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How the Economic Complexity of a National Economy Affects the Environment

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Oleksandr Dluhopolskyi[1], Volodymyr Martyniuk[2], Ihor Oleksiv[3]
Grzegorz Gliszczyński[4]

Abstarct:

Purpose: *The paper presents an investigation about connection between level of economic complexity and environment development of national economies.*
Design/Methodology/Approach: *The study is based on the assumption of a significant impact the economic complexity level that might have on the environment, as a high level of industrial knowledge in the country can encourage the introduction of environmentally friendly technologies and contribute to environmental sustainability of the economy in the future. Environmental Performance Index (EPI) was chosen as the dependent variable, while the economic complexity index (ECI) was chosen as the explanatory variable. STATISTICA software package was used to build the correlation and regression models.*
Findings: *The interpretation of the regression coefficients of the three constructed models confirms that by increasing the economic complexity index per unit it is possible to improve the environmental situation in the country from 5 (2012) to 10 (2014-2016) EPI units. The dynamics of indicators during 2012-2016 shows that the level of correlation of research indicators increases from year to year (0,582, 0,693 and 0,724).*
Practical Implications: *In the analyzed period of 2012-2016, the factor of economic complexity of the country has been confirmed by empirical studies conducted on a sample of almost 100 countries to have positive significant impact on the state of the environment.*
Originality/Value: *The effect of the economic complexity factor is most likely manifested through the synergy of knowledge about environmentally conscious production technology and environmental awareness of all economic entities. The more diversified the economy, the less likely is a possibility of rent-aimed "state capture".*

Keywords: *Economic complexity, environment, European Union, Environmental Performance Index (EPI), Economic Complexity Index (ECI).*

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[1]*Corresponding author, West Ukrainian National University, Ternopil Volodymyr Hnatiuk National Pedagogical University, Ternopil, Ukraine. E-mail: dlugopolsky77@gmail.com*
[2]*University of Economics and Innovation (WSEI), Lublin, Poland. E-mail: volmartynyuk@gmail.com*
[3]*Lviv Polytechnic National University, Department of Management and International Business, Lviv, Ukraine. Email: ol.ih33@gmail.com*
[4]*Corresponding author, Departament of Management, Faculty of Management, Lublin University of Technology, Poland. Email: g.gliszczynski@pollub.pl*

1. Introduction

Radical changes in the structure of the world economy have been going on for quite a long time. The first industrial revolution, which started in 1784, facilitated the transition from manual to mechanical production. Mass production boom was caused by the second industrial revolution, which began in 1870. In 1969 the third industrial revolution contributed to the transition to automated production. The fourth industrial revolution, which has begun in the 21st century, is based on the use of information technology in modern industrial production, the merger of material and virtual worlds, and the emergence of "smart" enterprises. With the help of the Internet of Things and artificial intelligence, the very same revolution in recent years has radically changed the possibilities of enterprise development in new conditions: from process optimization to access to new opportunities for both business and education (Marr, 2018; Stavytskyy *et al.*, 2019; Koziuk *et al.*, 2019; Zhylinska *et al.*, 2020).

The emergence of more complex industries and services can be considered as signs of so-called "creative destruction" process (Schumpeter, 1994) of the modern economy, which radically changes the environment of industries and enterprises, and affects the environment, labor market, financial system, etc., (Kuznets and Murphy, 1966; Koziuk *et al.*, 2018; 2019). At the same time, many national economies do not improve over time, but only worsen the structure of their own production and export potential, thus becoming resource-dependent economies that have fewer prospects for progress in today's VUCA world (Koziuk and Dluhopolskyi, 2018). Despite the vast scale of economic complexity research, some aspects still need further study. One of such aspects is the investigation of the impact of economic complexity on the environment. The current article aims to study the latter relation using Economic Complexity Index (ECI) and Environmental Performance Index (EPI). It is logical to presume that a high level of industry knowledge in the country can encourage the introduction of environmentally friendly technologies and contribute to the environmental sustainability of the economy in the future. Therefore, in the present study, we hypothesize that impact of the economic complexity on the environment is significant.

The paper is structured as follows: section 1 is the introduction to the issue of economic complexity and environmental economics, section 2 presents current literature review of the problem and working hypothesis, section 3 describes description of the research methodology, section 4 shows the main empirical results of the study, and section 5 covers the conclusions.

2. Literature Review

Previously, trade flows between countries was much easier to understand, because the finished products were moved directly between several countries. Today, about 6,000 officially classified products pass through global ports, and digital products or services are distributed across all countries without restriction, creating an additional level of difficulty in measuring economic activity. The more the country's "export basket" is characterized by a large variety of products that are simultaneously exported to other countries with high complexity, the more complex the country. So, the complexity of the product is the dependence on the number of countries specializing in exports and the complexity of exports of these countries.

