

Environmental Taxation: Role in Promotion of the Pro-Environmental Behaviour

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Abstract: - The purpose of the article is to investigate the potential of environmental taxation in the regulation of ecological responsibility and ensuring the pro-environmental behaviour of economic entities. To study the theoretical basis of environmental taxation and environmentally responsible behaviour, a bibliometric analysis of key words in scientific articles published on this topic was conducted. The results of the bibliometric analysis show that aspects of environmentally responsible behaviour are presented in the list of keywords that mediate the study of environmental taxation. Thus, pro-environmental behaviour is defined by the necessity of health risks avoiding, clean energy technology providing, waste generating reducing etc. The impact of environmental taxes on various aspects of environmentally responsible behaviour was modelled on the sample of six European countries (Belgium, France, Austria; Finland and Denmark) for 1994-2019. The results of the calculations show that environmental taxes have limited effectiveness in regulating various aspects of environmental liability. So, the average growth of environmental taxes revenue by 1 USD million provides a decrease in the Eco-Innovation Index by 0.001 point; the slow rise in CO₂ emissions (less than 0.000 %) and the growth in tobacco use (about 0.000 %). On the other hand, environmental taxes do not influence the country's environmental performance, as well as on the total alcohol consumption and renewable electricity consumption and output. Thus, an approach to the establishment of tax benefits for enterprises was proposed, considering the results of changes in the environmentally harmful effects they produce.

Key-Words: - Environmental taxes; Environmental behaviour; Environmental footprint; Green consumption; Regression analysis

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1 Introduction

The issue of sustainable development and solving global environmental problems has remained relevant for decades. Lyeonov et al., [1] prove that at the present stage environmental aspects are important in shaping the country's image and ensuring its competitiveness. Current research indicates that, despite the widespread global environmental problems, their solution is impossible without the use of special regulatory tools.

Thus, environmental aspects play a significant role in shaping public energy policy, [2], [3], ensuring macroeconomic stability and economic development, [4], [5], investment attractiveness of the country, [6], [7], [8], [9] and its security, [10]. Solving environmental problems is becoming relevant not only at the national but also at the regional level, especially in the context of the global trend towards decentralization of territories, [11], [12].

It is important that sustainable development in general and the improvement of its environmental aspects depend not only on the effectiveness of regulatory instruments but also on the overall level of quality of public administration, [13], [14]. Thus, the penetration of environmental protection tasks into all spheres and parts of the national economy has led to the emergence of a new global trend - the formation of a circular economy, [15], [16]. In the era of rapid development of digital technologies, the transition to a circular economy is often associated with the use of smart grids, [17], [18], [19], closed-loop supply chains, [20], [21] and the development of smart cities, which requires the involvement of all economic agents without exception and the appropriate adjustment of regulatory instruments, [22], [23].

At the same time, it is important to evaluate the effectiveness of their use in terms of reducing the destructive impact on the environment. It should be noted that the reasons for the growth of harmful environmental impacts are due not only economic but also psychological factors.

Thus, the current trend towards increasing environmental responsibility aims to minimize the irrational use of the environment. This determines both the emergence of new resource-efficient technologies and the reduction of consumption of goods, the production of which is environmentally polluted, as well as responsible waste management.

It is important to identify factors that can stimulate environmentally responsible behaviour. Given the proliferation of environmental taxes as regulatory tools, their effectiveness in this context should be examined.

2 Problem Formulation

2.1 Literature Review

Given the growing scale and intensity of industrial and agricultural production as well as other manifestations of anthropogenic impact on the environment. The need to form a comprehensive and harmonized at the supranational, national and regional levels of environmental policy is an important priority. At the same time, one of the most relevant aspects in terms of certain general issues is the search for and implementation of such instruments of state regulation of the economy that are most effective in the context of strengthening the level of environmental responsibility of economic agents. Environmental responsibility is a complex and multifaceted concept that covers not only the need for a particular subject of economic relations to comply with environmental legislation but also its actions to preserve the environment and improve the environmental situation. In the context of Ukraine's European integration vector, it is appropriate to consider this phenomenon from the standpoint of Directive 2004/35 / EC, which treats environmental liability as a type of civil liability that obliges the polluter to take measures to prevent or eliminate the consequences of environmental damage that existed before it was caused, and to cover the costs of the measures taken. In this context, it is also fair to note that the effectiveness of environmental taxation varies from country to country and is determined by several factors: the design of the environmental tax system (including the scale of tax coverage), the use of tax revenues, differentiation of tax rates and benefits.

