors not taken into account in the model. The rather high value of the correlation and determination coefficients indicates that this relationship is natural. Table 5 (Appendix G).

Based on the calculated criteria, the model was found to be reliable with a 95% probability. The calculated value of Fisher's criterion: $F_{\text{calculated}} = 3.450615$, the corresponding table value: $F_{\text{tabular}} = 0.224688$. Since the $F_{\text{calculated}}$ is greater than the F_{tabular} , this model is adequate.

According to the linear correlation-regression model, emissions of pollutants and carbon dioxide into the atmosphere decrease by an average of 0.345 thousand tons with an increase in current costs and capital investments by UAH 1 million (EUR 25.3 thousand on average at the rate of 2023).

The correlation coefficients confirm the existence of the relationship (Table 6 (Appendix H)).

The model has the following form:

$$y = 5238.96 - 0.155x_1 - 0.181x_2 \quad (1)$$

$$R^2 = 0.775 \quad (2)$$

To ensure the reliability of the analysis, it is necessary to check the accuracy of the model using a normal distribution graph (Fig. 3 (Appendix I)).

As can be seen from Fig. 3, the spread of values is small, i.e., the resulting model is quite accurate.

The study has shown that to ensure rational environmental management, investments should be one of the key instruments of the financial mechanism of environmental management (incentive).

The capital investment market or green finance market covers a wide range of goals and activities to ensure a favourable environmental impact (UK Green Finance Review).

Rasmussen et. al (2021) found that investments in the environmental sector have positive results for natural capital. We support this position, as mitigation of negative impacts, climate improvement, and provision of natural resources is possible only if there is funding for environmental protection measures at the state and local levels and incentives for business entities to improve themselves. It follows that the main sources of funding for environmental protection measures may include: budgetary funds; funds from intergovernmental, regional and other governmental and non-governmental organizations; funds from specialized funds and other institutions, funds from legal entities and individuals, loans, etc.

We believe that projects to restore contaminated areas should be implemented at the state, regional and local levels and at the expense of relevant institutions, necessarily with the

involvement of foreign partners. As Ukraine is currently engaged in hostilities, many lands (mostly agricultural land, which generates a significant portion of the country's income) and water bodies (such as the Kakhovka hydroelectric power plant) require significant financial investment to restore them to at least pre-war levels.

Greening and resource transformation of production processes at enterprises, institutions and organizations should be primarily funded by the business entities' resources and with the support of international and regional donors. This area of environmental investment is necessary to bring production to the European level in terms of environmental friendliness, given that Ukraine plans to become an active participant in its market.

Today, environmentally friendly products are gaining popularity. Of course, their production is characterized by a much higher cost, so they require additional investment at the initial stages to support the owners and encourage the expansion of the industry as a whole.

Kovshun et. al (2021) offered an interesting vision of the concept of environmental investment. They believe that the target and functional characteristics of eco-investments are multidimensional and should be interpreted as an opportunity to prevent negative environmental impacts. Among the objects of environmental investment, scholars identify the following: development and installation of treatment equipment, production of environmentally friendly goods, use of resource-saving technologies, zero-waste processes, recycling; formation of the material and technical basis for the use of environmentally friendly and renewable energy sources in production processes; implementation of projects in the field of rehabilitation of contaminated areas; educational and research activities. Kukharets, et.al (2023) propose to produce biofuels from crop by-products. They have also identified the potential to produce biodiesel from oilseed bran waste and biomethane and biohydrogen from livestock by-products. Such alternatives to eco-production can be an effective source of investment to ensure sustainable development and greening of Ukraine, as our country has significant reserves of agricultural raw materials.

An analysis of the structure of capital investment in environmental protection by type of environmental protection measure in Ukraine is shown in Table 7 (Appendix J).

Data excludes the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and part of the temporarily occupied territories in Donetsk and Luhansk regions.

During the period under review, the largest share in the structure of capital investments was accounted for by: investments in radiation safety in 2016-2017 (51.9% and 27.3%, respectively); investments in air protection and climate change in 2018 and 2020 (34.8% and 42.3%, respectively); and investments in waste management in 2018 (35.4%). The smallest amount of capital investment is in environmental research and development (0.02-0.07% from 2016 to 2020). The analysis of each item showed that investments in air protection and climate change issues; in the protection and rehabilitation of soil, groundwater and surface water are characterized by a

constant gradual increase (+123.6% and +508.1% in 2016-2020). Other areas of investment do not have a stable trend and include fluctuations, either upwards or downwards. It is worth noting that this distribution is quite relevant, given the environmental challenges, except for the costs of radiation safety, which need to be increased.