The progress of economies worldwide towards the increase of economic complexity is an issue of broad academic debate. The research of economic complexity mainly targeted the following aspects: the link between economic complexity and economic growth, economic complexity and income inequality, and economic complexity and environment (Hidalgo, 2021). The research confirmed the vital link between economic complexity and economic growth (Hidalgo and Hausmann, 2009; Hartmann *et al.*, 2017; Bishop and Mateos-Garcia, 2019). Some publications also confirmed the reverse dependence between economic complexity and income inequality (Hartmann *et al.*, 2017; Morais *et al.*, 2020). At the same time, the aspect of economic complexity impact on the environment brought some contradictory results.

Specifically, Doğan, Saboori, and Can (2019), who conducted a study for 55 countries for the period from 1971 to 2014, found that economic complexity negatively impacts the environment for lower and higher middle-income countries, while for high-income countries, the impact of economic complexity is controlled. At the same time, Romero and Gramkow (2021) based on the research for 67 countries from 1976 to 2012, reported that 0.1 increase in the economic complexity index generates a 2% reduction of emissions of kilotons of CO_2 in the following period. The impact of economic complexity on the environment was also studied for the separate countries, specifically for the USA (Pata, 2021) and France (Can and Gozor, 2017). Both studies confirmed the Environmental Kuznets Curve (EKC) dependence between economic complexity and the environment. The suggestions regarding a policy for environmental sustainability considering the transition to economic complexity were developed by (Foxon *et al.*, 2013).

Since it is challenging to calculate economic complexity, the researchers widely used the Economic Complexity Index (ECI) to estimate the level of the latter phenomenon (Hartmann *et al.*, 2017; Gala *et al.*, 2018, Pata, 2021). Economic Complexity index is the variable showing the complexity of country's exports (The Atlas of Economic Complexity). The researchers applied a wide variety of methods to analyze the impact of economic complexity on different social phenomena, ranging from multivariate regression analysis (Hartmann *et al.*, 2017) to panel quantile regression methodology (Doğan, Saboori, and Can, 2019).

The working hypothesis of the study is based on the assumption of a significant impact the economic complexity level might have on the environment, as a high level of industrial knowledge in the country can encourage the introduction of environmentally friendly technologies and contribute to environmental sustainability of the economy in the future. New technologies are able to bring a significant increase in "environmental welfare", which has the significant demand in the developed countries and under the growing interest in emerging economies.

3. Research Methodology

The working hypothesis was tested using the STATISTICA software package with the application of correlation and regression analysis methods. In the process of model specification, Environmental Performance Index (EPI) was chosen as the dependent, explanatory variable, while the Economic Complexity Index (ECI) was chosen as the regressor (independent, explanatory variable) (Rymarczyk, Kłosowski, Hoła, Sikora, Wołowiec, Tchórzewski and Skowron, 2021).

The Environmental Performance Index (EPI) provides a data-driven summary of the state of sustainability around the world. Using 32 performance indicators across 11 issue categories, the EPI ranks 180 countries on environmental health and ecosystem vitality (EPI, 2020). Economic Complexity Index (ECI) ranks of countries based on how diversified and complex their "export basket" is. Countries that are home to a great diversity of productive know-how, particularly complex specialized know-how, are able to produce a great diversity of sophisticated products (ECI, 2020).

This research is a logical continuation of the work (Hayda *et al.,* 2020), in which the authors tested the working hypothesis concerning the impact of economic complexity on the environmental situation in the world in 2017-2018. In this study however an attempt was made to test the current assumption on the data of a longer period of 2012-2016 and to verify their compliance with the results of 2018. To assess the state of the environment of the studied countries, the EPI value was used, which was first developed at the initiative of "Global leader for tomorrow" NGO in collaboration with the Center for Environmental Law and Policy of Yale University (USA) and the Center for International Scientific Information Networks of Columbia University together with the World Economic Forum (Switzerland) and the European Commission Joint Research Center (Italy).

4. Empirical Results

Until the middle of the twentieth century, trade flows between countries were much easier to understand, as the finished products moved directly between several countries. Today, about 6,000 officially classified products pass through global ports, and digital products and services are distributed across all countries without restriction, creating an additional level of difficulty in measuring economic activity (Hayda *et al.,* 2020). The more the country's "export basket" is characterized by a large variety of products that are simultaneously exported to other countries with high complexity, the more complex the country is. On the other hand, the product complexity means the dependence on the number of countries specializing in exports and the complexity of these countries' exports.