Environmental responsibility is one of the key dimensions of sustainable development. The environmental impact of economic functioning is closely related to social and economic perspectives, [24]. Thus, investigations of the prospect of environmental management strengthening should be comprehensive and based on the stakeholder approach. Modern research shows that the

behaviour of economic entities is largely determined by the level of their literacy in various fields. Thus, the growth of financial literacy not only improves the living standards of the population, [25], [26] but also forms the basis for more responsible household behaviour, [27]. At the same time, it has been proven that the social security of the population is largely determined by behavioural aspects, [28], [29]. In turn, other scientists determine that financial tools for influencing household behaviour remain the most effective, [30], [31], [32]. Thus price factors determine the activity of households in the use of equipment for green energy production, [33]. Analysing the behavioural determinants of the population, Yarovenko et al., [34], and Letunovska et al., [35] pay considerable attention to the level of literacy and information management, while Brychko et al., [36] focus on issues of trust. This suggests that government policies to promote pro-environmental behaviour must include educational aspects. Voronstova et al. [37] confirm that educational initiatives are successful in shaping the environmentally responsible consciousness of society.

The issues of sustainable development and environmental responsibility are becoming more widespread in the corporate sector of the economy, [38]. Thus, Bilan et al. [39], prove that the model of sustainable development ensures the success of a business and allows it to maintain its innovative activity. It has been confirmed that investing in sustainable development is the key to long-term business efficiency, [40], which, among other things, creates grounds for improving the financial condition of enterprises, [41], [42], [43]. This formed the basis for expanding aspects of monitoring the development of enterprises from traditional auditing to the formation of integrated reporting that reflects the environmental impact created in the process of functioning of corporations, [44], [45]. The key components of the implementation of a sustainable business model are the environmental and social responsibility of enterprises, [46], [47], [48]. Disclosure of ecologically and socially significant measures of corporations has a positive effect not only on the development of enterprises but also on increasing the country's competitiveness, [49], [50], which shows the interest of both regulators and corporations in the growth of the quality use of the environment.

The results of empirical research, [51], [52] confirm the importance of financial instruments in ensuring the achievement of sustainable development goals. Traditionally, tax instruments

occupy a central place in the system of state regulation, [53]. Thus, the effectiveness of their application is proven not only in the general provision of macroeconomic stability but also in the regulation of certain areas of the national economy, [54]. Thus, adjusting the overall level and structure of the tax burden states not only ensures economic growth but also maximizes the share of the green economy, [55], which in the long run creates benefits for all economic agents, [56]. The results obtained by Miller, [57], and Eddassi, [58] indicate that the fiscal regime plays a significant role in managing the country's resource potential. The integrated effect of environmental tax instruments has also been proven in ensuring economic, energy and environmental security, [59]. On the other hand, tax factors are one of the most important in correcting the behaviour of business agents, [60]. It is important that today, the design of tax instruments is determined not only by the needs of the national economy but also requires consideration of the effects of the global tax environment, [61], [62], [63], [64], which indicates the need for international analysis to identify the effectiveness of tax instruments. Thus, in European countries, there is a stable convergent trend in the application of environmental taxes, [65]. On the other hand, the overall effectiveness of environmental taxes also depends on their combination in the country, [66]. Along with the restrictions that create environmental taxes, successful tools for sustainable development today are identified in the growth of green investment, which not only directly affects environmental parameters but is also determinant of increasing quality of life, [67] and leads before the emergence of new sectors of the economy, [68]. The development of a green economy and green energy is impossible without a sufficient level of financial security, [69], [70]. At the same time, it has been proven that the effectiveness of regulatory instruments is largely determined by the size of the shadow economy, [71], [72], [73] which, along with the development of state strategies of influence requires an increase in economic and environmental awareness. It is determined that the effectiveness of the use of tax instruments depends not only on their design but also on the perception of taxpayers, [74]. That is why the use of tax instruments for the formation of environmentally responsible behaviour should also consider the national mentality, [75]. The analysis shows that environmental taxes have a significant potential to influence the regulation of environmentally responsible behaviour.

