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Does educational quality drive ecological performance? Case of high and low developed countries

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ABSTRACT

The study attempts to assess the impact of the educational level of the country's population, the level of science and technology development on the general environmental environment. The aim of this article is to assess the impact of educational level and level of science development on individual elements that reflect the state of the environment. To receive the obtained results is being used the package of statistical programs STATISTICA. The intense connection between educational level and aggregated evaluation of Environment Performance Index has been established. The significant correlation was found between the education index and the ecological conditions in countries with very high, medium and low level of Human Development Index. The significant correlation between the processes of implementation of educational and science public policy and a set of environment's criteria was found. The obtained models have been proved that for underdeveloped countries investment in education and science has a more significant impact on the ecological situation than in highly developed countries. Finally, this study concluded that public policy in the area of science and education, aimed at improving the ecological situation in the country, should be differentiated depending on the level of country development.

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INTRODUCTION

In the XXI century, in addition to the generally accepted indicators of material population well-being (GDP per person, average wages and pensions, the volume of social expenditures, etc.), environmental quality in which a person lives is gaining an ever-increasing role in the modern paradigm of the welfare state. Numerous studies of scientists (Klare, 2009; Wiesmeth, 2012; Guo and Ma, 2008; Povitkina, 2018) confirm the fact that the higher the level of GDP per person, the more people are inclined to invest additional resources in environmentally friendly products, their own health, environmental quality, and protection, etc. The environmental public policy, which is being actively pursued today in Nordic countries, Germany and many others, is an eloquent proof of the aforementioned. An important role in this is played by the state of the ecological consciousness and population education, which in high developed countries paid considerable attention both at the local and state levels. Today, the welfare state is hard to imagine without the function of institutional provision of environmental quality for all members of society. In the context of interdisciplinary research, the formation of the ecological consciousness of citizens as a way of being, is important today, in which people feel a direct connection with the natural world, trying to preserve it for posterity (On the Main Principles, 2011). Therefore, not only the growth of well-being but also active educational work aimed the modeling the ecological culture of the population is important to achieve these goals. In the third section of the Law of Ukraine «On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2020» among the strategic goals of the Ukrainian public environmental policy priority is given to raising the level of social-ecological consciousness, and one of the key tasks for achieving this goal is determined by the development and implementation of the ecological education strategies for sustainable development of Ukrainian society and national economy (On the Main Principles, 2011). Environmental education (EE) and education for sustainable development (ESD) are entire academic inter-disciplinary fields and areas of study which began in the late 1960th. The strengths and problems of different interpretations of ESD and how education should respond to environmental concerns are discussed in works by Bonnett (2003) as well as Bonnett (2013). The analysis of environmental and educational policies in the context of forming the ecological consciousness of citizens is devoted in (Analytical document, 2018; van den Bergh, Janssen, 2004; Church, 1992; Klare, 2009; Wiesmeth, 2012; Al-Tuwaijri, Christensen, Hughes 2004; Bazylevich, 2010; Koziuk, Dluhopolskyi, Hayda, Shymanska, 2018; Dluhopolskyi, Koziuk, Ivashuk, Klapkiv, 2019; Spannring, 2017). Through the discussion of The Ecocentric and Anthropocentric attitudes toward the sustainable development (EAATSD) some authors proposed to include environmental ethics into account of ESD and use circular economy approaches to reach Sustainable Development Goals (Kopnina, Meijers, 2014; Kopnina, 2018). Steady state economy (SSE) concept which includes sustainable population, low throughput of resources and greater equity and equality of incomes is discussed in (Washington, 2017). The urgent issue of harmonizing and approving environmental agreements on international level (for example, greenhouse gas emission reduction agreements) is a significant differentiation of environmental consciousness level in different countries of the world (Wiesmeth, 2012). The complexity of ecological consciousness analysis lies in its dependence on the level of the economic welfare of the population. A high level of environmental education and science, as well as environmental citizen consciousness, is a prerequisite for the development of a qualitative environmental policy. In some scientific researches (Rees, 2010; Crist, 2018) authors discuss how sustainable development is uncritically seen as somehow magically combining economic development, social inequality and ecological integrity. A number of studies conducted on the basis of empirical per capita income comparisons and the values of a certain set of representative environmental indicators confirm the conclusion on the affirmative influence of the economic growth factors on the environment (Arrow *et al.,* 1996; Callan, Thomas, 2000). This emphasizes the «U-like effect of interaction» (the growth of incomes is attributed to the degradation of the environment to a certain point, after which the quality of the latter improves). That is, at the initial stages of increasing pollution is considered an admissible side effect of growth and well-being. However, in the case of a country with a higher level of well-being, individuals begin to formulate requests for environmental measures that lead to the emergence of environmental legislation, new environmental protection institutes, etc. Environmental degradation necessitates institutional reforms that would force private consumers of natural resources to bear the full burden of social costs caused by their activities (Dasgupta, Mäler, 2000). The conflict between economic development and the environment in China is discussed in studies of Khan and Chang (2018) and Pannell (2008). Another vector of research focuses on the concept of «environmental resource base», which is reflected in a wide range of environmental systems but is characterized by limitation. As a result, careless use of it will irreversibly be marked by a decline in economic potential. That is why there is a need to develop an environmental policy that would consist in preserving the sustainability of ecosystems, provided that the nature and extent of economic activity are uncertain (Kozlovskyi, Khadzhynov, Vlasenko, Marynchak, 2017). Scientists came to the conclusion that economic liberalization, as well as any other policy that contributes to the growth of the gross national product, do not substitute for environmental policy. Of particular significance in this context are reforms that are based on «signals» from resource users. Environmental damage, including the loss of environmental sustainability, is usually characterized by inevitable negative manifestations. Ignoring such «signals» not only due to the disregard of the dynamic effects of ecosystem changes (for example, their boundaries, marginal productivity, loss of sustainability), but also the existence of institutional barriers, such as lacking of clearly established property rights. The progress of the relevant institutions depends, among others, on awareness the dynamics of ecosystems, based on the analysis of relevant indicators. Economic growth is not a panacea in the case of achieving an appropriate quality level of environment, its nature – the composition of inputs (input characteristics such as environmental resources) and outputs (the end result, like negative harms in the form of harmful effects) is considerably more important in this sense. In addition, the nature of growth is also determined by the activities of institutions that are designed to provide adequate incentives to protect environmental sustainability. Balancing measures in the framework of environmental policy will not only contribute to an increase in the efficiency of environmental resource allocation but will also ensure sustainable levels of economic activity in the social and ecological systems. Protecting their potential, driven by the need to maintain well-being, is important for both high and low developed countries (Arrow *et al.*, 1996; Unerman *et al.*, 2014). This study has been carried out in Ukraine in2017-2018 to assess the influence of educational level and level of science development on individual elements that reflect the state of the environment.