Standard economic theories assume a high level of countriess' specialization in specific industries. However, a direct analysis of the official databases of exported products to all countries of the world shows that the real situation is very different. Countries that are usually seen as developed, highly diversified, export a large number of products from very simple to very complex. Simultaneously, countries are generally considered to be less developed if they export only products that are also exported by most countries. In particular, the least complex countries at the bottom of the ECI rankings are those that export very few different types of products, and the products they export are produced in many other countries. By this logic, Germany or Japan has a high economic complexity, as it exports many different types of complex things, which are produced by only a few countries with similarly diversified production capacity.

The Economic Complexity Index (ECI) is an indicator that characterizes the complexity and diversification of the country's exported goods (Economic Complexity Rankings, 2020). The methodology of the index is based on the assumption that the more the country knows about production processes, the higher the technological level of its economy and the complexity of its export products. As the ECI provides information on domestic diversification and product prevalence, it is able to determine the extent of economic complexity, which contains information on both the diversity of a country's exports and its complexity.

The Table 1 shows that according to the index of economic complexity during 2000-2018, Japan, Switzerland, Germany, Sweden and Austria remain among the top 10 countries, whereas the former leaders of the 2000s, such as the United States, Britain, Finland, France and Ireland have lost positions today to South Korea, Singapore, the Czech Republic, Hungary and Slovenia. For almost 20 years, Poland has hardly changed its ECI position, whereas Ukraine has worsened its performance, moving from the 35th to the 44th place in the ranking. However, the most dramatic downgrades in the ECI happened to Venezuela and Azerbaijan, causing them to move from the 70th to the 119th place and from the 75th to 124th place respectively. With its 131st place, Angola invariably closes the list of countries according to the ECI rating.

Table 1. *Ranking of countries according to the dynamics of Economic Complexity Index*

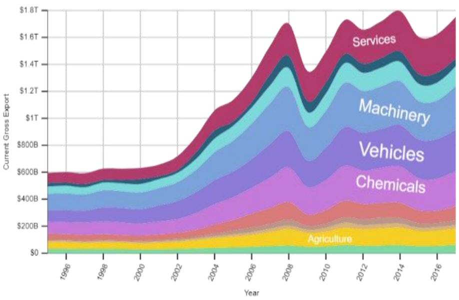
№	**Countries**	**ECI score**	**№**	**Countries**	**ECI score**
2000			**2018**		
1.	Japan	2,90	1.	Japan	2,43
2.	Germany	2,38	2.	Switzerland	2,17
3.	Switzerland	2,28	3.	South Korea	2,11
4.	UK	2,13	4.	Germany	2,09

5.	Sweden	2,11	5.	Singapore	1,85
6.	USA	2,01	6.	Austria	1,81
7.	Finland	1,91	7.	Czechia	1,80
8.	Austria	1,83	8.	Sweden	1,70
9.	France	1,64	9.	Hungary	1,66
10.	Ireland	1,62	10.	Slovenia	1,62
24.	Poland	0,94	23.	Poland	1,10
35.	Ukraine	0,61	44.	Ukraine	0,37
70.	Venezuela	-0,13	119.	Venezuela	-1,19
75.	Azerbaijan	-0,38	124.	Azerbaijan	-1,37
131.	Angola	-1,89	131.	Angola	-1,71

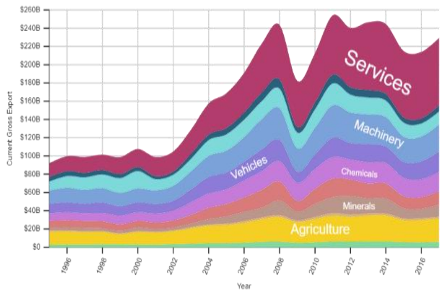
Source: *Own elaboration from Country & Product Complexity Rankings, 2020.*

Countries in the top ten (such as Japan, Germany), which have high ECI rates (Figure 1), export many low-prevalence goods produced by countries with highly diversified economies, which indicates the complexity and diversity of economic development of these countries. Countries with a low level of ECI (Figure 2), ranked at the bottom (for example, Nigeria, Venezuela), export only a few high-prevalence products, which are exported by countries that do not necessarily have to be highly diversified, thus indicating that these countries have a low economic complexity and a small variety of exported goods.