2.2. Methodology

The essence of environmental responsibility is manifested through three main functions: stimulating, compensatory and preventive, which is to maintain a stable balance of economic and environmental interests in the process of economic activity through prevention, reduction and recovery of losses in the natural environment. Therefore, there is a need for comprehensive implementation of the values of environmental responsibility in the practice of management and corporate culture of the organization. Environmental responsibility ceases to be something coercive; it becomes an internal rule of doing business. It is important to explore the key factors that determine the behaviour of economic agents, which is related to the use of the environment and, consequently, the functioning of environmental taxes. To this end, we will analyse the keywords associated with the queries «environmental responsibility», and «environmental behaviour».

In order to determine the contextual links that arise in the study of environmental responsibility, we will conduct a bibliometric analysis of keywords found in scientific articles indexed by the Scopus database. So, the Scopus database indexes 29 510 articles containing the words “environmental responsibility” in their titles, abstracts or keywords lists; 225 834 articles concerning the keywords “environmental behaviour” and 11 040 articles concerning the keywords “environmental behaviour”. Bibliometric analysis is conducted by the VOSviewer 1.6.1 version using. This allows for defining the general directions of scientific studies arising in the process of investigating the concepts of environmental responsibility and environmental behaviour and the implication of environmental taxation.

The next step of the research is devoted to the evaluation and measurement of environmental taxation impact on the parameters of environmental behaviour. Given the need for an international research context, the sample for analysis consisted of 5 European countries in which the system of environmental taxation is quite extensive and comprehensive (France, Austria, Finland, Denmark, Belgium).

The main factor variable is the level of the tax burden on environmental taxes (the total amount of revenues from environmental taxes). At the same time, to consider the national specifics of countries, the models take into account the level of national security (a complex parameter of environmental, economic and energy security), calculated according to Štreimikienė et al. The results of theoretical

investigations formed a background to choose the indicators of environmentally responsible behaviour. Parameters indicating pro-environmental behaviour are divided into three groups.

The first group resulting indicators are selected indices that characterize the state of the environment (Eco-Innovation Index, Environmental Performance Index) with the study period is 2012–2019.

The second group of indicators reflect the behaviour of economic entities in dealing with the environment (CO₂ emissions from manufacturing industries and construction, % of total fuel combustion; CO₂ emissions from transport, % of total fuel combustion; prevalence of current tobacco use, % of adults; total alcohol consumption per capita, litres of pure alcohol, projected estimates, 15+ years of age; renewable electricity output, % of total electricity output; renewable energy consumption, % of total final energy consumption). The analysis period for which the study was conducted includes 1994–2019.

Analysis of the available statistics using the Hausman test showed that a panel regression model with random effects should be chosen. At the same time, to test the hypothesis of the presence of delayed effects, we will also conduct an analysis considering time lags lasting from one to three years.

The proposed methodology combines the methods of theoretical and empirical analysis, which allows substantiating the channels of environmental taxation influence on ensuring environmentally responsible behaviour, as well as empirically verifying the presence of such influence by measuring its strength and direction. Choosing the integral index of national security as a control variable makes it possible to take into account the differences in the initial conditions that have developed in the countries. The proposed approach also allows for assessing the presence of a delayed impact, which is often observed when using economic instruments of indirect action. It should be noted that this study differs from existing ones both in the set of resulting and factor variables and in the combination of analysis methods.

Despite this, the proposed methodology has certain limitations. Thus, due to the diversity of environmental taxation systems, the effects identified for the studied sample of countries cannot be extended to other countries automatically, without additional research. At the same time, for a better interpretation of the channels of influence of environmental taxation on environmentally responsible behaviour, the results of economic and mathematical modelling should be supplemented

which reflect the context of changes in the functioning of living organisms in the process of ecological and climatic changes, including in relation to human development. The blue cluster combines 215 keywords, the most important of which are «human», «risk factor», «demography», «mortality», «smoking», «obesity», «epidemic», «lifestyle», «health behaviour», «diet», «age», which characterize the social threats that arise as a result of destructive anthropogenic impact on the environment. The yellow cluster includes 111 keywords, including «psychological aspect», «family», «adoption», «adolescent», «attitude», «genetics», and «individuality», which reflect the socio-psychological basis for the formation of pro-environmental behaviour. Thus, it is quite interesting that the context of studying the concepts of environmental responsibility and environmental behaviour to a greater extent includes the manifestations of these concepts and the factors that determine them.

In turn, it is important to study the context of the study of environmental taxes (Fig. 3).