To ensure sustainable development and achieve environmental and economic goals, it is important to green Ukrainian enterprises, which are currently at a rather low level.

According to Poiasnyk (2023), overcoming many of the problems that prevent enterprises from developing in this direction is possible after the end of the war, but some can be solved today. To do this, it is necessary to advise business structures on business modernization by the requirements of the European Union; create equal access for Ukrainian and foreign companies to EU funds and financial instruments; attract non-repayable financial assistance, affordable loans and invest in greening production and reducing emissions.

5. Summary and conclusion

The analysed studies (Dudjuk et al., 2016; Gindes, 2011; Lutkovska et al., 2020; Marchuk, 2018; Udovytsia, 2020) have shown that a significant number of authors emphasise the relevance of the economic mechanism of environmental management. In general, this vision of this concept is to some extent outdated and needs to be revised, taking into account the incentive tools used, in particular, such as investments, grants, bonuses, subsidies, etc. In other words, it is now advisable to treat this mechanism as a financial one, since this definition helps to ensure financial and economic interaction between entities that guarantee environmental safety.

We believe that, in general, the instruments of the financial mechanism should be divided into two types according to the functions they perform. Such differentiation facilitates an effective analysis of existing instruments, their comparison with those in place in the EU, of which Ukraine is seeking to become a member, and their modification following the requirements and needs of the economy and society as a whole. In the long run, it is equally important to balance these types of instruments. This will allow us to focus on the progressive development of a society that can adequately interact with the environment in a real economy. After all, sustainable development is only possible if a balance is struck between the environment, economy and society. The financial mechanism is linked to the first concept by adjusting the volume and structure of emissions; for the second, it serves as a source of budget revenues; in the third category, it forms a conscious use of nature.

Scholars and practitioners currently lack a unified view on the interpretation of the concept of a financial mechanism for environmental management. This situation requires a reorientation of views on the economic mechanism by transforming it into a financial one - focused on incentive factors rather than coercive ones.

The article assesses the financial mechanism of environmental management based on individual instruments and establishes that the current mechanism in Ukraine is imperfect

and requires significant transformations, in particular, in terms of revision of financial instruments. Improvements to tax instruments in line with EU requirements are proposed.

The correlation and regression analysis of the dependence of emissions on current expenditures and capital investments in air protection and climate change issues showed the existence of an inverse relationship between the factor and the resultant attribute.

The study of capital investments in environmental protection has shown that they should be made at all levels (state, local, and by the enterprise itself) and aimed at solving key urgent problems.

Based on the study, the following areas of environmental policy reform are proposed:

- The CO₂ tax should be replaced by a tax on energy (fuel oil, coal, natural gas, etc.);
- taxation of enterprises with annual CO₂ emissions of less than 500 thousand tonnes should be introduced;
- change the structure of distribution of environmental taxation revenues between the state and local budgets by reducing the share of revenues to the state budget and define defining the purposes of using local budget funds;
- introduce a system of tax rebates.

Promising areas for further research may include assessing the effectiveness of the transformation of the financial mechanism of environmental management in the dynamics and a detailed analysis of financial instruments, as components of the financial mechanism.

Author Contributions: Conceptualization, Oleksandr Labenko, Olga Faichuk and Taras Hutsol; Methodology, Valeriia Lymar and Inna Dolzhenko; Data curation Svitlana Belei, Sylwester Tabor and Stanisław Parafiniuk; Visualization, Lyidmila Kiurcheva; Software, Dariusz Kwasniewski; Resources, Oleksandr Labenko; Validation, Taras Hutsol; Project administration Sylwester Tabor.; Supervision, Taras Hutsol. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

Anonymous reviewers are gratefully acknowledged for their constructive review that significantly improved this manuscript and Ukrainian University in Europe (universityuue.com).