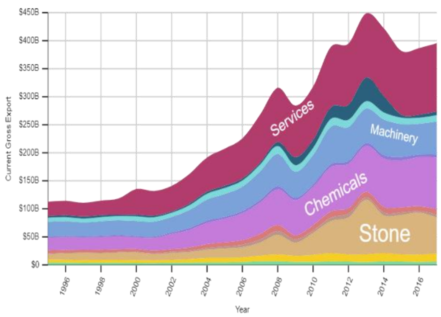
Figure 1. *Change in the export structure of some highly developed countries with diversified economic structure during 1996-2018*



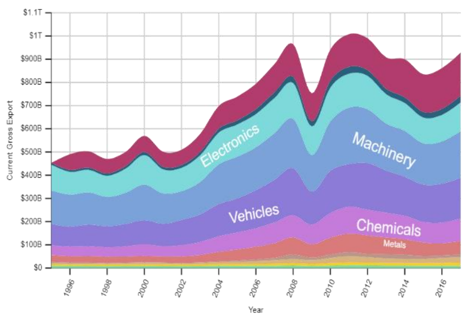
Germany



Sweden



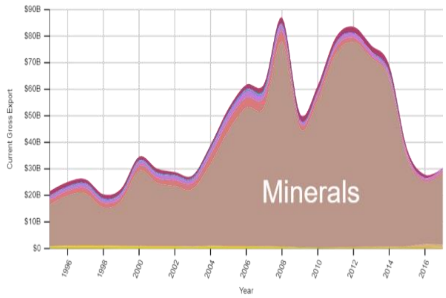
Switzerland

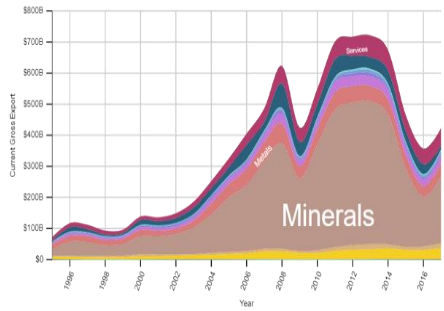


Japan

Source: *Own elaboration from the Atlas of Economic Complexity, 2020.*

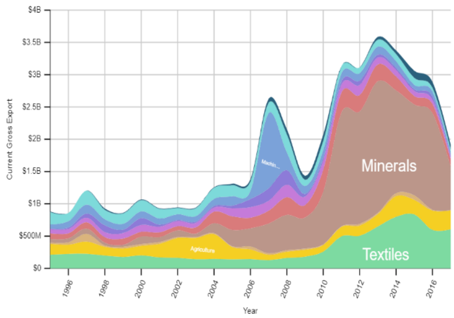
Figure 2. *Change in the export structure of some countries with resource-dependent economies during 1996-2018*

