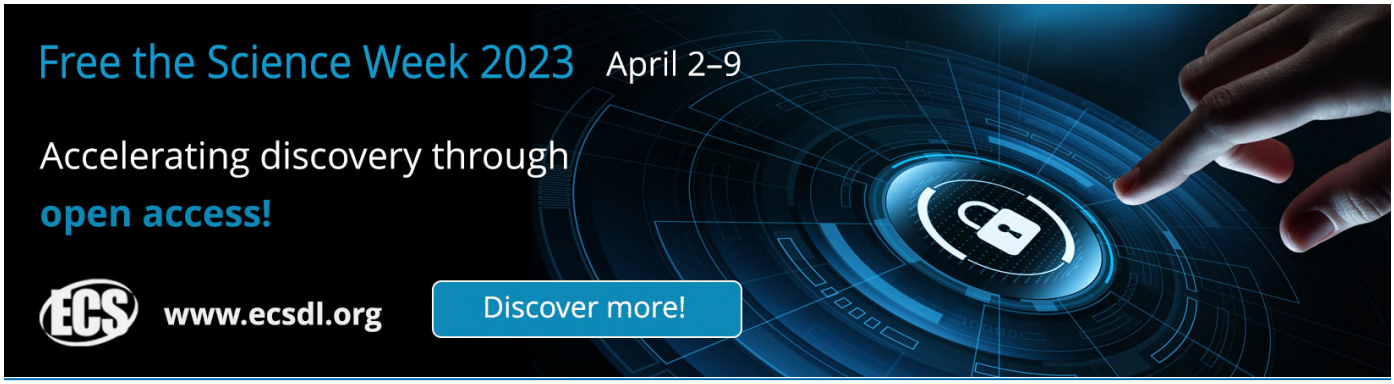
9th International Scientific Conference on Sustainability in Energy and Environmental Science



9th International Scientific Conference on Sustainability in Energy and Environmental Science

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Abstract. This paper represents a preface to the Proceedings of the 9th International Scientific Conference on Sustainability in Energy and Environmental Science (ISCSEES 2022) held worldwide on June 22–24 2022. Background information and the organizational structure of the meeting, program committee, and acknowledgments of the contributions of the many people who made the conference a success are presented.

1. Background

The **9th International Scientific Conference on Sustainability in Energy and Environmental Science** (**ISCSEES**) is a peer-reviewed international conference, which covers research on Sustainability in Energy and Environmental Science, including sustainable development, sustainable and efficient use of energy, natural resource, renewable, smart and green energy development, environmental management, science and technology, environmental restoration, ecological engineering, eco-technology, agriculture and environment sustainability, green enterprise development, modeling and regional environmental assessments, risk management in energy, Earth and environment systems, measuring, forecasting and monitoring sustainability, global threats, disaster and mitigation (figure 1).

The 9th International Scientific Conference on Sustainability in Energy and Environmental Science (ISCSEES 2022) is an event adressed to scientists and professional engineers from all over the world. The conference aims to give the opportunity to present and publish their work, discuss, exchange ideas and knowledge as well as network for future collaborations. The conference covers a broad range of on Sustainability in Energy and Environmental Science related topics.

2. Conference overview

Conference presentations are grouped into 7 tracks (figures 2, 3):

Figure 1. ISCSEES 2022 (`https://iscsees.nung.edu.ua/`) organizers.

- Sustainable development of renewable, smart and environmentally friendly energy [1–8]
- Science and technology in the field of environment [9–11]
- Environmental restoration, environmental engineering, eco-technology and sustainable development of agriculture and environment [12–18]
- Management in a circular economy [19–30]
- Measurement, forecasting and monitoring of infrastructure facilities stability, and risk management in energy, Earth and environment systems [31–35]
- Global and regional challenges for the development of communities and territories [36–45]
- Global threats, catastrophes, pandemics and emergency measures [46–48]

Figure 2. Conference highlights, part 1.

This volume contains the papers presented at ISCSEES 2022: 9th International Scientific Conference on Sustainability in Energy and Environmental Science. The spread of the coronavirus that causes COVID-19 and the ongoing Russian invasion of Ukraine has changed the conference organization. Therefore, the conference held on June 22-24, 2022 in a mixed format (full-time and part-time).

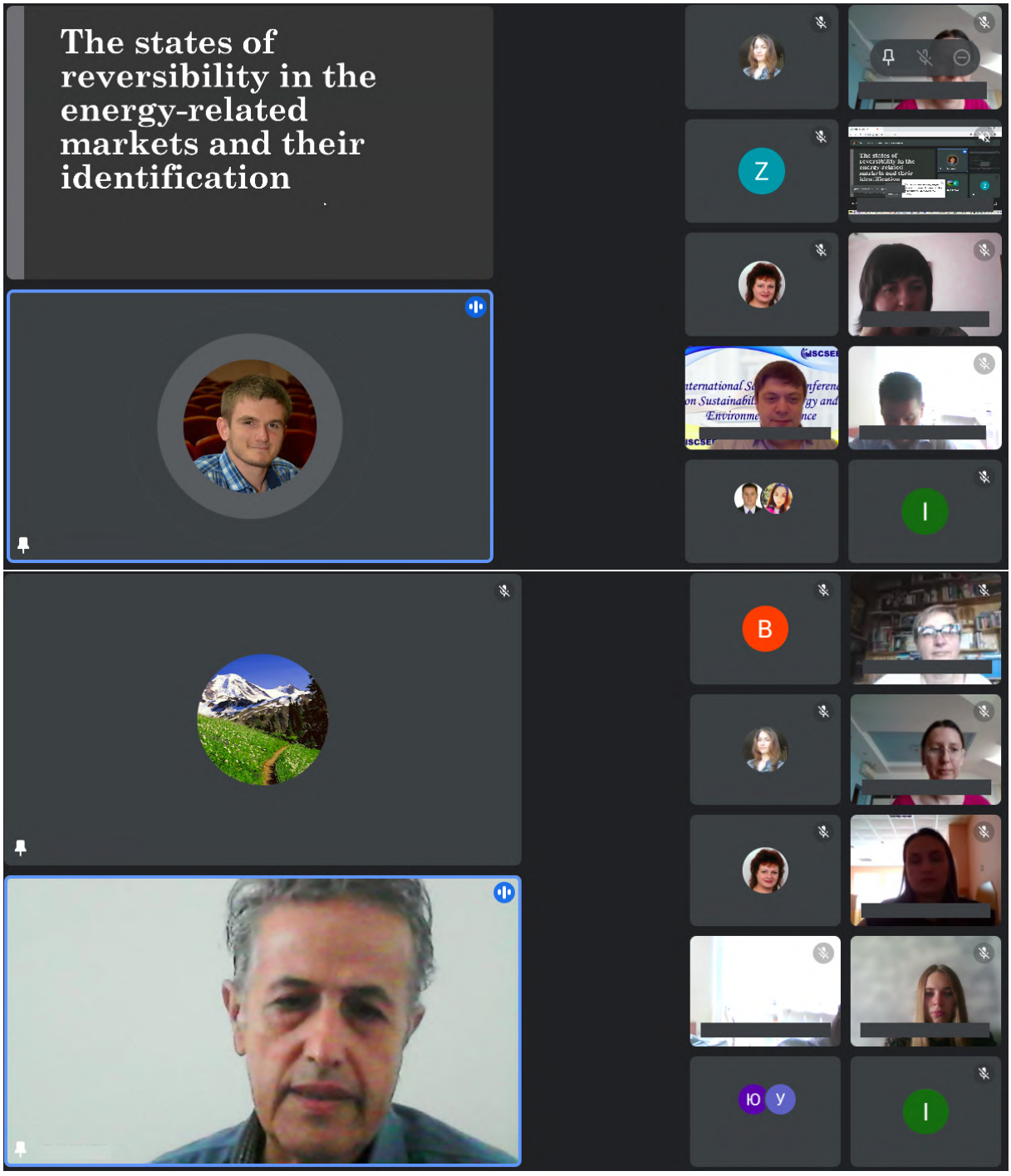

Figure 3. Conference highlights, part 2.

Authors were invited to submit full research papers including surveys, tutorials, perspective/colloquia articles in conference topics of interest (`https://www.morressier.com/call-for-papers/620bb7a0b4fa1600137d1ffc`). There were 75 submissions received. Each submission was reviewed by at least 2 program committee members. The committee decided to accept 48 papers.

More than 200 attendees from 18 countries are joined to ISCSEES 2022 using Zoom. The

presentation slots were defined as follows:

- invites talks (30 min): 20 min presentation, 10 min question answering and discussion,
- other talks (15 min): 10 min presentation and 5 minutes question answering and discussion.

The full program is available at the `https://iscsees.nung.edu.ua/files/conference_program_iscsees_2022.pdf` where details of the sessions, usually headed by one or more invited presentations. Video records of talks are available at the *New Trends in Economy* YouTube channel (`https://www.youtube.com/@user-vu7ic9jy7z`).

3. ISCSEES 2022 committees

3.1. Organizing committee

- *Olena Tretiak*, Director of NGO Cultural initiative
- *Ihor Chudyk*, Doctor of Technical Sciences, Professor, Vice-rector for research of Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine [49]
- *Oleh Novomlynets*, Doctor of Technical Sciences, Professor, rector of Chernihiv Polytechnic National University, Ukraine [50]
- *Liliana Horal*, Doctor of Economics Sciences, Professor, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine [51]
- *Inesa Khvostina*, Associated Professor of Applied Economics Department, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine [52]
- *Serhii Hushko*, Vice-rector for scientific and pedagogical, educational work and international affairs, State University of Economics and Technology, Ukraine [53]
- *Victoria Solovieva*, Assoc. Prof. PhD, State University of Economics and Technology, Ukraine [54]

3.2. Science committee

- *Victoria Prokhorova*, Doctor of Economics, Professor, Ukrainian Engineering Pedagogic Academy, Ukraine [55]
- *Valentyna Protsenko*, Doctor of Economics, Professor, Vice-Rector of Odessa National Medical University, Ukraine [56]
- *Vladimir N. Soloviev*, Doctor of Physical and Mathematical Science, Kryvyi Rih State Pedagogical University, Ukraine [57]
- *Serhiy Semerikov*, Doctor of Pedagogical Science, Professor of Computer Science and Educational Technology, Kryvyi Rih State Pedagogical University, Ukraine [58]
- *Viktoriya Margasova*, Doctor of Economics, Professor, Chernihiv National University of Technology, Ukraine [59]
- *Andriy Matviychuk*, Doctor of Economics, Professor, Kyiv National Economic University named after Vadym Hetman, Ukraine [60]
- *Myroslava Polutrenko*, Doctor of Technical Science, Professor, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine [61]
- *Nazariy Popadynets*, Doctor of Economics Sciences, Senior Researcher, Lviv Polytechnic National University, Ukraine [62]
- *Hanna Kucherova*, Doctor of Economics, Professor, State University Of Economics and Technology, Kryvyi Rih, Ukraine [63]
- *Iuliia Kostynets*, Doctor of Economics, Associate Professor, Kyiv National University of Technologies and Design, Ukraine [64]

3.3. Program committee

- *Michael Radin*, Rochester Institute of Technology, USA [65]
- *Szabolcs Nagy*, University of Miskolc, Hungary [66]
- *Olha Prokopenko*, University of the Third Age, Poland [67]
- *Badri Gechbaia*, Georgian Academy of Business Sciences, Georgia [68]
- *Andriy Matviychuk*, Kyiv National Economic University named after Vadym Hetman, Ukraine [69]
- *Valentyna Lukyanova*, Khmelnytskyi National University, Ukraine [70]
- *Władysława Łuczka*, Poznań University of Life Science, Poland [71]
- *Bård Borch Michalsen*, UiT The Arctic University of Norway, Norway [72]
- *Ramesh Chandra Rath*, Einstein Academy of Technology and Management, India [73]
- *Nadiia Shmygol*, Poznań University of Life Science, Poland [74]
- *Sofiia Kafka*, National Technical University of Oil and Gas, Ukraine [75]
- *Ketevan Goletiani*, Batumi Navigation Teachenng University, Georgia [76]
- *Giuseppe T. Cirella*, University of Gdansk, Poland [77]
- *Abdukhakim Mamanazarov*, Founder of the Center of Economic Culture Development, Uzbekistan [78]
- *Pankaj Srivastava*, FATER Academy of India, India [79]
- *Ewa Matuska*, Pomeranian University in Slupsk, Poland [80]
- *Olena Panukhnyk*, Ternopil Ivan Puluj National Technical University, Ukraine [81]
- *Małgorzata Sidor-Rzadkowska*, Warsaw University of Technology, Poland [82]
- *Vladimir N. Soloviev*, Kryvyi Rih State Pedagogical University, Ukraine [83]
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- *José Manuel Macedo Botelho*, Evora University PhD, Portugal [87]
- *Petia Tanova*, Frederick University of Cyprus, Cyprus [88]
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- *Daina Znotiņa*, Rezekne Academy of Tehnologies, Latvia [90]
- *Oleg Pursky*, Kyiv National University of Trade and Economics, Ukraine [91]
- *Arnold Kiv*, Ben-Gurion University of the Negev, Israel [92]
- *Hanna Kucherova*, Classic Private University, Zaporizhzhia, Ukraine [93]
- *Iluta Arbidane*, Rezekne Academy of Tehnologies, Latvia [94]
- *George Abuselidze*, Batumi Shota Rustaveli State University, Batumi, Georgia [95]
- *Iryna Fadyeyeva*, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine [96]
- *Serhiy Semerikov*, Kryvyi Rih State Pedagogical University, Ukraine [97]
- *Jozef Zaťko*, European institute of further education, Slovakia [98]
- *Abdel-Badeeh M. Salem*, Ain Shams University, Egypt [99]
- *Iveta Mietule*, Rezekne Academy of Technologies, Latvia [100]
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- *Viacheslav Dzhedzhula*, Vinnytsia national technical university, Ukraine [105]
- *Oleksandra Farat*, Lviv Polytechnic National University, Ukraine [106]
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4. Conclusion

Balancing the current mankind needs and protecting future generations' interests make up an important component of the society development, and the search for alternative and innovative approaches in the economy management is extremely relevant to ensure the balanced and sustainable development of a healthy society. Today, sustainable development is one of the promising modern ideologies, and one of the concepts of this ideology is innovatics. Increasing the dynamics of the external environment demands an adequate response from modern businesses, which is expressed in the formation of a new modern management paradigm – the management of organizational changes. Change management deserves special attention in the context of ensuring the business entities development in the post-crisis economy, as the goal of any improvement is the transition to a new stage of functioning.

National policy coherence calls for appropriate decisions in the economic sphere as well as clearly defined short- and long-term goals for the development of the social sphere, the labor market, and education. The issue of building up a sustainable development policy and its implementation requires solving urgent tasks related to: Sustainability in Energy and Environmental Science, including sustainable development, sustainable and efficient use of energy, natural resource, renewable, smart and green energy development, environmental management, science and technology, environmental restoration, ecological engineering, eco-technology, agriculture and environment sustainability, green enterprise development, modeling and regional environmental assessments, risk management in energy, earth and environment systems, measuring, forecasting and monitoring sustainability, global threats, disaster and mitigation.

IX International Scientific Conference on Sustainability in Energy and Environmental Science was a forum which united scientists from all over the world to talk about the sustainable development of territories, about ecological, economic and national security. Achieving the conference goal was being decided in discussions and materials provided by the participants.

Based on the conference results, a collection of scientific articles was created, which you can look through now. Among the large number of articles sent to the conference, those that best corresponded to the conference topic, had elements of scientific novelty, were developed using economic-mathematical and statistical-empirical research methods, and were based on the well-known scientists' teachings on the subject under study were selected.

Dear readers, by getting to know the articles' content, you will be able to deepen your knowledge on the sustainable economy development, in particular, find answers to questions that have bothered the scientific community in recent years, namely:

- What are the structural changes in electricity generation to reduce CO_2 emissions?
- What methodology is used for forecasting environmental problems arising because of oil and gas industry and for assessing the sustainable development of administrative-territorial units?
- What is happening to land management with self-sown forests in Ukraine and what are the main factors influencing forecasting agricultural business development in crisis situations?
- What are new concepts for carbon dioxide elimination from combustion plants flue gases as well as many other engaging topics?

The organizing committee is grateful for the support in publishing the conference materials to the IOP Publishing.

We invite all readers to participate in the upcoming X anniversary conference.

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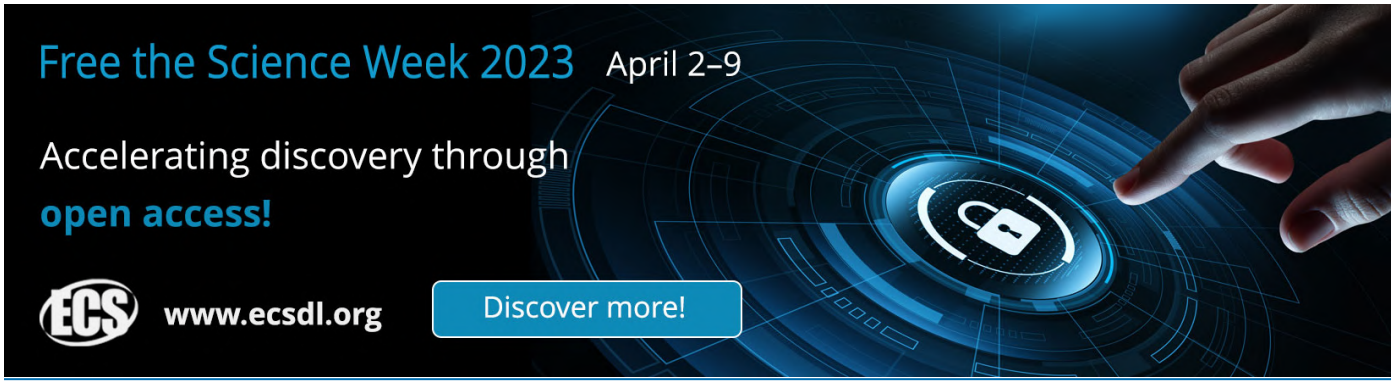

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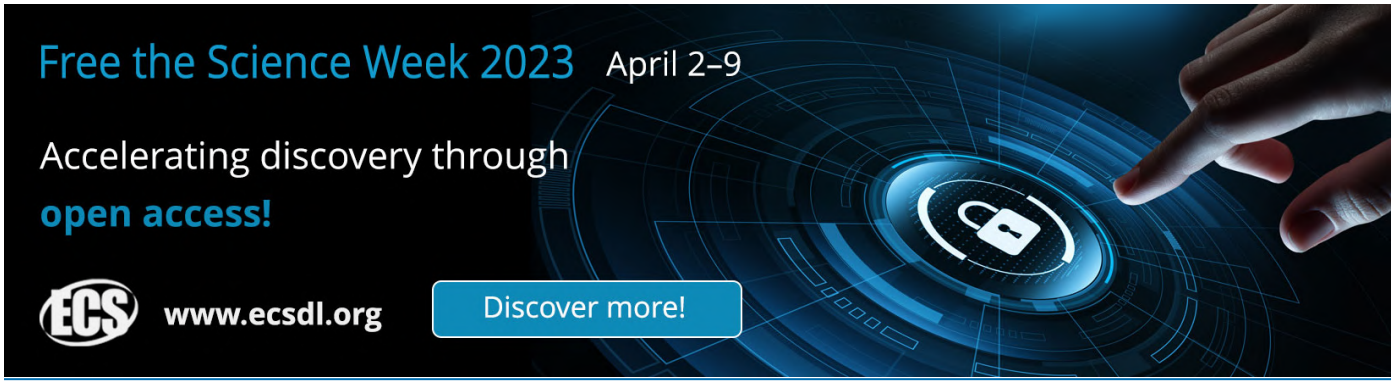
A new concept for carbon dioxide elimination from combustion plants flue gases



A new concept for carbon dioxide elimination from combustion plants flue gases

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Abstract. The production of energy from thermal power plants by burning fossil fuels is expected to remain a major part of the global energy mix for a significant period of time. The issue of pollutant emissions remains on the agenda, especially carbon dioxide (CO_2) due to its large quantities released. The article proposes a new concept for the elimination of carbon dioxide and other gaseous pollutants from the waste gases of combustion plants. Based on the assessment of the thermodynamic feasibility of the processes, metals and alloys were selected and initial tests were performed for the transformation of model waste gases from thermal power plants into solid products that could be further utilized by hydrometallurgical technologies. Removals achieved at small scale laboratory experiments were >89 % CO_2, > 71 % CO, > 96 % NO_x and > 60 % SO_2.

1. Introduction

The world needs energy for its development. The humankind requests energy for its everyday normal life. Different renewable energy sources have been and are being developed and used [1 - 3].

European Union pays special attention to renewals with the corresponding Directive [4] and the proposal for its revision as a part of the package to provide on the European Green Deal [5]. The efforts lead to an increase of share of renewals in different areas of our life and economy. For example, in 2020, renewable energy was 22.1 % of energy used in the EU-27 (in comparison to 9.6 % in 2004) and 2 % higher than the 2020 goal of 20 %. Spreading out the use of the solar and wind power as well as biofuels contributed significantly to the renewable electricity generation in Europe from 2009 to 2020 and it reached 37.5 % of electricity used in the EU in 2020. The renewable energy used in European transport in 2020 was 10.2 % [6].

However, the mentioned figures also point that still the major energy source in Europe (the world leader in green energy use) are not renewals but petroleum, coal and natural gas that are nonrenewables. Many countries for their energy production depend on nonrenewable energy sources. For example, in 2020 the USA the share of petroleum used in electricity production, transportation and industry was 34.7% and that of coal - 9.9 % [7].

Although the growth of renewable capacity is predicted to accelerate in the next five years and to account nearly 95% of the increase in global power capacity till 2026 [8], it is clear that for the present and in near future nonrenewables such as petroleum and coal will remain at least over 1/3 of the world energy source and one of their main uses will be in the electricity production by thermal power plants (TPPs) and in transportation.

However, TPPs are source of different pollutants, among them such as carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x) and sulfur dioxide (SO_2) [9].

Elevated CO concentrations decrease the oxygen transportation by the blood stream to the brain and heart thus causing dizziness, confusion, unconsciousness and even death. Short-term exposures to SO_2 can harm the human respiratory system. Elevated SO_2 amount in the air causes the generation of other sulfur oxides (SO_x) that participate in the particulate matter formation and pollution. High SO_x concentrations damage the leaves and reduce growth of trees and plants. Sulfur oxides participate in acid rain generation. Short exposure to NO_2 can aggravate respiratory diseases while longer exposures to high concentrations of NO_2 lead to respiratory infections and even to asthma. Acid rain is generated when NO_2 and other nitrogen oxides react with oxygen and water [10].

Carbon dioxide is the main pollutant in terms of amounts released and TPPs are one of the main contributors to the increased CO_2 levels throughout the world [11, 12]. Although the Global Warming Potential of CO_2 is the lowest, compared to other greenhouse gases, discharge of CO_2 is a considerable problem because of huge amounts of the gas released by TPPs and other sources. In addition, emissions of CO_2 cause increase in atmospheric concentrations of CO_2 that will be available thousands of years [13].

Different approaches and technologies for CO_2 capture and sequestration (CCS) have been proposed, tested and applied with the aim to mitigate the problem with release of CO_2 (and other gases) by TPPs [14-15].

Chemical absorption by liquids is mature and commercially available technology for CO_2 capture. For example, use of aqueous monoethanolamine and diethanolamine solutions is "classics". However, it is related to solvent loss caused by evaporation and degradation [16]. In addition, amines are toxic and monoethanolamine solution at high concentrations can cause corrosion of the equipment. Different ionic liquids have been also studied as absorbents of CO_2. However, because of their relatively low working capacity and high viscosity, they are still not widely applied in CO_2 capture [17].

Adsorption is considered as an encouraging technology for CO_2 capture because any power plant can be reconstructed to use it [16]. If the adsorbents are prepared by utilizing waste materials, the adsorption process could be probably sustainable. Current efforts are pointed to developing advanced adsorbents and using natural inexpensive materials, such as zeolites that are applied in gas and refinery industry. Some zeolites (such as 13X and Ca-A) have shown high CO_2 uptake - about 3 and 3.72 mmol/g, correspondingly [18]. However, zeolites are sensitive to wetness that leads to a considerable decrease in their of CO_2 uptake capacity [16].

Use of membranes for CO_2 capture and separation with the aim to store CO_2 or use it to enhance the recovery of oil from depleted reservoirs is also widely studied and applied [16, 17].

However, sometimes storage and oil recovery enhancement can cause negative effects on groundwater quality [11].

The concept of CO_2 capture and utilization (CCU) has also been risen [19]. The strategy is to integrate the CO_2 capture and its conversion to useful products, such as fuel [20, 21] and various chemicals - carbonates, urea derivatives, and formate salts [22 - 24] in one stage.

Serious authors argue that at the current technology development the role of CCS can be significantly greater than that of CCU in achieving the ultimate goal - reducing the amount of CO_2 in the atmosphere. Cost of needed hydrogen and the necessity of more efficient catalysts have been indicated as barriers to the CO_2 utilization through the production of fuel via Fischer–Tropsch processes [16, 17, 19].

Here we propose another concept for CCU - instead of carbon compounds to be produced, solid carbon (that could be further utilized) to be liberated as a result of CO_2 transformation.

2. Theoretical background

It is known that some metals, for example iron, are obtained by reduction with carbon, the process leading to the formation of carbon dioxide. In fact, the main reducer is carbon monoxide, which is an

intermediate. Of interest would be the possibility of returning the process back to carbon and solid material, i.e. the interaction of the waste CO_2 with a substance that would lead to the formation of carbon and solid product, with the prospect of recovery.

Ellington's diagrams [25] give an idea of such substances. According to them, aluminum (Al), magnesium (Mg), partially manganese (Mn) and zinc (Zn), and even tin (Sn) and iron (Fe) - at some temperatures can be pointed as affordable metals that would be able to bind CO_2 via reactions described in table 1.

Further, the possibility of such reactions can be checked with the help of appropriate software. HSC Chemistry 5.11 (Outokumpu Technology) was used to calculate the changes in Gibbs free energy and the equilibrium constants (K) of the corresponding reactions, i.e. the probability for the reactions described (table 1) to take place. Since besides the CO_2, the other main pollutants at the exit of TPPs are CO, SO_2, NO_2, NO and N_2O reactions with those pollutants were also checked. In addition, the possibility to bind CO in iron penta-carbonyl and manganese deca-carbonyl was also studied.

$$5CO_{(g)}+Fe=Fe(CO)_5$$

$$10CO_{(g)}+2Mn=Mn_2(CO)_{10}$$

As it can be seen in figure 1, Al, Mg, Mn and Zn may bind oxygen from CO_2 to produce the corresponding oxide in the temperature range 0 - 1000 ºC - figure 1A. The same metals and in the same order would be able to take oxygen from CO - figure 1B. Reactions of Al and Mg with carbon oxides are more favorable, compared to the reactions of those oxides with Mn and Zn. The reaction of Fe with CO_2 and CO is thermodynamically probable till about 600 ºC. Obviously, it is not suitable to use Sn. Concerning the reaction with SO_2, only Mg can react - figure 1C. All studied metals can react with nitrogen oxides to produce nitrogen - figures 1D - 1F. According to the highest negative values of the Gibbs energy change and the highest positive values of the equilibrium constants the metals studied can be arranged in the order Al > Mg > Mn > Zn > Fe ≅ Sn in the case of NO and N_2O, while for NO_2 Al and Mg exchanged their places.

It turned out that formation of $Fe(CO)_5$ and $Mn_2(CO)_{10}$ are favorable until approximately 100 ºC. In addition, $Mn_2(CO)_{10}$ decomposes at temperature higher than 400 ºC with release of CO. That is why Mn was not considered as a suitable material for the experiments.

3. Methods and materials

Experiments were conducted in home-made installation comprising a four-stroke gasoline engine that drives a 220 V AC generator and a reaction chamber - figure 2. An additional adjustable supply of CO_2 and SO_2 from gas cylinders to the chamber was provided. The generator was supplied with an adjustable load resistance, which changed the power of the engine and thus changed (if needed) the amount of flue gases (with temperature from 300 to 700 °C) passed to the chamber. The flows of the generator exhaust gases, CO_2 and SO_2 mixed in the system.

In order to react more fully with gases, the studied metals have to be as fine powder. For the purpose of our experiment aimed at the conception proving, it was useful to grind suitable metal (or alloy) rods that were fed into the reaction zone in order to produce powder in situ. This way of powders production would avoid metals preliminary oxidation by air. The metals-reductants were introduced in the area of the exhaust gas flow in the chamber by powdering the metal (alloy) rods by means of rotating abrasive discs [26]. The metal rods had a diameter of 2-10 mm and the rate of the abrasive discs was from 1000 to 10000 revolutions per minute. The obtained metal powder had particles' size of 0.1-1000 nm. Our preliminary experiments showed that both with respect of powder production and pollutants concentration decrease it was better to work with alloy with at least one hard metal as a support instead of with single metal rods. Aluminium, magnesium and zinc are relatively soft metals and this complicates both the mechanical stability of the metal rods used and the production of metal powder with the smallest possible particles and the largest contact surface. Therefore, rods of alloys of these metals with a supporting iron core were used.

Table 1. Considered reactions.