Funding

Publication was co-financed from the funds of the Ministry of Education and Science under contract No. KONF/SP/0507/2023/01 dated 13 January 2024 in the amount of 92113.85 PLN

Conflicts of Interest: The authors declare no conflict of interest

Reference

Al-Anbari M.A., 2024. Basic Concepts of Environmental Management. Available online: from https://www.academia.edu/116810211/Basic_Concepts_of_Environmental_Management?uc-g-sw=6434611 (accessed on 06.04.2024).

- Analytical note. Application of environmental taxes in Ukraine. 2022. 49 p. Available online: from <https://ces.org.ua/wp-content/uploads/2023/05/zastosuvannya-ekologichnih-podatkiv.pdf> (accessed on 03.04.2024).
- Borisova, V., Samohkina, I., Rybina, L., Shumkova, O., 2020. Financial Mechanism for Managing the Environmental Innovation Development of the Economy in Ukraine. *Journal of Environmental Management and Tourism*, 11(7), 1617-1633.
- Booth, Y., 2011. Practical experience of the EU member states on the application of the fiscal instruments in environmental policy. *Efektivna ekonomika*, 10. Available online: from <http://www.economy.nayka.com.ua/?op=1&z=729> (accessed on 05.04.2024).
- Chausson, A., Welden, E., Melanidis, M., Gray, E., Hirons, M., Seddon, N., 2023. Going beyond market-based mechanisms to finance nature-based solutions and foster sustainable futures. *PLOS Clim*, 2 (4): e0000169, DOI: 10.1371/journal.pclm.0000169.
- Dudjuk, V., Gobela, V., 2016. Economic incentives environmental safety. *Scientific Journal of Lviv State University of Internal Affairs*, 1, 40-48.
- Dziki, D., 2023. The Latest Innovations in Wheat Flour Milling: A Review. *Agricultural Engineering*, 27(1), 147-162, DOI: 10.2478/agriceng-2023-0011.
- Ecological taxes of Ukraine. Available online: from <https://www.saveecobot.com/analytics/ecotaxes> (accessed on 17.08.2023).
- Environmental tax revenues. Available online: https://ec.europa.eu/eurostat/databrowser/view/env_ac_tax/default/table?lang=en (accessed on 17.08.2023).
- García López, T., 2018. Instrumentos económicos para la protección ambiental en el derecho ambiental mexicano. *Sociedad y Ambiente*, 17, 247-266, DOI: 10.31840/sya.v0i17.1836.
- Gaura, M., Kuboń, M., Kowalczyk, Z., Kwaśniewski, D., Daniel, Z., Kapela, K., 2020. Quality Assessment of Delivery in the Supply Chain Optimization. *Agricultural Engineering*, 24(3), 21-30, DOI: 10.1515/agriceng-2020-0023.
- Gaichenko, V. A., 2006. Ecological management. Collection of scientific works of IAPM, 168-169.
- Gindes, O., 2011. Global risks of environmental degradation. *Economy and the state*, 7, 107-109.
- Golubovska-Onisimova, G, Havryliuk, R, Andrushevych, N, Kravchenko, O, Malkova, T. 2023. Assessment of environmental policy implementation in Ukraine: five systemic problems. Kyiv, 32 p.
- Hagedoorn, L.C., Koetse, M.J., van Beukering, P.J.H., Brander, L.M. Reducing the finance gap for nature-based solutions with time contributions. *Ecosystem Services* this link is disabled, 52, 101371, DOI: 10.1016/j.ecoser.2021.101371.
- Han, F., Li, J., 2020. Assessing impacts and determinants of China's environmental protection tax on improving air quality at provincial level based on Bayesian statistics. *Journal of Environmental Management*, 271, 111017, DOI: 10.1016/j.jenvman.2020.111017.
- Heine, D., Black, S., 2018. Benefits beyond Climate: Environmental Tax Reform. *Fiscal Policies for Development and Climate Action*, DOI: 10.1596/978-1-4648-1358-0_ch1.
- Irtysheva, I., Kramarenko, I., Stehnei, M., Boyko, E., 2022. The economic mechanism of ensuring resource conservation and natural use in the conditions of global challenges. *Innovation and Sustainability*, 4, 223-231.
- Karpuk, A., Marchuk, Yu., Myklush, T., 2020. Financial and investment support for integrated environmental management in the context of decentralization: specifics of the carpathian region. *AGROWORLD*, 7, 3-11, DOI: 10.32702/2306-6792.2020.7.3.
- Klingelhöfer, D., Müller, R., Braun, M., Brüggmann, D., Groneberg, D. A., 2022. Climate change: Does international research fulfill global demands and necessities?. *Environ Sci Eur*, 32, 137, DOI: 10.1186/s12302-020-00419-1.
- Kostornoi, S., Yatsukh, O., Tsap, V., Demchenko, I., Zakharova, N., Klymenko, M., Labenko, O., Baranovska, V., Daniel, Z. & Tomaszewska-Górecka, W., 2021. Tax Burden of Agricultural Enterprises in Ukraine. *Agricultural Engineering*, 25(1), 157-169, DOI: 10.2478/agriceng-2021-0013.
- Kovalenko, N., Hutsol, T., Kovalenko, V., Glowacki, S., Kokovikhin, S., Dubik, V., Mudragel, O., Kuboń, M., Tomaszewska-Górecka, W., 2021. Hydrogen Production Analysis: Prospects for Ukraine. *Agricultural Engineering*, 25(1), 99-114, DOI: 10.2478/agriceng-2021-0008.