MATERIALS AND METHODS

Investigating the connection between economic and environmental development is often confined to financial and economic interactions, leaving out the educational and scientific components of the problem. It is assumed that not only the level of income affects the Environmental Performance Index (EPI), but also factor of the population education and its general environmental awareness may also depend on the nature of the public choice of preferences for the benefit of the environment, reflected in the higher values of the EPI. On the basis of the above hypothesis, the paper attempts to assess the impact of educational level of population, the level of science and technology development as on the general ecological environment, as well as on individual elements that reflect the state of the environment. For the formation of the initial analytical matrix, available country ratings and databases, developed by renowned educational, scientific and financial institutions, were used. Thus, the rating estimates 180 countries by the EPI and its component criteria are taken from the report (Environmental Performance Index, 2018) prepared by the scientists from the Yale and Columbia Universities. The value of the Human Development Index (HDI) in 178 countries and educational level in 177 countries was derived from the report (Human Development Report, 2018) prepared by the relevant department of the United Nations Development Program (UNDP). Data on aggregate education expenditures as % of GDP (GovExEdGDP), % of total government spending (GovExEdtotalGE), research and development (R&D) are received from the World Bank database (The World Bank, 2018). The obtained matrix of the output data is used for correlation, regression and canonical analysis using the package of statistical programs STATISTICA (Halafyan, 2008).