Pollutant	Studied reactions
A. Reactions with CO_2	$1.5CO_{2(g)}+2Al=Al_2O_3+1.5C$
	$CO_{2(g)}+2Mg=2MgO+C$
	$CO_{2(g)} + 2\ Mn=2MnO+C$
	$CO_{2(g)}+2Zn=2ZnO+C$
	$CO_{2(g)} + 2\ Sn=2SnO+C$
	$CO_{2(g)}+2Fe=2FeO+C$
B. Reactions with CO	$3CO_{(g)}+2Al=Al_2O_3+3C$
	$CO_{(g)}+Mg=MgO+C$
	$CO_{(g)} + Mn=MnO+C$
	$CO_{(g)}+Zn=ZnO+C$
	$CO_{(g)} + Sn=SnO+C$
	$CO_{(g)}+Fe=FeO+C$
C. Reactions with SO_2	$3SO_{2(g)}+2Al=Al_2S_3+3O_{2(g)}$
	$SO_{2(g)}+Mg=MgS+O_{2(g)}$
	$SO_{2(g)} + Mn=MnS+O_{2(g)}$
	$SO_{2(g)}+Zn=ZnS+O_{2(g)}$
	$SO_{2(g)} + Sn=SnS+O_{2(g)}$
	$SO_{2(g)}+Fe=FeS+O_{2(g)}$
D. Reactions with NO_2	$2NO_{2(g)}+2Al=Al_2O_3+N_{2(g)}+0.5O_{2(g)}$
	$2NO_{2(g)}+4Mg=4MgO+N_{2(g)}$
	$2NO_{2(g)}+4Mn=4MnO+N_{2(g)}$
	$2NO_{2(g)}+4Zn=4ZnO+N_{2(g)}$
	$2NO_{2(g)}+4Sn=4SnO+N_{2(g)}$
	$2NO_{2(g)}+4Fe=4FeO+N_{2(g)}$
E. Reactions with NO	$3NO_{(g)}+2Al=Al_2O_3+1.5N_{2(g)}$
	$2NO_{(g)}+2Mg=2MgO+N_{2(g)}$
	$2NO_{(g)}+2Mn=2MnO+N_{2(g)}$
	$2NO_{(g)}+2Zn=2ZnO+N_{2(g)}$
	$2NO_{(g)}+2Sn=2SnO+N_{2(g)}$
	$2NO_{(g)}+2Fe=2FeO+N_{2(g)}$
F. Reactions with N_2O	$3N_2O_{(g)}+2Al=Al_2O_3+3N_{2(g)}$
	$N_2O_{(g)}+Mg=MgO+N_{2(g)}$
	$N_2O_{(g)}+Mn=MnO+N_{2(g)}$
	$N_2O_{(g)}+Zn=ZnO+N_{2(g)}$
	$N_2O_{(g)}+Sn=SnO+N_{2(g)}$
	$N_2O_{(g)}+Fe=FeO+N_{2(g)}$

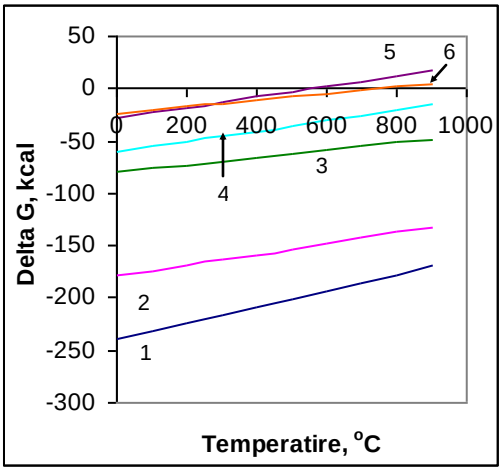


Figure 1 A1. Reactions with CO_2: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

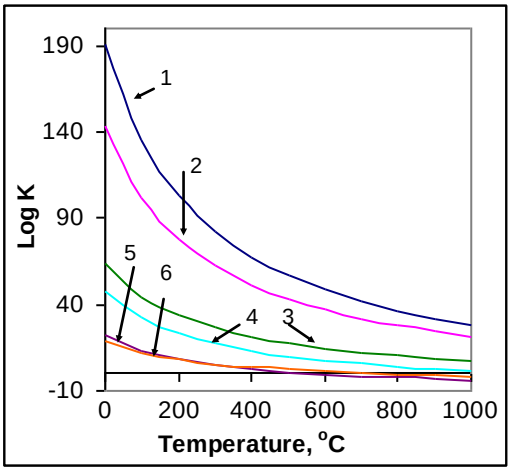


Figure 1 A2. Reactions with CO_2: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

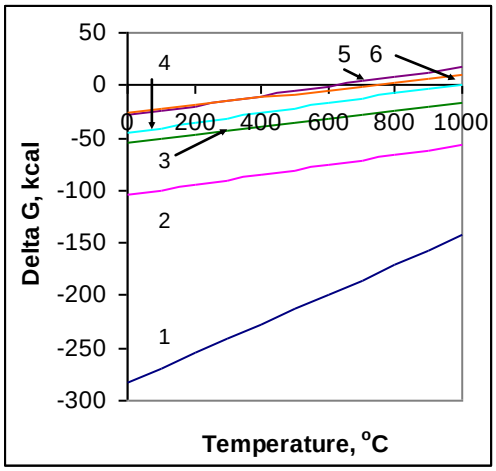


Figure 1 B1. Reactions with CO: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

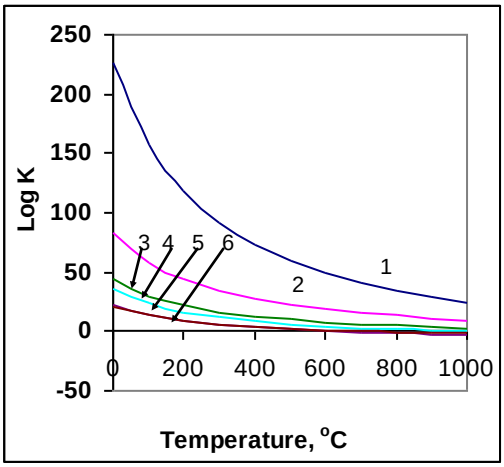


Figure 1 B2. Reactions with CO: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

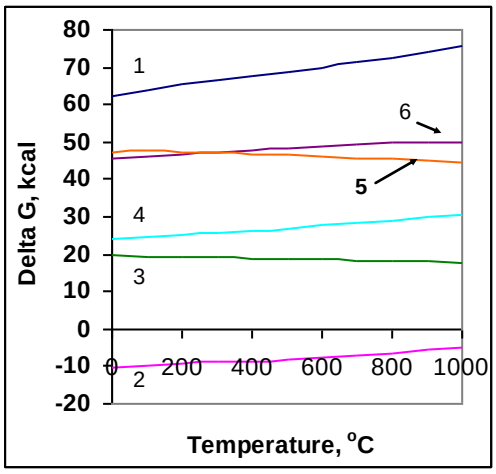


Figure 1 C1. Reactions with SO_2: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

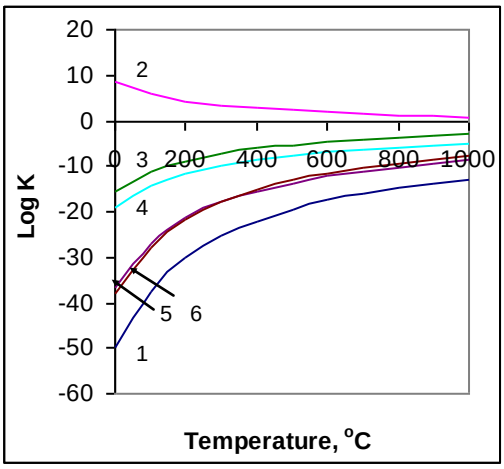


Figure 1 C2. Reactions with SO_2: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

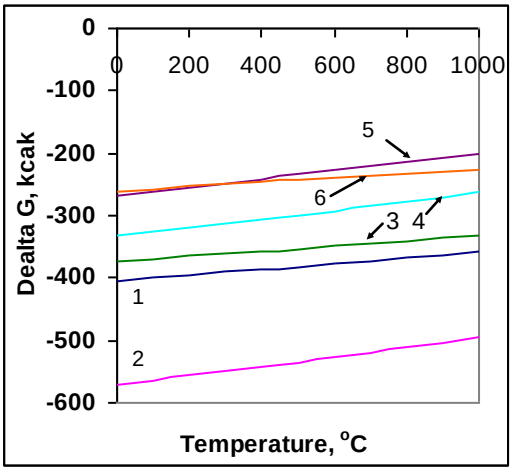


Figure 1 D1. Reactions with NO_2: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

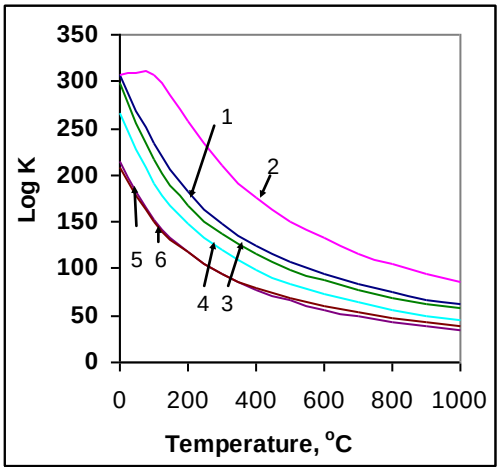


Figure 1 D2. Reactions with NO_2: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

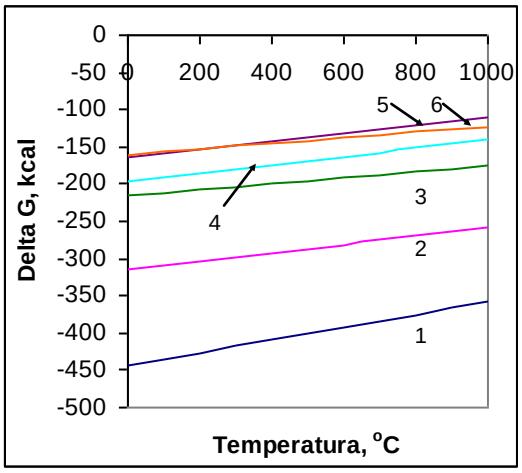


Figure 1 E1. Reactions with NO: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

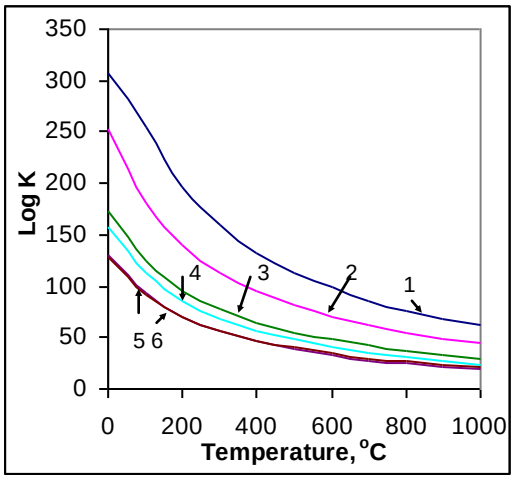


Figure 1 E2. Reactions with NO: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

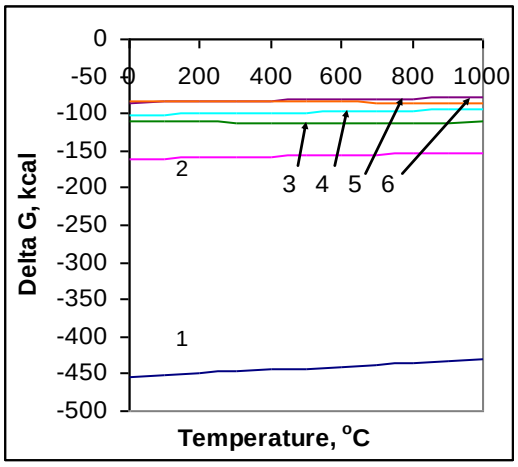


Figure 1 F1. Reactions with N_2O: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

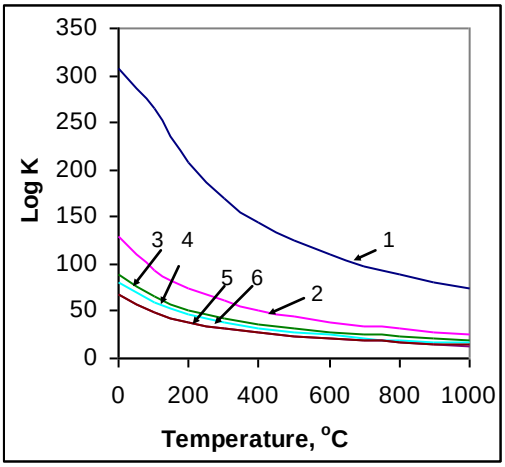
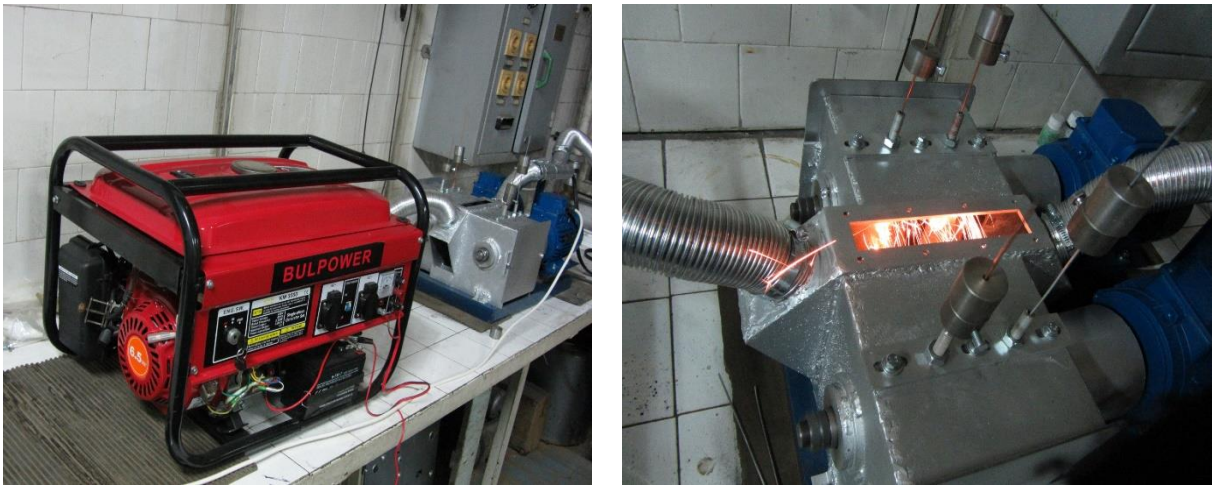


Figure 1 F2. Reactions with N_2O: 1 - Al, 2 - Mg, 3 - Mn, 4 - Zn, 5 - Sn, 6 - Fe

Based on the above mentioned considerations the choice was Fe, not Mn. Different compositions were studied. Over stoichiometric amounts of metals were used (determined by the mass loss of metals and known amount of exhaust gas that passed through the system).



A B

Figure 2. The installation used in experiments: A. Assembly, B Chamber inside - opened purposefully for a picture.

Concentrations of gases were determined with BTU4500-S Gas Emissions Analyser (E Instruments). The device measures nitrogen in exhaust gases as NO_x.

Solids fallen on the chamber bottom from several experiments were gathered and mixed. One part was dissolved in 20 % HNO_3 solution and subjected to ICP-OES analysis. The other part was used to check the availability of carbon with ELEMENTRAC CS-i (ELTRA GmbH) analyser.

An additional experiment was conducted in another lab (proprietary information) where mixture (with proper composition) of metals in powder form was converted to low temperature plasma state with the aim to decrease the amount of used metals to 1.2 times the stoichiometric one.

4. Results and discussion

Results from experiments with two alloy compositions and a mixture of metals powder are presented in table 2. Averaged data from two parallel experiments are given.

The analysis of gathered powder material gave approximately 42 % Mg, 31 % Al, 14 % C and 11% Fe. The solid product could be further utilized by hydrometallurgical processes.

Data presented in table 2, together with the content of the solid material, in our opinion, proved the concept of the possibility for decreasing the concentration of CO_2 and other gases released by TPPs via reaction with finely dispersed powder mixture of specific metals. That is why, at conceptual level, we have proposed a new method [27] for treating the polluting gases from TPPs - figure 3.

5. Conclusion

Based on thermodynamic considerations and the results of the experiments carried out, it could be stated that:

i) A possibility exists to decrease the concentration of CO_2 and other gaseous pollutants released by TPPs via reactions with some metals and their alloys.

ii) Solid products are formed that could be further utilized via hydrometallurgical processes.

We realize that the proposed treatment will be a difficult, long and expensive task, but perhaps at some point in the future it will justify its goals. Thus, in our opinion, the proposed treatment may be considered as another variant of CCU and deserves further research.

Table 2. Pollutants removal as a result of the treatment proposed.

Pollutant, unit	Initial concentration	Final concentration	Removal*, %
Alloy composition 1			
CO_2, %	13.2	1.5	88.6
CO, %	1.4	0.4	71.4
NO_x, ppm	2000	80	96.0
SO_2, ppm	20	10	50.0
Alloy composition 2 (higher Mg content compared to composition 1)			
CO_2, %	13.9	1.5	89.2
CO, %	1.5	0.4	73.3
NO_x, ppm	2200	86	96.1
SO_2, ppm	3000	1200	60.0
Mixture of metals powders			
CO_2, %	14.1	1.1	92.2
CO, %	1.5	0.3	80.0
NO_x, ppm	2200	82	96.3
SO_2, ppm	3000	1050	65.0

* Removal, % = (C_i - C_f) x 100 / C_i, where C_i - initial and C_f - final concentration of the pollutant

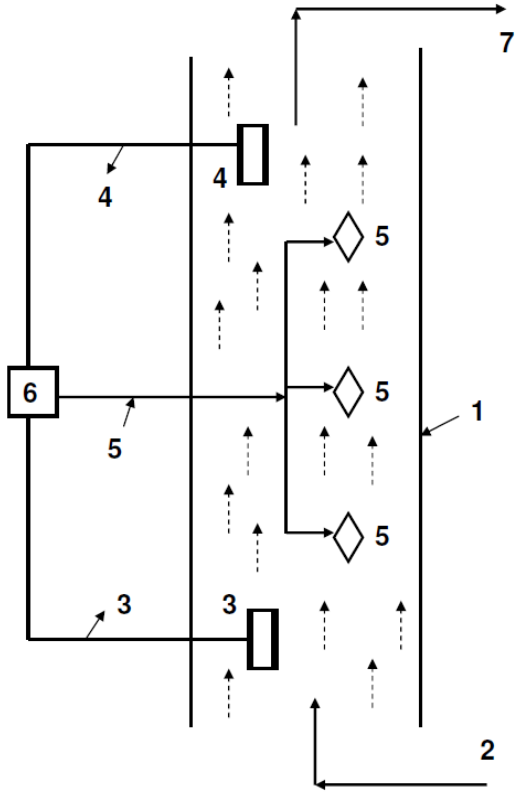


Figure 3. Block diagram of the proposed treatment methodology: 1 - TPP chimney, 2 - inlet emissions after the combustion of coal, fuel oil or other carbon source, 3 - inlet emissions analyser, 4 - outlet emissions analyser, after the treatment, 5 - system for plasma treatment of emissions with metal vapours, 6 - control device - controlling the amount of supplied metals powder depending on the concentration of various pollutants at the inlet and outlet, 7 - exhaust gases after the treatment.

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Adhocratic mechanisms of formation of innovative and creative directions for business entities development in conditions of transparency of economics

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Adhocratic mechanisms of formation of innovative and creative directions for business entities development in conditions of transparency of economics

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Abstract. The article defines that at the present stage of innovative and creative directions of industrial development there are strict requirements for waste management processes in order to reduce energy and resource consumption, increase their efficiency and ensure environmental safety at the level of world standards in conditions of transparency of economics. Modern scientific and technological progress has brought innovations to humanity, which have provided material resources for the accelerated development of society, as well as raised the question concerning the crisis of the use of limited resources and the emergence of environmental crises. The current status quo requires the production of adhocratic mechanisms for the formation of innovative and creative directions of development of economic entities in the conditions of transparency of economics to overcome this crisis in order to create a model of sustainable development. In this article the world practice of waste management and the current status quo of development of the system of waste formation and management in Ukraine for 2010-2020 have been analyzed. Using calculations of Chuprov, Cramer and Pearson coefficients, it has been determined that the correlation between the amount of waste formed and the amount of waste disposed in 2010-2020 in Ukraine is weak, which confirms the problem of waste management that needs to be addressed at different levels of management in conditions of transparency of economics. According to the results of the research, it has been suggested to develop and implement adhocratic mechanisms for the formation of innovative and creative directions of development of economic entities in conditions of transparency of economics.

1. Introduction

Effective waste management of resource-intensive and energy-intensive domestic industries is inextricably linked with the development of key industries of up-to-date industry in Ukraine. At the present stage of innovative and creative directions of industrial development, strict complex requirements are set for waste management processes in order to reduce energy and resource consumption, increase their efficiency and ensure environmental safety at the level of world standards in conditions of transparency of economics.

The current objective of this strand of research puts forward requirements that lead to the fundamental problem of developing adhocratic mechanisms for the formation of innovative and creative directions of economic development in conditions of transparency of economics, taking into account the main indicators of technology of use, processing and disposal of waste and environmental safety according requirements of waste management strategies in Ukraine until 2030 (Order of the Cabinet of Ministers of Ukraine № 820-r dated November 2018 as amended).

The traditional approach to waste management, based on collection, processing, disposal, incineration, biodegradation, high-temperature production processes, involves the loss of valuable components, with a partial reduction of technology-related surcharge in specific areas of the country. The negative impact of industrial waste on the environment and human health is a significant environmental problem, mainly due to its high toxicity.

The organization of waste management system based on high-level processing of useful components of waste requires the development of a scientific basis for forecasting areas of evaluation, use of resource potential of existing and new recycling technologies to develop adhocratic mechanisms for innovation and creative development of economic entities in conditions of transparency of economics.

2. Critical literature review

In recent years, a sufficient number of scientific papers have been published, which are related to the subject of waste management, but a number of aspects in the development of theoretical and practical aspects of waste use and processing in economic development have not been sufficiently studied.

Such scientists as Beletska G., Dabert, P., Valinkevych N., Viswanathan S., Matyushenko I., Logan M., Prokhorova V., Savchenko M., Tremiet, A., Fisgativa, H., Shkarlet S., Shkurenko O. and others were engaged in research of the subject under study.

In scientific papers devoted to the considered problems the questions of production of adhocratic mechanisms of formation of innovative and creative directions of development of business entities in the process of waste recycling in the conditions of transparency of economics are insufficiently analyzed.

Modern scientific and technological progress has brought innovations to humanity, which have provided material resources for the accelerated development of society, as well as raised the question of the crisis of the use of limited resources and the emergence of environmental crises. The current status quo requires the production of adhocratic mechanisms for the formation of innovative and creative directions of development of economic entities in the conditions of transparency of economics to overcome this crisis in order to create a model of sustainable development.

The strategic direction of solving these problems is to preserve resources in their main form, i.e. waste recycling.

In the conditions of depletion and non-renewal of most natural resources, the issue of stimulating the involvement of innovative and creative technologies for the processing of secondary resources is of important significancy. Domestic practice in this direction is behind the developed countries of the world, whose experience shows that in different countries there are different approaches to waste management which are shown in Fig. 1.

The problem of waste disposal is one of the current areas of socio-economic and environmental development of most foreign countries. At the same time, there is a great role of the state which through legislative, financial and administrative activities can stimulate the progressive development of this process. Waste management programs should include: investment tax credits that reduce the amount of corporate income tax by a certain percentage; tax benefits for innovative and creative programs for waste recycling in transparent economics, namely to create conditions for openness, accountability and transparency. In general, the system of benefits contributes to the creation of such conditions under which it is more profitable for business entities to recycle waste or transfer it for recycling to other business entities than to simply destroy it [2-5, 7, 11].

Recommendations to change the waste management system in Ukraine don't fully comply with the experience and goals used in the world's leading countries, due to the lack of innovative and creative areas of economic development in conditions of transparency of economics [1].

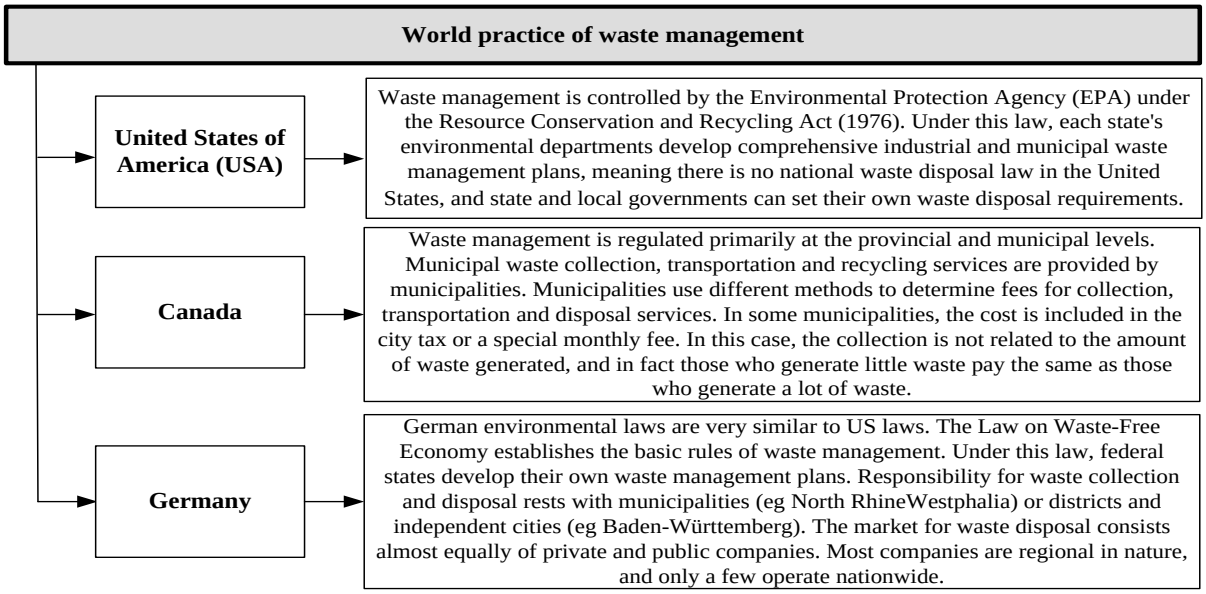

Figure 1. World practice of waste management

The essence of adhocratic mechanisms of formation of innovative and creative directions of development of economic entities in conditions of transparency of economics is the need to optimally combine environmentally friendly management with economic success at different levels of management. To create an effective waste management system, it is necessary to form compromise mechanisms between environmental issues and the competitiveness of the national economy.

3. Materials and Methods

In conditions of reduction of world resources, it is especially important to improve the collection, acquisition and rational use of waste, as they can be used as additional raw materials.

Industrial waste accompanies any activity of business entities. Wastes, depending on toxicity, have differing degrees of impact on the environment and can be extremely hazardous [7-9].

The level of negative impact of waste on the environment is assessed by the degree of the toxicity, which leads to differing degrees of environmental problems in the places of its production and disposal.

The current status quo of development of the system of waste formation and management in Ukraine for 2010-2020 is given in Table 1 and in Fig. 2, Fig. 3.

Table 1. Waste formation and management in Ukraine for 2010-2020, thousand tons. [6]

Years	The amount of waste formed	The amount of waste disposed	The amount of waste incinerated	The amount of waste disposed of in specially designated places and facilities	The total amount of waste accumulated during operation, in specially designated places and facilities
a	b	c	d	e	f
2010	422549,9	144866,6	1056,8	311649,0	13219983,9
2011	443795,5	153368,2	1039,2	251352,0[3]	14372055,1

a	b	c	d	e	f
2012	446716,9	143110,3	1201,1	263562,6	14856638,5
2013	445262,1	146733,1	917,9	264665,6	15111636,2
2014*	355000,4	109280,1	944,7	203698,0	12205388,8
2015*	312267,6	92463,7	1134,7	152295,0	12505915,8
2016*	295870,1	84630,3	1106,1	157379,3	12393923,1
2017*	366054	100056,3	1064,3	169801,6	12442168,6
2018*	352333,9	103658,1	1028,6	169523,8	12972428,5
2019*	441516,5	108024,1	1059,0	238997,2	15398649,4
2020*	462373,5	100524,6	1008,0	275985,3	15635259,6

* Since 2014, data are given without taking into account the temporarily occupied territory of the Autonomous Republic of Crimea, Sevastopol, as well as without part of the temporarily occupied territories in Donetsk and Luhansk regions

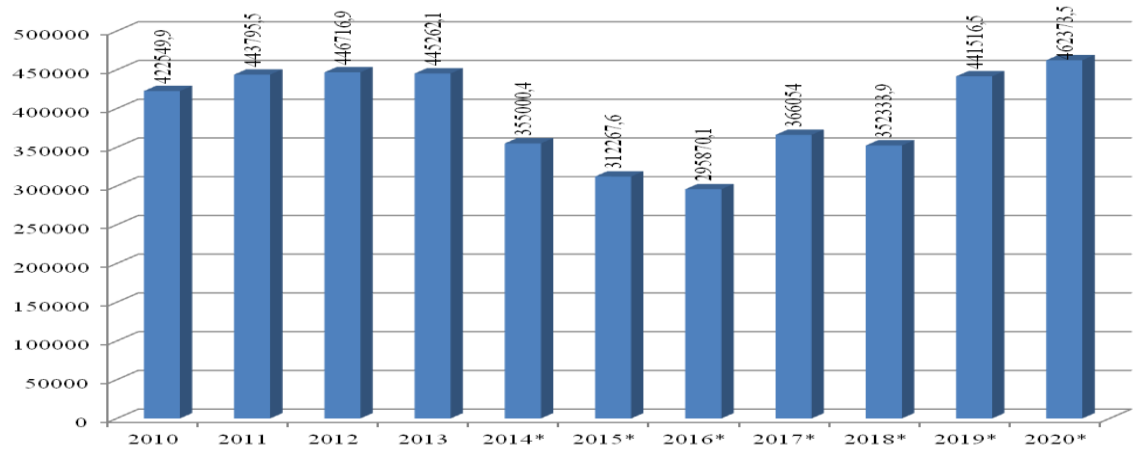

Figure 2. Amount of recycled waste for 2010-2020 in Ukraine according to the State Statistics Service of Ukraine [6]

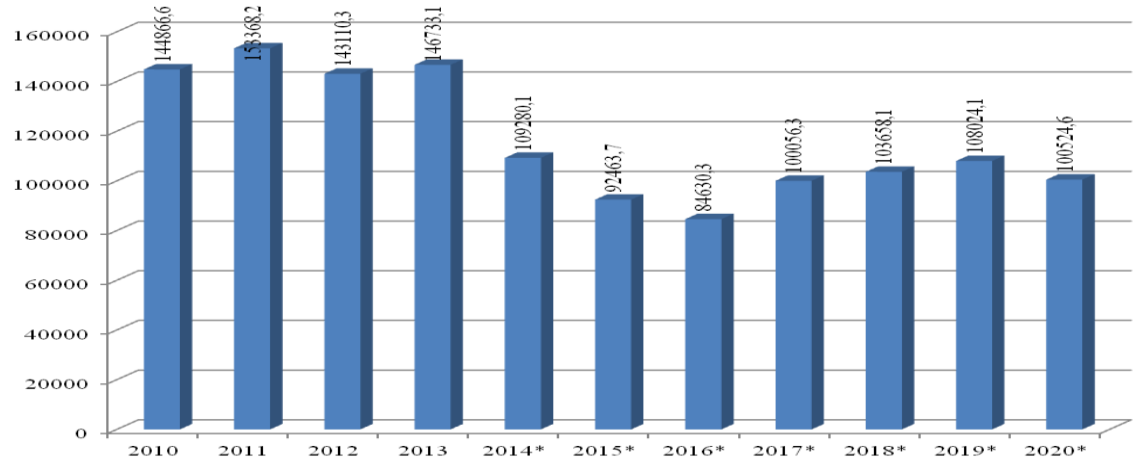

Figure 3. The amount of waste formed in 2010-2020 in Ukraine according to the State Statistics Service of Ukraine [6]

The analysis of the dependence of the amount of waste formed and the amount of waste disposed for 2010-2020 in Ukraine provided an opportunity to obtain a distribution of these indicators. The results are included in Table 2.

Table 2. Matrix of distribution of dependence of the amount of waste formed and the amount of waste disposed for 2010-2020 in Ukraine.

	A1	A2	n_{i*}
B1	422549,9	144866,6	567416,5
B2	443795,5	153368,2	597163,7
B3	446716,9	143110,3	589827,2
B4	445262,1	146733,1	591995,2
B5	355000,4	109280,1	464280,5
B6	312267,6	92463,7	404731,3
B7	295870,1	84630,3	380500,4
B8	366054	100056,3	466110,3
B9	352333,9	103658,1	455992
B10	441516,5	108024,1	549540,6
B11	462373,5	100524,6	562898,1
n_{*j}	4343740,4	1286715,4	5630455,8

To test the independence of the signs "A" and "B", we test the null hypothesis H0: ($p_{ij} = \pi \cdot p \cdot j$ for all i, j). Statistics $\chi 2$ of observations are calculated by the formula:

$$\chi^2 = \sum\sum \frac{(n_{ij} - n'_{ij})^2}{n'_{ij}}$$

where n_{ij} – are the observed frequencies.

If the value of $\chi 2$ of observations is in the critical domain: $\chi 2 > \chi 2$ is critical (α ; v=10), the null hypothesis is rejected with a probability of error α and the signs are considered dependent.

In this case, it makes sense to measure the correlation between the amount of waste formed and the amount of waste disposed in 2010-2020 in Ukraine using the coefficients of correlation.

We calculate the theoretical frequencies according to the following formula:

$$n'_{ij} = \frac{n_i \cdot n_j}{n}$$

The results of the calculation for the first indicator are given:

$$n'_{11} = \frac{n_1 \cdot n_{.1}}{n} = \frac{567416{,}5 \cdot 4343740{,}4}{5630455{,}8} = 437746{,}08$$

We obtain a table of combinations of theoretical distribution frequencies (Table 3).

Table 3. The results of calculations of the combination of theoretical frequencies of the distribution of the correlation between the amount of waste formed and the amount of waste disposed for 2010-2020 in Ukraine.

	A1	A2	n_{i*}
B1	437746,083	129670,417	567416,5
B2	460695,223	136468,477	597163,7
B3	455035,317	134791,883	589827,2
B4	456707,868	135287,332	591995,2
B5	358179,522	106100,978	464280,5
B6	312238,966	92492,334	404731,3
B7	293545,499	86954,901	380500,4
B8	359591,162	106519,138	466110,3
B9	351785,174	104206,826	455992
B10	423955,323	125585,277	549540,6
B11	434260,263	128637,837	562898,1
n_{*j}	4343740,4	1286715,4	5630455,8

The calculation of statistics $\chi 2$ according to the Table of $\chi 2$- distribution makes it possible to obtain $\chi 2$crit (0.05;10) = 18,30704

where v = (r-1) (s-1) = (11-1) (2-1) = 10 – the number of degrees of freedom.

The critical domain has the form $\chi 2 > \chi 2$crit. Since the calculated value of $\chi 2$ falls into the critical domain, the hypothesis of independence is rejected with a probability of error of 0.05.

Next, we use the information criterion to test the hypothesis of independence of the signs.

The following formula can be used for computational convenience of calculation:

$$\chi_I^2 = 2\sum\sum n_{ij} \ln \frac{n_{ij}}{n'_{ij}}$$

considering that the theoretical values of the frequencies n_{ij} are found according to the formula:

$$\chi_I^2 = 2(\sum\sum n_{ij} \ln n_{ij} - \sum n_i \ln n_i - \sum n_j \ln n_j + n \ln n)$$

and properties of logarithms:

$$\chi_I^2 = 2(422549{,}9 \cdot \ln(422549{,}9) + 144866{,}6 \cdot \ln(144866{,}6) + 443795{,}5 \cdot \ln(443795{,}5) + 153368{,}2 \cdot \ln(153368{,}2) + 446716{,}9 \cdot \ln(446716{,}9) + 143110{,}3 \cdot \ln(143110{,}3) + 445262{,}1 \cdot \ln(445262{,}1) + 146733{,}1 \cdot \ln(146733{,}1) + 355000{,}4 \cdot \ln(355000{,}4) + 109280{,}1 \cdot \ln(109280{,}1) + 312267{,}6 \cdot \ln(312267{,}6) + 92463{,}7 \cdot \ln(92463{,}7) + 295870{,}1 \cdot \ln(295870{,}1) + 84630{,}3 \cdot \ln(84630{,}3) + 366054 \cdot \ln(366054) + 100056{,}3 \cdot \ln(100056{,}3) + 352333{,}9 \cdot \ln(352333{,}9) + 103658{,}1 \cdot \ln(103658{,}1) + 441516{,}5 \cdot \ln(441516{,}5) + 108024{,}1 \cdot \ln(108024{,}1) + 462373{,}5 \cdot \ln(462373{,}5) + 100524{,}6 \cdot \ln(100524{,}6) + 4343740{,}4 \cdot \ln(4343740{,}4) - 1286715{,}4 \cdot \ln(1286715{,}4) - 567416{,}5 \cdot \ln(567416{,}5) - 597163{,}7 \cdot \ln(597163{,}7) - 589827{,}2 \cdot \ln(589827{,}2) - 591995{,}2 \cdot \ln(591995{,}2) - 464280{,}5 \cdot \ln(464280{,}5) - 404731{,}3 \cdot \ln(404731{,}3) - 380500{,}4 \cdot \ln(380500{,}4) - 466110{,}3 \cdot \ln(466110{,}3) - 455992 \cdot \ln(455992) - 549540{,}6 \cdot \ln(549540{,}6) - 562898{,}1 \cdot \ln(562898{,}1) + 5630455{,}8 \cdot \ln 5630455{,}8) = 19225{,}066$$

According to the results of the calculation we have received χ_I^2 = 19225,07

Critical domain when testing this hypothesis is: $\chi_I^2 > \chi 2$table = 18,30704

Since $\chi 2$ = 19225,07 falls into the critical domain, hypothesis H0 is rejected with a probability of error of 0.05.