- Kovalenko, N., Kovalenko, V., Hutsol, T., Ievstafieva, Y., Polishchuk, A., 2021. Economic Efficiency and Internal Competitive Advantages of Grain Production in the Central Region of Ukraine. *Agricultural Engineering*, 25(1), 51-62, DOI: 10.2478/agriceng-2021-0004.
- Kovshyun, N.Ye., Piatka, N.S., Zhylyk, A.I., 2021. Efficiency of environmental investment in Ukraine. *Herald NUVWR. Series «Economic sciences»*, 3 (95), 30-42, DOI: 10.31713/ve320214.
- Kowalczyk, Z., Twardowski, S., Malinowski, M., Kuboń, M., 2023. Life cycle assessment (LCA) and energy assessment of the production and use of windows in residential buildings. *Scientific Reports*, 13(1), 19752.
- Kukharets, V., Hutsol, T., Kukharets, S., Glowacki, S., Nurek, T., Sorokin, D., 2023. European Green Deal: The Impact of the Level of Renewable Energy Source and Gross Domestic Product per Capita on Energy Import Dependency. *Sustainability*, 15, 11817, DOI: 10.3390/su151511817.
- Kukharets, V., Juočiūnienė, D., Hutsol, T., Sukmaniuk, O., Čėsna, J., Kukharets, S., Piersa, P., Szufa, S., Horetska, I., Shevtsova, A., 2023. An Algorithm for Managerial Actions on the Rational Use of Renewable Sources of Energy: Determination of the Energy Potential of Biomass in Lithuania. *Energies*, 16, 548, DOI: 10.3390/en16010548.
- Kwaśniewski, D., Akdeniz, C., Durmaz, F. and Kömekçi, F., 2020. Economic Analysis of the Photovoltaic Installation Use Possibilities in Farms. *Agricultural Engineering*, 24(4), 47-60, DOI: 10.1515/agriceng-2020-0035.
- Lemko, Y., 2022. Features of EU environmental policy: regional dimension. *Lviv University Bulletin*, 43, 289-294, DOI: 10.30970/PPS.2022.43.35.
- Levochkin S.V., 2003. Macrofinancial stability in Ukraine in the context of economic growth: Monograph. Kyiv: Nasha kultura i nauka, 432 p.
- Lutkovska, S., Kaletnik, G., 2020. Modern Organizational and Economic Mechanism for Environmental Safety. *Journal of Environmental Management and Tourism*, XI, 3 (43), 606-612, DOI: 10.14505/jemt.v11.3(43).14.
- Marchuk, Yu., 2018. Financial and economic mechanism of nature management: essence, components and prospects for improvement. *Investments: practice and experience*, 24, 13-18. DOI: 10.32702/2306-6814.2018.24.13.
- Metelenko N.G., Shulga O.P., 2016. Concept of financial Mechanism. *black sea economic studies*, 10, 171-179.
- Monzón Aldama, Y., Pérez Diaz, S., Marrero Marrero, M., Petersson Roldán, M., 2022. Theoretical approach to economic-financial instruments and mechanisms for the environmental management of bays. *COODES*, 10, 1, 161-186.
- National bank of Ukraine. Macroeconomic indicators. Available online: <https://bank.gov.ua/ua/statistic/macro-indicators#4> (accessed on 12.08.2023).
- Pandey, S., Dogan, E., Taskin, D., 2020. Production-based and consumption-based approach hes for the energy-growth-environment Nexus: evidence from Asian countries. *Sustain. Prod. Consumpt*, 23, 274-281, DOI: 10.1016/j.spc.2020.06.006.
- Poiasnyk, H., 2023. The role of ecological entrepreneurship in the conditions of post-war reconstruction. *Economy and Society*, 47, DOI: 10.32782/2524-0072/2023-47-11.
- Rashid Khan, Haroon Ur., Zaman, Khalid, Usman, Bushra, Nassani, Abdelmohsen A., Aldakhil, Abdullah Mohammed, Qazi Abro, Muhammad Moinuddin, 2019. Financial management of natural resource market: Long-run and inter-temporal (forecast) relationship. *Resources Policy*, 63, DOI: 10.1016/j.resourpol.2019.101452.