Correlation analysis is used to calculate the pairwise Pearson correlation coefficients, which illustrate the direction and closeness of the linear stochastic link between variables characterizing the state of ecology, education, and science in the country. Since the target group of countries in our study is the welfare state, the correlation analysis is conducted differently for OECD countries, countries with different levels of revenue and human development. Forasmuch the probable different nature of the interconnection between the determined independent and dependent variables, tools of linear, nonlinear, including the method of piecewise linear regression was used. For a visual assessment of the adequacy of the linear-piecewise model, we constructed a normal credibility plot of residuals. The canonical analysis was used to evaluate the relationship between the lists (sets) of variables that characterize the state of the environment on the one hand and on the other the level of development of education and science in the country.

RESULTS AND DISCUSSION

Informational knowledge about the influence of individual indicators characterizing the level and system of education and science in different countries on the state of the ecological situation is important for the substantiation of proposals for certain areas of state ecological and educational policy and their coordination. In order to conduct a regression analysis, EPI has been selected as a dependent variable, while, Education Index (EI), GovExEdGDP, GovExEdtotalGE, R&D as independent variables. To estimate the level of stochastic dependence between the above-mentioned variables, a correlation analysis was performed, the results of which are presented in the matrix format of Pearson correlation coefficients (Table 1). As the results show, all pair correlation coefficients between the variables are statistically significant. Strong direct correlation dependence (according to the Chaddock table) was found between the EI and EPI (r = 0,889). Between expenditures on research and development and the dependent variable (EPI) there is a significant (r = 0,535) and between the regressor GovExEdGDP and the regressant EPI moderate (r = 0,341) correlation. The negative correlation coefficient (r = -0,256) characterizes the weak inverse relationship between the state of the country ecology and the expenditures on education in % to the total government expenditures.

It was found the significant correlation of educational level in country with the aggregated assessment of the state of the environment that has led to a more detailed correlation analysis of EI for each of the 9 categories of environmental policy (health, air quality, drinking water and drainage, water resources, agriculture, forestry economy, fisheries, climate and energy, biodiversity and nature reserve fund). It is significant that for the aggregate sample covering all 177 countries studied (Table 2), the educational level indicator correlates significantly with all estimating components of EPI, while the most strongly – with the quality of drinking water and drainage (r = 0,890), the level of exposure risks water and air pollution to health (r = 0,844) and the quality of wastewater treatment that pollutes water resources (r = 0,779). The correlation analysis of the above indicators by groups of countries with diverse levels of HDI revealed a significant correlation between the EI and EPI with very high, medium and low HDI (r = 0,583-0,629) and weak (insignificant) – with high. As in the case of an aggregate sample of countries, for countries with very high, medium and low HDI there is a significant correlation between the EI and EPI on population health, pollution of water

Table 1: Correlation matrix of the EPI and indicators characterizing educational and science level in the country

Indicators	Indicators				
	EPI	EI	GovExEdGDP	GovExEdtotalGE	R&D
EPI	1,000	0,889***	0,341***	-0,256**	0,535***
EI	0,889***	1,000	0,303***	-0,333***	0,603***
GovExEdGDP	0,341***	0,303***	1,000	0,415***	0,385***
GovExEdtotalGE	-0,256**	-0,333***	0,415***	1,000	-0,244*
R&D	0,535***	0,603***	0,385***	-0,244*	1,000

Coefficient of correlation * – p < 0,05, ** – p < 0,01, *** – p < 0,001.