The analysis revealed the presence of six clusters of keywords that mediate contextual links in the

study of environmental taxation. The largest red cluster contains 158 keywords, among which the most common are «economics», «human», «waste management», «adult», «policy», and «willingness to pay», which generally reflects the relationship of environmental tax policy with the activities of economic entities. The second largest cluster (green) contains 124 keywords, the most common of which are «carbon dioxide», «energy policy», «gas emissions», «life cycle», «energy efficiency», «fossil fuels», «renewable resource», «energy conservations». Thus, this cluster deals with the relationship between environmental taxation and energy policy and environmental pollution. The next largest cluster (blue) includes 108 keywords, among which such words as «economic instrument», «tax reform», «regulatory approach», «pollution control», «sustainability», «political economy» etc. occupy a special place. In general, this cluster reflects the regulatory function of environmental taxation in ensuring the sustainability of the national economy. The yellow cluster includes 73 words, among which

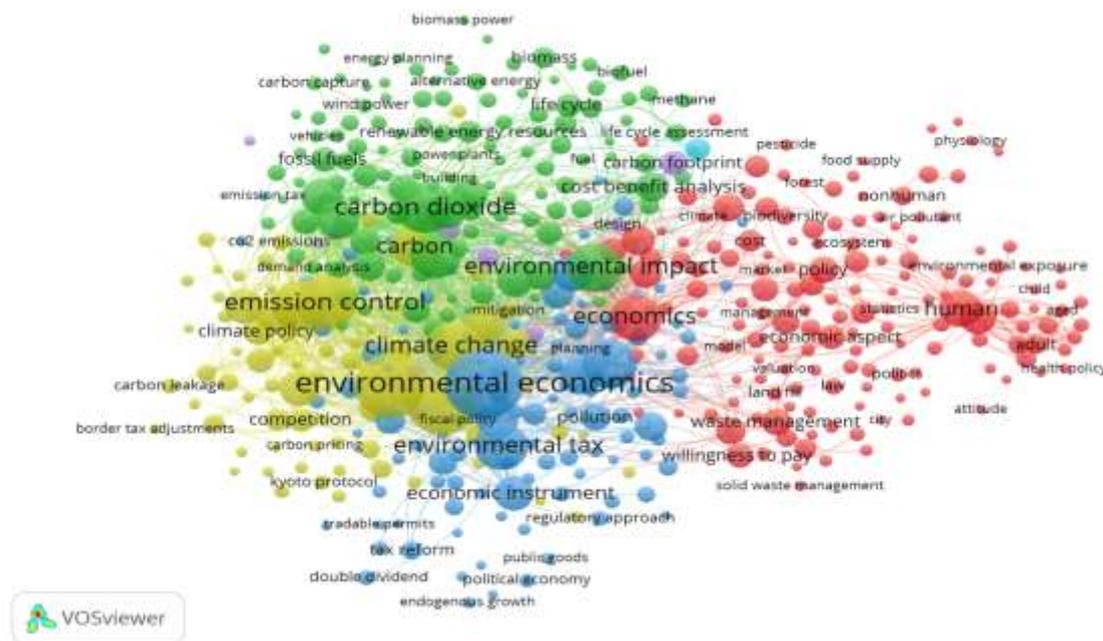


Fig. 3: Results of bibliometric analysis of keywords co-occurrence on the request «environmental tax»

Note: red colour indicates the keywords of scientific research concerning the economic activity determined by environmental tax policy; green colour – keywords concerning the energy policy and environmental tax interaction; blue colour – keywords concerning the environmental taxation impact on the sustainability ensuring; yellow colour – concerning the targets of environmental taxes implication; purple colour – parameters of the economic and environmental performance of the enterprises; turquoise colour – environmental impact on the households.

Source: VOSviewer 1.6.1 results

should be noted such aspects as «emission control», «climate change», «emissions trading», «environmental policy», and «competitiveness», which reflect the target orientation of environmental tax instruments. The last two clusters are much smaller. Thus, the purple cluster consists of 13 keywords, such as «profitability», «supply chains», and «manufacturing», which largely reflect the resulting parameters of enterprise development, which are related to environmental taxation. In turn, the last (turquoise) cluster is represented by the keywords «greenhouse effect», which characterizes the relationship of environmental taxation with households. Thus, it can be noted that an important role in the development of environmental taxation (both in its establishment and in ensuring its effectiveness) is played by the relationship with the subjects of taxation, which confirms the analysis.