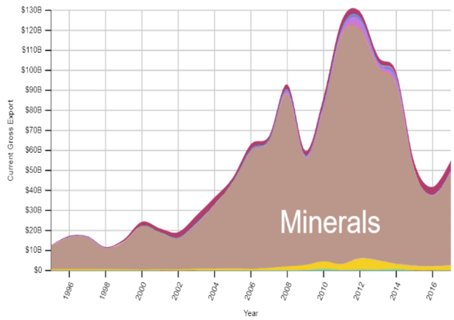




Venesuela

Russian Federation





North Korea

Nigeria

Source: *Own elaboration from the Atlas of Economic Complexity, 2020.*

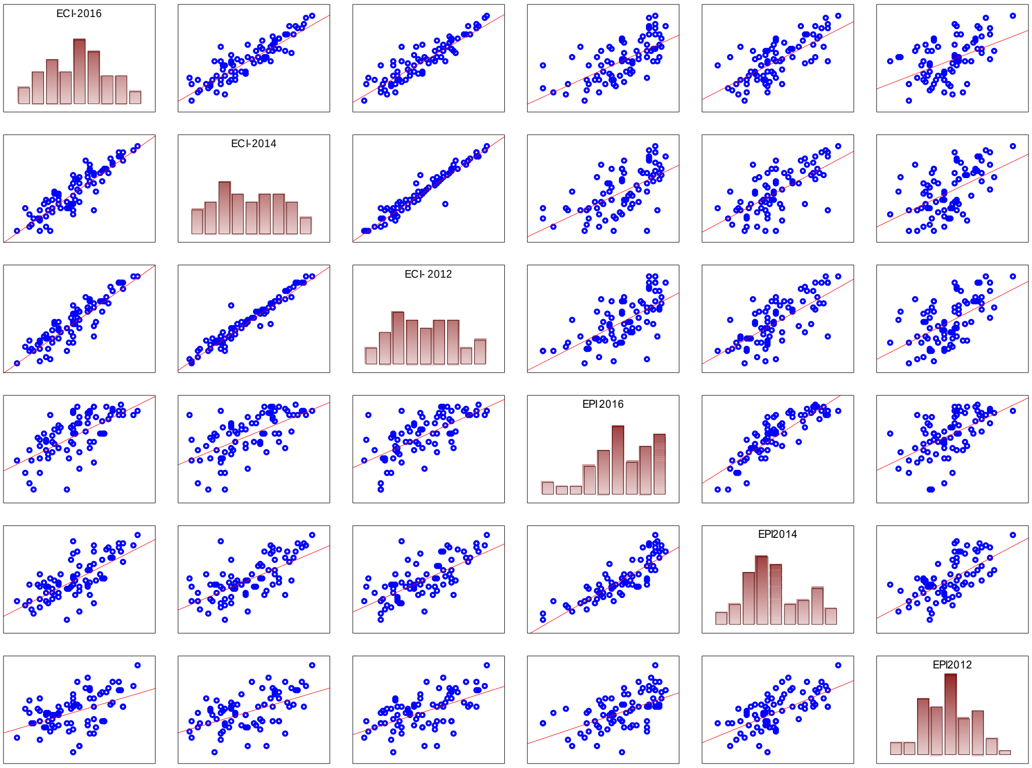
Correlation analysis revealed a significant relationship between ECI and EPI in the country in 2012-2016. The value and sign of the calculated Pearson correlation coefficients (r = 0,572, 0,672 and 0,667) illustrate the existence of a significant positive connection between these variables (Table 2). This is also confirmed by the configuration of points on pairwise scattering diagrams (Figure 3).

Table 2. *Correlation matrix of indicators of economic complexity and environmental performance in the country (ECI and EPI correlation matrix)*

	EPI_{2016}	EPI_{2014}	EPI_{2012}	ECI_{2016}	ECI_{2014}	ECI_{2012}
EPI_{2016}	1,000	**0,857**	**0,566**	**0,667**	**0,622**	**0,678**
EPI_{2014}	**0,857**	1,000	**0,657**	**0,721**	**0,672**	**0,708**
EPI_{2012}	**0,566**	**0,657**	1,000	**0,474**	**0,531**	**0,572**
ECI_{2016}	**0,667**	**0,721**	**0,474**	1,000	**0,893**	**0,906**
ECI_{2014}	**0,622**	**0,672**	**0,531**	**0,893**	1,000	**0,969**
ECI_{2012}	**0,678**	**0,708**	**0,572**	**0,906**	**0,969**	1,000

Note: *Correlation coefficients shown in bold are significant for P <0.05; The sample consists of 77 countries.*
Source: *Own elaboration.*

Figure 3. *Matrix of scattering diagrams between Environmental Performance Index (EPI) and Economic Complexity Index (ECI) variables*



Source: *Own elaboration.*

The correlation analysis results prompted the implementation of regression analysis and the construction of single-factor regression linear models. In total, 3 models were built (Table 3), which all turned out to be significant. Interpretation of adequate models suggests that increment in one ECI unit results in the environmental situation improvement by 5-10 EPI units. So, if in 2012 by increasing the ECI per unit it was possible to improve the environmental situation in the country by 5 units of EPI, in 2014-2016 – by 10 EPI units. These values are confirmed by a sample of almost 100 countries with open source obtainable data.

Table 3. *Single-factor regression analysis results (dependent variable – Environmental Performance Index, independent variable – Economic Complexity Index)*

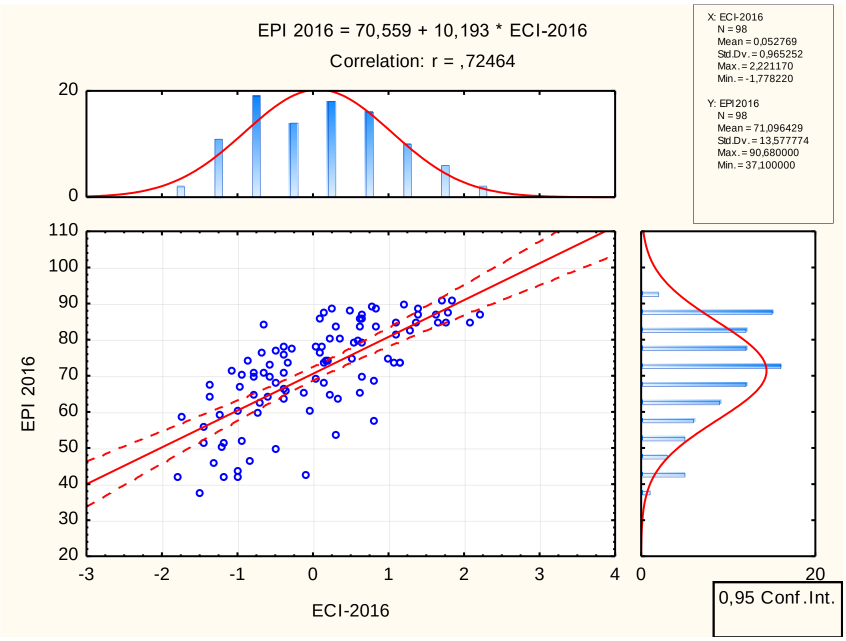
Model №	Analytical form of model	sample (N countries)	Criteria for adequacy and significance of model parameters			
			R^2	F-Fisher' criterion	Values of p < for	
					inter-cept	Regression coefficient (b)
1.	EPI_{2016} = 70,559 +	98	0,724	106,2	0,0001	0,0001