We determine the strength of the correlation by the contingency coefficients.

To estimate the strength of the correlation, we calculate the point estimations of the coefficients.

The Chuprov coefficient has been calculated by the formula:

$$C = \sqrt{\frac{\chi^2}{n\sqrt{(r-1)(s-1)}}} = \sqrt{\frac{18804{,}903}{5630455{,}8\sqrt{(11-1)(2-1)}}} = 0{,}0325$$

The Cramer coefficient has been calculated by the formula:

$$K = \sqrt{\frac{\chi^2}{n \cdot \min[r-1, s-1]}} = \sqrt{\frac{18804{,}903}{5630455{,}8 \min[11-1{,}2-1]}} = 0{,}05785$$

The Pearson correlation coefficient has been calculated by the formula:

$$P = \sqrt{\frac{\chi^2}{\chi^2 + n}} = \sqrt{\frac{18804{,}903}{18804{,}903 + 5630455{,}8}} = 0{,}0577$$

Thus, the correlation between the amount of waste formed and the amount of waste disposed of in 2010-2020 in Ukraine is weak, and this fact confirms the problem of waste management that needs to be addressed at different levels of management in transparent economics.

Accordingly, it is necessary to create universal hubs that would unite business entities engaged in the collection, storage, disposal, processing and sale of garbage. Cities need to implement programs to

encourage businesses and the public to sort waste, as well as to organize further transportation of separate, selective categories of waste to the nearest specialized recycling points.

Payments under state and municipal contracts should be made only after the removal of waste to landfills. In the short term, the key objective is to resolve the problem of illegal landfills. It is impossible to achieve specified targets without state support for the implementation of specific projects aimed at reducing environmental damage, which are implemented by private enterprises [10, 12].

We suggest to analyze the structure of expenditures on environmental protection by types of economic activity in 2020 in Ukraine, which are given in Table 4.

Table 4. Expenditures on environmental protection by types of economic activity in 2020 in Ukraine (in actual prices, thousand UAH). [6]

Activities	Total		Including					
			Capital Investments				current expenses	
			total		where capital repairs			
	thousand UAH	%	thousand UAH	%	thousand UAH	%	thousand UAH	%
Total	**41332201,7**	**100**	**13239649,8**	**100**	**1691248,1**	**100**	**28092551,9**	**100**
Agriculture, forestry and fisheries	388444,4	0,94	15092,5	0,114	470,5	0,028	373351,9	1,329
Mining and quarrying	11289872	27,31	3762622,6	28,419	250194,7	14,793	7527249,4	26,794
Manufacturing industry	12151044,6	29,40	5608008,7	42,358	752506,3	44,494	6543035,9	23,291
Supply of electricity, gas steam and air conditioning	2366392,5	5,73	1135558,7	8,577	54525,4	3,224	1230833,8	4,381
Water supply; sewerage waste management	9956567,5	24,09	1149457,2	8,682	208458	12,326	8807110,3	31,350
Construction	184848,8	0,45	3445,7	0,026	–	0,000	181403,1	0,646
Wholesale and retail trade repair of motor vehicles and motorcycles	99578,3	0,24	23261,3	0,176	–	0,000	76317	0,272
Transport, warehousing postal and courier activities	807445,1	1,95	90146,5	0,681	31036,9	1,835	717298,6	2,553
Temporary accommodation and catering	950	0,00	–	0,000	–	0,000	950	0,003
Information and telecommunications	1141,7	0,00	–	0,000	–	0,000	1141,7	0,004
Financial and insurance activities	24095,5	0,06	213,1	0,002	–	0,000	23882,4	0,085
Real estate transactions	253277,9	0,61	163265	1,233	46449	2,746	90012,9	0,320
Professional, scientific and technical activities	331358,7	0,80	76584,7	0,578	421,3	0,025	254774	0,907
Activities in the field of administrative and support services	1606117,7	3,89	285090,2	2,153	–	0,000	1321027,5	4,702
Public administration and defense; compulsory social insurance	1162581,6	2,81	614803,6	4,644	343452	20,308	547778	1,950
Education	13856,3	0,03	517,5	0,004	–	0,000	13338,8	0,047
Health care and social assistance	19704,2	0,05	4778,3	0,036	3121,2	0,185	14925,9	0,053
Arts, sports, entertainment and recreation	640319,2	1,55	305800,6	2,310	612,8	0,036	334518,6	1,191
Provision of other types of services	34605,7	0,08	1003,6	0,008	–	0,000	33602,1	0,120

According to the results of the analysis, one may state that the largest percentage of environmental expenditures by type of economic activity in 2020 in Ukraine is accounted for by the industrial industry (29.4%) and mining and quarrying (27.31%).

Accordingly, it is necessary to develop and implement adhocratic mechanisms for the formation of innovative and creative directions of development of business entities in transparent economics (Fig. 4).

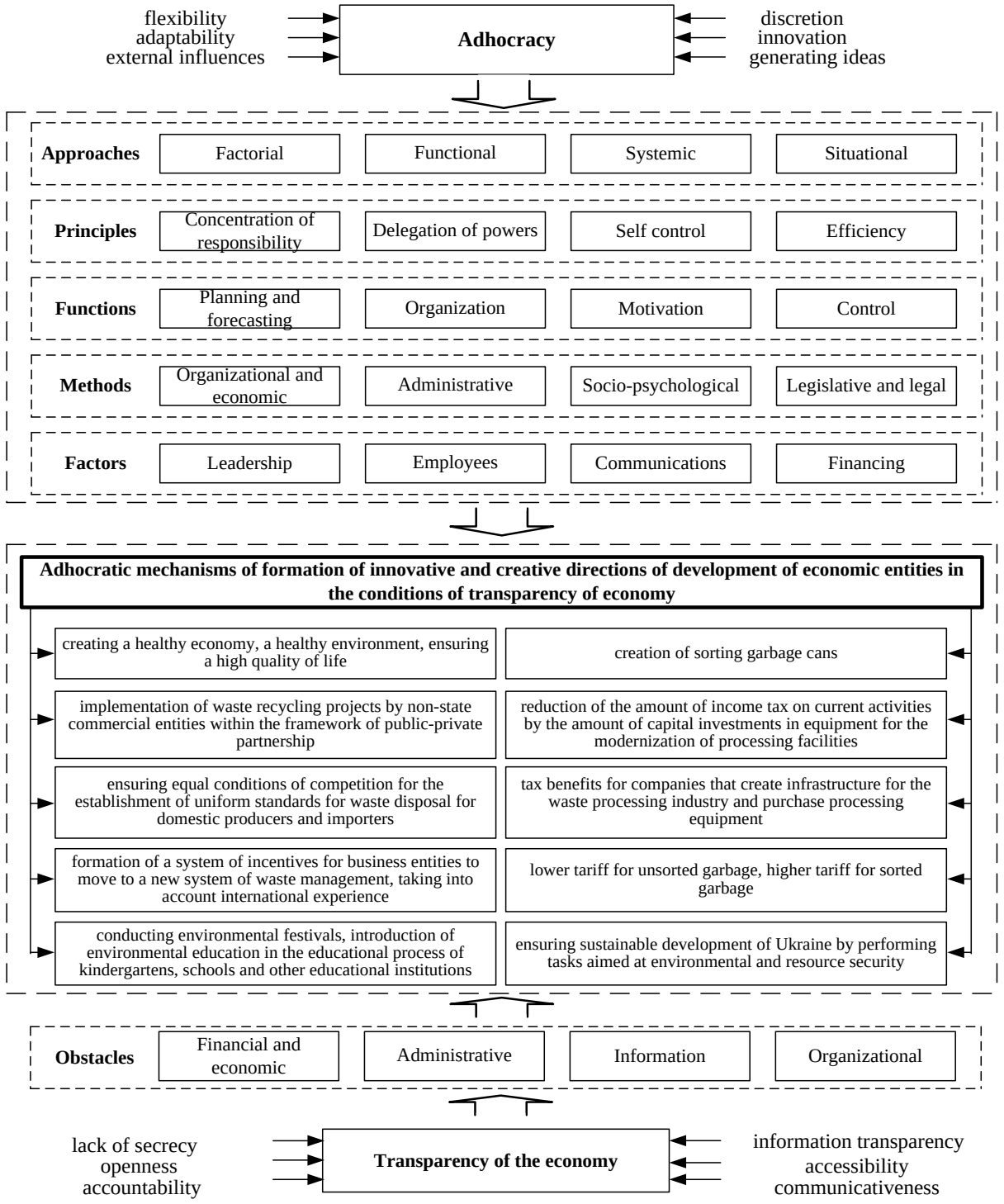

Figure 4. Adhocratic mechanisms of formation of innovative and creative directions for business entities development in the conditions of transparency of economics

Waste management is closely linked to sustainable economic development due to constant demand for raw materials, declining resources, and ultimately depleting potential natural resources. Rational use of social production resources is important in their effective provision.

The most important objective of innovation and creative areas is the organization of waste processing in order to dispose of them and rational use. This objective can be solved only when the environmental consequences of economic decisions will be considered as the main ones, along with socio-economic ones.

The issue of nature protection is closely related to politics, economics and social sphere, which makes it necessary to consider this problem in various aspects such as socio-political, legal, technical and technological, environmental and economic, socio-hygienic ones through the implementation of adhocratic mechanisms for innovative and creative directions of development of business entities in the conditions of transparency of economics.

The experience of waste management abroad has shown that market relations are not able to effectively regulate waste management processes directly, and resource conservation processes as a matter of priority.

4. Conclusions

In connection with the above-mentioned problems, it is necessary to take into account the experience of developed countries in the development and improvement of regulations, including legislation, standards and other guidelines needed to reform the waste management system which is an actual objective for countries.

At present, it is necessary to develop adhocratic mechanisms for the formation of innovative and creative directions of economic development in transparent economics aimed at recycling industrial waste, as well as the relevant production sector, because without economic and technical development of recycling the state will have to overcome the environmental crisis and overcoming the shortage of certain types of raw materials for businesses.

The need to develop and improve adhocratic mechanisms for the formation of innovative and creative directions of economic development in transparent economics in the field of waste recycling in accordance with ever-changing external and internal conditions, the need to intensify commercial implementation of waste recycling, importance and timeliness of waste processing in contemporary conditions are gaining relevance at all levels of management.

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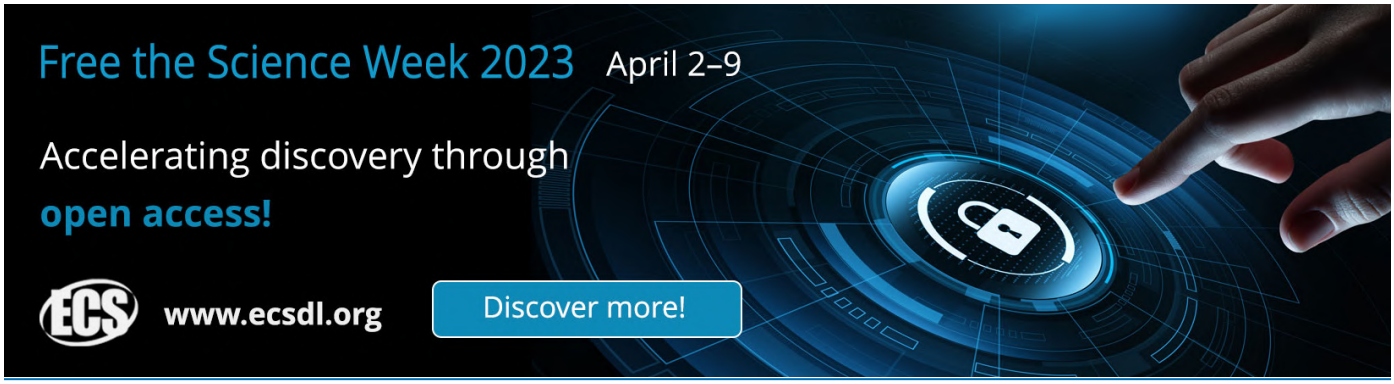
Resource efficiency and pricing policy of industries the sustainable development context



Resource efficiency and pricing policy of industries the sustainable development context

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Abstract. In the article, the authors analyzed the theoretical foundations of sustainable economic growth based on the research of modern foreign and domestic scientists. It is proved that the economy of the linear type has exhausted itself due to the effect of scale. That is why, today, one of the foreground of research areas among leading domestic and foreign scientists is the concept of sustainable development which should be based on cyclical or circular economy principles. One of the directions of development is working out methods of products price formation taking into account resource-efficient strategies. The article presents price equilibrium scenarios developed by the authors, which were implemented in the oil and gas industry based on business activities for 2015-2020. These scenarios were developed by the authors using Leontiev's cross-industry model, which explores how do these changes can impact the performance of resource use, based on changes in direct cost ratios, value added ratios and intermediate consumption ratios.

1. Introduction

Ensuring stable and long-term social and economic development is a top priority of state regulation of the government of every country and an ultimate goal of which is to permanently improve of living standard for the population. At the same time, opponents of the rapid growth of the international economy cite for their own benefit such arguments as: irreversible changes in the environment due to its pollution and a natural resources depletion due to their excessive consumption. In the global dimension, such trends pose threats not only to individual regions, but also create risks for the existence of humanity in general.

It can be stated that the economy of the linear type has exhausted itself due to the effect of scale. That is why, today, one of the foreground of research among leading domestic and foreign savants is the concept of sustainable development which should be based on cyclical or circular economy principles, which determines the relevance and timeliness of this work. Sustainable development involves a radical change in the paradigm of social production, which is based on the need to fully reproduce the environment due to the anthropogenic impact of economic activity on it.

The issues of resource efficiency and strategic management were the subject of the works of the following scientists: Hassan A. [1], Karev A. [2], Ediger V. and Berk I. [3]. Nechully S., Pokhriyal S.,

Thomas S. [4], Milovidov K. [5], Wild E., Wansbury N., Crudgington J., Andrews Mark [6] and others researchers have paid attention to investments for oil and gas industries.

Study questions of sustainable development and competitive environment, effective governance, including on the basis of a balanced scorecard, socially sensitive corporate social responsibility issues, was addressed by Nortje C. and others [7], Abubakar M., Ahmad S. [8], Frynas G. [9], Dzwigol H. [11], Perevozova, I. [12], Tkachenko V., [13], Smoluk-Sikorska J., Łuczka W. [14, 15].

If we would talk about the oil and gas sector of economy some of the scientific works is also often dedicate to the climate impact of oil and gas companies and also to country's energy security. These issues were elaborated by: Bach M. [10], Sanyal R.K. [16], Pinchuk A., Tkalenko N, Marhasova V. [17], J. Polcyn, S. Stepien, A. Tosovic-Stevanovic [18]. However, many issues remained unresolved.

The analysis of the studies of modern scientists proved the relevance of this direction of research, but showed that to a greater extent they are of a theoretical nature. At the same time, government regulation is associated with a continuous decision-making process. Therefore, there is a need for more active use of the economic and mathematical apparatus.

2. Methodology

The criteria for national economy sustainable development were formed on the basis of the circular economy conceptual principles. Statistical and economic analysis of key indicators of sustainable development was carried out before studying the problems and features of pricing policy. The formation of pricing policy in terms of resource efficiency is based on the implementation of Leontiev's intersectoral model. According this assessment were formulate recommendations for Ukrainian oil and gas sector price policy formation.

3. Results and discussion

The complex of measures of rational nature use in the conditions of a circular economy provides for: a significant decreasing in the consumption of resources due to the mass introduction of resource-saving technologies; production technologies should provide opportunities for reprocessing of final products and multiple use of waste; environmental pollution should be minimized. That is why indicators of national economy sustainable development should comprehensively take into account the indicated areas and quantitatively assess their dynamics.

Thus, in this case, we are talking about profound transformational changes of a technological nature, from the point of view of statistical observations, it is appropriate to consider the long-term period. The reasons for this are:

– firstly, short-term trends may be formed under the influence of random factors and may not always reflect the general dynamics of social development in a strategic dimension;

– secondly, the transition from a traditional linear economy to a closed cycle economy is a long-term process that cannot be completed in the medium term, lasting 5-7 years. Therefore, it is important to assess the stability of the chosen sustainable development strategy over a long period of time.

Therefore, in this study, the statistical base of observations was limited to 2010-2020, it is a continuation and expansion of the scientific work started in 2015 [11-13].

As for 2021, not all summary indicators of economic and social development and the state of the environment are currently publicly available. Average annual rates of their growth were used to measure the dynamics of time series. Next, to build the model, it is necessary to determine the criteria for national economy sustainable development, Fig. 1

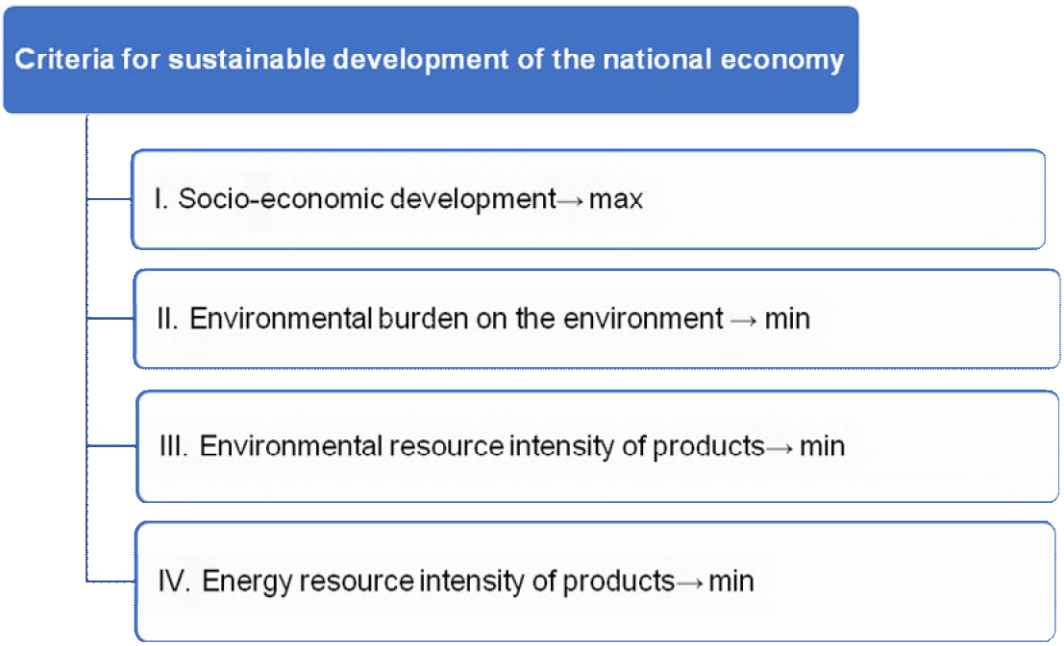

Figure 1. Criteria for national economy sustainable development.
Proposed by the authors

First of all, any state development strategy should ensure social and economic growth, which should be maximized, while simultaneously reducing the environment ecological burden. The level of environmental pollution is determined by the amount of atmospheric emissions, the generation of industrial waste, the intake and discharge of untreated water, as well as the irrational use of agricultural lands, as a result of which they lose their fertility.

It is possible to achieve a simultaneous growth of social production with a quantitative reduction in the volume of anthropogenic influence only if the rate of reduction of emissions per unit of production exceeds the corresponding rate of GDP growth.

Therefore, the next criterion of sustainable development, which was included in the consideration, is the ecological resource intensity of products, which should be minimized.

Multiple use of industrial and household waste as a resource base for production needs is one of the key requirements for the effective functioning of a closed-loop economy. The result of its implementation is the maximum reduction of consumption of non-renewable natural resources. Taking into account this prerequisite is another mandatory criterion of sustainable development, which aims to reduce the energy resource intensity of products.

To assess the successful implementation of each of the considered criteria, a corresponding set of statistical and economic indicators is used. Let's consider their composition in more detail.

1. The level of development in social and economic direction:

– the most important indicator of the economic growth of countries used in international comparisons is the Gross Domestic Product (GDP). At the level of voivodships (provinces), this is the gross regional product;

– a positive rate of GDP growth does not always mean an improvement in the standard of population living. If the growth rate of its number exceeds the rate of economic growth, then the welfare of the population will deteriorate and vice versa. Therefore, the model includes the indicator of gross domestic, or regional product per capita. Positive values of these indicators also indicate the intensive nature of development at the expense of labor productivity, and are also a necessary prerequisite for the permanent growth of the population's income;

– the average level of real wages in the country and regionally should be maximized.

The reduction of individual indicators to the generalized ones in the case of growth rates, according to statistical practice, is performed according to the formulas of the geometric mean.

2.The level of ecological burden on the environment.

Available statistics contain natural indicators of the amount of pollution both for the country as a whole and for regions [11]. However, they do not provide an idea of the intensity of emissions in certain territories, since they differ in area. Therefore, the relative indicators of environmental pollution will be calculated as the ratio of pollution volume to the plane of a certain region.

The indicators of this group included:

– volumes of emissions of :

a) sulfur dioxide,
b) of nitrogen oxide,
c) carbon dioxide
d) carbon monoxide into the atmosphere, relative to the area of pollution;

– volumes of generated industrial waste per area of pollution;

– water intake from natural sources for production purposes and volumes of untreated water discharge per area of the region.

Another indicator of this group is the share of agricultural land that has lost its fertility due to excessive intensity of use.

According to economic content, all indicators of this group should be minimized.

3. The level of ecological resource intensity of products.

In the economy, resource intensity characterizes the resources level spent on a unit of production and should be minimized. In our case, it is necessary to minimize anthropogenic impact, which is a consequence of social production. Therefore, the indicators of this group will be calculated as the ratio of the amount of pollution to the gross domestic product.

The following indicators were included in the sustainable growth model:

– volumes of emissions of sulfur dioxide, nitrogen oxide, carbon dioxide and carbon monoxide into the atmosphere in relation to GDP;

– volumes of generated industrial waste, in relation to GDP;

– water intake from natural sources for production purposes and volumes of untreated water discharges, in relation to GDP.

All indicators of this group should also be minimized..

4.The level of energy resource intensity of products.

Today, the energy component is an important factor in the national security of any country of the European Union. The reuse of waste and renewable energy sources makes it possible to significantly reduce the consumption of natural resources and reduce this dependence on external political and economic levers of influence. The calculation of most of the indicators of this direction of evaluation is the ratio of the amount of consumed resources to the gross domestic product.

The indicators of this group include:

– consumption volumes of hard coal, crude oil, coke, gasoline, diesel fuel and fuel oil, natural gas as a percentage of GDP;

– the amount of consumed electricity to GDP;

– the share of non-renewable sources of electricity in the total volume of its consumption. Renewables include: geothermal, biomass, wind and hydropower.

The given indicators of the energy resource intensity of products should be minimized.

Volume of oil and gas production during 2015-2018 had a positive annually growth more than 11% (Figure. 2).

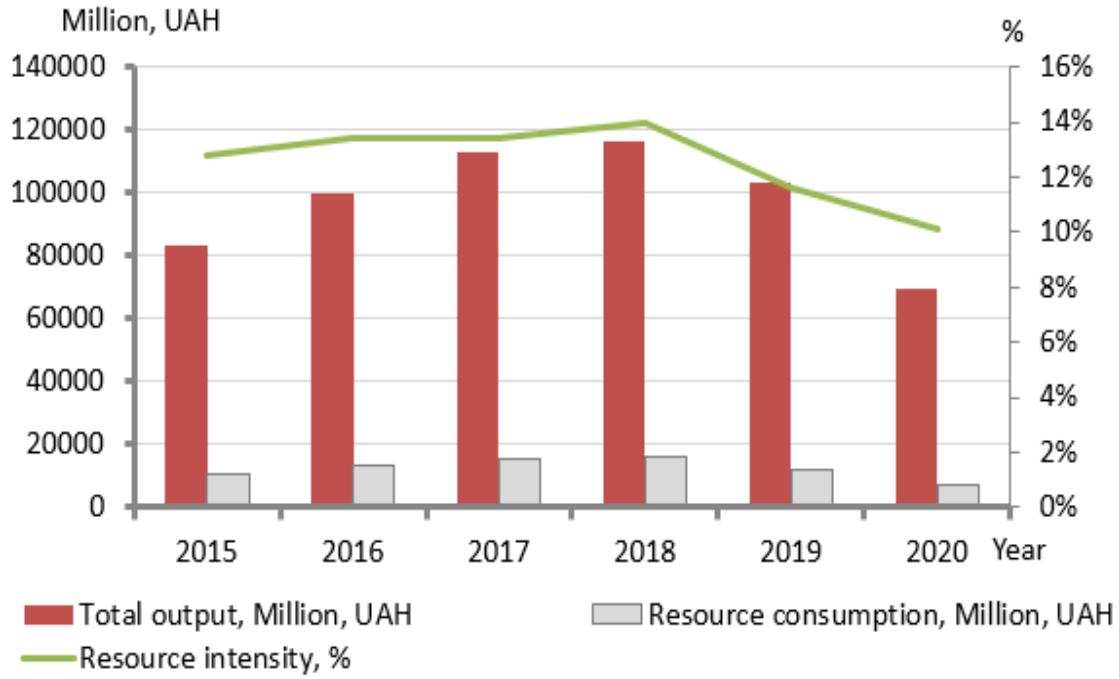

Figure 2. Oil and gas sector 2015-2020 total production and dynamics of resources consumption and production resource intensity.

Author's proposals according to [19, 20]

As for 2019-2020, the overall reduction in output at comparable prices was -40.1%. As a result, the volume of production in 2020 was only 83.4% of the level of 2015. Such changes led to the fact that resource consumption for the same period decreased by -56.4%, and resource intensity decreased from 13.9% to 10.1% .

Thus, we have a tendency when resource efficiency deteriorates during economic growth and improves during a period of economic downturn.

Let's consider the dynamics of the share of added value and of oil and gas production profitability for 2015-2020 Figure. 3.

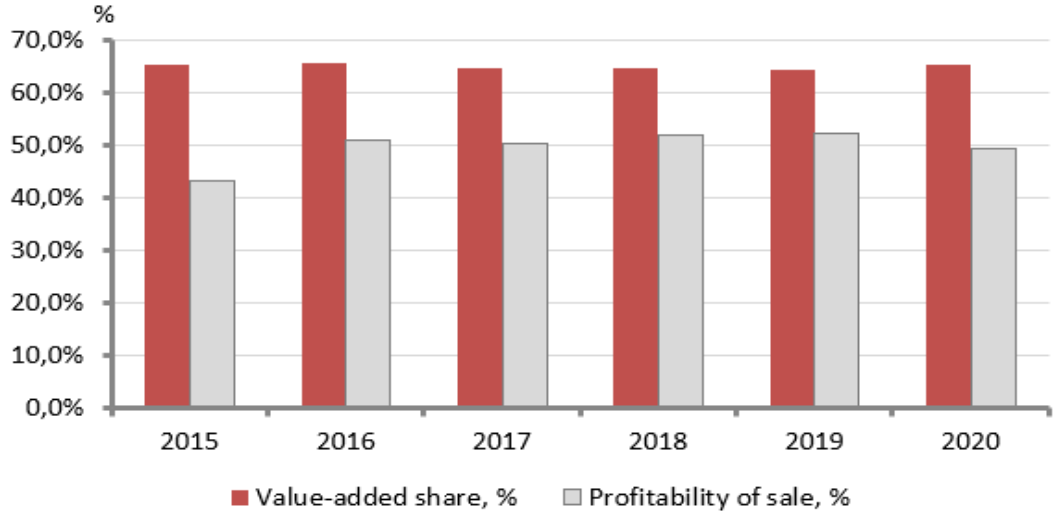

Figure 3. Value-added share, dynamics and sales profitability of oil and gas production for 2015-2020.

Proposed by the authors based on [19, 20]

As can be seen from Figure. 4, after 2018, there was a decline in production, as a result of which at the end of the reporting period its volume reached the level of 2015. Similarly, the level of resource intensity decreased to 22.1%.

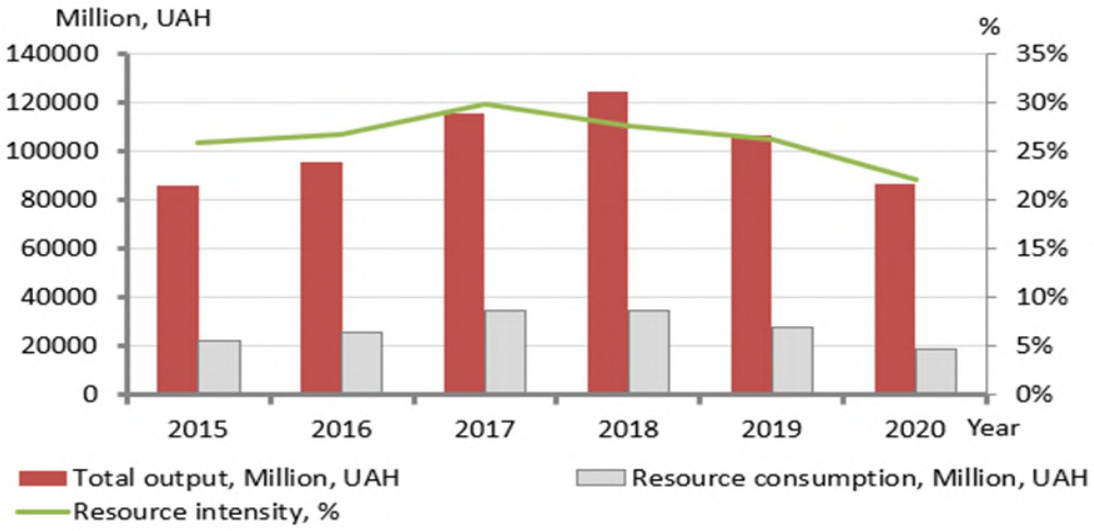

Figure 4. Production volume of oil refining products for 2015-2020. Dynamics of resource consumption and their resource intensity.

Proposed by the authors based on [19, 20]

Thus, on the basis of an expert assessment, we will determine the ways of resource-efficient development of the industry with indicators of intermediate consumption and value added, as well as financial performance, fig. 5.

As we can see from the diagrams presented the oil and gas sector of Ukraine, there are certain contradictions associated with pricing policy. This issue is also can be subject to research since in the Ukrainian open economy the energy resources price should remain competitive in the domestic market from domestic producers.

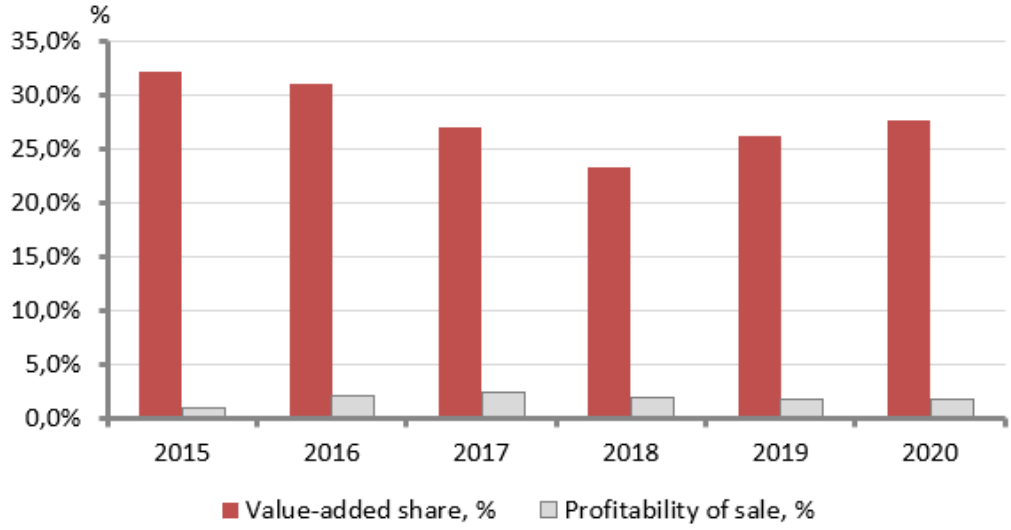

Figure 5. Value-added share of oil refining products manufacturing for 2015-2020. Dynamics of profitability of their sales.