Table 2: Correlation coefficients between the EI and EPI, as well as its individual components

Groups of countries	Indicators									
	EPI	Health Impacts	Air Quality	Water and Sanitation	Water Resources	Agriculture	Forests	Fisheries	Biodiversity and Habitat	Climate and Energy
All countries	0,889***	0,844***	0,385***	0,890***	0,779***	-0,257***	-0,172*	-0,233**	0,296***	-0,334***
Countries with very high HDI (48 countries)	0,602***	0,536***	0,279	0,523***	0,354*	0,238	-0,462***	-0,023	0,230	0,382**
Countries with high HDI (50 countries)	0,257	0,230	0,075	0,276	0,023	0,128	0,022	0,079	-0,067	0,195
Countries with average HDI (25 countries)	0,583**	0,506**	0,381	0,145	0,418*	0,301	-0,075	0,368	-0,027	-0,244
Countries with low HDI (54 countries)	0,629***	0,636***	0,270	0,596***	0,792***	0,111	-0,202	-0,215	0,636***	0,270
OECD countries (34 countries)	0,466**	0,360*	0,080	0,643***	0,429*	-0,057	-0,061	-0,136	0,326	0,466*
Countries with high revenue level (46 countries)	0,673***	0,550***	0,151	0,715***	0,472***	0,285	-0,542***	-0,067	0,356*	0,349*
Countries with average revenue level (93 countries)	0,748***	0,751***	0,297**	0,753***	0,505***	-0,118	-0,163	0,036	0,147	-0,208*
Countries with low revenue level (41 counties)	0,775***	0,709***	0,168	0,660***	0,590***	-0,094	-0,250	-0,128	0,221	-0,492**

Coefficient of correlation * – p < 0,05, ** – p < 0,01, *** – p < 0,001.

drainage. Indicators of forest area changes and the CO_2 emission trend significantly correlate with the EI only in a group of countries with very high HDI, and a variable that integrally characterizes biodiversity, species protection and bionomy – in a group of countries with low HDI. In the sample that unites the OECD countries, significant Pearson correlation coefficients were found for the same pairs of variables, which for countries with high HDI, with the exception of a pair with a change in forest area.

Within the World Bank classification groups, which combine countries with different revenue levels (Nielsen, 2011), there is almost a similar picture of the relationship between the EI and the integral EPI, as well as its constituent categories. It should be noted that the coefficient of correlation between EI and EPI consistently increases from high-revenue countries (r = 0,673), to a group of countries with an average (r = 0,748) and low (r = 0,775) level of revenue. Significant correlation coefficients between the EPI and the indices and indicators that somehow characterize state policy in education and science have led to multiple regression analysis in order to clarify the relationship between the above variables. The results of the linear multidimensional simulation are shown in Table 3. As can be seen, model 3, in which all variables are included as regressors, is generally adequate for Fisher criterion (F_{fact} = 103,9 > $F_{0,01}$ (4,83) = 3,56), and the multiplier regression coefficient is high (R^2 = 0,913). However, the model parameters, with the exception of the free member and the coefficient near EI, are insignificant. A better model is 1, which includes three predictors. Although it is significant as a whole, as well as all

Table 3: Linear and nonlinear multivariate regression modeling (dependent variable – EPI)

Predictors	*Linear models*								
	Model 1 (N=118)			Model 2 (N=180)			Model 3 (N=88)		
	b	t	p	b	t	p	b	t	p
EI	39,28*	3,81	0,0002	74,40	20,80	0,000	74,23	13,27	0,000
RD				-0,02	-0,03	0,979	-0,03	-0,04	0,970
GovExEdGDP	0,85	2,25	0,0265				0,82	1,45	0,151
GovExEdtotalGE							-0,09	-0,45	0,655
HDI	42,22	3,77	0,0002						
Intercept	10,22	3,37	0,001	21,67	10,55	0,000	20,45	4,23	0,000
Statistical criteria's									
R^2	0,853			0,755			0,835		
Adjust R^2	0,849			0,752			0,826		
F statistic	220,8			272,5			103,9		
p	0,000			0,000			0,000		
	Nonlinear models								
Predictors	Model 4 (N=89)			Model 5 (N=89)			Model 6 (N=89)		
	b	t	p	b	t	p	b	t	p
EI	71,56	17,58	0,000						
1/RD	-0,32	-2,96	0,004	-0,33	-3,27	0,002			
$GovExEdGDP^4$				0,0012	2,01	0,048	0,001	2,09	0,039
$\sqrt{EI}$				112,53	18,45	0,000	114,51	18,98	0,000
RD^4				-0,03	-2,75	-0,007			
Intercept	25,79	8,56	0,000	-17,96	-3,55	0,001	-21,47	-4,40	0,000
Statistical criteria's									
R^2	0,830			0,855			0,825		
Adjust R^2	0,826			0,848			0,821		
F statistic	210,22			123,78			202,50		
p	0,000			0,000			0,000		