	$10{,}193ECI_{2016}$					
2.	$EPI_{2014} = 55{,}819 + 10{,}721ECI_{2014}$	89	0,694	80,8	0,0001	0,0001
3.	$EPI_{2012} = 53{,}962 + 5{,}163ECI_{2012}$	87	0,582	43,6	0,0001	0,0001

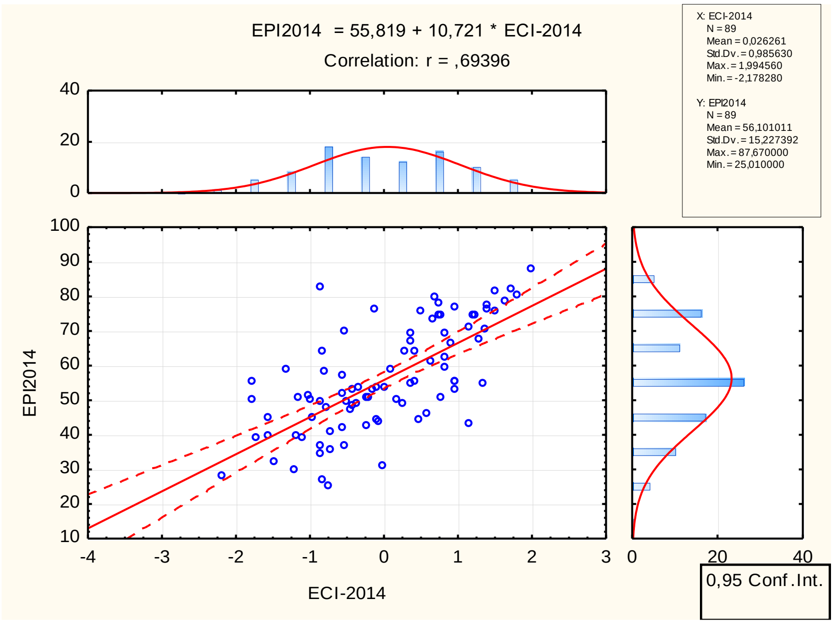
Note: *$F_{tab.0,01}(1,80) = 6{,}96$, $F_{tab.0,01}(1,30) = 7{,}56$.*
Source: *Own elaboration.*

The graphic representation of the obtained results of single-factor modeling is presented in fig. 4. The dynamics of indicators during 2012-2016 shows that the level of correlation of research indicators increases from year to year (from 0,582 in 2012 to 0,724 in 2016). This means that from 58,2 to 72,4% of the variability of the dependent variable (EPI) is determined by the variation of the independent variable (ECI). A possible explanation for the connection between economic complexity and environment development is that countries to be able to progress in environmenal development because of groving expected public good demand "environmental welfare" that based on export diversity, technology development and human needs progress.