Proposed by the authors based on [19, 20]

When analyzing the trade markups distribution between processing and mining enterprises in the oil and gas industry, we determined that oil refining, unlike gas and oil production, is characterized by production activity at almost the lowest level, the break-even level. Therefore, it is important to continue researching the relationship between pricing and resource conservation, in this case using the Leontiev model [11, 20], which found in the "Input-Output" table of the State «Statistics Service of Ukraine» for 2015-2020 and presented in Table 1. This table presents the volumes of intermediate consumption and intermediate costs, final demand, added value, total production by industries, divided by types of activities.

Let's take a closer look at the relevant economic and mathematical links. So the equation in matrix is:

$$X=AX+F,\ a_{ij}=\frac{X_{ij}}{X_j} \tag{1}$$

where

A - the direct costs coefficients

X - total output vector; Xj - total output by the j-th industry; Xij - intermediate consumption by the *i* - th industry of j-th industry production

F - final demand vector;

a_{ij} – ratio of the direct cost;

n - the number of industries.
i, j = 1, 2, … n.

Table 1. «Input-output» tables.

Type of economic activity		Intermediate consumption				Final demand, F	Aggregate output, X
		Branch of economy I	Branch of economy II	⋮	Branch of economy n		
Intermediate consumption	Branch of economy I	X_{11}	X_{12}	…	X_{1n}	F_1	X_1
	Branch of economy II	X_{21}	X_{22}	…	X_{2n}	F_2	X_2
	…	…	…	…	…	…	…
	Branch of economy n	X_{n1}	X_{n2}	…	X_{nn}	F_n	X_n
Gross added value, GV		GV_1	GV_2	…	GV_n		
Total output, X		X_1	X_2	…	X_n		

The elements of final demand F, according to the system of national accounts, include: final consumption expenditure of households, non-profit organizations and the general government sector; gross fixed capital formation and change in tangible current assets; net exports, equal to exports-imports difference in the value of goods and services. The current method of calculating gross domestic product by expenditure involves finding the sum of all elements of final demand.

The price spread effect by another Leontiev's model balance equation with following transformations is:

$$v_j^{'} = 1 - \sum_{i=1}^{n} a_{ij}^{'} \quad for\ j=1\ldots n, \tag{2}$$

where $a_{ij}^{'}$ - is the ratio of direct cost. It is calculated according to price indices of industry.

$a_{ij}^{'}$- the direct cost ratio.

(This ratio is calculated taking into account changes in prices and the share of value added in various sectors of the economy).

We have the appropriate economic and mathematical methods for the development of scenarios that provide for the partial elimination of the price policy contradiction between oil and gas production using the example of 2020 data. The developed scenario provided for a +10% increase in the prices of oil refining products with a simultaneous 10% drop in oil and gas production consumer prices.

According to the spread effect, such changes in pricing policy at the sectoral level will have an impact on the entire economy of Ukraine, due to appropriate adjustments to the coefficients of direct costs. This, in turn, will lead to a recalculation of value added shares.

According to the data of 2020, the shares of value added by industry, which were calculated on the basis of [20], are given in column (2) of table. 2.

They reaffirmed that there are price imbalances in oil and gas production and refining in Ukraine today, which have a negative impact on the development of the processing industry in this sector of the economy.

So, based on the developed scenario, sectoral value –added share, are given in Table 2, column (3).

Table 2. Assessment of the impact of the established price for the oil and gas complex products on the value added of various sectors of the economy according to 2020 data.

Industry	Value-added share, %		
	2020 data	Scenario	Change, %
1	2	3	4
Agriculture	38,76%	38,49%	-0,27%
Construction	22,13%	21,93%	-0,20%
Insurance and Financial	66,30%	66,29%	-0,01%
Oil and gas production Oil refined products	65,58% 27,73%	62,01% 35,66%	-3,58% +7,93%
Processing industry	31,53%	31,52%	-0,01%
Eectricity, gas and water production and distribution	32,92%	33,86%	+0,94%
Technical and Scientific activities, telecommunications	52,11%	52,07%	-0,04%
Real estate transactions	71,62%	71,63%	+0,01%
Transport and communication	45,17%	44,80%	-0,37%
Trade	50,63%	50,52%	-0,12%
Other	68,08%	68,06%	-0,02%
Total	41,35%	41,38%	+0,03%

So, we see that according to the developed scenario, the new equilibrium state of the economic system functioning involves the following changes:

- adjustment of the coefficients of direct costs, due to which the resource intensity of oil and gas complex products will change (it will decrease by -3.4% to 18.7% in oil refining and increase by +0.9% to 11.0% in oil and gas production)

- as well as an increase in the share of added value by +7.93% to 35.66% in oil refining and a decrease in oil and gas production by -3.58% to 62.01%.

4. Conclusion

Criteria for the national economy sustainable development are defined, which are based on the need for complete reproduction of the environment due to the anthropogenic impact of economic activity on it, as the concept of circular economy provides.

They included: maximization of indicators of social and economic status with simultaneous minimization of environmental and energy resource intensity of products, as well as environmental burden of regions. The specified criteria made it possible to form a system of indicators for assessing sustainable development.

Thus, according to the presented scenario, which we chose as the most promising, it will allow oil refining companies to reduce resource intensity of products, and can also be expressed in further economic growth at the expense of own sources. So, the article presents price equilibrium scenarios developed by

the authors, which were implemented in the oil and gas sector of the economy based on the industry's activities for 2015-2020. These scenarios were developed by the authors using Leontiev's cross-industry model, which explores how might these changes affect performance of resource use, including through the change in direct costs coefficients, in value added share and in intermediate consumption.

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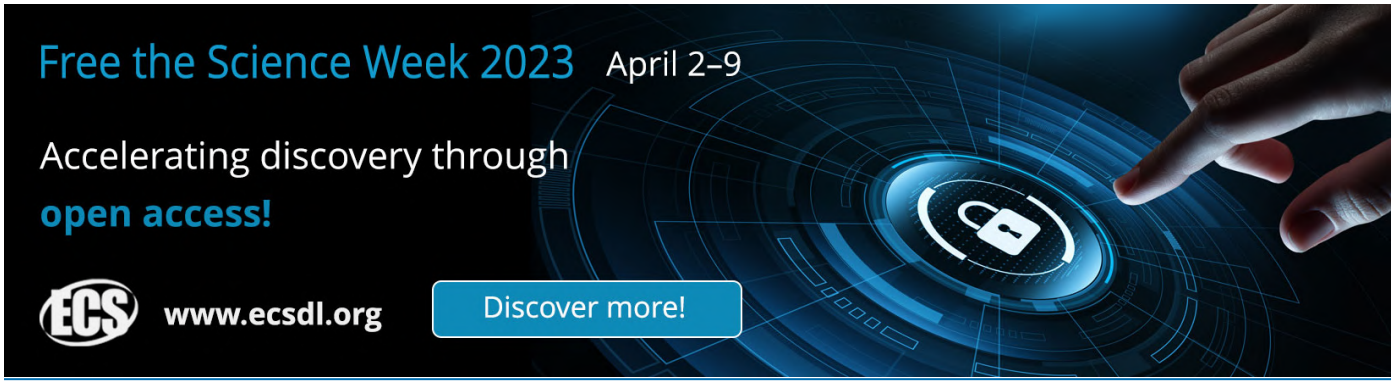
Development of territorial communities: aspects of natural capital conservation and budget financing



Development of territorial communities: aspects of natural capital conservation and budget financing

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Abstract. The development of efficient local governance and establishment of comfortable conditions for the living activity are the major strategic tasks of the public governance and authorities' decentralization system modernization that is currently underway in Ukraine. The complicated socio-environmental and economic situation faced by Ukraine due to the deployment of military and political events, the collapse of the national currency, the deformation of industrial infrastructure, the depletion of natural capital, the exhaustion of natural resources, the spread of coronavirus infection COVID-19, and other destabilizing factors constitutes an incredibly high threat to the socio-political and economic security of the state as a whole and of each territorial community (TC). In this perspective, each element of the complex national economy system is important and should be translated into the principles of intellectualization in a strategic perspective. Today, the economic systems of both the state and the TCs are largely supported by international organizations – mainly through the provision of international loans and grants. The harmonization of national legislation on the preservation and reproduction of natural capital with European directives is the priority area of the foreign policy of Ukraine. Cooperation with international organizations sets a number of requirements for Ukraine, including the transparency of financial flows and natural capital accounting. Clear regulation of accounting, storage, and reproduction of natural capital is an urgent task of the public administration system. Taking into account the fact that climate security is a global problem, adaptation of national standards to European directives will make it possible to unify the information support of public finances and form a strategy for the development of natural capital. The main factors of economic efficiency in the Republic of Poland and Ukraine are compared. The research verifies the regression relationships between budget funding of territorial communities and the population of these territorial communities and provides conclusions about the efficiency of TCs' funding in Ukraine.

1. Introduction

The decentralization of authorities and finances in favor of local governments is the mainstream reform of present times. It is impossible to achieve the goals of the decentralization reform without the adequate economic development level of respective territories, their financial sufficiency, and enough sources to generate budget revenues. Preservation and reproduction of natural capital are among the most important components of the state environmental policy strategy of Ukraine. Natural capital forms a safe

environment for human life and health, provides the population with food, medicine, and raw materials for industry, forms a natural barrier for the spread of the COVID-19 coronavirus infection. In addition, it supports the functioning of ecosystems, in particular the cycle and purification of natural waters, soil conservation, and climate stability. For the population, natural capital has economic, recreational, cultural, environmental, and other values. Ukraine, occupying only 6% of the total area of Europe, owns 35% of its biodiversity. However, the impact of human activities on its condition is very noticeable. Widespread drainage works have resulted in the destruction of landscapes. Over 80% of wetlands have lost their original importance. Significant changes have been observed in steppe natural ecosystems, which have been preserved only in fragments. Natural forest ecosystems account for 5.1 million ha, while artificially created forest ecosystems account for 4.3 million ha. The natural reserve fund of Ukraine is more than 5 million ha or only 8% of the country's territory, and it needs to be significantly increased. Preservation and reproduction of natural capital are among the key components of sustainable development strategy and ecological policy of the EU countries and globally. The efficiency of conservation of human, plant, and animal gene pool depends to a large extent on the efficiency of state and local authorities. Therefore, studying the organizational structure of the system of management of natural capital storage and reproduction processes becomes particularly important.

The article aims to solve the applied problem of conservation and reproduction of natural capital for the effective development of the united territorial communities on the basis of the introduction of new principles of socio-economic security, intellectualization of economic development, the introduction of innovative and information technologies, rational use of natural resources, and consideration of military and political security standards. Relevance of the topic is justified by the European integration processes in Ukraine and the need to take into account climate change since the preservation of natural capital is a global problem of humanity. That is why the urgent task is to raise the level of socioecological and economic security at the level of basic units of local self-government – territorial communities. The authors offer the ways to improve the implementation of budget policy of financing measures for the preservation of natural capital based on the formation of its real value and the condition of life support of the society. The research provides recommendations on regulatory and institutional support of activities in the conservation and reproduction of natural capital through harmonization of the national regulatory framework with the current EU directives in this area.

Territorial communities of Ukraine and their natural capital as the country's national wealth are the object of the study.

The process of natural capital development in Ukraine under conditions of climate change on the basis of increasing the level of social, environmental, and economic security of the territorial communities on the example of Poland is the subject of the study.

2. Critical literature review

The development of territorial communities in Ukraine should currently be considered in the context of the relationship between the natural capital and financial resources of their reserves and ways of increasing. Their interaction generates modern directions and opportunities for the use of each resource to secure the environmental and socio-economic development of a territory. Hasenko L.V. et al. [1] analyze the process of territorial communities' establishment in Ukraine and pay special attention to the sources of revenues to local budgets. They argue that the payment of land taxes is one of the major sources. K. Patytska et al. [2] offer the methodology for the diagnostics of the territorial communities' financial capacity by revenues. The methodology is directed at securing the complex qualitative and quantitative evaluation of the strengths, condition, and weaknesses of the community economy, role and place determining of the local budgets in securing the economic-socio development of the territory. The research is very important because it has detected the problems of generating the revenues to the community budget and substantiated the directions of increasing the financial capacity and preserving the natural capital. I. Hryhoruk et al. [3] and O. Panukhnyk et al. [4] consider these issues based on the development of bioresources at the territories of the newly established communities and thus pay attention to the development of entrepreneurship. The detailed research of the methodological

framework for evaluation of natural resources capacity and losses from environmental pollution based on the ecosystem approach and budgetary funding is carried out in the studies of I Khvostina et al. [5], N. Pylypiv et al. [6], M. Stehnei et al. [7], O. Dovgal et al. [8], A. Sakhno et al. [9]; B. Danylyshyn et al. [10].

It is worth noting the research of natural capital preservation conducted by V. Bondarenko et al. [11] as the authors outline the problems of efficient use of natural resources capacity in conditions of financial and administrative-territorial reform in Ukraine. They argue that the problems related to the fact that most communities weren't aware of what resources they own and how they can be used correctly for community development and financial capacity increase were the first to display themselves. H. Voznyak et al. [12] analyze the process of financial decentralization in terms of communities' financial capacity development and determine the main mechanisms for budget redistribution at different levels. H. Oleksyuk et al. [13-14] substantiate the concept of local finances as a system and argue that local finances consist of revenues, ways to get revenues, system institutes, entities and objects of the system, and relationships among them. In this regard, Siryk Z. et al. [15] examined the processes of adaptation of modern territorial entities' forms into the existing territorial system in the country. In particular, they analyze the division of competencies between various levels of authority in conditions of changing the administrative-territorial structure of Ukraine.

However, most of these studies are related to territorial development in Ukraine. In our research, we analyze the Polish experience and select the best practices for Ukraine.

3. Materials and Methods

On the basis of the system method of researching the domestic and world experience, the study develops the directions of the natural capital preservation on the basis of systematization of socio-environmental and economic safety indicators of the state across its structural elements and levels to create the complex system for definition of the integral level of climate safety. The dialectical method applied to examine the prospects for the conservation of ecosystems and their environmental functions and the sequence of information generation, which is the basis for the development of the base of indicators of socio-environmental and economic security, and identify possible ways of adaptation of domestic standards of the natural reserve fund accounting in the public and private sectors to international directives and standards. The following general scientific and special methods are used in the study:

- dialectical and abstract-logic methods – to generalize theoretical provisions and define the essence of socio-environmental and economic security of the TCs; to develop a concept of intellectualization of the economy of the UTCs for their effective socio-economic development, preservation of natural capital, its replicability, genetic information for present and future generations as an indisputable condition of the society's activity;
- system analysis – to form a generalized system of indicators of socio-environmental and economic security and its impact on the volume and cost indicators of the preservation and reproducibility of natural capital. The list of indicators should provide, on the one hand, the most reliable analysis and, on the other hand, the possibility of quick obtaining of the information and calculations;
- economic-statistical method – to assess the condition and development of the natural capital of the united territorial communities, the impact of climate change on the state and dynamics of the natural capital of the territorial units, and financial indicators of the implementation of socio-economic security measures;
- factor analysis by the method of the main components – to substantiate the weight coefficients for separate components of socio-environmental and economic security of TCs;
- economic and mathematical modeling – to build an economic and mathematical model of the UTCs' budget financing for the development of their natural capital.

4. Results and Discussion

The development of an efficient system of natural capital conservation and reproduction to increase the level of socio-environmental and economic security of local communities will minimize the negative

impact of climate change, as well as ensure the strategic development of UTCs based on the intellectualization of the economy, and negative impact mitigate of the spread of the COVID-19 coronavirus infection. There are many scientific studies in global and domestic science addressing natural capital preservation based on the improvement of the TCs' socio-economic and environmental security and substantiation of the methodology for accumulating the information from initial economic entities to public governance entities. Therefore, there is a need to conduct a reliable evaluation of the integral level of the TCs' socio-economic and environmental security to adequately manage them and achieve the proper level of social and environmental security of the TCs' functioning. The measures of natural capital development must take into account the interests (economic, social, informational, environmental, financial, managerial) of each territorial community to ensure sustainable development and reproduction of natural capital for the safe functioning and life support of modern and future generations in conditions of instability of economic and social development, that is based on the intellectualization of the process of natural resource management.

According to the Ministry of Finance of Ukraine [16], the State Treasury Service of Ukraine [17], the State Statistics Service of Ukraine [18], the revenues to the general and specific funds of territorial communities in Ukraine in 2021 amounted to UAH 180.4 billion, the collected land payment was UAH 22.67 billion, and local taxes and fees were UAH 52.19 billion. Meanwhile, the land profitability of each community (general fund) on average amounted to UAH 40,870. The area of all communities in Ukraine was 554,740 km2 as of 1 January 2021, while the number of the population residing there was 36.13 million persons. The research calculates the territorial communities' budget revenues typical for all Ukrainian regions on the example of 65 communities in Rivnenska oblast. The results are consolidated in Table 1.

Table 1. The analysis of financial budgetary resources of territorial communities, their population, and area

Community	Area, sq km	Population, thous.	Budget, million UAH	Community	Area, sq km	Population, thous.	Budget, million UAH
Antonivska	114	5.7	7.843	Mizotska	360	14.1	20.942
Varaska	600	52.9	467.347	Oleksandriyska	208	9.8	27.577
Volodymyretska	707	26.4	45.757	Ostrozka	709	42.8	91.517
Zarichnenska	1103	28.6	45.357	Rivnenska	63	254.8	1469.271
Kanonytska	170	6.2	6.381	Sosnivska	320	6.8	17.554
Loknytska	361	5.9	10.167	Shpanivska	80	10.6	39.798
Polytska	179	5.7	12.407	Berezivska	498	12	12.562
Rafaliska	111	7.3	12.828	Vyrivska	389	12.9	35.585
Bokiymivska	195	5.5	11.581	Vysotska	298	5.7	13.587
Boremelska	105	3.2	6.93	Dubrovytska	1091	34.7	66.344
Varkovytska	148	5.4	10.234	Klesivska	344	10.5	46.914
Verbska	117	4.6	11.606	Mylyatska	431	6.2	11.055
Demydivska	312	12.01	35.547	Nemovytska	283	11.3	21.293
Dubenska	27	37.4	165.661	Rokytnivska	1591	39.5	89.845
Kozynska	180	7.3	15.583	Sarnenska	820	66	189.331
Krupetska	300	8.9	29.955	Starosilska	274	6.9	7.155
Myrohoshchanska	115	6.8	12.035	Stepanska	224	7.1	12.294
Mlynivska	401	19.8	55.08	Klesivska	344	10.5	46.914
Ostrozhetska	138	5.8	14.781	Malolyubashanska	416	5.7	19.648
Pidloztsivska	65	1.8	5.592	Hoshchanska	484	22.9	72.019
Povchanska	92	2.9	4.601	Derazhnenska	226	6.2	12.121
Pruvilnenska	153	5.5	20.739	Dyadkovytska	157	5.8	16.119
Radyvylivska	229	18.7	62.754	Zdovbytska	150	9.9	16.721
Semydubska	214	4.5	12.203	Zdolbunivska	151	31.6	146.316
Smyzka	194	7.4	26.64	Zoryanska	193	13.4	45.059

Tarakanivska	220	7.9	17.154	Klevanska	112	13.8	76.461
Yaroslavytska	109	2.7	8.101	Koretska	530	24.4	55.802
Babynska	121	6.9	20.305	Kornynska	68	7.5	22.337
Bereznivska	1197	51.3	116.502	Kostopilska	661	44.1	150.356
Bilokrynytska	127	9.9	30.955	Malynska	201	5.6	12.188
Buhrynska	88	4.1	6.616	Velykoomelyanska	101	3.7	18.775
Velykozhmerytska	192	7.9	13.544	Holovynska	202	7.1	14.731
Horodotska	134	10.7	58.233				

Source: based on the data from the [18].

Based on mathematical modeling and correlation-regression analysis, the dependence between the funding of territorial communities and the population in each TC was detected (Table 2).

Table 2. Regression statistics and model values

Regression Statistics					
Multiple Correlation coefficient R			0.966264022		
Coefficient of determination R-square			0.933666159		
Adjusted R-square			0.932613241		
Standard error			49.07216862		
Cases			65		
Indicators	df	SS	MS	Fisher's Cr. (F)	Significance F
Regression	1	2135342.413	2135342.413	886.7414803	7.93659E-39
The rest	63	151708.8972	2408.077733	Fcr	3.993364924
Total	64	2287051.311		tcr	1.998340543
Standard Error	t-Statistics		P-value	Coefficients	Upper 95%
6.936926579	-4.79448519		1.03482E-05	bo=-33.25899	-19.39665012
0.186223649	29.77820479		7.93659E-39	b1=5.5454059	5.917544216

Source: the authors' own calculation.

The choice of the analytical form of the model, which describes the dependence between the amount of budget funding of territorial communities and the population in these communities, is based on the constructed scattering diagram, which is a graphical representation of the selected statistical sample. The relationship between the amount of budget funding of territorial communities and their population is close to linear, so in this case, as a relationship between variables, it is advisable to choose a linear function. The selective linear regression function, in this case, will look like this:

$$\hat{y} = b_0 + b_1 x \quad (1)$$

where $\hat{y}$ – estimation of mathematical expectation of the dependent variable model (budget funding of territorial communities); x – independent model variable (the number of the population of territorial communities); b0, b1 – selective regression parameters.

Accordingly, the model of dependence between the budget funding of territorial communities and the population is:

$$Y=-33,258+5,545x \quad (2)$$

The rates of the TCs' budgetary funding and the data on the number of the population were used to determine the b0, b1 model parameters estimates (table 1).

The verification of the model for adequacy, quality, and significance was carried out to check if the choice of the structure of the model of dependence between the funding and population of a territorial community in the form of linear regression is correct. The determination and correlation coefficients are used to assess the quality of this model. The model's statistical significance has been tested on the basis of criteria of Student and Fisher.

To assess the adequacy of the model with statistical data, the value of this determination coefficient R^2 is calculated. Since the value of the coefficient of determination R2=0.9336, the impact of population on the budget funding of territorial communities is quite significant. The strength of the linear

relationship between the model variables is estimated using the correlation coefficient. Based on the value of R = 0.9662, the close linear relationship between the indicators of the model is detected. The following F-statistics (Fisher's F-criteria) are used for verification:

$$F = \frac{R^2}{1-R^2} \cdot \frac{n-k}{m} \quad (3)$$

which has a Fisher distribution with degrees of freedom v1=m i v2=n – k.

According to the statistical tables of Fisher's F-distribution at a given level of significance α = 0.05, the critical value of Fisher's criterion Fcr = 3.9934. Since Fisher's criterion is F=886.74, which is more than its critical value of Fcr =3.9933, the model is adequate and statistically significant. To determine the significance of which parameters of the model provides the overall statistical significance, t-statistics was used (Student's criterion):

$$t_{b_j} = \frac{b_j}{\hat{\sigma}_{b_j}},\ j = \overline{0,m} \quad (4)$$

where bj – estimation of the parameter βj of the theoretical regression, $\hat{\sigma}_{b_j}$ – standard error of the j parameter of the model.

According to the significance selected level of α = 0.05 and freedom degrees according to the statistical tables of the Student's *t*-distribution, the Student's criterion critical value t_{kr} = 1.9983 has been found. The values of bo= -33.2589917 and b1=5.545405949 exceed the critical value tcr=1.998340543, which also confirms the adequacy and significance of this regression model (table 2).

The verification of the model of dependence between budget funding of territorial communities and the population indicates the adequacy of the model and the existence of a close linear relationship between its variables, as well as the significance of the model as a whole and its parameters.

It is worth mentioning that the parameters of local budgets execution show the overall economic and social condition of the respective territory and its capacity to develop sustainably. The availability of enough resources in local budgets provides a territorial community with an opportunity to provide more diversified and qualitative services to its residents, implement infrastructural projects and good social decision, create conditions for the attraction of investment capital and the entrepreneurship development, fund other activities for comprehensive improvement of living standards for the community residents.

Compared to other middle-income countries, in a short time Poland became a high-income nation. The annual growth in Poland, in 2009-2019, according to the data of the World Bank, has averaged to 3.6%. It happen due to the successful macroeconomic management, good investment in human capital, increasing of productivity, strengthened institutions. In 2019, the Polish GDP grew by 4.1%, boosted by higher wages and increased domestic consumption [19]. In 2020, however, the growth has declined only to 0.4%. The worldwide lockdown pandemic COVID-19 had a far-reaching impact on the whole Polish economy state, when businesses closed down.

The authors of this study have reviewed the Polish and Ukrainian economies prior to the global pandemic and highlighted the main four challenges these countries faced on their road to economic recovery [20]. In 2020, the economy of Ukraine faced about UAH 60 billion damage due to the coronavirus pandemic. According to data of International Monetary Fund, in 2016, Ukraine's economy had 50th place in the world in terms of GDP (Gross Domestic Product) at PPP (Purchasing Power Parity) – $ 353 billion. The Ukrainian SSR economy played a important role in the USSR's whole economy. Donbas (Donetska and Luhanska oblasts), the Dnipro River area (Dnipropetrovska and Zaporizka oblasts), as well as the cities of Kharkiv, Lviv, Kyiv and Odessa are the most economically developed regions of Ukraine [21].

In 1972, the Convention concerning the Protection of World Cultural and Natural Heritage was adopted by the General Conference of UNESCO. At present, over 150 countries have signed the document. It is considered the major universal international legal tool for cultural and natural heritage protection [24]. The territories located in the North-East part of the country ("Polish Green Lungs") and Subcarpathia are of special value. There are 23 beautiful national parks on the Polish territory. South-

East Poland is acknowledged as a region with unique natural features. The most valuable natural areas are protected by law. There are two national parks (the third one is planned), 70 nature reserves, 11 landscape parks, 21 landscape reserves, and over 1200 natural landmarks. The mentioned protected areas account for 50% of the Polish part of the Carpathian Euroregion. Polish national parks cover less than 1% of the total area. The protected area is not allocated at all in some national natural parks, so recreation areas and tourist routes cover almost the entire park area. Babigórski National Park – the modern tourist Mecca of Poland – is an example of such an organization. Almost all Polish national parks can be visited without a guide. The only exception is the full protection zone of Białowieża National Park, where the size of the group of visitors is limited and the visits must be accompanied by a guide. Yet, the number of groups of visitors is not limited. So the groups can visit the full protection zone literally one after another [25].

The data in the Table 3 shows that natural capital is preserved in a range of nature reserve areas and objects. Most of them are nature landmarks both in Poland and Ukraine, although the largest area in Ukraine is covered by protected landscapes – 1.39 million ha and in Poland – 6.9 million ha, respectively, i.e. five times more. Overall, the nature reserve fund of Poland covers over 10 million ha, which is twice more than in Ukraine. National parks are considered the major component of the natural capital protection system. They are ranked the highest among the nature protection forms in Poland. In late 2021, the number of objects of this type reached 1, 463 and their total area was over 164,000 ha (0.5 % of the country's area and 1.6 % of the nature reserve fund area of the country) (Table 3).

Table 3. The comparative characteristics of Polish and Ukrainian nature reserve funds

The nature reserve fund category	The Republic of Poland		Ukraine	
	The number of areas and objects	Area, ha	The number of areas and objects	Area, ha
National parks	23	314474.5	49	1311637.834
Nature reserves	1463	164202.1	24	685741.42
Landscape parks	121	2 529 022.0	81	786025.3491
Protected landscapes	386	6 990 047.7	3167	1389674.793
Natura 2000 areas	967	9 362 632.0	-	-
Environmental lands	6877	51 029.5	-	-
Nature and landscape complexes	318	93 463.6	572	13288.759
Documented sites	155	885.2	98	4230.82
Nature landmarks	36293	-	3441	29769.1795
Total	45636	10 143 124.6**	8245	4318224.126

**excluding the Natura 2000 areas.
Source: based on data from the [26].

The Law of 16 April 2004 defines nature reserve as an area that covers the spaces preserved in unchanged or slightly changed condition, ecosystems, biotopes of plants, animals, mushrooms, and objects and components of inanimate nature that have specific natural, scientific, cultural, or landscape values. The landscape parks are created in the areas that have natural, historical, cultural, and landscape values for preservation and promotion of these values in conditions of balanced development. The park is designated to serve local recreation, i.e. tourism, leisure, and education. A network of Natura 2000 areas is the complex European environmental network created in Europe to preserve endangered natural biotopes and species. In Poland, this form of protection was introduced in 2004. These spaces are planned to cover about 15–20 % of the country's area. The network stipulates the establishment of a system of spaces connected by environmental corridors, i.e. landscape elements, which contribute to migration, spread, and exchange of the genetic fund of species. The network aims to preserve biodiversity by protecting both the most valuable and rare nature elements and the most typical and common natural systems peculiar to biogeographical areas [26]. Therefore, such natural capital preservation objects are the "business card" of territorial communities, and in the future, they will

become the ground for the marketing strategy of their development and positive territorial image promotion.

5. Conclusions

The value of the proposed studies lies in a multidisciplinary approach to the substantiation of indicators of socio-environmental and economic safety of the TCs based on the approaches of modern economic theory with an in-depth analysis of their compliance with international standards of accounting and financial reporting, which, unlike the existing ones, take into account the formation of an information environment in fuzzy logic. The value of the study results lies in the improvement of the concept of sustainable development and the application of tools of "green" economy, which is the basis for a new strategy for the preservation and reproduction of natural capital, increasing the level of socio-environmental and economic security of territorial communities, their favorable socio-economic development based on the intellectualization of local economies. The theories of biodiversity conservation known to world science will be supplemented with new concepts and theories, taking into account the economic value of the natural reserve fund, assimilation functions of natural capital, and the level of economic, environmental, and social security of local communities.

The authors conclude that the natural capital preservation objects (nature reserve fund areas and objects) are the “business card” of territorial communities, and in the future, they will become the ground for the marketing strategy of their development and positive territorial image promotion. As the data in the Table shows, the natural capital is preserved in a range of nature reserve areas and objects. Most of them are nature landmarks both in Poland and Ukraine, although the largest area in Ukraine is covered by protected landscapes – 1.39 million ha and in Poland – 6.9 million ha, respectively, i.e. five times more. Overall, the nature reserve fund of Poland covers over 10 million ha, which is twice more than in Ukraine. Therefore, Ukraine should develop the national nature parks network as the major component of the natural capital protection system.

The research detects an interdependence between budget funding of territorial communities and their population. The verification model’s results indicated the adequacy of the model to statistics and the existence of a close linear relationship between its variables, as well as the significance of the model as a whole and its parameters. The correlation coefficient is close to 1.0 and is 0.93. This means that 93% of the change in the annual funding rate of a territorial community depends on the population of that community and not on the available natural resources as a natural resource.

The unstable financial and economic situation of Ukraine and the tense military and political situations of the country are the major risks to the Ukrainian economy. However, the need for systematic research aimed at ensuring the transparency of information provided to public authorities at the level of Ukraine and the international community is maximally connected with the need for close cooperation with international financial organizations, among the requirements of which are transparency of budget indicators and comparability of environmental, economic and information security indicators. However, even within our state, the distortion of information flows does not allow making the right decisions in the implementation of budgetary and financial policy. In addition, the financing of measures to preserve natural capital is carried out from the state budget based on a residual principle. All this brings certain risks and the need to find new ways to finance nature protection. That is why the justification of the new methodology for calculating the norms for the distribution of financial resources in the preservation of natural capital between the different levels of the budget system and the effective functioning of the TCs based on the intellectualization of their development for a reliable assessment of the integral level of the components of national security of the state are among the important tasks in today’s conditions of military and political instability, climate change, and the spread of coronavirus infection (delta virus, omicron, deltacron, etc.).