N – sample size

its parameters are significant, it is characterized by multicollinearity, as evidenced by the high coefficient of correlation between the independent variables EI and HDI (r = 0,945). In model 3, which includes only two regressors, the regression coefficient near the variable that characterizes the financing of research and development was insignificant.

In the process of nonlinear regression analysis (Table 3), several adequate models are obtained, but two of them contain only two predictors (model 4 and 6), and one contains three (Model 5). Matrix visual analysis of pair scatters diagrams between regressant and regressor has illustrated (Fig. 1) that for the aggregate sample of countries, there is no linear connection between the variables of EPI and R&D, EI and R&D. Probably, in the variation range of the dependent variable, there is a value (breakpoint), after which the linear connection between the regressant and the regressors changes radically. Therefore, to find such a breakpoint and to calculate the parameters of the linear regression equations before and after, the STATISTICA non-linear evaluation module, namely, the Piecewise linear regression procedure, was used.

As a result of such regression analysis, were obtained models for two clusters of countries:

1) EPI = 13,71 + 70,56EI + 0,08GovExEdGDP + 0,42GovExEdtotalGE + 3,79R&D, when EPI < 73,41 (low developed countries);

2) EPI = 60,29 + 29,66EI + 0,84GovExEdGDP – 0,33GovExEdtotalGE + 0,01R&D, when EPI > 73,41 (high developed countries).

The adequacy of the constructed models is evidenced by rather a high coefficient of multiple correlation R^2 = 0,947 and a significant percentage (89.7%) of the variation in the dependent variable, which is due to the variation in the independent variables. Correct conducting of regression analysis is confirmed by the visual analysis of the normal probabilistic graph (Fig. 2). Since the points on the graph lie on or near the line, it can be argued that the