3.2 Results of the Assessment of the Environmental Impact on the Pro-Environmental Behaviour Ensuring

The next step is to study the causal links that arise between environmental taxes and pro-environmental behaviour indicators. Regression results of the assessment of environmental taxes on the Eco-

Innovation and Environmental Performance indices are presented in Tables 1-2.

It should be noted that the obtained results were statistically significant, which allows us to adequately interpret the impact of environmental taxation parameters on the country's economy from the point of view of environmental innovations and environmental performance. Income from environmental taxes is characterized by an inverse relationship with the country's position on the eco-innovation index. This indicates the fact that potential environmental taxpayers are faced with a choice - to continue to carry out their activities under current conditions and, accordingly, pay additional taxes, or to implement environmental innovations, which will reduce the tax base and the amount of revenues from environmental taxes. It is important that such an effect is observed in a period without a time lag, which affects the operational efficiency of environmental taxes. On the other hand, despite the statistical significance of the built model, the connection between revenues from environmental taxes and the environmental performance of the country turned out to be unconfirmed.

Table 1. Results of the assessment of environmental taxation impact on the countries' Eco-Innovation Index

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Model 1 (without lag)							
Environmental taxes revenue	-0.001	0.000	-2.03	0.042	-0.001	0.000	**
National security Index	16.375	7.539	2.17	0.030	1.600	31.150	**
Constant	132.635	17.633	7.52	0.000	98.075	167.195	***
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	-1.50	0.135	-0.001	0.000	
National security Index	14.918	9.776	1.53	0.127	-4.243	34.078	
Constant	127.808	11.469	11.14	0.000	105.329	150.286	***
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	-1.62	0.104	-0.001	0.000	
National security Index	46.835	29.806	1.57	0.116	-11.584	105.254	
Constant	102.857	22.981	4.48	0.000	57.814	147.899	***
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	-1.12	0.262	-0.001	0.000	
National security Index	47.248	15.511	3.05	0.002	16.847	77.650	***
Constant	99.855	13.678	7.30	0.000	73.047	126.663	***

Note: *** indicates statistical significance at level 99% ($p < 0.01$), ** – statistical significance at level 95% ($p < 0.05$), * – statistical significance at level 90% ($p < 0.1$).

Source: authors' calculations

Table 2. Results of the assessment of environmental taxation impact on the countries' Environmental Performance Index

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
Model 1 (without lag)							
Environmental taxes revenue	0.000	0.000	0.48	0.629	0.000	0.000	
National security Index	19.296	11.141	1.73	0.083	-2.540	41.131	*
Constant	63.091	8.560	7.37	0.000	46.313	79.869	***
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	0.84	0.400	0.000	0.000	
National security Index	13.845	13.600	1.02	0.309	-12.811	40.500	
Constant	65.995	10.097	6.54	0.000	46.205	85.786	***
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	0.32	0.748	0.000	0.000	
National security Index	21.937	19.868	1.10	0.270	-17.004	60.877	
Constant	59.808	15.290	3.91	0.000	29.840	89.775	***
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	0.45	0.650	0.000	0.000	
National security Index	26.583	15.937	1.67	0.095	-4.653	57.819	*
Constant	55.814	12.750	4.38	0.000	30.824	80.804	***

Note: *** indicates statistical significance at level 99% (p<0.01), ** – statistical significance at level 95% (p<0.05), * – statistical significance at level 90% (p<0.1).

Source: authors' calculations

The next step is to investigate the impact of environmental taxes on the environmental impact of businesses and households. Thus, the general results of the built panel regression models with random effects, reflecting the effects of environmental taxes on certain areas of environmentally related behaviour of economic entities, are presented in Tables 3-8.

The first pair of studied indicators characterize the indicators of CO2 emissions from production and transport, which characterizes the level of environmentally responsible behaviour for both

enterprises and households. Thus, the data in Table 3 show that environmental taxes have a weak quantitative but statistically significant positive effect on the growth of CO2 emissions from industry and construction, which is observed in calculations performed with different lengths of time lag. This indicates the fact that the growth of environmental taxes does not encourage companies to switch to less environmentally polluting technologies. Similar trends are also observed with regard to the impact of environmental taxes on CO2 emissions from transport (Table 4).