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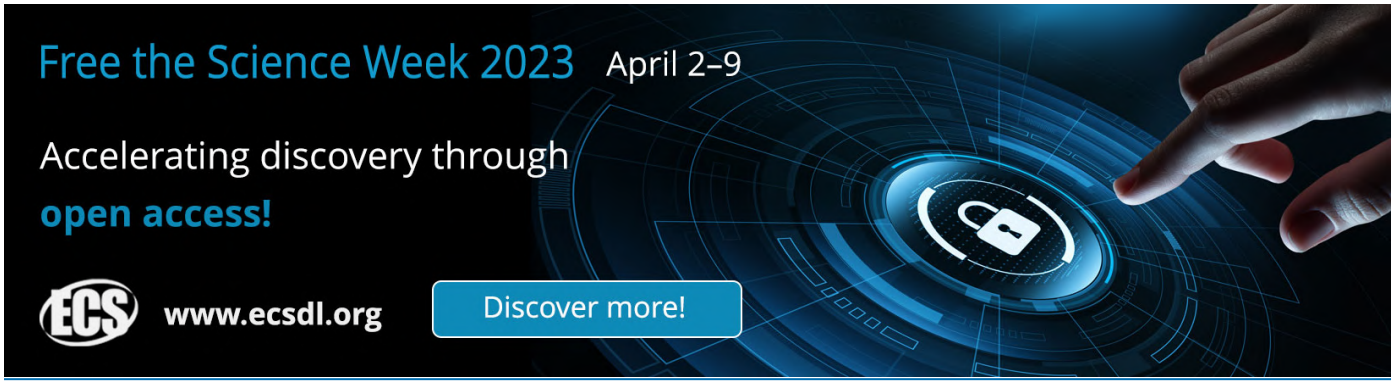
The european green deal: shaping the future of the eastern partnership



The european green deal: shaping the future of the eastern partnership

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Abstract. The article has focused on the European Green Deal [EGD], its goals, key tasks and components. Particular attention has been paid to the specifics of the implementation of the EGD in the partner countries of the Eastern Partnership [EaP]. The author's approach to singling out clusters of the EaP countries on the integration of their green policies, taking into account the level of convergence of the EaP countries environmental and climate policies and the peculiarities of the implementation of the EGD, has been presented. The potential of the countries of the region in terms of readiness to switch to green energy has been identified on the basis of the Energy Transition Index and the dynamics of the EaP Environmental and Climate Policy Sub-Index. The degree of correlation between the general degree of convergence of the EaP countries to the European Union and the degree of convergence of the EaP countries environmental and climate policies to the EGD has been determined. The ways of transformation of the strategy of formation and implementation of the EGD for the Eastern Partnership countries, taking into account the current challenges, have been outlined. Thorough conclusions and recommendations for the EaP countries in the context of EGD implementation have been presented.

1. Introduction

In the modern world there are structural transformations of state energy policies, the replacement of the model of energy sector functioning dominated by fossil fuels, ineffective networks, large producers, insufficient competition in energy markets with a modern model, which forms a better competitive environment; attention to the alternative energy development and energy production from renewable sources is increasing; there is a reorientation to the principles of energy efficiency and energy conservation; socially vulnerable population groups are supported in matters of partial reimbursement of their energy consumption; measures to prevent and combat global climate change as one of the long-term priorities for global energy development are implementing. Current global trends towards the green policy in all spheres of economy and public life have also affected the European Union, and in particular the EU's policy towards its neighbours, including the Eastern Partnership countries. The priorities of the EGD diplomacy in the world are shaping new directions of this policy towards the EaP. As of today, the EaP countries are at different levels of integration into the EU's political and legislative system. Georgia, Ukraine and the Republic of Moldova have certain agreements in the field of EGD in the framework of the Association Agreement. As none of the countries has a well-established state program for the implementation of the EGD, its main challenges and benefits, it is important to analyse the impact of this EU policy on the EaP countries. In the context of current global environmental and climate issues and the dependence of the Eastern Partnership countries on the energy resources of the Russian Federation, the implementation of European values of the green policy in the countries of this region is topical.

2. Review of Literature

In recent years, the theme of the EGD has become particularly popular. One of the groups of sources that have become the basis for this study were the works of scientists analysing the European Green Deal Policy [5; 6; 7; 8; 9; 10; 20]. The normative and legal acts governing the European Green Deal have been also important for our study [1; 2; 3; 13; 14]. The next group of sources consisted of analytical materials on the Eastern Partnership Index for 2011-2021 years [18] and the Energy Transition Index [19], has served as a basis for analysing the state of convergence of the Eastern Partnership countries to EGD. Another group of sources has become the basis for studying the direction of the EGD implementation in the EaP countries [11; 12; 15; 16; 17].

In the article of the authors Bocquillon P., Brooks E. and Maltby T. analyze the shifts that have taken place/have happened in EU government, which are characterized by "hard soft government". In the study, the authors focused attention on two areas, namely health care and energy – government of which is very similar to architecture – the European Semester and the Energy Union Government Regulation. The authors explain this by the fact that in both cases the issue of "hard soft government" arose due to incomplete powers and sovereignty problems[6].

Similarly, these issues are also raised by such authors as Schoenefeld J. and Jordan A. noting, meanwhile, the issue of monitoring the implementation of the EU climate policy[9].

Berosa M., Ball R., Glendell M. focus on the European Green Deal and raise the question whether EGD will help improve freshwater quality in Europe outside the Water Framework Directive[10].

Instead, such authors as: Dobbs M., Gravey V., and Petetin L. highlight the problem of implementation the EGD in the conditions of turbulent changes and outline the prospects for its implementation[8].

Challenges related to climate change and energy problems, which encourage more and more participants to participate in management mechanisms of information exchange and mutual study of policies, are described by such modern foreign researchers as: De Francesco F., Leopold L., and Tosun J.[7].

3. Purpose

The purpose of this study is to analyse the impact of the EGD on environmental policy and cooperation of the EaP countries and its main challenges based on the analysis of factors and indices of convergence and readiness of partner countries to switch to green energy.

4. Methodology

To achieve this goal, it is proposed to use the following research methods: general and scientific methods (analysis, induction), empirical (historical, systemic, structural-functional, comparative, forecasting, institutional, generalization) and special (statistics). Statistical data of the indices has become important for the research. Using the method of analysis, the source base of the study of the EGD has been analysed. The historical method has been used in the study of historical factors in the formation of the EGD in the Eastern Partnership countries and the dynamics of the EaP Index in the field of Environmental policy. The systematic method has helped to identify and study the interrelated institutions, mechanisms and tools for implementing the EU's EGD in the EaP countries. Priority mechanisms for the implementation of the EGD in the countries of the region have been studied using the structural-functional method. The comparative method has helped to compare the achievements and dynamics of countries' participation in EU green policy. The prospects of the EU's and the EaP countries cooperation's within the framework of the EGD have been outlined using the forecasting method. The analysis of statistical data has been used in the study of the EaP Index. The induction method has helped to summarize the conclusions on key achievements and threats in the framework of the EGD for the EaP countries. The analysis of the EaP Climate Policy Index, which shows the degree of integration of the EaP countries, as well as the Energy transition Index, which helps identify the readiness of the EaP countries to switch to green energy, has been a methodological basis of the study. The method of

generalization has helped to single out conclusions and practical recommendations on the research issues.

The interest of the EaP states in deepening European integration processes and cooperation within the framework of the initiative plays an important role for the European Union. Thus, in 2011, the International Renaissance Foundation initiated the creation of the EaP Index, which will reflect and compare the successes of each of the partner countries. The EaP index is calculated according to two categories: approximation to the EU – reflects the results of adoption of EU norms and international standards; linkage with the EU[18].

The calculation of the EaP Index is based on the systematic data collection, that is, empirical information obtained by local experts of each of the six countries operating under the auspices of the EaP Civil Society Forum, since 2014[18].

The article also presents the data of the Energy Transition Index (ETI), so let's dwell on its characteristics in more detail. The ETI benchmarks progress on energy transition in 115 countries. Developed be the World Economic Forum's. ETI consists of 38 indicators characterizing one or another component of the readiness of the country's energy system to switch to renewable energy sources or the levrl of efficiency of the state's energy system[23].

5. The results

On December 11, 2019, the European Commission adopted The Communication on the EGD has been adopted on December 11, 2019 by the EU Commission[1]. The EGD is a new EU strategy with the main idea – zero greenhouse gas emissions in 2050. The ultimate goal of the EGD is a "green" Europe by 2050[1]. The main goal of the EGD is to turn Europe into a climate neutral continent by 2050. An important direction of the EU's Green Deal policy is the vector of the Eastern Partnership countries[1; 2; 5; 6; 7; 8].

The key mechanisms for the implementation of the EGD in the EaP countries are cooperation at the level of permanent meetings: 1) Summits of the Heads of State of the EaP and the EU; 2) Meetings of high and middle level officials; 3) EaP Civil Society Forum; 4) Panel on Environment and Climate Change; 5) Working Group "Energy, Transport, Environment and Climate Change" of the EaP Civil Society Forum[1; 5; 6; 7; 11; 12].

Normative regulation of cooperation between the EU and the partner countries of the EaP in the field of Green policy is carried out by: 1) Joint working document of the European Commission and the EU High Representative on Foreign Affairs and Security Policy "Eastern Partnership"; 2) Declaration on Cooperation on Environment and Climate Change in the EaP countries; 3) Work Program of Platform 3 "Interconnections, Energy Efficiency, Environment and Climate Change" of the EaP. This platform is the key format of cooperation between the EU and the EaP countries in the implementation of the Green Deal policy[5; 6; 7; 8; 11].

Consider the features of the implementation of the EGD in the EaP countries. The position of the Republic of Moldova approves the implementation of this policy in the state. Official Chisinau seeks to attract EU green investment, actively participates in regional environmental initiatives and projects. Ukraine has declared its goal to synchronize its policies with the EGD [13], which will be implemented through climate commitments under the Paris Climate Agreement, green economic transformation, energy efficiency, fair transformation of coal regions, etc. Achieving climate commitments requires synchronizing energy, environmental, economic and infrastructure policies [14]. However, Ukraine needs to overcome a number of internal factors: energy poverty, problems related to the functioning of natural and unnatural energy monopolies. Georgia has a high interest in climate issues and is a stable partner of Ukraine in the energy sector. There is great potential for such cooperation in Georgia, which remains a consistent partner of Ukraine in the implementation of joint projects. It is worth mentioning the Euro-Asian oil route, which aims at an alternative transport corridor for the supply of Caspian oil to Europe via Azerbaijan, Georgia, Ukraine and Poland[4].

As for Armenia, Azerbaijan and Belarus, their position on the EGD is due primarily to the fact that key assets in the energy sector are controlled by Russian government agencies. Therefore, any attempts

to modernize them are unsuccessful. In particular, for Belarus, after the sharp deterioration of relations with the EU in 2020, Minsk's interest in climate issues has declined, and even more so in the EGD. The main concerns about the EGD for Minsk are fears that the carbon tax will reduce the competitiveness of Belarusian products, as well as demand for petroleum products, which are the main item of Belarusian exports to the EU[4].

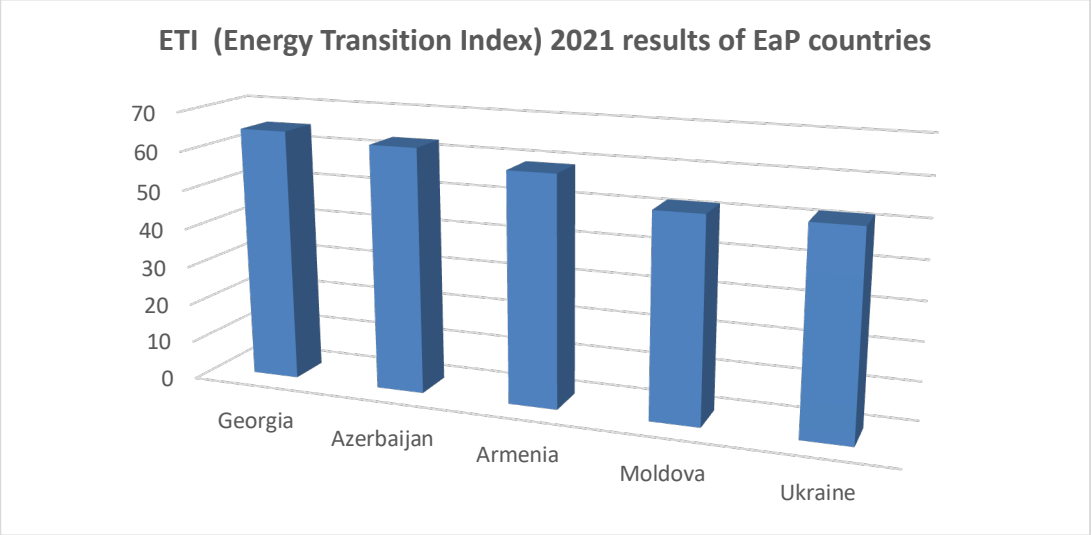
The directions of development of the EaP countries differ significantly. After three decades of transition of these states to stable and highly developed states, the result is different levels of their progress, including in the field of transition to green energy. According to the analysis of the current situation of the EaP countries EGD implementation process and the assessment of the level of convergence of environmental and climate policies of these countries to EU standards, we can identify the following clusters of Green Policy Integration of the EaP countries:

1. The EGD countries (Republic of Moldova) are countries characterized by a high degree of integration of national policy to EU standards, the convergence of environmental legislation to European one, the tendency to transition to renewable energy sources and green economy.
2. Countries aspiring to the EGD (Ukraine, Georgia) are countries that are pursuing the integration of national green policy into the European green space, implementing appropriate reforms in the field of green policy, but facing certain obstacles in implementing such policies and taking all necessary decisions to switch to the green economy, sustainable environmental and climate policy.
3. Countries sabotaging the EGD (Armenia, Azerbaijan, Belarus) are countries that, due to subjective and objective factors, are reluctant to accomplish the EU Green Deal in their national policies. In particular, this is accompanied by the impact on the energy sector by the Russian Federation, the authoritarian type of government in these countries, corruption components.

In order to avoid "ecological dumping" in the process of trade liberalization, the EU, within the framework of the Green Deal, is introducing a Carbon border adjustment mechanism, which will be applied to the import of certain energy- and carbon-intensive goods coming from outside the EU.

For Ukraine, such a mechanism can become an obstacle on the way to the further increase of export volumes and its diversification in the European direction. The mechanism itself should stimulate production to reduce CO2 emissions, as the cost of goods will immediately increase when crossing the European border. According to preliminary calculations, additional costs of Ukrainian companies in case of export to the EU may increase by almost €600 million/year. This can be avoided by adopting and implementing European climate standards, as well as carrying out industrial modernization. Ukraine currently remains one of the most carbon-intensive economies among the EU countries. Also, in Ukraine, there is almost no progress in weakening the relationship between economic growth and CO2 emissions[21].

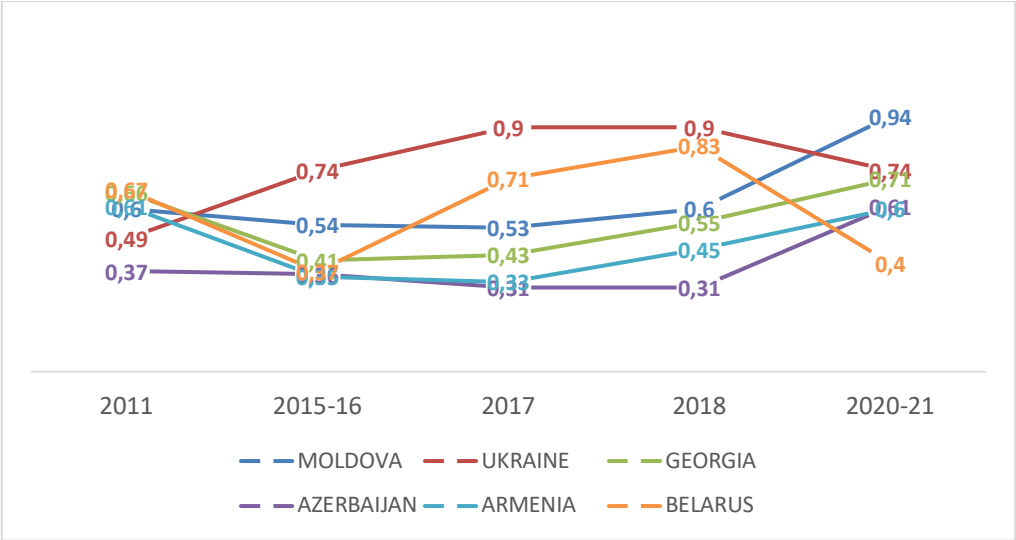
To analyse the potential of the countries of the EaP region, it is advisable, in our opinion, to highlight the data of the ETI 2021. The index is calculated by the World Economic Forum [19].



Graph 1. ETI (Energy Transition Index) 2021 results of EaP countries [based on 19] [19].

According to an analysis of the ETI for 2021, Georgia's energy system is best prepared for the transition to green energy. The energy systems of Azerbaijan and Armenia also have good potential for the transition to renewable energy. The values of the Republic of Moldova and Ukraine, whose energy system needs more thorough transformations in the direction of green energy, are worse. In general, according to the analysis of this index, we can conclude that the energy system of the EaP countries is not sufficiently ready for the accomplishment of the EU Green Deal and needs significant reforms in this area[19].

In order to analyse the convergence of the EaP countries to the European Green policy, we will analyse the dynamics and current state of the Environmental and Climate Policy Index of the EaP countries (Graph 2).

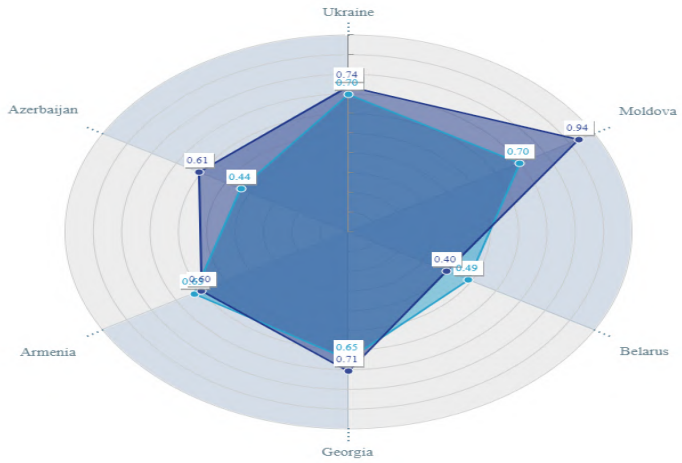


Graph 2. Dynamics of the Environmental and Climate Policy Index of the EaP countries [based on 18].

According to the analysis of Graph 2, which shows the dynamics of the convergence of the Green Deal of the EaP countries with the EU Green Deal policy implemented under the EU EaP Initiative, the ten-year period of the Sub-Index of Environmental and Climate Policy of the EaP countries has been

analysed. During this period, we can observe a positive dynamic of growth of the Index value in such countries as Moldova, Georgia, Azerbaijan and Armenia. In the final period there is a stagnation of the score in Ukraine and Belarus (due to the collapse of the European foreign policy). According to the analysis of the Sub-Index score for 2020-2021, we can determine that the Republic of Moldova is the closest to the European Green Deal. In Ukraine and Georgia, indicators point to a strong desire to implement an EU green policy in the national sphere. Armenia and Azerbaijan are problematic in approaching the EU green policy. Besides, the situation is critical about Belarus, which has sabotaged this area, and in 2021 suspended its participation in the EU Eastern Partnership initiative. In general, we can conclude that in addition to Belarus, the EaP countries are trying to intensify the green policy and move closer to EU standards in this area[18].

In order to study the EGD implementation process in the EaP countries, we will analyse the correlation between the EaP Index and the Environmental and Climate Policy Index of the EaP countries (Graph 3).



Graph 3. Correlation of the EaP Index* and the EaP Sub-Index of Climate and Environmental Policy** (2020-2021) [based on 18].

*Blue Field – Eastern Partnership Index

**Purple Field – Sub-index of the EaP Climate and Environmental Policy

According to Graph 3, we can analyse the interdependence of the general degree of convergence of the EaP countries to the European Union and the degree of convergence of environmental and climate policies of the Eastern Partnership countries to the EU's Green Deal. According to the data in the graph, we observe an approximately general trend of coincidence of the Indices. A slightly larger discrepancy is observed in the Republic of Moldova (the EaP index is 0.7, and the EaP Environmental and Climate Policy Sub-Index is 0.94). We can conclude that the Republic of Moldova has made much more progress in climate and environmental policy within the framework of the EU Eastern Partnership Initiative than in all other integrated indicators and is close to full integration (max – 1). Also, the indicators of the Republic of Azerbaijan differ slightly. The state has made much more progress in cooperation with the EU in the field of environmental and climate policy (Sub-index - 0.61) than in general convergence (Index – 0.44). In other countries there is an approximate correlation between the overall indicator of the EaP Index (1) and the EaP Environmental and Climate Policy Sub-Index (2): Ukraine (1 – 0.70; 2 – 0.74); Georgia (1 – 0.65; 2 – 0.74); Armenia (1 – 0.63; 2 – 0.60); Belarus (1 – 0.49; 2 – 0.4)[18].

Threats to the implementation of the EGD in the EaP countries are: global climate change; low level of economic development of the EaP countries; practical lack of legislation in the field of green energy; lack of common vision of all countries in the region on the implementation of EGD rules; obsolescence of energy systems of the EaP countries; lack of a national course on green energy, climate policy and the green economy; corruption in the EaP countries; low level of foreign investment; energy dependence of the countries of the region on the Russian Federation; obsolete technologies in the field of renewable energy; outdated technologies in the economy; harmful technologies in the field of energy; lack of sustainable climate policy; low level of ecological culture of the society of the EaP countries[4; 11; 12; 15; 16; 17; 20].

Recommendations and prospects for improving the dynamics of the transition to the Green Deal by the EaP countries. Possible scenarios for the development of the European Green Deal in the Eastern Partnership countries: 1) all Eastern Partnership countries are undergoing significant changes in the Green Deal (unlikely option); 2) the Eastern Partnership countries will be divided into two blocs (Associated Trio countries – are making the most progress in this direction, the rest of the countries will have a weak level of implementation of the EGD – the most likely option); 3) the EaP countries will refuse to implement the EGD (unlikely option).

As for the prospects of implementing the EGD, in the near future Georgia, Ukraine and Moldova will actively cooperate with the EU on implementing the Green policy in their countries and maximum convergence to European standards in this area. Armenia, Azerbaijan and Belarus will pursue deterrent policies to implement EU green policy reforms in their national energy policies. The latter has temporarily suspended its participation in the EaP Initiative, so in the near future it may not have any cooperation with the EU in green energy.

As for the recommendation for improvement, the first precondition for the successful transition of the EaP countries to the EGD is the launch of international processes, the establishment of partnerships and agreements with countries with common environmental and climatic interests.

The second precondition is to ensure the proper institutional capacity of the relevant ministries and agencies as the main tools for decision-making and implementation at the international level. An element of strengthening institutional capacity may be the creation of an institute of special environmental representatives or ambassadors.

The next step is to strengthen the information capacity. After all, digital diplomacy, or digital green diplomacy, plays an important role in the success of the transition of the EaP countries to the EGD. The digitalization of green diplomacy creates new opportunities for countries to promote environmental messages online. Thorough reforms in the field of green energy should be implemented. Reducing greenhouse gas emissions in the EaP countries should be a priority. It is important to build a green economy and switch to clean technologies and renewable energy, fight of countries against climate change, develop national strategies in green energy, attract green investment, strengthen cooperation with the EU and other international actors to reform the national energy system and ensure sustainable climate and environmental policies in the EaP countries that meet European standards.

And lastly, the transition of the EaP countries to the EGD should be based on the principles of openness and transparency, public involvement in the process.

6. Conclusion

Detailed goals and plans for cooperation on EGD today are the subject of negotiations between the governments of the EaP countries and the European Commission. Having analysed the European Green Deal for the Eastern Partnership countries, we can identify three groups of countries on the level of implementation of this area: European Green Deal countries (Republic of Moldova); Countries aspiring to the European Green Deal (Ukraine, Georgia); Countries sabotaging the European Green Deal (Armenia, Azerbaijan, Belarus). According to the ETI analysis, the Georgian energy system is most ready for the transition to alternative energy, Azerbaijan and Armenia have an average rating among the Eastern European countries. The energy systems of the Republic of Moldova and Ukraine are the least ready for the transition to green energy. In general, all EaP countries have average positions on this

indicator among all countries in the world. Analysing the Index of Environmental and Climate Policy of the EaP countries, it can be noted that the Republic of Moldova has the highest level of convergence to the EGD, Ukraine and Georgia are slightly lower. In the other three countries of the EaP – Armenia, Azerbaijan and Belarus – there are worse positions. It should be noted that the Eastern Partnership Index does not always correlate with the level of convergence of the EaP countries to European environmental and climate policy. As for the prospects, significant progress in implementing the EU's Green Deal can be expected in the near future in Ukraine, Georgia and the Republic of Moldova. In the other three countries – Belarus, Armenia and Azerbaijan – there will be no major changes in this direction. The EaP countries should cooperate more actively with the EU in the field of Green policy, reform national energy sectors, develop national green energy strategies, reduce greenhouse gas emissions, and strengthen international cooperation in this area.

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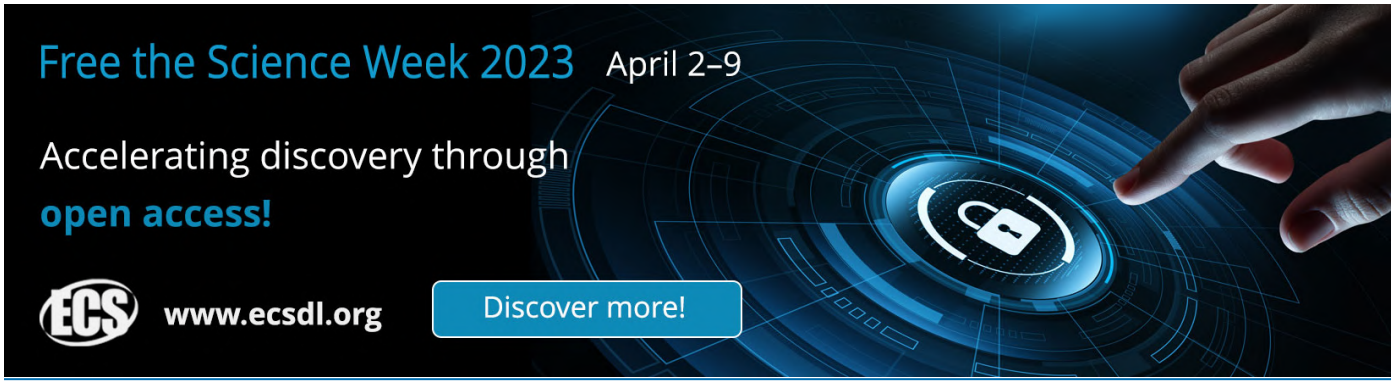
Poly-scale principle of urban environment geoinformation monitoring



Poly-scale principle of urban environment geoinformation monitoring

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Abstract. The article discusses general approaches for monitoring the urban environment based on geoinformation technologies. The purpose of these studies is to use the properties of poly-scale geoinformation monitoring in modeling and forecasting the state of the urban environment. The urgency of identifying the spatio-temporal features of the development of the urban environment at different territorial levels is shown. Each territorial level carries its own level of detail. These levels are the global level, regional, local, macro, meso level and primary level. The set-theoretic representation of the principle of poly-scale modelling of objects of the urban environment is considered. Based on this approach, models and methods of geoinformation monitoring at each scale level can be represented as a composition of ordered pairs of different structural types. An example of a hierarchy of methods and models used in studies of the urban environment is given. The concept of basic composition models is introduced. On the basis of such models, a technology for constructing poly-scale compositions is presented. Such compositions make it possible to convey the computational essence of the corresponding mathematical models at each level of the poly-scale approach in the study of the urban environment. A generalized scheme for applying the principle of poly-scale decomposition of a geoinformation monitoring object has been developed. At the same time, at each level of the information space, the construction of the corresponding models of the monitoring object is provided.

1. Introduction

The study of intensive changes in the spatial and temporal characteristics of the state of the urban environment, as well as obtaining operational information (including in a visualized format) requires the use of modern geoinformation technologies. The functionality of such technologies should ensure the prompt systematization, modeling and visualization of large arrays of heterogeneous statistical data.

The development of the theory and methodology for creating poly-scale maps in the last decade has been moving in the mainstream of applied work focused on specific tasks. Among these tasks, it is necessary to highlight the creation of specialized database structures, analysis and comparison of data at different scales, the development of algorithms for generalization and poly-scale data visualization [1]. At the same time, there is a lack of theoretical works that would determine the role of poly-scale monitoring based on the use of geoinformation technologies.

Today, poly-scale research is associated with solid mechanics, physics, chemistry, materials science. This direction received a significant impetus and evolved into an international interdisciplinary activity [2, 3, 4]. Poly-scale modeling is aimed at analyzing the behavior of a complex system at one level using information (models) from different scale levels. The urban environment, as a complex system, is associated with various organizational, socio-economic and environmental phenomena. These phenomena manifest themselves at different temporal and spatial scales. In such situations, poly-scale modeling increases the efficiency of decision-making in the management of territorial development.

Imagine the urban environment in the form of a hierarchy of different scale levels. At each level, there are many subjects of the transformation of the urban environment. These subjects often have and pursue asymmetric and conflicting interests. In addition, there is a multi-level system of institutions, which ensures the regulation of the interaction of the population with the environment. It follows that when analyzing the urban environment, it is advisable to use the hierarchical approach.

When implementing the hierarchical approach in geoinformation monitoring technology, the principle of poly-scale is followed. This principle is based on the studies of Treivish A.I., Rauzhin I.G. [5, 6] and other scientists. The principle of poly-scale is that in order to identify the spatial patterns of phenomena or processes within a specific monitoring object, different scales-ranks of the territory are used.

The multiscale approach is characterized by two technological elements. The first element is the ability to move along the scale in both directions, both up and down [7]. The second element is the use of both discrete scaling and continuous "zoom", a kind of "ladder without steps" [8]. There are also certain meaningful features of the multi-scale approach [9]:

– assignment of the studied objects to the groups of monoscale, polyscale, omniscale (i.e. all scale) and off-scale;

– representation of each place as a whole world of scales and interscale relationships;

– the study of not only the scale of territories, cities and other objects, phenomena, processes, but also the scale of functioning, rhythms, flows, connections, etc.

V Karbovskii and co-authors showed how "scale expansion" (changing the level of the territory, expanding the study area) can help in automatically determining the boundaries of the study area and its parts in relation to landscape analysis tasks [10].

In addition, a special journal "Multiscale Modeling and Simulation" (http://epubs.siam.org/loi/mmsubt) has been published in the USA since 2003. This journal studies the issues of multiscale mathematical modeling. At the same time, it solves the problems of ecology, the problems of the functioning of transport infrastructure, etc.

The presence of territorial scales inspired scientists to make theoretical generalizations, including: the science of the region, the concept of small countries [11], the idea of the theory of large countries [12].

Back in the 1980s, the term Glocalisation (global localization) appeared in Japan. This term defines the existence of simultaneously two opposite tendencies towards globalization and localization [13]. These global and local trends are mutually complementary and mutually permeable. At the same time, these two tendencies can come to asymmetry and contradiction in some specific situations.

The principle of poly-scale geoinformation monitoring (GM) allows in practice to implement the motto of the Club of Rome "Think globally, act locally." This motto first appeared in the sixties of the last century. Currently, the motto has received a tool for consistent and comprehensive research.

2. Urban environment as an object of poly-scale geoinformation monitoring

The use of poly-scale GM in conjunction with Internet technologies makes it possible to provide high-quality and operational monitoring of such a complex system as the urban environment. Following the principle of poly-scale, we get the opportunity [14]:

– to significantly expand access to indicators of different territorial levels;

– to simplify the procedure for displaying statistical information and its operational change;

– to automate the process of analyzing spatial patterns of objects, phenomena, processes and calculating forecasts;
– to increase the efficiency and effectiveness of the work of public authorities in the development of a policy for sustainable development of territories, taking into account the glocal features of the socio-economic, environmental, urban planning situation.

The poly-scale of the GM is determined by the size of the observed area. Poly-scale can be represented as an inverted tetrahedral pyramid, where the slices of the pyramid correspond to scale levels. The facets of this pyramid are scaling attributes: object, process, geoinformation monitoring phenomenon, territory and time. Figure 1 shows an example of five scale levels of the observed area: primary level, meso-level, local level, regional and global levels.

The primary level is applied to the primary planning elements of the social planning structure of the settlement. Such elements are: a land plot, a group of land plots, buildings and structures, as well as engineering support objects.

The meso-level is applied to the elements of the social planning structure of settlements. These elements are usually defined in government building codes. Examples of such structures are residential neighborhoods, enterprises and institutions of periodic services for the population, green spaces of general use, as well as objects of the street and road network.

The local level is applied to individual objects and areas subject to anthropogenic impact. Such objects are separate water bodies, forests and mountain ranges, urban areas, the surface air layer, surface and ground waters, industrial and domestic wastewater, atmospheric emissions, areas with radioactive radiation.

The regional level (ecosystem monitoring) is used to survey large territorial zones that form separate urban, natural, forest and aquatic ecosystems [15]. The purpose of regional monitoring is to control the parameters of ecosystems. This monitoring includes an assessment of the differences in parameters from background values, as well as the establishment of the influence of sources of anthropogenic impact on the values of the observed parameters. In the course of regional monitoring, the biological circulation and its disturbances are investigated. At the same time, the population of representatives of the animal world is monitored, as well as the possibilities of natural resources to ensure the vital activity of the regions. Regional monitoring also includes the study of regional changes in the parameters of the atmosphere, hydrosphere and lithosphere.

The global level (monitoring of global processes) [16] is used to study processes with a wider scale than at the regional level. At the global level, the general trends of changes in the state of the urban environment under the influence of anthropogenic factors are investigated. For example, they determine the types of pollutants of the atmosphere, soil, water resources and groundwater.

The physical reality of the surrounding world can be described using the information field, which contains some quantitative and qualitative characteristics of the information space. The information space is only a passive reflection of the surrounding world [17].