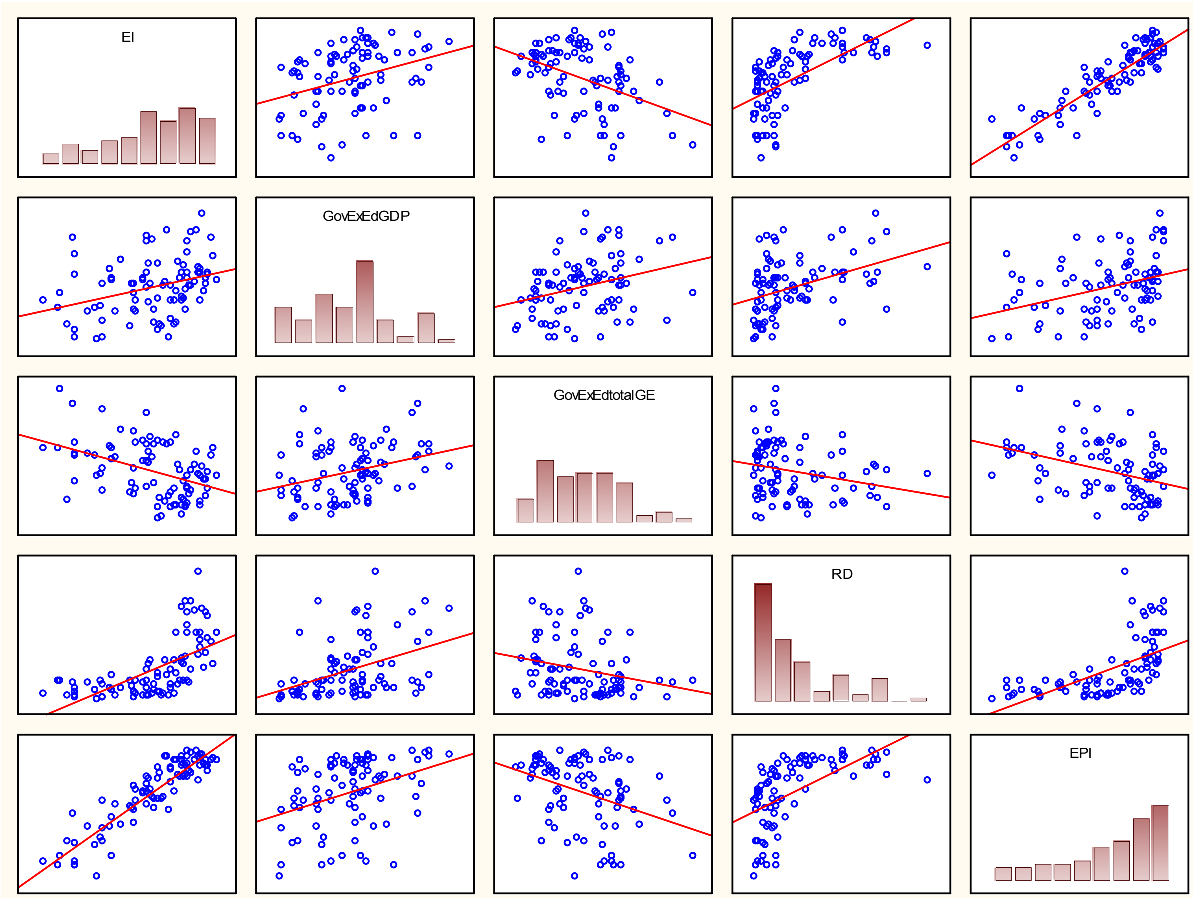

Fig. 1: The matrix of scattering diagrams between the dependent variable (EPI) and independent variables (EI, GovExEdGDP, GovExEdtotalGE, R&D)

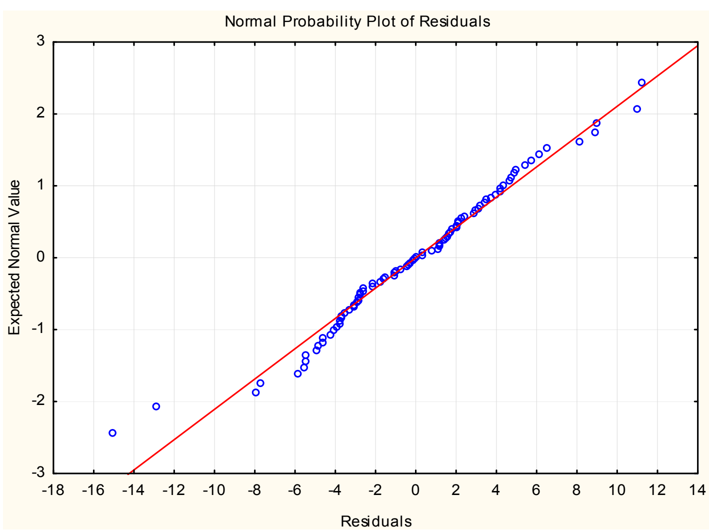

Fig. 2: Normal credibility plot of residuals of the piecewise linear regression model

distribution of residuals is close to normal law. This is another evidence of the adequacy of the constructed piecewise linear model.