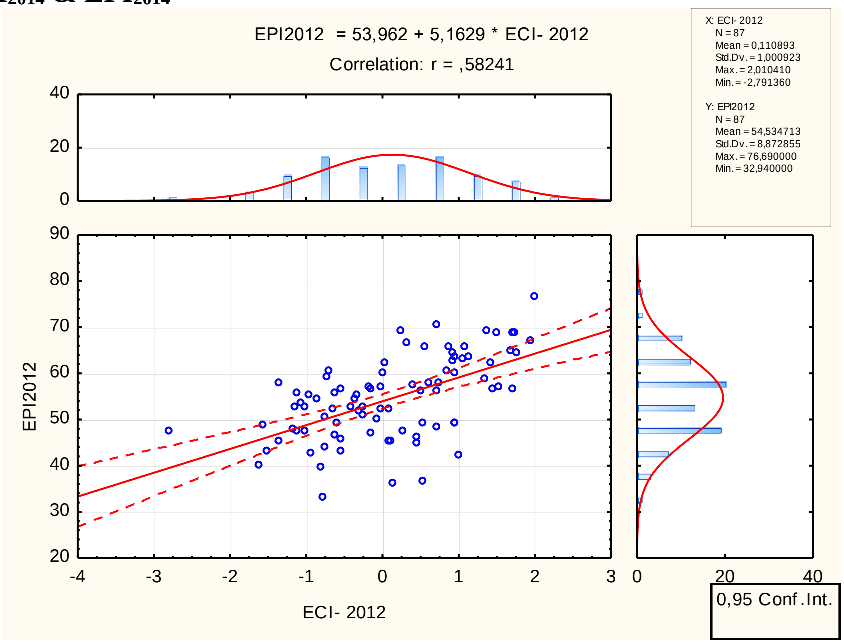
Figure 4. *Regression lines of the studied variables and their main descriptive characteristics*



a) ECI_{2016} & EPI_{2016}



b) ECI$_{2014}$ & EPI$_{2014}$



c) ECI$_{2012}$ & EPI$_{2012}$
Source: *Own elaboration*

5. Conclusions

Empirical studies during the analyzed period 2012-2016 have confirmed the positive significant impact of the factor of country's economic complexity on the level of environment development in it. The effect of the factor of economic complexity is manifested through the synergy of knowledge about technology, greening of production and environmental awareness of all economic entities. The high level of industrial knowledge in the country can encourage the introduction of environmentally friendly technologies and promote the development of a "green economy" ("environmental welfare").

In highly developed countries with a significant stock of industrial knowledge about modern manufacturing technologies, the latest technologies (environmentally friendly production, environmentally friendly modes of transport) are used, which do not pollute the environment, so as not to take measures to eliminate such pollution in the future. So, the costs incurred by these countries today will, over a period of time, allow for so-called "double dividends" – the lack of monetary costs for cleaning up the environment and the unpolluted environment.

The effect of the economic complexity factor is most likely manifested through the synergy of knowledge about environmentally conscious production technology and environmental awareness of all economic entities, as evidenced in more detail in (Koziuk, Dluhopolskyi *et al.*, 2019; Zúñiga, Földes, 2020; Hellman *et al.*, 2020). The more diversified the economy, the less likely is a possibility of rent-aimed "state capture" as the policy when private and public actors with private interests redirect public policy decisions away from the public interest, using corrupt means and clustering around the certain state organs and functions.

References:

Bishop, A., Mateos-Garcia, J. 2019. Exploring the link between economic complexity and emergent economic activities. National Institute Economic Review, 249. doi.org/10.1177/002795011924900114.

Boleti, E., Garas, A., Kyriakou, A. et al. 2021. Economic Complexity and Environmental Performance: Evidence from a World Sample. Environmental Modeling & Assessment, 26, 251-270. doi.org/10.1007/s10666-021-09750-0.

Can, M., Gozgor, G. 2017. The impact of economic complexity on carbon emissions: evidence from France. Environmental Science and Pollution Research, 24, 16364-16370. doi.org/10.1007/s11356-017-9219-7.

Country & Product Complexity Rankings. 2020. URL: https://atlas.cid.harvard.edu/rankings

Doğan, B., Saboori, B., Can, M. 2019. Does economic complexity matter for environmental degradation? An empirical analysis for different stages of development. Environmental Science and Pollution Research, 26, 31900-31912. doi.org/10.1007/s11356-019-06333-1.

Economic Complexity Rankings (ECI). 2020. URL: https://oec.world/en/rankings/country/eci/?year_range=2013-2017.

Environmental Performance Index (EPI). 2020. URL: http://sedac.ciesin.columbia.edu/data/collection/epi/sets/browse.

Eurostat Database. 2020. URL: https://ec.europa.eu/eurostat/data/database.

Foxon, T.J., Köhler, J., Michie, J., Oughton, C. 2013. Towards a new complexity economics for sustainability. Cambridge Journal of Economics, 37, 187-208. doi.org/10.1093/cje/bes057.

Gala, P., Rocha, I., Magacho, G. 2018. The structuralist revenge: economic complexity as an important dimension to evaluate growth and development. Brazilian Journal of Political Economy, 38, 2(151), 219-236. doi.org/10.1590/0101-31572018v38n02a01.

Hartmann, D., Guevara, M.R., Jara-Figueroa, C., Aristaran, M., Hidalgo, C.A. 2017. Linking economic complexity, institutions, and income inequality. World Development, 93, 75-93. doi.org/10.1016/j.worlddev.2016.12.020.