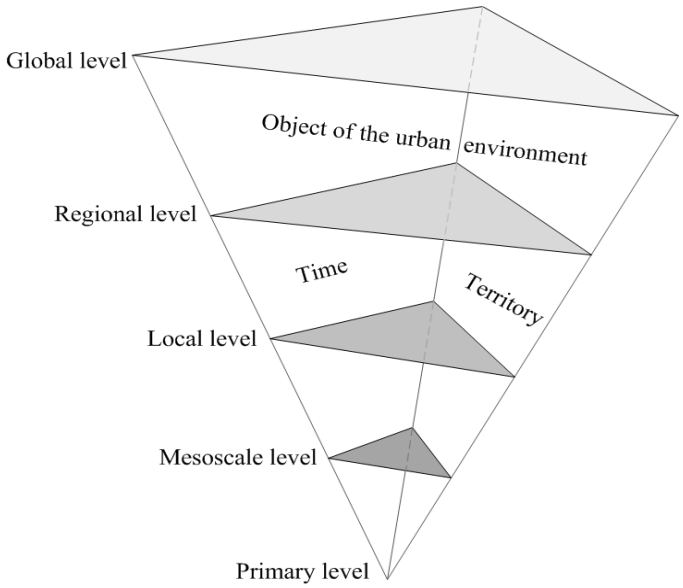

Figure 1. General scheme of the poly-scale model of the urban environment.

The information field can be characterized by various independent measurements, including the measurement of space, measurement of time, measurement of "field density" and others [3].

The main part of the mathematical models used in monitoring objects, physical processes and phenomena is intended to describe them in the same space-time scale. The tasks of geoinformation monitoring of the urban environment are directly related to the presentation of geographically distributed, spatio-temporal indicators. Moreover, these tasks should be solved in conditions of variable detail. That is, you need to visualize generalized views at a variety of scales. In the process of studying the urban environment when constructing a geoinformation monitoring scheme, it is possible to build a hierarchy of methods and models, taking into account the poly-scale of objects, processes and phenomena.

Poly-scale models have certain advantages in the process of assessing the results of geoinformation monitoring. The poly-scale approach allows the study of objects, phenomena and processes of much larger size (or longer in time) than those that could be studied at the microscale level.

Thus, in cases where it is necessary to monitor an object, phenomenon or process within one model, geoinformation monitoring provides the ability to integrate models of various scale levels. All this requires the development of theoretical foundations for combining such models.

3. The principle of poly-scale modeling of urban environment objects based on set theory

Consider the set-theoretic representation [18] of the principle of poly-scale modeling of objects of the GM urban environment. GM models and methods at each scale level can be represented as a composition of ordered pairs of basic sets of different structural types:

$$K^i = \langle \{VX_j^i, \dot{M}M_j^i\} \rangle.$$

Here i is the number of the scale level, $i = \overline{0, L}$;
L is the number of levels under consideration;
j is serial number of the model of the monitoring object at the scale level, $j = \overline{0, N}$;
N is number of monitored object models at j level.

Let us define the main content of the sets: $VX_j^i = \{V_j^i, X_j^i\}$ is data set, where V_j^i is set of input data, X_j^i is set of monitoring model outputs. The set of $\dot{M}M_j^i = \{\dot{M}_j^i, M_j^i\}$, where $\dot{M}_j^i$ is the set of methods for processing input data, and M_j^i is the set of models of the monitoring object.

We define the set of methods and models $\dot{M}M_j^i$ in more detail:

$$\dot{M}M_j^i = \{\dot{M}_j^i, M_j^i\} = \{s_j^i, \delta_j^i, \dot{m}_j^i, \dot{m}_j^{i,\dots,i^*}\}.$$

From the standpoint of variability, the set of models included in the set $\dot{M}M_j^i$ can be conditionally divided into two classes of models: static (s_j^i) and dynamic (δ_j^i) models. There can also be quasi-dynamic models. Data processing methods $\dot{m}_j^i$, $i = \overline{0,L}$, $j = \overline{0,N}$ can be specialized or universal. Specialized methods are used only in a specific model at a separate scale level. Meanwhile, universal methods are used by various models of the monitoring object at different scale levels $\dot{m}_{j,\dots,j^*}^{i,\dots,i^*}$, where $i, \dots, i^*$ is the number of levels.

The unifying elements between the models of the monitoring object at different scale levels are parameters (indicators). It is these parameters that play the main role in the transfer of data between scale levels.

Below we give a description of some poly-scale composition. This composition contains information on the models and methods of GM used at the respective scale levels. In addition, this composition shows how data is exchanged between models of different scale levels.

Let us assume that at the i scale level, within the framework of some object, we have a composition of output data, methods and models of geoinformation monitoring: $K^i = \langle \{VX_j^i, \dot{M}M_j^i\} \rangle$. Accordingly, at the i^*-th level, the composition is presented in the form: $K^{i^*} = \langle \{VX_{j^*}^{i^*}, \dot{M}M_{j^*}^{i^*}\} \rangle$.

Now let's build a poly-scale composition K^{i,i^*}. Basic sets K^{i,i^*} are:

$$K^{i,i^*} = \langle \{V_j^i \cup V_{j^*}^{i^*}, X_j^i \cup X_{j^*}^{i^*}, \dot{M}_j^i \cup \dot{M}_{j^*}^{i^*}, M_j^i \cup M_{j^*}^{i^*}\} \rangle.$$

Between compositions from different scale levels included in K^{i,i^*}, we have some connecting elements. They are called parameters or indicators. Formally, these parameters ϑ are: $\vartheta \in VX = \{V_j^i \cup V_{j^*}^{i^*}, X_j^i \cup X_{j^*}^{i^*}\}$. These parameters are directly related to the set $X_j^i \cap X_{j^*}^{i^*}$. As you can see, this set is obtained as the result of the intersection of two sets. The first set in this intersection is the set of output data X_j^i from the lower scale level, and the second set is, respectively, the set of input data $V_{j^*}^{i^*}$ from the upper scale level:

$$X_j^i \cap X_{j^*}^{i^*} = \{\vartheta : (\vartheta \in X_j^i) \cap (\vartheta \in V_{j^*}^{i^*}), \vartheta \in VX\}.$$

In figure 2 shows an example of a hierarchy of methods and models. Such a hierarchy can be used for geoinformation monitoring of the urban environment. According to this concept, at the first scale level, for example, at the regional level, models and methods of remote sensing of the Earth are used. These methods are based on the theory of electromagnetic radiation. At a larger scale, cartographic methods and models are already being used. Moreover, these methods can be combined, for example, with artificial intelligence methods.

With this approach, the results of modeling monitoring objects at the global or regional levels can be used as input data for methods and models at the primary scale level. This will ensure the adoption of more effective urban planning decisions in the management of the city's economy.

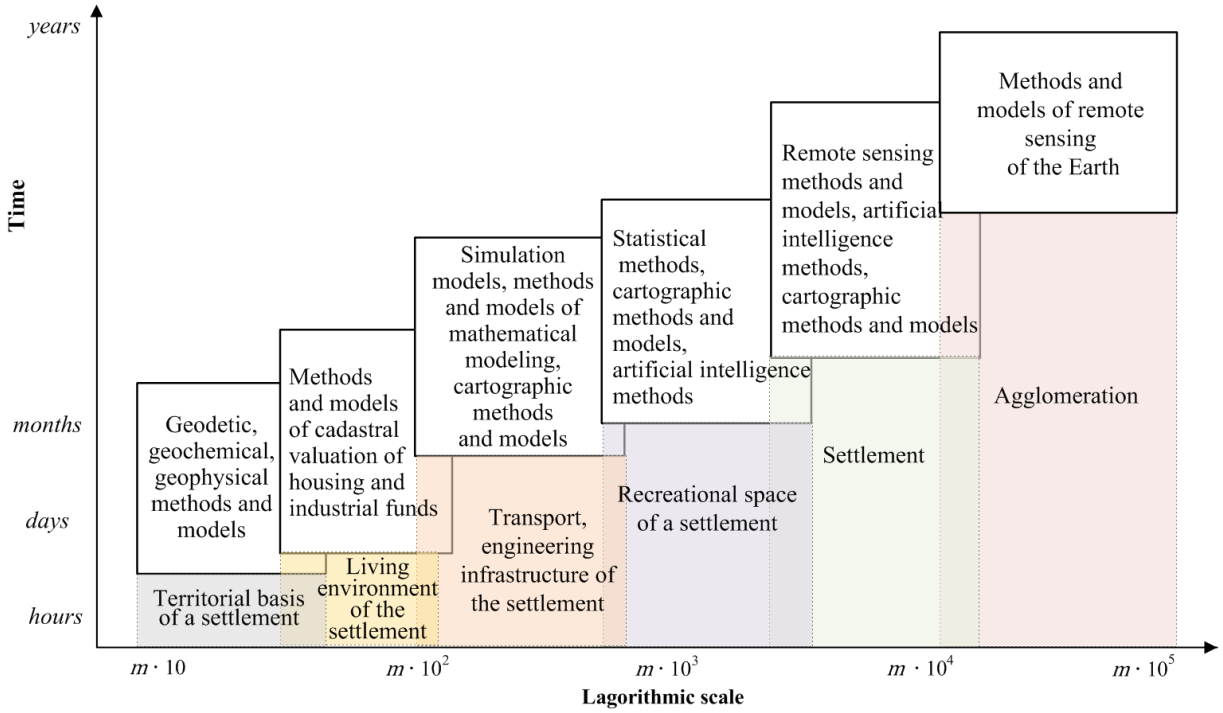

Figure 2. An example of a hierarchy of methods and models used in urban research.

Consider the implementation of the principle of poly-scale modeling for solving GM problems in order to determine the properties of specific objects. The principle of poly-scale modeling has a dual nature. That is, this process has two directions, namely detailing and generalization (decomposition and composition). At the stage of object detailing, a poly-scale decomposition of the object under study is carried out.

As a result of this decomposition, we obtain a hierarchical structure that determines the mathematical basis of modeling. This structure corresponds to the coverage and configuration of the territory, the size of the GM objects, as well as the peculiarities of the spatial relationships of these objects. The resulting hierarchy determines the structure of the spatial database with interconnected information layers, as well as with such levels of detail that correspond to the scale of mapping. In addition, resulting from the decomposition, such a hierarchical structure determines the requirements for heterogeneous data sources for methods and models at each level of modeling detail.

The reverse process is generalization (composition). This process involves climbing large-scale levels. Suppose we have a monitoring object ob_l, which corresponds to the scale level l of the territory, and for which a number of properties are determined. Let's perform a poly-scale decomposition of the monitoring object ob_l, highlighting its constituent objects (composition elements). Let's perform a poly-scale decomposition of the monitoring object ob_l, highlighting its constituent objects (composition elements). Note that these objects belong to different scale levels.

We denote $ob_l^1 = ob_l$. Decomposition is performed sequentially at each scale level. At the i-th step of the decomposition (this step corresponds to the i-th scale level), we define the elements (monitoring objects) of the lower level:

$$ob_i^m \to \left\{ob_i^{1m}, \quad ob_i^{2m}, \quad \cdots, \quad ob_i^{M_{i-1}}\right\}, \quad m = 1, \ldots, M_i.$$

Here M_i is the number of composition elements at the i-th scale level.

As a result, we obtain a hierarchical structure that reflects the compositional structure of the monitoring object (Figure 3). It should be noted that in Figure 3 we use relative numbering of scale levels. That is, here the levels involved in the decomposition are numbered sequentially from top to

bottom. An important element of this process is the transfer of data between models of different scale levels.

For a more detailed description of this process, we divide the set of input data of the poly-scale composition into three groups:

$D_{ij} = B_{ij} \cup C_{ij} \cup T_{ij}$.

Here B_{ij} is a set of data coming from models of the lower scale level:

$$B_{ij} \subset \bigcup_{m} X_{i-1,m} = D_{ij} \cup \bigcap_{m} X_{i-1,m} ;$$

C_{ij} is set of data coming from models of the current scale level:

$$C_{ij} \subset \bigcup_{k<j} X_{ik} = D_{ij} \cup \bigcap_{k<j} X_{ik} ;$$

T_{ij} is a set of data that are specific for the current level and for a given model.

Multilevel data transformation is carried out between the models of the monitoring object of adjacent scale levels. Taking into account the constructed hierarchy, the principle of poly-scale geoinformation monitoring ensures unambiguity and completeness of data transmission.

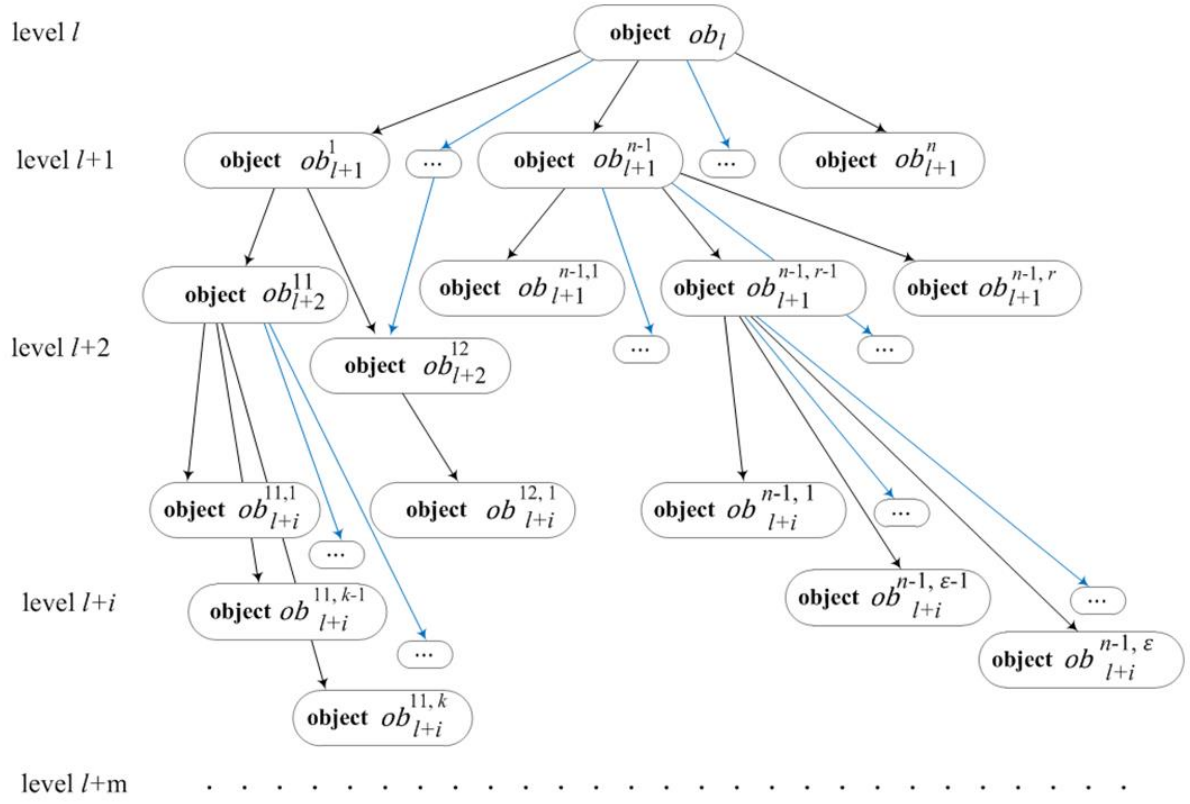

Figure 3. An example of a poly-scale decomposition of an object, with the selection of its components, which refer to different levels of scale.

It should also be noted that the multiscale-related structure of monitoring objects will not always be able to ensure the intersection of the output data of the upper-level model with the input data of the lower-scale models.

4. Conceptual model of poly-scale decomposition of urban environments

To describe the basic compositional models and the technology for constructing poly-scale compositions, we also used the set-theoretic representation. This approach allows you to convey the computational essence of the corresponding mathematical models. In fig. 4 shows an example of applying the principle of poly-scale decomposition of a geoinformation monitoring object. The object of monitoring is the urban environment. Corresponding monitoring models are defined at each level of the information space. A scale range is set for each level of detail. Within this range, methods and models of geoinformation monitoring, data processing, generalization of new data, as well as visualization of this data are used.

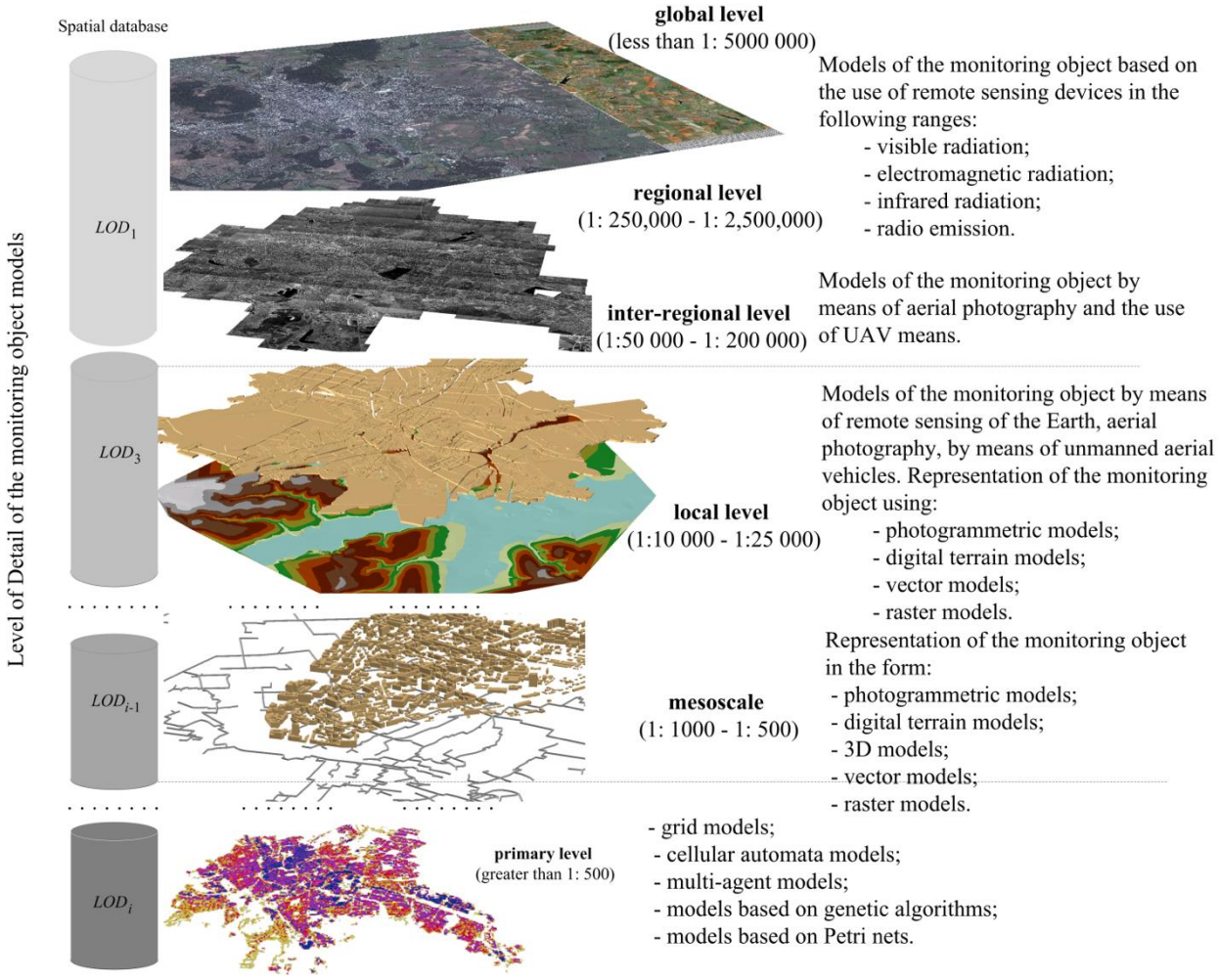

Figure 4. Conceptual model of application of the principle of poly-scale decomposition of the object of geoinformation monitoring with the allocation of its components.

The results of poly-scale modeling of geoinformation monitoring objects are stored in a spatial database in the form of levels of detail. The considered principle of poly-scale GM allows to improve the organization of monitoring studies of the urban environment when planning strategic directions and programs for sustainable development of territories of various sizes. The use of set-theoretic representation allows the most complete transfer of the computational essence of multiscale modeling of complex systems.

5. Conclusion

Based on the systems analysis and relying on the logical constructions of the theory of sets, we have analyzed the features of the principle of the poly-scale of the GM. It is shown that the main technological feature of the poly-scale approach is the ability to study the interaction of scales (for example, primary level, meso-level, local level). In this case, you can use not only the territorial scale, but also the scale of objects, processes, phenomena and time scaling. In addition, it is advisable to move along the scale in both directions (up and down), and also use not only discrete scaling, but also continuous.

One of the main tasks of studying poly-scale objects of the urban environment is to determine the features of using models and methods of geoinformation monitoring at each scale level. At the same time, it is necessary to identify such indicators and parameters that change when moving along the scale bar. Another key task of the poly-scale approach of geoinformation monitoring is the interaction of different-scale levels. This interaction is manifested in the monitoring of relationships and interconnections between the components and subsystems of the urban environment within the same territory, but at different scales and at different time periods.

The proposed model of poly-scale decomposition of the monitoring object is generalized and reflects the principle of poly-scale geoinformation monitoring, which has a dual character. As a result of such a decomposition, we obtain a hierarchical structure that determines the mathematical basis for modeling geoinformation monitoring objects. The hierarchical structure corresponds to the coverage and configuration of the territory, to the peculiarities of spatial relationships between objects, components and monitoring subsystems. In addition, such a hierarchical structure allows you to determine the requirements for heterogeneous data sources for methods and models at each level of detail of the monitoring object.

A conceptual model of the poly-scale decomposition of the object of geoinformation monitoring is proposed on the example of the urban environment. The developed conceptual model will make it possible to ensure the formation of a plan for conducting monitoring studies of the urban environment, as well as to formulate the purpose and objectives of monitoring at each stage of the poly-scale decomposition of the monitoring object.

Using the principle of poly-scale GM, it becomes possible to solve the problems of modeling the multi-level structure of complex systems, processes and phenomena. It is difficult to fully implement such tasks on the basis of traditional methods of monitoring the urban environment. The tasks of monitoring the urban environment are complex in nature and require the use of analytical models of processes, phenomena in geosystems, developed by specialists of different profiles, for their solution.

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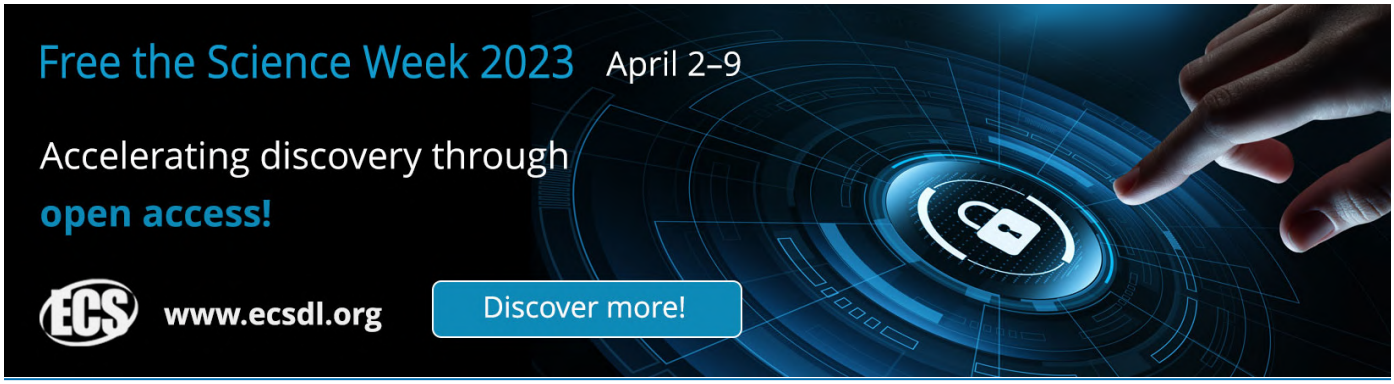
Integrated approach to land management with self-sown forests in Ukraine



Integrated approach to land management with self-sown forests in Ukraine

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Abstract. Protection and recovery of land natural ecosystems is a relevant task of sustainable development. Natural recovery of forests is an important instrument to solve the problem. The article describes the integrated approach to management of land use with self-sown forests, which have become a wide-spread phenomenon on the agricultural lands in Polissia and Forest-Steppe zones of the western Ukraine. The authors conducted an interview, which demonstrated people's attitude to self-afforestation of lands. The idea of protecting self-sown forests was supported by one third of the respondents. Among those, who wish to possess a land plot with forests, the main share is represented by people of the age category of 21-40 years old. The authors substantiate the potential value of ecosystem services, which can be supplied by self-sown forests by introducing different practices. A focus is made on the ecosystem benefits from protection of self-sown forests, which cannot be expressed in money terms, but are of environmental and social value for the community. A model of integrated management of agricultural lands with self-sown forests was developed. It is suggested to use planning as an instrument, which involves assessment of the potential of land and other resources, to determine alternatives of land use, considering economic and social conditions of the territory development and landscape characteristics. Ukraine should develop a policy, establish institutes and approve procedures intended to protect self-sown forests. In the future, it will reduce the area of ploughed land and improve biodiversity of the territory.

1. Introduction

Development of modern society needs expansion of agricultural lands for growing products of crop production and animal breeding on one hand, and protection and recovery of natural ecosystems to improve ecological conditions of the environment, increase of biological diversity of the territory, reverse of land degradation and desertification processes, etc. on the other hand [1; 2]. To solve these complicated tasks, it is necessary to achieve an optimal balance between the humanity demands and the nature potential. To fulfil the tasks, at the global level it was decided to approve the Concept of Sustainable Development, including 17 goals, which all countries should achieve within the frames of global partnership [3]. The Goal 15 aim is focused on the fight against climate change and protection of oceans, lands, forests, biological diversity, mountainous landscapes.

In the SDG 15, a particular attention is paid to forests. Forest is a multi-functional ecosystem of dry land, which positively influences the processes of air purification and soil formation, regulation of climate and water streams, reduces the risks of natural disasters, increases biological diversity of territories, improves living conditions of people, and supports stability of communities [4]. However, forests are constantly subjected to destruction because of devastation, fires, pests, drought conditions,

invasion kinds. From 2015 to 2020, deforestation of territories of the world reached 10 million ha per year [5]. Such situation requires measures, which would not just protect forests from negative impacts, but also support for recovery of forest vegetation to expand the area of forest ecosystems [6]. Reforestation can be done artificially (planting trees) and naturally (self-growing forests on the deforested areas, abandoned lands, including agricultural lands), but natural recovery is preferred [7].

In the recent decades, Ukraine has experienced the phenomenon of self-afforestation of agricultural lands [8]. Colonization of agricultural land by plants is considered a violation of the land legislation of Ukraine, because it is interpreted as the "use of a land plot with violation of its purpose" [9]. Such plants should be uprooted to bring the land plot to its previous conditions (arable land, hay field, grassland, garden). However, the situation conflicts with the tasks and indicators of achieving the Goal 15 sustainable development program of Ukraine – to reclaim the degraded lands and soils; to expand the area of forests and natural reserve territories; to reduce the area of arable lands; to restore the biodiversity [10].

In Ukraine, a considerable share of self-sown forests is located on private lands. The research [11] confirms that the prospects of such private forest protection (conservation) are influenced by the following factors: the land owner is a woman, has higher education, is not elderly and not interested in agriculture; legitimate management of the forest lands; a small plot of land; awareness of the conservation value of land. The problem is to assess the value of ecosystem services, which are not expressed in money terms, but are important for the community or society. For instance, one can evaluate such cultural services as tourism and recreation, whilst can hardly set the price of religious, esthetic and existence services [12]. It is therefore necessary to apply multi-functional approaches to protection of self-sown forests, especially in conditions of environmental degradation and climate change.

To solve the complicated tasks, it is necessary to apply the integrated approach to land management, which is focused on cessation of the anthropogenic impact and management of land for sustainable use of other resources (water, forest, wild nature) [13]. The integrated approach to natural resources management aims to secure productive and healthy ecosystems by integrating economic, social, biological demands and values. Integrated management means each natural resource is considered not separately, but in the complex with other elements of the ecosystem to obtain ecological and economic benefits [14; 15]. The integrated management identifies compromises that are specific for each decision concerning the natural resources use.

Considering the above-mentioned, the goal of the article is to discuss the benefits, which self-sown forests on agricultural lands can provide for ecosystems and communities in Ukraine. A particular attention is paid to the scientific concepts, which can be applied to manage lands with self-sown forests for the purpose of sustainable development of land use.

2. Materials and Methods

The work uses the methodology of integrated land management, which is a system of agreed decisions, based on:

(i) the concept of ecosystem services [16], which proves that forest ecosystems provide population with the following services: climate regulation, carbon sequestration, erosion protection, soil formation, recreation, landscape aesthetics, recreation, wood, fuel, fresh water, etc. [17], and

(ii) the concept of land degradation neutrality, which aims to support, protect and improve land resources in space and time, as well as related ecosystem functions and services to satisfy demands of the present and future generations [2].

To substantiate the advantages of forest restoration, the authors of the research used findings of the scientific researches on supply of the ecosystem services by forest ecosystems [4; 6; 7; 17].

The method of analysis was applied to study agricultural land with self-sown forest. Information about afforestation was obtained from online platform "Global Forest Watch" [18], GEO-information services "Public Cadastral Map of Ukraine" [19] and "GISFILE" [20].

The visualization of self-forested areas was carried out using a cartographic method. The process of self-afforestation on the examined area is demonstrated by overlapping the analytical GIS maps.

The survey method was applied to collect information about the use of land plots with self-sown forests in the future. Both face to face (F2F) and online interviewing (Zoom platform) was conducted. The abstract and logical method was used to sum up the results and to make conclusions.

The research the use of agricultural lands with self-sown forest was conducted on the territory of western Ukraine (Volyn and Lviv regions). The territory of Volyn region is represented by Polissia landscape, characterized by lowlands, mostly sandy and sandy-loam soils. There are some kinds of turf-podzolic and swamp soils, a dense river network, coniferous and deciduous forests, grasslands, swamps, wetlands in the zone. In the past, a large area of the territory was covered by forests. The territory of Lviv region is mostly covered by forest steppes, characterized by hilly terrain, with prevailing turf-podzolic and grey podzolic soils. There are also kinds of black land soils and swamps, a dense river network, coniferous and deciduous forests, grasslands, wetlands. The central part of Lviv region is represented by mixed forests and Polissia landscape, the southern part – by pre-mountainous Carpathian landscape [21].

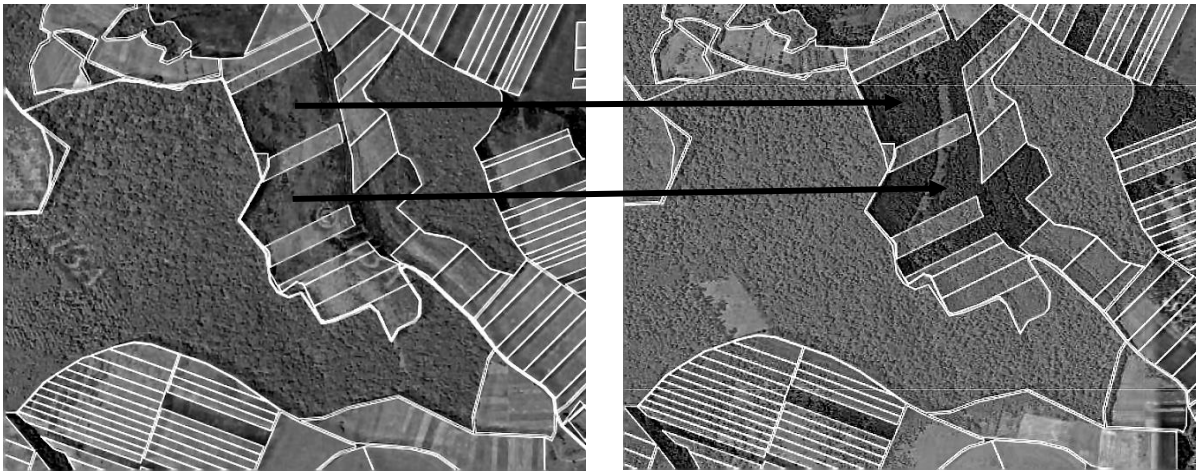
3. Results and Discussion

Referring to the data from the Global Forest Watch in Ukraine, in 2000 the natural forest covered 11.1 mln ha (18%). However, from 2001 to 2020, Ukraine lost 1.08 mln ha of tree cover, including 79.3 thou ha of natural forest was lost in 2020. From 2001 to 2012, the tree cover growth made 353 thou ha, whereas the loss of it – 557 thou ha. The last decade information about the growth of forests is not available in the database [18].

In Ukraine, agricultural lands occupy 41.4 mln ha (68%), including 32.7 mln ha of arable lands (54%) [22]. It is a rather high figure of territory development that negatively influences the ecological conditions of land and environment. In Ukraine, 315.6 thou ha of marginal lands, above 1.1 mln ha of agricultural lands, mostly arable ones, should be conserved [22]. The soil cover loses its fertility, the processes of water and wind erosion expend [23]. In 2018, emission of greenhouse gases from agriculture exceeded the volume of carbon, sequestrated by forests [24].