Thus, according to the obtained piecewise linear model for countries with an EPI lower than 73,4, the increase of the EI by 0,1 can lead to an increase of 7,06 points in the EPI. An increase in the share of government spending on research and development in GDP by 1% increases the EPI by 3,79 points. The influence of the other two regressors on the dependent variable is much smaller. For a group of countries with an EPI level of more than 73,4, to which in 2016 were the 36 most developed countries, the regression coefficients for predictors are slightly different. Increasing education index in such countries by 0,1 can logically lead to a much lower increase of the EPI – by 2,96 points. At 0,84 points, this index will increase if the share of education expenditures on GDP increases by 1%. An increase in allocations for R&D by 1% is likely to have an undivided impact on the value of EPI. Thus, it should be emphasized that public policy in the area of science and education, aimed at improving the ecological situation in the country, should be differentiated depending on the level of country development. In addition, it would be worthwhile to expect different effects of such policies. As four indicators are used to characterize the effectiveness of the public educational and science policy, and EPI is an integral one, which is evaluated on the basis of nine policy criteria, we conducted a canonical analysis to test the hypothesis of existence dependency between the sets of the above variables. The results of the analysis indicate a strong canonical correlation (R_c = 0,930, χ^2 (36) = 202,5, $\chi^2_{0,01}$ = 58,62) between sets of indicators, one of which characterizes educational level and science in the country, and the other – different aspects of state of the environment in it. The scattering diagram of canonical correlations clearly illustrates the connection between the two groups of indicators, which is close to the linear one (Fig. 3).

As a result, four canonical roots (variables) were identified, but the first variable with the actual value of 0,865 was the criterion χ^2 for the level p < 0,01. Fig. 4 shows a piecewise linear graph of decreasing eigenvalues of the corresponding canonical roots. As we can see, the eigenvalues for the second and subsequent canonical roots drastically decrease in comparison with the value of the first one, and the segments of the graph corresponding to them become flat. Therefore, for the further interpretation, only the first canonical root was used.

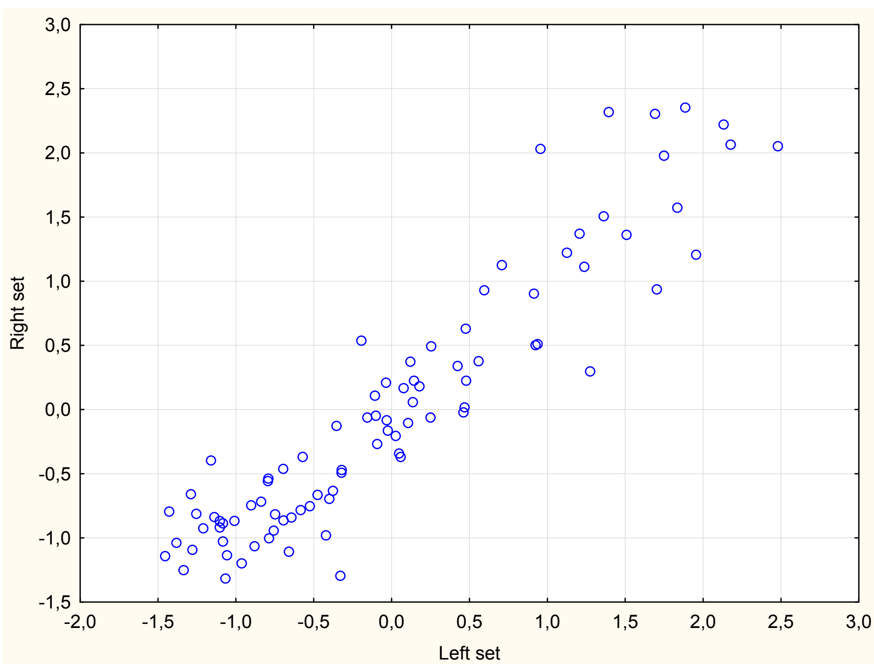

Fig. 3: Scattering diagram of canonical correlations for the first canonical root