Table 3. Results of the assessment of environmental taxation impact on the countries' CO2 emissions from manufacturing industries and construction

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
Model 1 (without lag)							
Environmental taxes revenue	0.000	0.000	-5.30	0.000	0.000	0.000	***
National security Index	1.196	1.579	0.76	0.449	-1.900	4.291	
Constant	18.643	1.787	10.43	0.000	15.141	22.146	***
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	-5.25	0.000	0.000	0.000	***
National security Index	-0.434	1.515	-0.29	0.774	-3.403	2.535	
Constant	19.654	1.796	10.94	0.000	16.134	23.174	***
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	-5.36	0.000	0.000	0.000	***
National security Index	-2.132	1.418	-1.50	0.133	-4.912	0.648	
Constant	20.658	1.974	10.46	0.000	16.788	24.528	***
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	-5.36	0.000	0.000	0.000	***
National security Index	-2.319	1.409	-1.65	0.100	-5.081	0.443	
Constant	20.807	2.010	10.35	0.000	16.866	24.747	***

Note: *** indicates statistical significance at level 99% (p<0.01), ** – statistical significance at level 95% (p<0.05), * – statistical significance at level 90% (p<0.1).

Source: authors' calculations

Table 4. Results of the assessment of environmental taxation impact on the countries' CO2 emissions from transport

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
Model 1 (without lag)							
Environmental taxes revenue	0.000	0.000	4.44	0.000	0.000	***	
National security Index	16.048	1.574	10.20	0.000	12.964	19.132	***
Constant	17.048	2.223	7.67	0.000	12.691	21.404	***
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	3.65	0.000	0.000	0.000	***
National security Index	12.098	1.870	6.47	0.000	8.433	15.764	***
Constant	18.671	2.317	8.06	0.000	14.129	23.213	***
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	3.60	0.000	0.000	0.000	***
National security Index	11.510	1.828	6.29	0.000	7.926	15.093	***
Constant	18.746	2.277	8.23	0.000	14.283	23.209	***
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	3.08	0.002	0.000	0.000	***
National security Index	11.564	1.865	6.20	0.000	7.909	15.218	***
Constant	18.804	2.349	8.00	0.000	14.200	23.409	***

Note: *** indicates statistical significance at level 99% (p<0.01), ** – statistical significance at level 95% (p<0.05), * – statistical significance at level 90% (p<0.1).

Source: authors' calculations

Thus, the presence of a statistically significant correlation indicates that the level of air pollution from transport emissions is gradually increasing, which continues to increase in terms of paying environmental taxes.

The next group of studied indicators characterizes the behavioural trends of the population of countries, which reflect the level of their responsibility, including environmental. Thus, the results of the assessment of the impact of environmental taxes on current tobacco use presented in Table 5 showed a positive statistically significant relationship. At the same time, the analysis of the obtained coefficients shows that the revealed relationship is direct - the increase in

revenues from environmental taxes is associated with an increase in tobacco consumption. It is important that this relationship has a rather low level of coefficients, but it is also observed with a one-year lag introduced into the model. This points to the fact that environmental taxes are not an effective tool to influence the environmentally harmful habits of the population. On the other hand, the results of assessing the impact of environmental taxes on the intensity of alcohol consumption (Table 6) did not allow obtaining statistically significant results. Thus, environmental taxes are not a relevant tool for regulating this aspect of life. The conducted research proves that financial levers are insufficient to stimulate the considered aspects of ecologically responsible behavior of the population.

Table 5. Results of the assessment of environmental taxation impact on the countries' prevalence of current tobacco use

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
Model 1 (without lag)							
Environmental taxes revenue	0.000	0.000	1.99	0.046	0.000	0.000	**
National security Index	-7.740	3.231	-2.40	0.017	-14.073	-1.407	**
Constant	28.969	3.643	7.95	0.000	21.828	36.110	***
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	1.96	0.050	0.000	0.000	*
National security Index	-6.245	3.306	-1.89	0.059	-12.724	0.234	*
Constant	27.494	4.693	5.86	0.000	18.295	36.692	***
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	1.30	0.192	0.000	0.000	
National security Index	-8.624	3.175	-2.72	0.007	-14.846	-2.401	***
Constant	31.430	3.839	8.19	0.000	23.907	38.954	***
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	1.26	0.208	0.000	0.000	
National security Index	-8.843	2.558	-3.46	0.001	-13.858	-3.829	***
Constant	31.612	4.125	7.66	0.000	23.527	39.696	***

Note: *** indicates statistical significance at level 99% ($p < 0.01$), ** – statistical significance at level 95% ($p < 0.05$), * – statistical significance at level 90% ($p < 0.1$).