- Rasmussen, L.V., Fold, N., Olesen, R.S., Shackleton, Sh., 2021. Socio-economic outcomes of ecological infrastructure investments. *Ecosystem Services*, 47, 101242, DOI: 10.1016/j.ecoser.2020.101242.
- Santos, F.D., Ferreira, P.L., Pedersen, JST., 2022. The Climate Change Challenge: A Review of the Barriers and Solutions to Deliver a Paris Solution. *Climate*, 10 (5): 75, DOI: 10.3390/cli10050075.
- Shergina, L., Zhemba, A., Kovtun, V., 2020. Formation of modern model of resources management in the era of globalization. *European Journal of Economics and Management*, 6, 14-19, DOI: 10.46340/eujem.2020.6.4.2.
- Skorokhod, I., Horbach, L., 2021. Innovation-investment provision of regional environmentally safe development. *Financial and Credit Activity Problems of Theory and Practice*, 3 (38), 456-464, DOI: 10.18371/fcaptop.v3i38.237478.
- Skorokhod, I., Kukharyk, V., Boiar, A., Kytsyuk, I., Horbach, L., 2022. Financial provision management for the environmental protection of the transborder region. *Financial and credit activity: problems of theory and practice*, 3 (44), 251-260, DOI: 10.55643/fcaptop.3.44.2022.3748.
- State statistical office. Available online: <https://www.ukrstat.gov.ua/> (accessed on 10.08.2023).
- The Imperative for Impact Management: Clarifying the relationship between impacts, system-wide risk and materiality. Available online: <https://impactmanagementplatform.org/wp-content/uploads/2023/06/The-Imperative-for-Impact-Management.pdf> (accessed on 20.08.2023).
- Udovytsia, O.F., 2020. Ways to improve economic environmental mechanism in Ukraine. *Market infrastructure*, 40, 359-362, DOI: 10.32843/infrastructure40-61.
- UK Green Finance Review. Opportunities for Growing Investment in Preserving our Natural Heritage and Supporting Nature Recovery. Available online: <https://www.heritagefund.org.uk/sites/default/files/media/attachments/Finance-Earth-UK-Green-Finance-Review-Heritage-Fund-February-2022.pdf> (accessed on 15.08.2023).
- Ukrainian centre for economic and political. Alexander Razumkov Center for economic and political studies, 2022. *National security and defense*, 1-2, 131 p.
- Umar Farooq, Bilal Haider Subhani, Muhammad Nouman Shafiq, Seemab Gillani, 2023. Assessing the environmental impacts of environmental tax rate and corporate statutory tax rate: Empirical evidence from industry-intensive economic. *Energy Reports*, 9, 6241-6250, DOI: 10.1016/j.egy.2023.05.254.
- United Nations Environment Programme. Making Peace with Nature: A scientific blueprint to tackle the climate, biodiversity and pollution emergencies. Available online: <https://www.unep.org/resources/globalassessments-synthesis-report-path-to-sustainable-future> (accessed on 02.09.2023).
- United Nations Environment Programme. State of Finance for Nature. Time to act: Doubling investment by 2025 and eliminating nature-negative finance flows. Available online: <https://wedocs.unep.org/20.500.11822/41333/> (accessed on 06.09.2023).
- Zimon D., 2017. The Impact of Implementation of Implementation of the Requirements of the ISO 14001 of the Requirements of the ISO 14001 Standard for Creating Sustainable Supply Chains. *Environmental management*, 18(158), 99-102.
- Zioloa, M., Bakb, I., Cheba, K., 2019. Environmental taxes - how public policy makers can use them in the decision-making process? *Procedia Computer Science*, 159, 2216-2223.
- Živković S., Veljković M., 2020. The concept and objectives of environmental management. *Economics of sustainable development*, 4(2), 37-47, DOI: 10.5937/ESD2002037Z.