Hayda, Y., Dluhopolskyi, O., Melnyk, O. 2020. Interaction of the economic complexity, environmental taxes and environmental situation in the countries: the results of empirical exploration. Eastern Europe: Economy, Business and Management, 2(25), 97-105. doi.org/10.32782/easterneurope.

Hellman, J.S., Jones, G., Kaufmann, D., Schankerman, M. 2000. Measuring Governance, Corruption, and State Capture: How Firms and Bureaucrats Shape the Business Environment in Transition Economies. Policy Research Working Paper, 2312. World Bank, Washington, D.C.

Hidalgo, C.A. 2021. Economic complexity theory and applications. Nature Reviews Physics, 3, 92-113.

Hidalgo, C.A., Hausmann, R. 2009. The building blocks of economic complexity. Proceedings of the National Academy of Sciences, 106(26), 10570-105755. doi.org/10.1073/pnas.0900943106.

Koziuk, V., Dluhopolskyi, O. 2018. Resource Curse: The Role of Weak Institutions and Crony-Sectors. Ideology and Politics Journal (Post-Soviet Transit and Demodernization), 1(9), 68-102. ISSN 2227-6068.

Koziuk, V., Dluhopolskyi, O., Farion, A., Dluhopolska, T. 2018. Crony sectors as a barrier to economic well-being and ecologization (Case of Ukraine). Economics and Sociology, 11(3), 113-132. doi.org/10.14254/2071-789X.2018/11-3/7.

Koziuk, V., Dluhopolskyi, O., Hayda, Y., Klapkiv, Y. 2019. Does education quality drive ecological performance? Case of high and low developed countries. Global Journal of Environmental Science and Management, 5(S1), 22-32. doi.org/10.22034/GJESM.2019.05.SI.03.

Koziuk, V., Hayda, Y., Dluhopolskyi, O., Klapkiv, Y. 2019. Stringency of environmental regulations vs. global competitiveness: empirical analysis. Economics and Sociology, 12(4), 264-284. doi.org/10.14254/2071-789X.2019/12-4/17.

Kuznets, S., Murphy, J.T. 1966. Modern economic growth: Rate, structure, and spread. Yale University Press: New Haven. http://www.jstor.org/stable/1914358.

Lapatinas, A., Garas, A., Boleti, E., Kyriakou, A. 2019. Economic complexity and environmental performance: evidence from a world sample. MPRA Paper, 92833. URL: https://mpra.ub.uni-muenchen.de/92833.

Marr, B. 2018. What is Industry 4.0? Here's A Super Easy Explanation For Anyone. URL: https://www.forbes.com/sites/bernardmarr/2018/09/02.

Pata, K. 2021. Renewable and non-renewable energy consumption, economic complexity, CO_2 emissions, and ecological footprint in the USA: testing the EKC hypothesis with a structural break. Environmental Science and Pollution Research, 28, 846-861. doi.org/10.1007/s11356-020-10446-3.

Romero, J.P., Gramkow, C. 2021. Economic complexity and greenhouse gas emissions. World Development, 139. doi.org/10.1016/j.worlddev.2020.105317.

Rymarczyk, T., Kłosowski, G., Hoła, A., Sikora, J., Wołowiec, T., Tchórzewski, P., Skowron, S. 2021. Comparison of Machine Learning Methods in Electrical Tomography for Detecting Moisture in Building Walls. Energies 2021, Vol. 14, No 2777. https:// doi.org/10.3390/en14102777.

Schumpeter, J.A. 1994. Capitalism, Socialism and Democracy. London: Routledge.

Stavytskyy, A., Dluhopolskyi, O., Kharlamova, G., Karpuk, A., Osetskyi, V. 2019. Testing the fruitfulness of the institutional environment for the development of innovative-entrepreneurial universities in Ukraine. Problems and Perspectives in Management, 17(4), 274-288. doi.org/10.21511/ppm.17(4).2019.23.

The Atlas of Economic Complexity. 2020. URL: http://atlas.cid.harvard.edu/explore.

Zhylinska, O., Bazhenova, O., Zatonatska, T., Dluhopolskyi, O., Bedianashvili, G., Chornodid, I. 2020. Innovation processes and economic growth in the context of European integration. Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration, 28(3), 1-12. doi.org/10.46585/sp28041209.

Zúñiga, N., Földes, A. 2020. Examining state capture. Undue Influence on Law-Making and the Judiciary in the Western Balkans and Turkey. Transparency International. URL: www.transparency.org.