Source: authors' calculations

Table 6. Results of the assessment of environmental taxation impact on the countries' total alcohol consumption per capita

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
Model 1 (without lag)							
Environmental taxes revenue	0.000	0.000	0.60	0.551	0.000	0.000	
National security Index	-3.085	1.201	-2.57	0.010	-5.439	-0.732	**
Constant	13.838	0.823	16.81	0.000	12.224	15.452	***
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	0.01	0.996	0.000	0.000	
National security Index	-3.982	0.807	-4.93	0.000	-5.564	-2.400	***
Constant	14.607	0.607	24.07	0.000	13.417	15.796	***
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	0.43	0.667	0.000	0.000	
National security Index	-3.146	1.175	-2.68	0.007	-5.449	-0.843	***
Constant	14.099	0.802	17.57	0.000	12.526	15.671	***
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	0.77	0.439	0.000	0.000	
National security Index	-2.204	0.920	-2.40	0.017	-4.006	-0.401	**
Constant	13.409	0.657	20.41	0.000	12.121	14.697	***

Note: *** indicates statistical significance at level 99% ($p < 0.01$), ** – statistical significance at level 95% ($p < 0.05$), * – statistical significance at level 90% ($p < 0.1$).

Source: authors' calculations

The last block of the studied indicators characterizes the intensity of the transition of economic entities to the production and consumption of renewable energy. It should be noted that the results presented in Table 7 and in Table 8 indicate that environmental taxes are almost ineffective in regulating this behaviour of economic entities. Moreover, the studied effects do not appear at different durations of time lags. Thus, given the low efficiency of environmental taxes in regulating environmentally responsible behaviour, we note the need to find ways to improve their impact on the

activities of economic entities. When using these tools, one should consider the risks that may threaten: the growth of environmental tax arrears, reducing the solvency and financial stability of the taxpayer, tax evasion and the use of poor-quality treatment facilities. One of the promising options for reducing pollutant emissions may be a permit to deduct the cost of environmental costs from the amount of environmental payments, as well as the possibility of tax holidays for environmental taxpayers, temporary exemption from taxation of certain transactions and exclusion from the tax base projects.

Table 7. Results of the assessment of environmental taxation impact on the countries' renewable electricity output

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
Model 1 (without lag)							
Environmental taxes revenue	0.000	0.000	-0.08	0.939	0.000	0.000	
National security Index	41.482	5.676	7.31	0.000	30.357	52.607	***
Constant	8.016	14.716	0.55	0.586	-20.826	36.858	
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	-0.48	0.630	0.000	0.000	
National security Index	36.858	5.697	6.47	0.000	25.691	48.024	***
Constant	10.839	14.718	0.74	0.461	-18.008	39.686	
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	-0.88	0.377	0.000	0.000	
National security Index	32.786	5.684	5.77	0.000	21.646	43.926	***
Constant	13.520	14.692	0.92	0.357	-15.277	42.316	
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	-0.97	0.332	0.000	0.000	

National security Index	30.929	5.689	5.44	0.000	19.779	42.080	***
Constant	14.191	14.688	0.97	0.334	-14.597	42.979	

Note: *** indicates statistical significance at level 99% (p<0.01), ** – statistical significance at level 95% (p<0.05), * – statistical significance at level 90% (p<0.1).

Source: authors' calculations

Table 8. Results of the assessment of environmental taxation impact on the countries' renewable energy consumption

Variable	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Model 1 (without lag)							
Environmental taxes revenue	0.000	0.000	0.86	0.391	0.000	0.000	
National security Index	26.357	2.654	9.93	0.000	21.155	31.559	***
Constant	4.085	5.591	0.73	0.465	-6.874	15.044	
Model 2 (lag 1 year)							
Environmental taxes revenue	0.000	0.000	0.25	0.805	0.000	0.000	
National security Index	25.160	2.541	9.90	0.000	20.179	30.140	***
Constant	4.997	5.627	0.89	0.375	-6.032	16.026	
Model 3 (lag 2 years)							
Environmental taxes revenue	0.000	0.000	-0.25	0.799	0.000	0.000	
National security Index	23.423	2.582	9.07	0.000	18.364	28.483	***
Constant	6.103	5.462	1.12	0.264	-4.603	16.809	
Model 4 (lag 3 years)							
Environmental taxes revenue	0.000	0.000	-0.43	0.669	0.000	0.000	
National security Index	21.681	2.662	8.15	0.000	16.464	26.898	***
Constant	6.698	5.356	1.25	0.211	-3.799	17.195	

Note: *** indicates statistical significance at level 99% (p<0.01), ** – statistical significance at level 95% (p<0.05), * – statistical significance at level 90% (p<0.1).