Appendix

Appendix A

Table 1: Interpretation of the concept of financial and economic (economic) mechanism of nature management (source: systematized according to (Dudjuk et al., 2016; Gindes, 2011; Marchuk, 2018; Irtyshcheva et al., 2022))

Key elements of the concept	Dudjuk & Gobel	Gindes	Marchuk	Irtyshcheva, Kramarenko, Stehnei and Boyko
Measures aimed at regulating environmental management	+			+
Incentive system	+			+
Payment for the use of resources	+	+	+	+
Compensation for environmental damage	+	+		
Redistribution of funds from environmental payments	+		+	
Financing and lending for environmental protection measures		+	+	+
Penalties			+	
Reproduction of natural resource potential and environmental protection			+	+

Appendix B

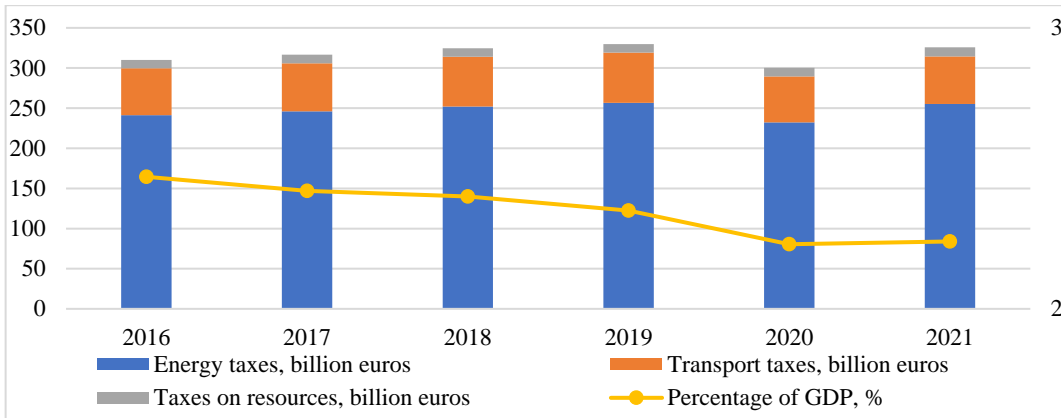


Fig. 1. Dynamics of environmental taxes in the EU (source: according to (Shergina et al., 2020))