The data prove the importance of protection and restoration of forests in Ukraine. The Ukraine's Sustainable Development Goal 15 [10] aims to increase the forest cover up to 20% (almost 2 mln ha). One of the ways to achieve the set goal is to expand the forest-covered area naturally, i. e. by means of self-afforestation, including on agricultural lands, which are not fertile, degraded, or unattractive for investments. In Ukraine, the inventory of self-afforested lands has not been conducted. Nevertheless, according to the data [22], 2.9 mln ha (7%) of agricultural lands are not cultivated. Therefore, one can assume that those lands are subjected to the process of self-afforestation. That process can be observed at orthophotos of the geoportal "Public Cadastral Map of Ukraine" [19] and space images of the GEO-information service "GISFILE" [18] (Figure 1).

The visual comparative analysis of the Figures 1a and 1b shows that in 2009, the processes of self-afforestation of agricultural lands on the studied territory were insignificant. However, in 12-year period, a large area of the agricultural lands has become covered with forests. Within the self-afforested territory, there are land plots of private ownership with the area from 0.6 to 1.4 ha. According to the State Land Cadaster, the purpose of such land plots is "to run commercial agricultural production". The area is segmented by ravines, 3-4° slopes that can cause erosion in case of intensive agricultural use. The erosion threat is also witnessed by the soil conditions, represented by slightly washed-off dark-grey podzolic soils.



(a) (b)

Figure 1. Example of self-afforestation of agricultural lands of private ownership within the area of Peremyshliany territorial community in Lviv region: a) image from the Public Cadastral Map of Ukraine (orthophoto 2009); b) image from the geoportal GISFILE (space image Google Satellite 2021).
Source: own research.

The land laws of Ukraine declare that self-afforested agricultural lands are the lands, which are not used according to their purpose. The purpose of a land plot is identified by its belonging to a particular category of lands and the corresponding use. Therefore, any other use is unintended. Such violation by land owners is administratively punished (fine). However, the laws provide for the land owners the opportunity to change the purpose of their land plots. To do this, they should develop a project of land organization. However, since July 2021, the purpose of a land plot is identified referring to the corresponding kind of the territory functional intention, which is approved by the complex plan of spatial development of a territorial community or the general layout of a settlement [9].

To get information on using self-afforested agricultural lands, the authors of the research made sociological interviewing in October-November 2021. In total, 400 residents of Volyn and Lviv regions were asked. The respondents were divided into two groups: the first group included 200 people, who owned agricultural land plots; the second group – 200 people, who did not possess any land. Each group consisted of respondents of different age, namely 21-30 years old, 31-40 years old, 41-50 years old, and 51-60 years old, i. e. 50 people of each age category.

Respondents of the first group were asked the questions (Figure 2a): 1) Do you think the self-sown forests on agricultural lands should be cut down? 2) Would you agree to exchange your land plot for a forest? On average, 25% owners of agricultural land plots were against cutting down the self-sown forests, and 20% agreed to own forest lands. However, the greatest support in favour of forest lands was demonstrated by the owners of the age category of 21-40 years old.

Respondents of the second group were asked (Figure 2b): 1) Do you think the self-sown forests on agricultural lands should be cut down? 2) Would you like to possess a land plot with forest? On average, 59% respondents, who did not possess land, were against destruction of self-sown forests, 38% wished to possess forest lands. The greatest share of those, who were against cutting down the self-sown forests, was represented by respondents of the age category of 21-30 years old, whereas the wish to possess forest lands was declared by the 21–40-year-old respondents.

Therefore, in spite of the fact that most respondents do not support the idea of protecting self-sown forests, there are still people, who wish to possess forest lands. They are mostly young people, who can become potential owners of such land plots and/or create conditions for the self-sown forest protection.

Another positive aspect is that self-afforestation happens naturally (natural forest regeneration). These forest ecosystems will be more resistant to negative natural phenomena, more valuable for territory biological diversity [6; 7]. It is one more argument in favour of the self-sown forest protection.

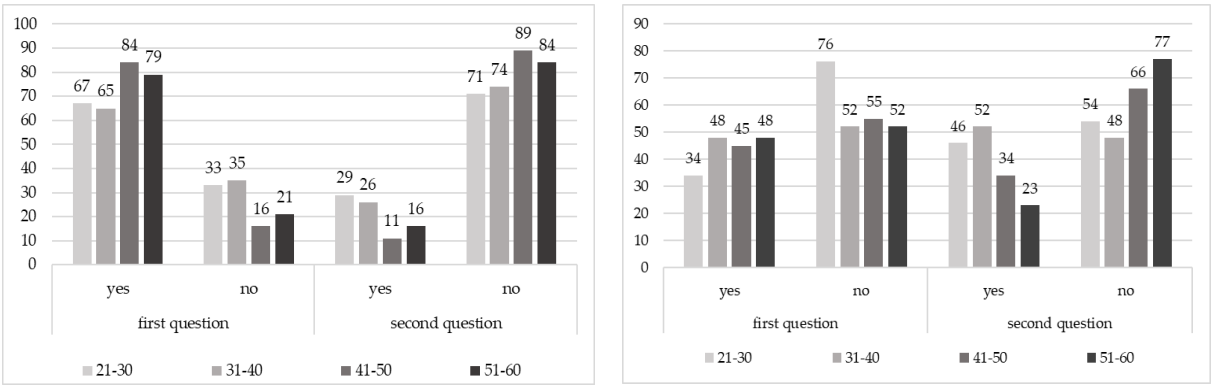


Figure 2. Results of the interview (%): a) owners of agricultural land plots; b) people, who do not possess any land.
Source: own research.

The integrated approach to land use management aims to ensure the use of land resources to satisfy human needs (agriculture and forest husbandry, recreation, habitat, etc.) along with protection of the most important social and economic, as well as ecological functions of land for future generations [13]. In other words, integrated management of land use is focused on protection, improvement and recovery of ecosystem services and functions, supplied by land surface ecosystems. Forest ecosystems provide a great number of ecosystem services and functions, namely supply (timber, berries and mushrooms, game animals, fresh water, fuel, etc.); regulation (control of climate and quality of water, carbon sequestration, pollination of plants, noise reduction, places of habitat and reproduction of fauna, etc.); support (soil formation, protection from soil erosion, retention and purification of water, nutrient retention, support for biological diversity, etc.); cultural (protection of the aesthetic landscapes, space for recreation and ecotourism, development of science and education, etc.) [4; 15; 17]. Therefore, management of agricultural lands with self-sown forests should consider compromises concerning the use of self-sown forests along with concern of the final goal, i. e. maintenance of human comfort living. Referring to the current research goal, it is necessary to evaluate advantages of the ecosystem services of young forests and their contribution to the welfare of both land-holders and the community of the land plot location, as well as prosperity of the region and the whole country. The task is rather complicated. It is worth noting that the ecosystem functions of supply and regulation are social benefits that have non-market value and cannot be privatized (e. g. support for biological diversity, process of water purification, soil formation, climate regulation, etc.). Therefore, there is no a unified approach to the use of self-sown forests. In each separate case, it can involve different practices (agroforestry, forestry, recreation, conservation), which should consider goals of the community development and environmental policy of the country. It is also important to consider the territory natural potential and global challenges (ecological crisis, shortage of natural resources, spreading of health risks, etc.). In Table 1, the authors present their views on the value of some ecosystem services provided by self-sown forests.

In that context, integrated management of land use should involve the practices of protection and growth of the surface natural capital, which considers edaphic, geomorphological, hydrological and biotic peculiarities of the territory. Those practices should be focused on achievement of the land degradation neutrality by recovering or rehabilitating of the degraded ecosystems. While balancing the

natural and man-made ecosystems, one should consider the land potential, which is determined by such properties as relief, climate, soil, vegetation cover, fauna [2; 25]. It is important to mention that man-made ecosystems (e. g. agricultural ones) should be combined with natural ecosystems (e. g. forests) through the landscape-ecological organization of territory. The territory that is organized in the best possible way is highly productive, non-conflict and aesthetically attractive [26].

Table 1. Potential value of ecosystem services provided by self-sown forests in the studied region.

	Agroforestry	Forestry	Recreation	Conservation
Protect genetic resources (wild species, indigenous populations)	+	+	+	+ + +
Provide habitat and food for wild nature	+	+ +	+	+ + +
Sustain biodiversity or help to compensate anthropogenic footprints	+	+	+ +	+ + +
Supply timber by felling during the main and intermediate exploitation	+ +	+ + +	+	-
Supply agricultural crops	+ + +	-	-	-
Provide area for ecotourism and agritourist	+ + +	+ +	+ + +	+
Create the landscape aesthetics	+ +	+ + +	+ + +	+ + +
Protect from erosion, purify air and water	+ +	+ + +	+	+ + +

+ + + high value
+ + medium value
+ low value

The best instrument to implement the decisions of integrated management is to make land-use planning. The integrated planning of land use also involves evaluation of the potential of land and other resources, alternatives of land use, economic and social conditions of the territory development in order to choose and approve the variant of land use, which will best satisfy the human needs along with saving resources for the future [27]. In that context, it is required to consider (1) the structure of landscapes and dynamics of their development; (2) ecosystem values, related with landscapes and their development; (3) structure of management to control the landscape development [27; 28]. Basing on the data analysis, it is recommended to make zoning that will clearly distinguish land plots by their functional use (agricultural, forest or urban territories). Moreover, the land use plan should be in compliance with the natural ecological priorities (protection of biological diversity, availability of fresh water, halt of land degradation, etc.) and should consider the ecosystem sensitivity to climate changes.

Therefore, the authors of the research propose a conceptual basis for protection of self-sown forests on agricultural lands, which is founded on the integrated approach to land use management, including political, financial, technical, social support for introduction of better practices of sustainable land use [29] (Figure 3).

The authors of the work suggest that in Ukraine, it is reasonable to solve the problem of protection and recovery of the land surface natural capital by motivating land-owners and land-users to make changes in the use and management of their agricultural lands. Such motivation can be achieved by combining financial instruments (grants, subsidiaries, privileges, etc.) and non-financial (ecological education, public participation, etc.). It is necessary to develop a system of non-legal social responsibility with the focus on moral obligations and self-identity.

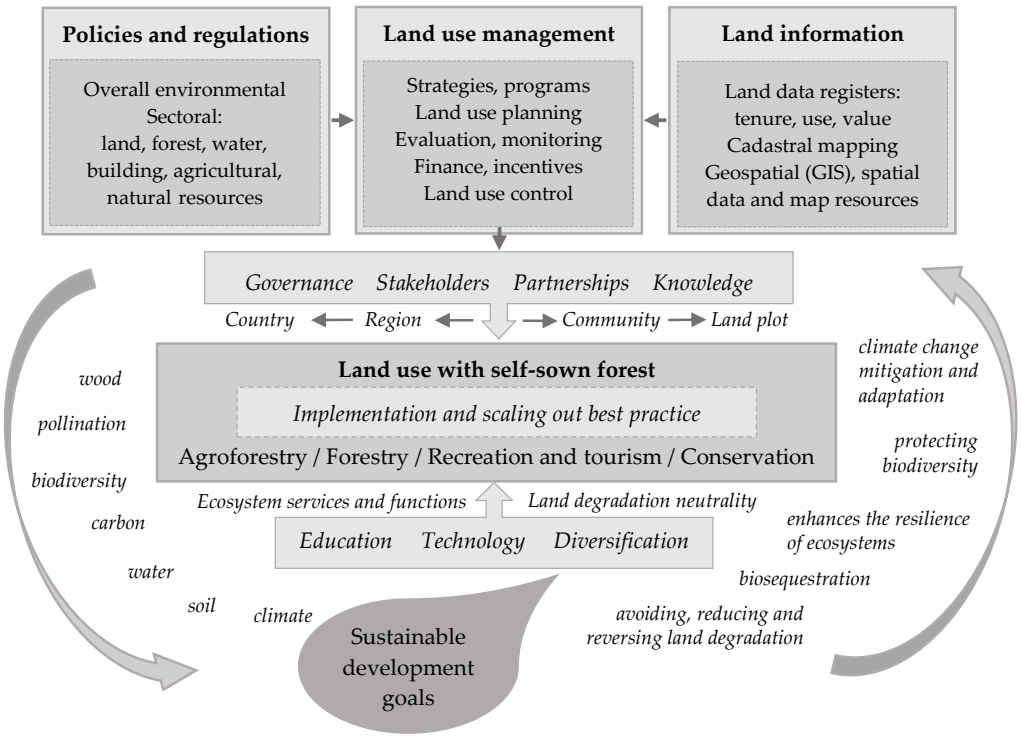


Figure 3. Integrated approach to management of agricultural lands with self-sown forests. Source: own research.

An important aspect is to overcome obstacles on the way of introducing practices of sustainable land use (e. g. no motivation, stimuli) by integrating sustainable management of land use into the key processes of making decisions on the self-sown forest use. Assessment and monitoring of the practices of sustainable management of lands along with other information create a basis for identification of the kinds of land use, which should be focused on the stimuli "forest or mixed", for example, forest+cropland (agroforestry); forest+cropland+grazing land (agro-silvo-pastoralism); cropland+grazing land (agro-pastoralism); forest+grazing land+other (silvo-pastoralism) [30]. Another way to protect self-sown forests is to develop tourism by diversifying farms [31]. Moreover, rural tourism should be defined as one of the best kinds of tourism in conditions of the Covid-19 pandemic [32].

Land governance should include the policy, institutes, rules, procedures, processes, which are involved in making decisions on using lands with self-sown forests, as well as ways of the decision implementation and fulfilment. The strategy of introduction of the integrated management of agricultural lands with self-sown forests should be focused on identifying stakeholders, knowledge management, partnership development. That strategy can be developed at the national, regional and local levels. The responsible management of landscapes needs development of partnership relations between business, power authorities and civil society to achieve the Sustainable Development Goals due to joint actions and application of innovative and environmentally sustainable methods, like integrated systems (agroforestry, other mixed biomass production systems), reforestation, assisted natural regeneration, buffer zones, etc.

4. Conclusions

Forests have significant advantages for human well-being, because they provide many ecosystem services. The issue of self-sown forests on agricultural lands is actual and relevant for Ukraine. It requires an integrated approach to land management based on the concepts of ecosystem services and achievement of the neutral degradation. In the future, it will reduce the area of ploughed lands, expand

the forest area, will contribute to improvement of biodiversity and prevent losses of the natural land capital.

An interview of the residents of Volyn and Lviv region confirms that 20-25% land owners are against destruction of self-sown forests and agree to have them in their ownership; 59% respondents, who do not possess any land, are also against destruction of self-sown forests, whilst 38% wish to possess forest lands. The respondents, who are against cutting down the self-sown forests, are mainly represented by people of the age category of 21-30 years old, whereas the wish to possess forest lands is declared by the 21–40-year-old respondents. It proves the expediency of protecting self-sown forests because young generation is interested in possessing such kind of lands.

Determination of the future purpose of using agricultural land with self-sown forests necessarily requires consideration of the values of ecosystem services, which can be supplied by applying different practices. The greatest environmental ecosystem value of self-sown forests can be achieved by conservation. In cases of agroforestry, forestry, recreation, the ecosystem value of self-sown forests is revealed in ensuring the social and economic goals of the territory development.

The authors propose a model of the integrated management of agricultural lands with self-sown forests, which should be considered in land use planning of communities in Ukraine. Particularly, it deals with the decisions concerning the purpose of lands; specification of the territory for reservation, afforestation, renaturalization and reclamation of degraded lands, or other natural ecosystems; development of measures on protection of land, water, forests and other natural resources; creation of ecological networks.

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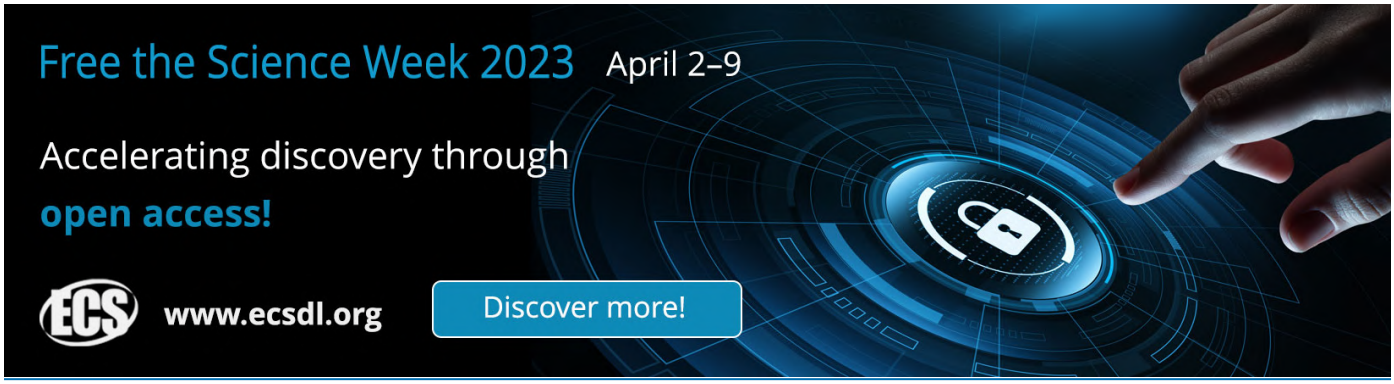
Profit as a main factor in forecasting agricultural business development



Profit as a main factor in forecasting agricultural business development

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Abstract. The essence and role of profit in forecasting the development of agricultural production are investigated in the article. The value of profit in modern conditions as an important driving force of the economy is determined and proved. It is revealed that forecasting the development of agricultural business is a set of studies of economic activities of the enterprise using appropriate sources of information, determining available reserves, analysing the results of activities and developing the necessary measures for efficient production. The DuPont model was used to analyse the impact of indicators on return on equity. It was found that the factor analysis of the profitability of own capital makes it possible to determine the impact of key factors on performance. Research has shown that return on equity depends on three factors: return on sales, asset turnover and the structure of advance capital. These factors summarize all aspects of financial and economic activities of the enterprise, their statics and dynamics. Based on the factor model, the possibilities of quantitative and qualitative growth of the basic economic indicators of activity of the agricultural enterprise, which are expressed in underused reserves of production resources, are defined. Possible directions of increasing the company's profit in modern conditions have been studied, among which the main ones may be: growth of production and sales volumes, optimization of production and sales costs and improvement of its quality.

1. Introduction

To ensure a stable position of the agricultural enterprise in the market it is necessary to be able to effectively assess its financial and economic position and the presence of potential competitors. Evaluation of financial and economic results is the most important characteristic of the financial activity of the organization, increasing the efficiency of which is possible on the basis of improving the internal planning of profits and profitability of the enterprise in order to rationally use resources and achieve maximum results.

The purpose of the article is to study the internal and external factors that affect profits, its role in forecasting business development and identifying reserves to increase the profitability of the enterprise.

There is no consensus on the definition, analysis and forecast of profitability, but there are differences in the interpretation of the economic content of indicators, which can lead to erroneous conclusions in the analytical work. However, the existing diversity in the definition of profitability only indicates the relevance of the topic.

2. Materials and methods

The theoretical and methodological basis of the research is a dialectical, systemic method and complex approaches to the study of scientific domestic and foreign research results on the role of profit in the development of agriculture. To achieve this goal were used: monographic method - to study and systematize domestic and foreign scientific achievements and practical experience of the development of agricultural enterprise, economic and statistical method - to study and summarize trends and patterns of dynamics of enterprise efficiency, calculation and constructive method - to calculate the main financial and economic results, the method of factor analysis - for to characterize the development of production and increase the effectiveness of economic activity, the method of financial analysis - to assess key factors to maximize profits.

3. Results

Profitability indicators are used to evaluate the effectiveness of agricultural activities enterprises and characterize both its overall efficiency and profitability of various activities (production, business, investment) [1, 2]. Profitability is used as an instrument of investment policy and pricing, characterizes the result, as its value means the ratio of the obtained effect to those involved resources, which reflects the company's ability to effectively use its funds to maximize profits [3].

It should be noted that in countries with developed market economies, chambers of commerce, industry associations or governments usually publish information annually on "acceptable" regulatory values of profit indicators. Comparing the company's own performance with their allowable values, we can draw conclusions about its financial and economic condition. In Ukraine, such an approach is not yet available, so the only basis for comparison is information on the value of indicators for previous years.

Various factor models are used to analyse profit indicators, from simple two-factor to multi-factor, which reveal the causal relationship between financial performance and financial condition of the enterprise [4].

One way to use appropriate indicators for the systematic transmission of information is the DuPont model [5]. Indicators of profitability of sales and turnover of assets became quite common in early twentieth century [6]. However, these indicators are used in a sense unsystematically, independently, without reference to factors of production.

In 1919, representatives of DuPont proposed a factor scheme analysis, which is shown in Figure 1.

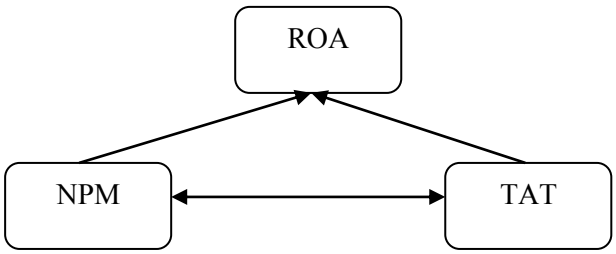

Figure 1. DuPont model scheme

In the DuPont factor model, for the first time, several indicators are interconnected, represented as a triangular structure. Return on total capital (ROA) is used as one of the important indicators of efficiency of capital investments. The activity of the enterprise is based on resource efficiency (TAT) and profitability of sales (NPM) [7].

The mathematical representation of the modified DuPont model has the form (1):

$$ROE = \frac{PE}{BH} \times \frac{BH}{A} \times \frac{A}{VK} \qquad (1)$$

where: ROE - return on equity;
PE - net profit;
A - the amount of assets of the organization;
BH - (production volume) sales revenue;
VK - equity of the enterprise.

This model shows that these factors summarize all aspects of economic activities of the agricultural enterprises, their statics and dynamics.

The topic of small and medium business development is very relevant today, as it is a socio-economic foundation, without which any innovation-oriented economy of a European country cannot develop. Small and medium enterprises are the most popular form of business activity and ensure socio-economic stability of development [8,9].

The role of small business in the modern economy cannot be overestimated. It is manifested in the fact that due to small business is:

- absorption of surplus labour and creation of new jobs, which contributes to the effective solution of employment and unemployment, especially in times of crisis;
- saturation of the consumer market with quality goods and services, meeting individual demand and stimulating aggregate demand as a whole;
- expanding the tax base for state and local budgets;
- rapid response to changes in market conditions, increasing flexibility and dynamism; increasing the welfare of the population and reducing poverty;
- formation of the business class as the basis of the middle class;
- mitigation of social tensions in society, democratization of market relations, ensuring socio-economic and political stability;
- giving the modern economy a competitive character and weakening monopoly tendencies, etc.

That is why supporting the development of small business is a strategic task of national governments to restore macroeconomic, as well as political and social stability. Small business hopes for quick and effective economic changes, an exit from the economic crisis and the creation of favourable conditions for economic growth.

Therefore, we will consider the main economic indicators of small agricultural enterprises of Ukraine and conduct a factor analysis of the gross profit of these enterprises (table 1).

Table 1. Data for the factor analysis of the formation of the gross profit of small agricultural enterprises of Ukraine for 2016-2020, UAH million

Indicator	2016	2017	2018	2019	2020	2020 in % to 2017
Net income from sales of products (goods, works, services)	144018	177513	198129	206240	238031	165,3
Cost of goods sold (goods, works, services)	110755	153503	178696	188211	207414	187,3
Gross profit	33263	24010	19433	18029	30617	92,1

Source: Compiled by the authors.

The analysis found that in these enterprises for the period 2016-2020 there is a gradual increase in net income - by 65.3%. At the same time, the increase in the cost of sales is faster, which leads to a decrease in gross profit by almost 8%.

The results of analysis of factors of the formation of gross profit under these conditions are given in table 2.

Table 2. The factor analysis of gross profit formation of small agricultural enterprises of Ukraine in 2016-2020, UAH million

Factors	2017	2018	2019	2020
Impact of changes in sales	12839	3940	1035	1840
Impact of changes in the structure and range of products sold	-5102	-1152	-239	940
Impact of changes in the level of costs per 1 UAH of sold products	-16990	-7365	-2199	9808
Total change in gross profit	-9253	-4577	-1403	12588

Source: Compiled by the authors.

Analyzing the influence of factors in 2017-2019 on the formation of the company's profit, it was found that that the decrease in the gross profit of small agricultural enterprises was mainly due to the negative changes in the structure and assortment of sold products and an increase in the level of expenses by 1 UAH of sold products. In 2020, gross profit compared to 2019 increased by 12,588 UAH million due to an increase in sales by 1,840 UAH million, changes in the structure and range of products sold - by 940 UAH million and a decrease in expenditures by 1 UAH of sales - by 9,808 UAH million. Factual analysis shows that the value of gross profit largely depends on the level of consumption per 1 UAH of sold products.

Direct profit shows the absolute effect of enterprises without taking into account the resources used, so for a more complete analysis the level of profitability should be taken into account. It is the degree of profitability of enterprises characterizes the profitability, the data for factor analysis of which are given in table 3.

Table 3. Data for factor analysis of return on equity of small agricultural enterprises of Ukraine.

Indicator	Conditional value	2016	2020	Deviation
Net profit, thousand UAH		35710	32620	-3090
Net income from sales of products, thousand UAH		144018	238031	94013
Value of assets, thousand UAH		943137	471022	-472115
Cost of equity, thousand UAH		131393	241429	110036
Profitability of sales	a	0,25	0,14	-0,11
Asset turnover ratio	b	0,15	0,51	0,36
Coefficient of financial dependence	c	7,18	1,95	-5,23
Return on equity	y	0,27	0,14	-0,13

Source: Compiled by the authors.

Analysis of the data for the factor analysis of return on equity of small agricultural enterprises shows that similarly to gross net profit of these enterprises decreased. The cost of equity increases, but the value of assets decreases. It is worth noting that the return on sales decreased by 44%, return on equity - by 48.2%, the ratio of financial dependence - by 72.8%, while the turnover ratio increased by 3.4 times, which led to an increase in income from product sales for UAH 94013 million.

Table 4 presents the initial data of LLC "Biotech LTD" for the calculation of factor analysis of return on equity.

Table 4. Data for factor analysis of return on equity of LLC "Biotech LTD".

Indicator	Conditional value	2018	2021	Deviation
Net profit, thousand UA		7381,0	12875,3	5494,3
Net income from sales of products,		61604,0	78456,7	16852,7

thousand UA				
Value of assets, thousand UA		61211,5	85302,5	24091,0
Cost of equity, thousand UAH		5393,0	4026,0	-1367,0
Profitability of sales	a	0,12	0,16	0,044
Asset turnover ratio	b	1,01	0,92	-0,087
Coefficient of financial dependence	c	11,35	21,19	9,838
Return on equity	y	1,37	3,20	1,829

Source: Compiled by the authors.

Analysis of the provision that almost all baseline indicators tend to increase. It is worth noting the increase in return on sales by - 33.3%, the ratio of financial area - 86.7%, while the turnover of assets decreased by 9%.

The results of calculations of the influence of factors on return on equity are summarized in table 5.

Table 5. Influence of factors on return on equity.

Factors	Calculation	Small enterprises of Ukraine	LLC "Biotech LTD"
ΔYa	$\Delta a \cdot b_o \cdot c_o$	-0,122	0,506
ΔYb	$a_1 \cdot \Delta b \cdot c_o$	0,347	-0,161
ΔYc	$a_1 \cdot b_1 \cdot \Delta c$	-0,362	1,485
Total impact		-0,137	1,829

Source: Compiled by the authors.

The calculation of the influence of factors on the profitability of the equity capital of small agricultural enterprises confirms that the change in the profitability of the equity capital of enterprises has a direct impact to a certain extent on all the above factors. Thus, an increase in the value of the factor affects the increase in return on equity positively, and, accordingly, a decrease - negatively.

It is established that the growth of return on equity of LLC "Biotech LTD" by 1,829 units is influenced by all factors. Thus, an increase in the return on sales increased the return on equity by 0.506 units, decrease in asset turnover - decrease in the return on equity by 0.161 units, an increase in the coefficient of financial dependence led to an increase in the return on equity by 1,485 units.

4. Discussion

The three-factor DuPont model has been the focus of many researchers. In particular, Eliseeva E N believes that this model shows the impact on the profitability of the company's operating, investment and financial activities, as the effectiveness of the organization's sales system directly determines the return on equity and, as a result, the investment attractiveness of the enterprise [10].

Likhutin P N and Savchenko A emphasize that the DuPont three-factor model is used to analyze the factors that affect the value of return on equity over time, without taking into account their variability. Therefore, he proposes to apply the DuPont three-factor model in terms of assessing the impact of growth rates of individual factors on the growth rates of the return on equity. Depending on the interests of stakeholders, the decomposition of the three-factor DuPont model is proposed, which allows building a typology of companies based on the degree of importance of individual factors [11].

Padake V and Soni R consider the DuPont model as part of a coefficient analysis methodology to monitor and increase business profitability. Liesz T J and Maranville S J believe that the concept of return on assets and return on equity provides a better understanding of drivers of profitability and profitability of its owners [12].

Vasile Burja and Radu Mărginean also point out that the DuPont model is a very useful tool for researching financial and economic indicators [13].

Hak-Seon Kim notes that in order to obtain a higher return on equity (ROE), assets should be valued at their gross book value, not net worth.

Satya Sontanam and Soliman M T emphasize the importance of taking into account in DuPont's analysis the various key financial indicators that contribute to return on capital and help investors make informed decisions.

In modern economic conditions, the agricultural enterprise is forced to independently determine the prospects for its development. Therefore, we believe that the successful solution of urgent economic problems certainly depends on the development of the theory of factor analysis, which allows determining the efficiency of the enterprise's economic activity, to identify patterns of change in the main results of its activities.

The use of the DuPont model can become the main competitive element of an agricultural enterprise, because with the help of the model, the factors that determine efficiency are revealed enterprises, evaluate their impact and trends. This model is used to compare the risk of investing or lending to a particular enterprise.

5. Conclusion

The development strategy of each enterprise should be aimed at improving the efficiency of production and profitability of its activities.

DuPont's multifactor model allows identifying the main problematic factors of agribusiness that have the greatest impact on the efficiency of the use of the assets and equity capital of the enterprise.

The authors believe that according to the results of research using this factor model, all factors can be considered as reserves to increase the return on equity capital. It is proved that an increase in the funds involved (increasing financial dependence) also leads to a certain increase in the level of return on equity. That is, the agricultural enterprise receives a profit in the form of an increase in the rate of return on equity based on financial risks and borrowed funds.

Based on the results obtained, the company can prevent the impact of negative trends, identify the presence and apply unused opportunities, thus providing additional increase in profit due to increase in sales profitability. Analytical studies show that the company the greatest attention should be paid to attracting internal reserves.

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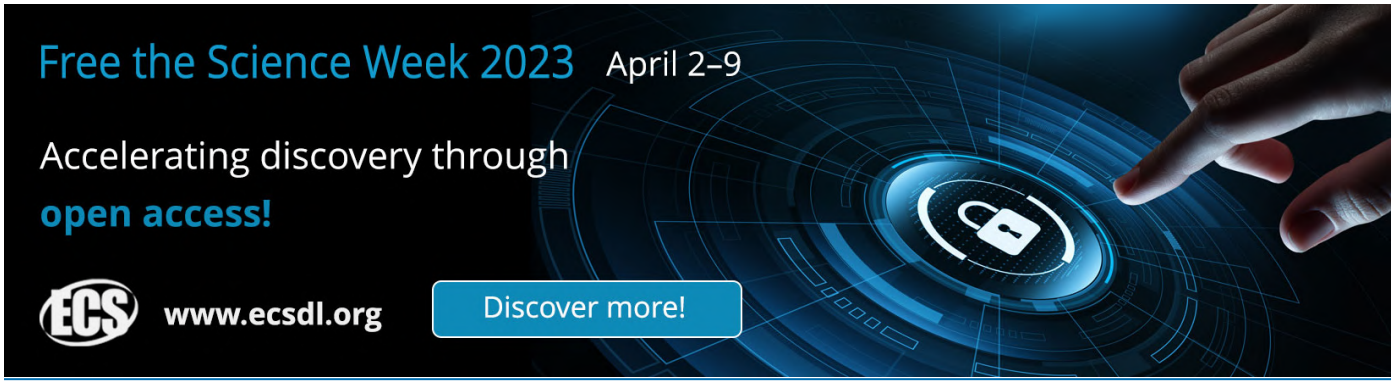
Modeling the sustainable development of the foreign economic activity of agricultural enterprises (case for Ukraine)



Modeling the sustainable development of the foreign economic activity of agricultural enterprises (case for Ukraine)

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Abstract. The level of any country's involvement in foreign trade significantly influences its economic situation, primarily because it is a major channel of foreign exchange earnings. The development of agriculture in Ukraine is the basis for increasing the gross domestic product, as it provides jobs to a significant part of the population. The success of foreign economic activity of agricultural enterprises is primarily determined by their level of strategic competitive advantage in the world market. Making management decisions on foreign economic activity, according to the position of competitiveness of agricultural enterprises, is a rather complex process, which should be preceded by analysis and assessment. Building strategic competitive advantages of agricultural enterprises ensures the efficiency and effectiveness of their foreign economic activity. The article deals with a methodical approach to classifying agricultural enterprises in Ukraine according to the degree of foreign economic activity, which includes calculation of the regional index of export competitiveness of agricultural enterprises and their grouping by the degree of foreign economic activity. For grouping, we propose to use a simple method for one grouping feature at regular intervals. As a result, three groups of agricultural enterprises of the regions of Ukraine are singled out in accordance with the degree of development of the foreign economic activity, namely with a low, medium, and a high degree of development.