Source: authors' calculations

These tools should be the primary way to form environmentally responsible behaviour of economic entities.

Given the results of calculations, analysed the experience of EU countries and domestic realities, we conclude that Ukraine needs to harmonize the domestic system of environmental taxation with European practices in order to preserve the environment and efficient use of environmental tax revenues in terms of the above areas. It is noteworthy that most countries that are characterized by effective environmental tax policy, use not one but several tax and (often) and non-tax instruments to stimulate environmentally sound activities and reduce the harmful effects on the environment. In this regard, the development of theoretical and methodological support for assessing the complex impact of the state on the activities of environmental taxpayers, which is associated with changes (positive or negative) in their impact on the environment.

Therefore, the overall impact of state tax policy on the activities of environmental taxpayers should be assessed as follows (1):

$$\Delta ET_e = \frac{\sum_{i=1}^n ETR_i \cdot ETB_i}{TFR} - \frac{\sum_{j=1}^m TI_j}{TFR} \quad (1)$$

where ΔET_e – the general influence of the tax ecological policy of the state connected with change of the tax burden arising as a result of ecologically influencing activity of subjects of business;

ETR_i – environmental tax rate for the i -th type of environmental pollution;

ETB_i – the amount of harmful substances by the i -th type of environmental pollution, which serves as a tax base;

n – the number of types of environmental pollution;

TI_j – the amount of tax revenues that have not been paid in connection with the benefit of the j -th type of tax other than environmental;

m – the number of types of taxes, other than environmental, for which benefits are established in connection with the reduction of harmful effects of the enterprise on the environment;

TFR – the amount of the financial result of the enterprise, which is the source of taxes.

At the same time, the amount of tax revenues that have not been paid in connection with benefits

other than environmental, is estimated as follows (2):

$$TI_j = TST_j - TSF_j \quad (2)$$

where TST_j – the amount of taxes accrued at normal rates and conditions of taxation;

TSF_j – the amount of taxes actually paid, accrued at the usual rates and conditions of taxation.

The developed theoretical and methodological model creates a basis for further factor analysis of changes in the tax burden of business entities in order to draw conclusions about the effectiveness of state tax policy in the field of nature management and environmental protection.

4 Conclusion

The study showed that one of the goals of the introduction of environmental taxes is to regulate environmentally responsible behaviour of enterprises and households. At the same time, bibliometric analysis shows that the behaviour of economic actors is more due to psychological than economic factors. Importantly, empirical research has shown the limited effectiveness of environmental taxes in regulating various aspects of environmental responsibility. Thus, an increase in the tax burden from environmental taxes by one million US dollars on average leads to a reduction in the Eco-Innovation Index by 0.001, as well as to a slight increase in CO₂ emissions from manufacturing industries and construction and from transport. This points to the fact that now environmental taxes are mostly a fiscal tool, which is perceived as additional costs of economic activity and does not determine the need for environmentally oriented changes in approaches and technologies.

Moreover, environmental taxes do not actually have a deterrent effect in the regulation of environmentally harmful anthropogenic impacts, and in some cases provide further incentives for environmentally harmful activities. This points to the fact that the regulatory purpose of the application of environmental taxes indicates the need to reform the mechanism of their application. In this regard, the approach to determining the tax benefits for the payment of environmental taxes, which should be applied to enterprises that reduce the environmental impact of the environment, was justified. The above recommendations are important for adjusting the environmental tax policy of countries in the context of improving their efficiency.

At the same time, the obtained results are scientifically valuable from the point of view of confirming the need to find an optimal set of regulatory tools to ensure environmentally responsible behaviour of economic agents. Thus, it is promising to study the interaction of environmental taxes and state environmental investment programs, as well as directive methods of influence on the use of environmentally safe technologies.

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The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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