Appendix C

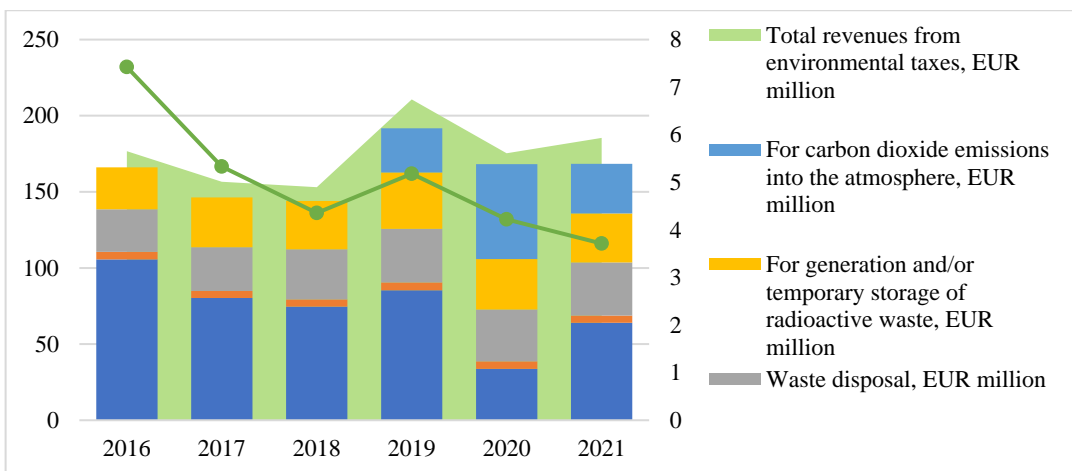


Fig. 2. Dynamics of environmental taxes in Ukraine (Source: systematized according to (State statistical office; Marchuk, 2018; Ecological taxes of Ukraine.))

Appendix D**Table 2.** Dynamics of pollutant and CO₂ emissions into the atmosphere and current expenditures and capital investments for air protection and climate change (source: according to (State statistical office))

Period	Emissions of pollutants and carbon dioxide into the atmosphere, thousand tons (y)	Current expenditures on air protection and climate change issues, UAH million (x ₁)	Capital investments in air protection and climate change, UAH million (x ₂)
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
2020	3807.2	2375.8	5595.3

Appendix E**Table 3.** Matrix of pairwise correlation coefficients of pollutant and carbon dioxide emissions into the atmosphere and current expenditures and capital investments for air protection and climate change

	y	x ₁	x ₂
y	1		
x ₁	-0.602847093	1	
x ₂	-0.852637909	0.48101101	1

Appendix F**Table 4.** Results of the regression analysis of the model of dependence of emissions on the factor attributes

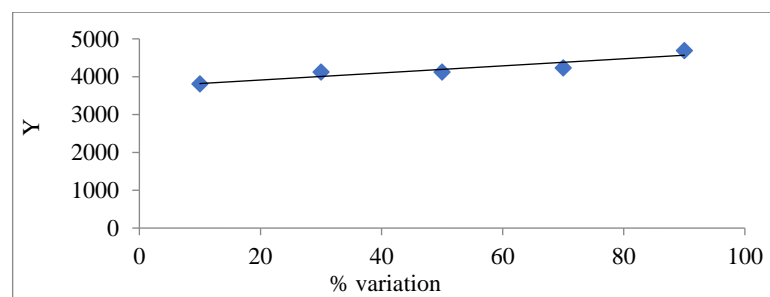
Indicator	Value of the indicator for the factors x ₁ , x ₂
Multiple R	0.881
R ²	0.775
Normalized R ²	0.551
Standard error	213.181
Observation	5

Appendix G**Table 5.** Analysis of variance

	Df	SS	MS	F	Value F
Regression	2	313635.1	156817.5	3.450615	0.224688
Balance	2	90892.5	45446.25		
Разом	4	404527.6			

Appendix H**Table 6.** Table of coefficients

	Coefficients	Standard error	t- statistics	P- value
Y- section	5238.496	515.604	10.160	0.010
Variable x ₁	-0.155	0.236	-0.656	0.579
Variable x ₂	-0.181	0.095	-1.915	0.196

Appendix I**Fig. 3.** Graph of the normal distribution

Appendix J

Table 7. Capital investments in environmental protection by type (source: according to (State statistical office))

Type	2016, million eu- ros	2017, million euros	2018, million eu- ros	2019, million euros	2020, million euros	Deviations, 2020/2016	
						Absolute, million eu- ros	Relative, %
On air protection and climate change issues	88.5	86.9	109.1	147.7	181.7	93.3	105.4
For wastewater treatment	41.0	42.5	52.7	60.6	51.3	10.3	25.0
For waste management	78.1	82.4	36.8	198.8	94.2	16.1	20.6
To protect and rehabilitate soil, groundwater and surface water	14.8	42.8	44.9	59.5	83.0	68.1	458.8
To reduce noise and vibration impact	3.4	5.4	1.9	0.2	2.5	-0.8	-24.5
To preserve biodiversity and habitats	1.8	5.9	2.3	7.3	12.1	10.3	587.5
On radiation safety	245.4	100.4	63.4	85.6	4.6	-240.8	-98.1
For environmental research and development	0.08	0.13	0.2	0.3	0.3	0.2	275.2
Other areas of environmental protection activities	0.3	1.0	2.3	1.4	0.3	0.05	16.5