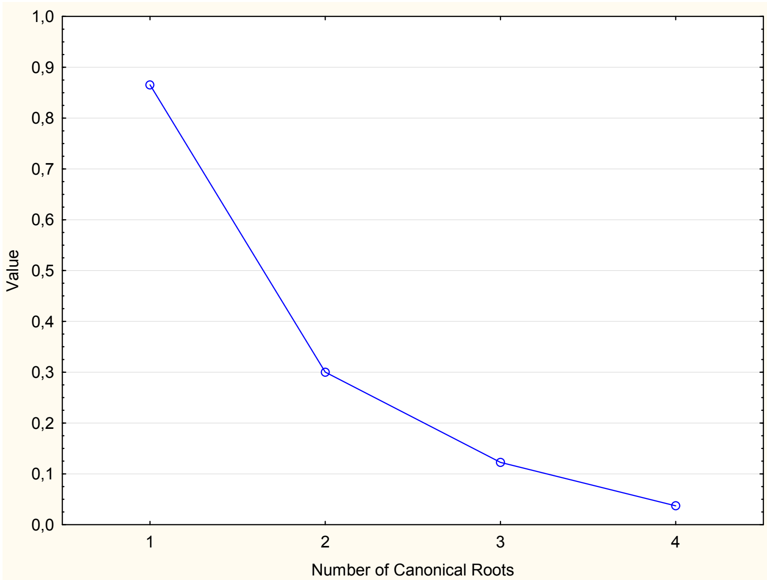

Fig. 4: Graph of eigenvalues corresponding to canonical roots

Table 4: Canonical weights and variable loadings of the first canonical root

Left			Right		
variables	canonical weight	canonical loads	variables	canonical weight	canonical loads
EI	-0,937	-0,997	Health Impacts	-0,096	-0,911
GovExEdGDP	-0,068	-0,387	Air Quality	-0,105	-0,538
GovExEdtotalGE	0,028	0,422	Water and Sanitation	-0,639	-0,952
R&D	-0,044	-0,664	Water Resources	-0,245	-0,907
			Agriculture	-0,139	0,094
			Forests	0,073	0,255
			Fisheries	0,013	0,186
			Biodiversity and Habitat	-0,070	-0,384
			Climate and Energy	-0,049	0,184

According to the data of the Table 4, in the first (left) set of indicators of the educational level and science the greatest weight for the first canonical root has an EI, and for the second (right) set of environmental indicators, the greatest weights are inherent in the criteria of water quality and water drainage, reduction of water pollution, as well as influence on population health. The values of canonical factor loadings, which represent correlations between sets of alternatives and the corresponding canonical variables, also illustrate the important role of the above variables in the corresponding sets.

Thus, as a result of the canonical analysis, a strong link was found between the processes of implementation the educational and science policy and a set of criteria that characterize the state of the environment in the country. Moreover, the key role in this process is played by indicators of the expected year numbers of studying children and the average length of training adults, which adequately reflect the state of the education system in the country.

CONCLUSION

Summing up the conducted research, we note that the obtained models for highly developed and underdeveloped countries allow differently assess the impact of public expenditures on science and education, as well as the impact of educational level on the EPI. It is empirically confirmed that education does not only affect the value of EPI, but is more closely related to the EPI than income. For example, for a group of countries with an EPI of < 73,41 points, an increase in the education index by 0,1 could lead to an increase of 7,06 points for the EPI, and an increase in the share of government spending on science in GDP by only 1% increases the EPI by 3,79 points. For a group of countries with EPI > 73,41 points, an increase in the education index by 0,1 could lead to a significantly lower increase of the EPI by only 2,96 points, and only 0,84 points increase this index if the share of education expenditures in GDP will increase by 1%, the increase of the same allocations for science by 1% will have an undue influence on the value of EPI. From this, it can be concluded that for underdeveloped countries, investments in education and science have a more significant impact on the state of the ecological situation than in highly developed, and therefore public policy should be aimed at increasing government allocations for science and education with a simultaneous increase in efficiency of spending resources.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

CO_2	Carbon dioxide
EAATSD	The ecocentric and anthropocentric attitudes toward the sustainable development
EE	Environmental education
EI	Education index
EPI	Environment Performance Index
ESD	Education for sustainable development
GDP	Gross Domestic Product
GovExEdGDP	Government expenditures on education, % of GDP
GovExEdtotalGE	Expenditures on education in % to total government costs
HDI	Human Development Index
OECD	The Organization for Economic Co-operation and Development
R&D	Expenditures on research and development
SSE	Steady state economy
UNDP	United Nations Development Program

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