1. Introduction

Agricultural enterprises implementing foreign economic activity are in severe competition with foreign and domestic producers. The region in which the enterprise operates may have favorable or less favorable conditions for foreign trade activities. Accordingly, one of the tasks that need to be solved for developing a strategy of foreign trade activities of agricultural enterprises is to determine the degree of development of foreign trade activities of the particular regions. Reasonable division of the regions into groups will allow identifying for the region's competitiveness (in which the agricultural enterprise operates). The obtained results enable it to single out its strengths and weaknesses and to form a plan of activities with regional competitors, taking into account these features. The choice of further development strategy also depends on this information.

2. Critical literature review

The growth of the national economy is possible due to the effective implementation of foreign trade activities, depending on the characteristics of the economy in the particular countries. Agricultural products have the largest share of total Ukrainian exports. However, the analysis of the foreign trade activities of agricultural enterprises shows the existence of systemic issues in this segment of the

economy and a significant number of unused reserves to increase the capacity of national enterprises in foreign markets of agricultural goods. The competitiveness of a country's agricultural products depends not only on its ability to export agricultural goods, but also on the sustainability of its agricultural sector [1]. The development of the agricultural sector considerably contributes to improving the economic well-being of society [2]. An important issue of agricultural policy in Ukraine is the use of available natural and labor resources in a sustainable manner, ensuring the effective, long-term and sustainable development of agriculture in territorial communities [3]. The foreign trade activities of Ukrainian agricultural enterprises are characterized by both positive features, such as an increase in production and export sizes, improvement of food self-sufficiency, and negative features: an irrational consumption structure, a decline in the share of processed products, and the raw material orientation of agro-food exports [4]. These aspects have to be taken into account when building a strategy for the development of foreign trade activities of agricultural enterprises. The increasing need for agricultural products in the world necessitates agricultural enterprises to increase their strategic competitive advantage, which in turn will increase the level of demand in foreign markets.

More often companies are facing external pressures related to high competition because of globalization and advances in technology [5]. In such conditions, the process of increasing competitiveness is important. According to A Liučvaitienė, K Peleckis, N Slavinskaitė and T Limba "competitiveness is the ability of an enterprise to operate with competitive advantage" [6]. Issues of global agribusiness competitiveness are of concern to many economists and scholars about the need to create a competitive advantage in the sector, especially in developing countries [7].

According to A Chikán, E Czakó, B Kiss-Dobronyi and D Losonci, for measuring competitiveness, we need:

- to take into account the enterprise's resources;
- to consider the ways of resources used for creating operational and adaptive capabilities (use and research of resources);
- to measure the effectiveness of the use of their capabilities in the process of combining them (such as, the implementation of business functions) [8].

The following foreign scientists study the formation of competitive advantages of enterprises: O L Rua and C Santos [9], S Adomako and M D Tran [10], T T Le and M Ikram [11], H Su, F Hou, Y Yang, Z Han and C Liu [12], J Falciola, M Jansen and V Rollo [13] and others. The growing demand for agricultural products around the world requires the agricultural sector to be constantly competitive, which depends on the developed strategy [14]. Practice shows that the effective development of agricultural enterprises, as well as other organizations, is possible only based on a detailed strategic development plan [15-17].

G S Fedoseeva [18] mentions that "for the development of the foreign trade activities, agricultural producers in Ukraine have such natural competitive advantages as sufficient labor force, favorable climatic conditions, rich agricultural resources, an abundance of water resources, achieved progress in agricultural trade and business development, as well as proximity to major foreign markets with an ever-increasing demand for agricultural products".

Yu F Hudz [19] studies the effectiveness of foreign trade activities of the agro-industrial complex at the regional level. In the research, he singled out the following main problematic issues and tasks of European integration cooperation: low competitiveness and quality of products of commodity producers; the need to expand markets and promote local goods and services on foreign markets; increase in exports of products of processing enterprises of the agricultural sector; lack of experience in developing specific cross-border projects, lobbying them in the relevant structures of the European Union to obtain funds under international technical assistance programs, etc.

According to M V Zapolska and Yu V Moroz [20], "the success of foreign trade activities of agricultural enterprises in the community depends on many internal and external factors, among which the formation and implementation of an effective strategy of foreign trade activities are one of the most important".

As we can see, in recent years much attention has been paid to the study of the foreign trade

activities of agricultural companies. However, the method of dividing Ukraine's regions based on the degree of development of the foreign trade activities of agricultural companies has not been formed yet.

The purpose of the research is to develop and implement a methodological approach to the classification of agricultural enterprises in the regions of Ukraine according to the level of development of foreign trade activities.

3. Materials and Methods

Information for the classification of agricultural enterprises in the regions of Ukraine based on the degree of development of the foreign economic activity is taken from the State Statistics Service. It includes data on the volume of exports of agricultural enterprises, total exports, exports by region. Data on agricultural exports are taken from regional statistical services.

A simple method of grouping by one grouping criterion (the index of export competitiveness of agricultural enterprises by region) with equal intervals is used for grouping agricultural enterprises in the regions of Ukraine based on the degree of development of the foreign economic activity.

4. Results and Discussion

The authors formed a methodological approach that allows classifying agricultural enterprises in the regions of Ukraine based on the degree of development of the foreign trade activities. The developed approach includes the assessment of the export competitiveness of agricultural companies in the region. The ratio of imports to exports greater than one indicates a positive trade balance.

The methodical approach to the classification of agricultural enterprises in the regions of Ukraine based on the degree of development of foreign economic activity consists of the following stages [21].

1 stage. At this stage, the regional index of export competitiveness of agricultural enterprises should be calculated. It is determined by the following formula:

$$RCA_p = \frac{x_i \times X}{x_i^{kp} \times X_i^{kp}} \quad (1),$$

where x_i is export of agricultural products in the region;

X is region's overall exports;

x_i^{kp} is export of agricultural products in the country;

X_i^{kp} is country's overall exports.

Stage 2. At this stage, agricultural enterprises in the regions of Ukraine should be grouped due to the degree of development of the foreign economic activity.

There are different methods of grouping agricultural enterprises in the regions of Ukraine by the level of foreign economic activity. In our opinion, among them, it is most appropriate to use a simple method of grouping on one grouping basis (in our case, it is the index of export competitiveness of agricultural enterprises by region) at regular intervals. The value of the interval is determined by the following formula:

$$i = \frac{x_{\max} - x_{\min}}{m} \quad (2),$$

where $x_{\max}$ is the maximum value of the grouping feature;

$x_{\min}$ is the minimum value of the grouping feature;

m is number of groups (in our case three groups).

Therefore, the boundaries of the three groups of agricultural companies in the regions of Ukraine due to the degree of advancement in their foreign economic activity will be as follows (Table 1).

Table 1. Classification of agricultural enterprises in the regions of Ukraine by the degree of advancement of the foreign economic activity.

The value of the index of export competitiveness of agricultural enterprises by region	The degree of advancement of foreign trade activities of agricultural enterprises in the regions
$x_{min} + i = x_1$	Low degree of advancement of foreign trade activities of agricultural enterprises in the regions
$x_1 + i = x_2$	Medium degree of advancement of foreign trade activities of agricultural enterprises in the regions
$x_2 + i = x_{max}$	High degree of advancement of foreign trade activities of agricultural enterprises of the regions

Source: authors' own research

At the next stage, we test the formed methodological approach, which allows the classification of agricultural enterprises in Ukraine's regions according to the degree of advancement of the foreign economic activity. First, we calculate the regional index of export competitiveness of agricultural enterprises (Table 2). Calculations are made on the basis of data from the State Statistics Service of Ukraine and the Main Departments of Statistics in the regions [22].

Table 2. Regional index of export competitiveness of agricultural enterprises in 2017-2019.

Region	Index, RCA_p		
	2017	2018	2019
Vinnytsya	0,00157644	0,00184958	0,00148320
Volyn	0,00012522	0,00010508	0,00009364
Dnipropetrovsk	0,00475667	0,00451412	0,00387955
Donetsk	0,00118692	0,00043648	0,00161674
Zhytomyr	0,00011354	0,00010766	0,00013436
Zakarpattya	0,00021088	0,00020696	0,00017046
Zaporizhzhya	0,00179514	0,00182199	0,00168201
Ivano-Frankivsk	0,00011518	0,00008196	0,00011861
Kyiv	0,00257543	0,00251883	0,00227370
Kirovohrad	0,00015498	0,00023052	0,00035939
Luhansk	0,00001046	0,00000951	0,00000409
Lviv	0,00087370	0,00113478	0,00143187
Mykolayiv	0,00324751	0,00348265	0,00288061
Odesa	0,00300925	0,00227400	0,00130580
Poltava	0,00136501	0,00105218	0,00117935
Rivne	0,00005123	0,00004491	0,00004371
Sumy	0,00028631	0,00041927	0,00043176
Ternopil	0,00007416	0,00009106	0,00005922
Kharkiv	0,00085723	0,00078017	0,00090961
Kherson	0,00006828	0,00005334	0,00004209
Khmelnytskiy	0,00016164	0,00029675	0,00025194
Cherkasy	0,00056204	0,00063175	0,00055903
Chernivtsi	0,00000772	0,00001269	0,00001336
Chernihiv	0,00031281	0,00042298	0,00041281

Source: authors' own research

Therefore, it is necessary to group agricultural enterprises of regions of Ukraine due to the degree of the foreign trade activities, on the basis of the index of export competitiveness of agricultural enterprises by region in 2017-2019. For this purpose, we use a simple grouping method to divide

agricultural enterprises into three groups at regular intervals (Fig. 1-3).

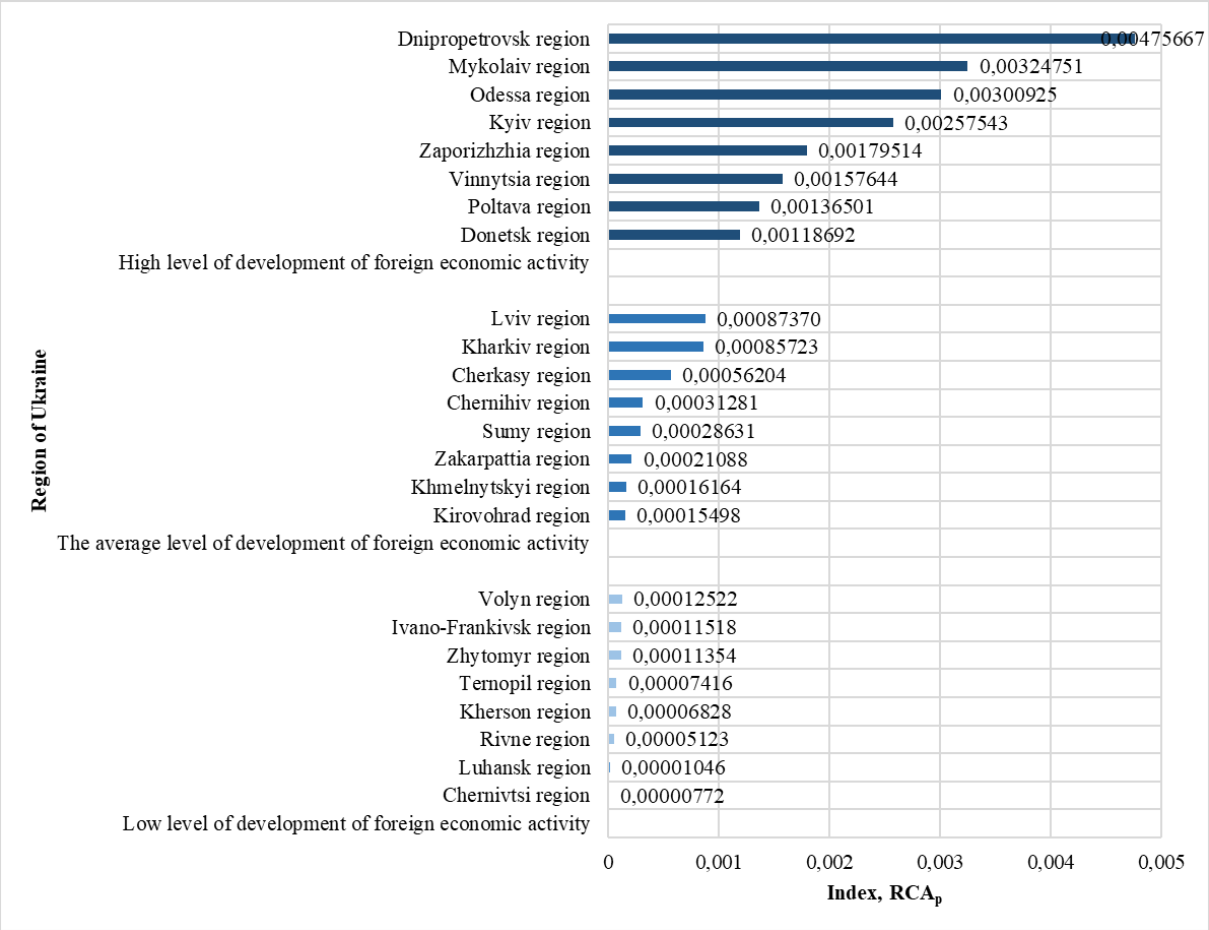

Figure 1. Classification of agricultural enterprises in the regions of Ukraine due to the degree of advancement of the foreign economic activity in 2017.

Source: authors' own research

According to the results of the grouping, 3 groups of agricultural enterprises of the regions of Ukraine were determined due to the degree of economic development in 2017. The regions with a low degree of economic development in 2017 included the following: Chernivtsi, Luhansk, Rivne, Kherson, Ternopil, Zhytomyr, Ivano-Frankivsk, and Volyn. The regional index of export competitiveness of agricultural enterprises of these regions in 2017 ranged from 0.00000772 to 0.00012522.

The regions with an average level of economic development in 2017 included the following: Kirovohrad, Khmelnytskyi, Zakarpattia, Sumy, Chernihiv, Cherkasy, Kharkiv and Lviv. The regional index of export competitiveness of agricultural enterprises of these regions in 2017 ranged from 0.00015498 to 0.00087370.

The regions with a high degree of economic development in 2017 included the following: Donetsk, Poltava, Vinnytsia, Zaporizhzhya, Kyiv, Odesa, Mykolaiv, and Dnipropetrovsk. The regional index of export competitiveness of agricultural enterprises of these regions in 2017 ranged from 0.00118692 to 0.00475667.

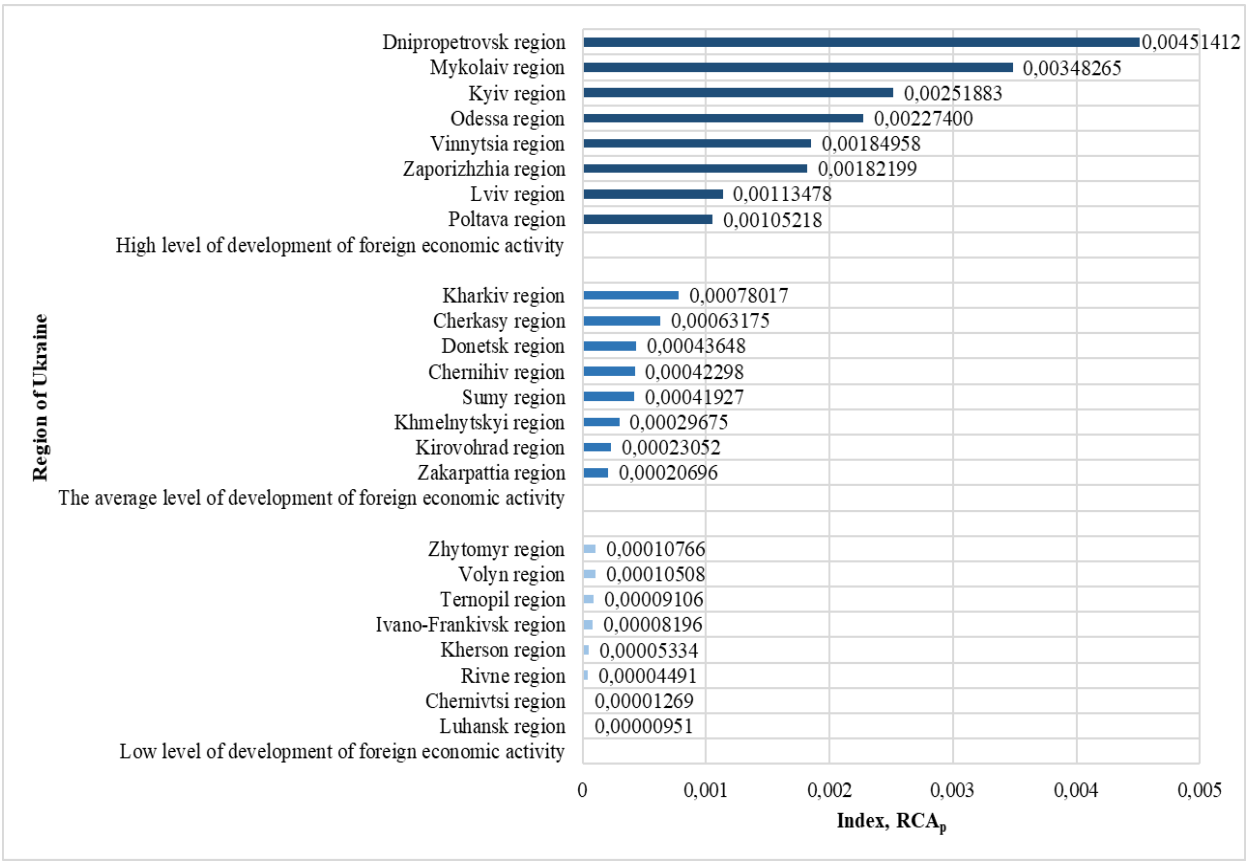

Figure 2. Classification of agricultural enterprises in the regions of Ukraine due to the degree of advancement of the foreign economic activity in 2018.

Source: authors' own research

As a result of the grouping, we identified 3 groups of agricultural enterprises in the regions of Ukraine due to the degree of economic development in 2018. The regions with a low degree of economic development in 2018 included the following: Luhansk, Chernivtsi, Rivne, Kherson, Ivano-Frankivsk, Ternopil, Volyn and Zhytomyrskyi. The regional index of export competitiveness of agricultural enterprises of these regions in 2018 ranged from 0.00000951 to 0.00010766.

The regions with an average level of economic development in 2018 included the following: Zakarpattia, Kirovohrad, Khmelnytskyi, Sumy, Chernihiv, Donetsk, Cherkasy and Kharkiv. The regional index of export competitiveness of agricultural enterprises of these regions in 2018 ranged from 0.00020696 to 0.00078017.

The regions with a high degree of economic development in 2018 included the following: Poltava, Lviv, Zaporizhzhya, Vinnytsia, Odesa, Kyiv, Mykolaiv, and Dnipropetrovsk. The regional index of export competitiveness of agricultural enterprises of these regions in 2018 ranged from 0.00105218 to 0.00451412.

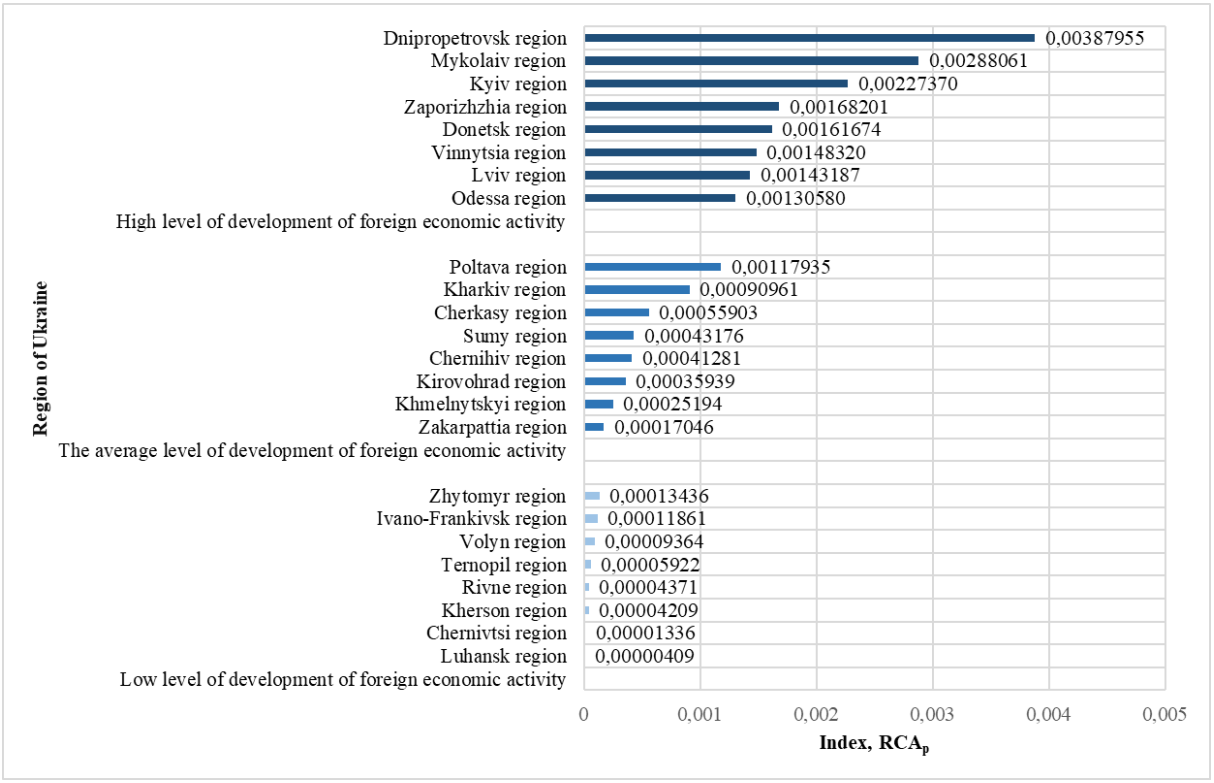

Figure 3. Classification of agricultural enterprises in the regions of Ukraine due to the degree of advancement of the foreign economic activity in 2019.

Source: authors' own research

According to the results of the grouping, three groups of agricultural enterprises in the regions of Ukraine were identified by the level of foreign economic activity in 2019. Luhansk, Chernivtsi, Kherson, Rivne, Ternopil, Volyn, Ivano-Frankivsk Zhytomyr are the regions with the lowest level of foreign trade activities in 2019. The regional index of export competitiveness of agricultural enterprises in these regions in 2019 ranged from 0.00000409 to 0.00013436.

Regions with a medium degree of development of foreign trade activities in 2019 are Zakarpattia, Khmelnytsky, Kirovohrad, Chernihiv, Sumy, Cherkasy, Kharkiv, and Poltava. The regional index of export competitiveness of agricultural enterprises in these regions in 2019 ranged from 0.00017046 to 0.00117935.

Regions with a high degree of development of foreign trade activities in 2019 are Odesa, Lviv, Vinnytsia, Donetsk, Zaporizhia, Kyiv, Mykolaiv, and Dnipropetrovsk. The regional index of export competitiveness of agricultural enterprises in these regions in 2019 ranged from 0.00130580 to 0.00387955.

At the next stage, we conduct a comparative analysis of agricultural enterprises in the regions of Ukraine due to the degree f economic development in 2017-2019 (Table 3).

Table 3. Comparative analysis of agricultural enterprises of the regions of Ukraine due to the degree of development of foreign trade in 2017-2019.

Place in the rating	Region	Index, RCAp	Region	Index, RCAp	Region	Index, RCAp
	2017		2018		2019	
High level of development of foreign economic activity						
1	Dnipropetrovsk	0,00475667	Dnipropetrovsk	0,00451412	Dnipropetrovsk	0,00387955
2	Mykolayiv	0,00324751	Mykolayiv	0,00348265	Mykolayiv	0,00288061
3	Odesa	0,00300925	Kyiv	0,00251883	Kyiv	0,00227370
4	Kyiv	0,00257543	Odesa	0,00227400	Zaporizhzhya	0,00168201
5	Zaporizhzhya	0,00179514	Vinnytsya	0,00184958	Donetsk	0,00161674
6	Vinnytsya	0,00157644	Zaporizhzhya	0,00182199	Vinnytsya	0,00148320
7	Poltava	0,00136501	Lviv	0,00113478	Lviv	0,00143187
8	Donetsk	0,00118692	Poltava	0,00105218	Odesa	0,00130580
The average level of development of foreign economic activity						
9	Lviv	0,00087370	Kharkiv	0,00078017	Poltava	0,00117935
10	Kharkiv	0,00085723	Cherkasy	0,00063175	Kharkiv	0,00090961
11	Cherkasy	0,00056204	Donetsk	0,00043648	Cherkasy	0,00055903
12	Chernihiv	0,00031281	Chernihiv	0,00042298	Sumy	0,00043176
13	Sumy	0,00028631	Sumy	0,00041927	Chernihiv	0,00041281
14	Zakarpattya	0,00021088	Khmelnytskiy	0,00029675	Kirovohrad	0,00035939
15	Khmelnytskiy	0,00016164	Kirovohrad	0,00023052	Khmelnytskiy	0,00025194
16	Kirovohrad	0,00015498	Zakarpattya	0,00020696	Zakarpattya	0,00017046
Low level of development of foreign economic activity						
17	Volyn	0,00012522	Zhytomyr	0,00010766	Zhytomyr	0,00013436
18	Ivano-Frankivsk	0,00011518	Volyn	0,00010508	Ivano-Frankivsk	0,00011861
19	Zhytomyr	0,00011354	Ternopil	0,00009106	Volyn	0,00009364
20	Ternopil	0,00007416	Ivano-Frankivsk	0,00008196	Ternopil	0,00005922
21	Kherson	0,00006828	Kherson	0,00005334	Rivne	0,00004371
22	Rivne	0,00005123	Rivne	0,00004491	Kherson	0,00004209
23	Luhansk	0,00001046	Chernivtsi	0,00001269	Chernivtsi	0,00001336
24	Chernivtsi	0,00000772	Luhansk	0,00000951	Luhansk	0,00000409

Source: authors' own research

Agricultural enterprises in the region with a high level of foreign economic activity are characterized by a significant share of exports of agricultural goods compared to the overall exports of the region. This indicates their importance at the regional level as enterprises with a high degree of competitiveness.

Agricultural enterprises in the region with a medium level of foreign economic activity are characterized by instability in agricultural exports, as their share in the overall exports of the region is less significant. They have the potential to increase or decrease this type of activity.

Agricultural enterprises in the region with a low level of foreign economic activity are characterized by a low share of agricultural exports compared to the overall exports of the region. It reveals a low level of export orientation or low production capacity of agricultural enterprises in the region.

5. Conclusions

Thus, a methodological approach is formed to classify agricultural enterprises according to the level of development of foreign trade activities into three groups, such as low, medium, and high. Approbation

of the developed methodological approach is carried out according to the official statistical reporting in 2017-2019.

The classification of agricultural enterprises of the regions of Ukraine due to the degree of advancement of foreign economic activity makes it possible to determine which region of Ukraine is favorable and competitive for the implementation of foreign trade activities. Based on this, the management of an agricultural enterprise operating in a certain region can determine its strengths and weaknesses, form a plan for working with regional competitors and choose a further development strategy.

For increasing the regional index of export competitiveness of agricultural enterprises, the factors of four levels should be taken into account: micro-level, meso-level, macro-level and mega-level. The micro-level factors influencing the formation of strategic competitive advantages in the development of agricultural enterprises include resource, operational and strategic factors. The meso-level includes factors related to the development and functioning of the agricultural industry. These are political, economic, socio-cultural, and technological factors (factors of the distant external environment), as well as intra-industry competition. The macro-level factors affecting the formation of strategic competitive advantages of the development of agricultural companies include geopolitical and socio-economic factors of the country's development, institutional and legal support. Mega-level factors are sectoral international trade, the development of the main exporting countries and importing countries, as well as the market position of the main competitors.

Further research should focus on developing a mechanism for assessing the degree of potential for the formation of strategic competitive advantages of foreign economic activity of agricultural enterprises, which will allow to development of an appropriate development strategy. In order to carry out a comparative analysis of the potential for increasing the strategic competitive advantages of the development of agricultural enterprises' foreign economic activity, in our opinion, we should take into account the factors of the micro level, which will be unique for each individual agricultural enterprise that carries out foreign economic activity. Meso-, macro-, and mega-level factors have the same input conditions for all agricultural enterprises of Ukraine, since they include factors related to the development of foreign trade activities at the level of the industry, the country, and at the international level. Thus, further research should analyze the use of resource, operational and strategic factors to determine the potential for increasing the strategic competitive advantages of the agricultural enterprise's foreign economic activity.

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Development of the environmental market in Ukraine in the strategic perspective

Development of the environmental market in Ukraine in the strategic perspective

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Abstract. The article reveals the features of organizational and economic support for the development of the environmental market in Ukraine. It shows the analysis of development of the environmentally friendly products market and services in Ukraine. Here we built a multiple-regression model of organic consumption in Ukraine, and the analysis is based on the following factors: the number of certified producers of organic products; the volume of consumption of organic products on the domestic market; the area of agricultural land allocated for organic production and the capacity of the organic market in Ukraine. It is proved that in order to intensify the organizational and economic support of the environmental market in Ukraine, it is necessary to determine the main socio-ecological and economic tools for creating a system of environmental goods production, including the adoption of new legislation; the implementation of the Ukraine-EU Association Agreement; informatization of the economy, formation of online services; the dissemination of environmental audit activities; the environmental insurance services in the agro-industrial complex; the digitalization of production cycles from production, logistics to preservation of quality and terms of realization and delivery of ecological production. We offered a number of strategic directions for ecological market development in Ukraine.

1. Introduction

The transition to sustainable development requires improving the quality of the environment and the quality of life in the population. One of the areas of environmental safety is the formation and development of environmental entrepreneurship. Environmentally oriented production and sale of environmental goods is a promising and profitable activity. One of the new opportunities for business is the formation and development of environmentally friendly products market and services. According to the implementation of the Association Agreement with the European Union and Ukraine's support for the objectives of the European Green Course, it is important to comply with the norms and standards of organization of organic production. Solving this problem requires qualitatively new changes in management methods in the areas of modernization and greening of industry and sustainable agriculture. Ensuring the transition to models of sustainable consumption, production and balanced management of natural resources provided by Sustainable Development Strategy for Ukraine until 2030 is impossible without the introduction of new tools and business models of organic

production from the standpoint of sustainable growth, digitalization, circular economy, organic production. Such approaches include the use of preventive management strategies which increase the efficiency of natural resources, minimize waste generation and are based on the use of tools of "green" economy, environmental culture, regulations of environment friendly production, etc.

2. Critical literature review

Theoretico-methodological and applied provisions of organizational and economic support for the system of organic production in Ukraine are revealed in the scientific works of V Granovska [2], L Granovska [3], V Prokhorova [4], R Ostapenko [5], K Pylypenko [8], M Bahorka [10], K Moskalenko [11]. The scientific works of N Andrusenko [1], O Veklych [6], T Galushkina [7], S Marova [9], Y Herasymenko [12], D Mishchenko [13], V Savchuk [14], P Skrypchuk [15], A Yakymchuk [16] reveal aspects of formation of the environmental market and services. However, they need further research on the issue of organizational and economic support for the development of the environmental market in Ukraine in the context of European integration.

S Marova, D Solokha, O Bieliakova and V Kysil define the formation of the ecological market as a complex process that requires the coordination of the interests of all its actors, especially producers, consumers and society. Goods that meet the interests of only one market participant are unclaimed, because their promotion is actively opposed by other market participants. The authors believe that it is necessary to choose environmentally friendly goods that best meet the interests of all actors involved in the market formation. This will help to avoid unnecessary costs and extend the life cycle of this product [9].

P Skrypchuk and O Suduk note that the environmental market in Ukraine is developing extremely slowly and there is no effective mechanism to support the promotion of entrepreneurship in the field of environmental protection. To attract entrepreneurs to the development of environmental business, it is necessary to create a flexible mechanism for the interaction of environmental and market structures, ensuring material interest and support for entrepreneurial activity by the state [15].

In our opinion, the environmental market in Ukraine, despite the backwardness of similar markets of developed countries, has an extensive infrastructure and a wide range of services. Its capabilities allow domestic enterprises to use innovative mechanisms and tools to make a qualitative assessment of enterprises and develop more effective environmental management strategies. Wider use of innovations on the environmental goods and services market at the regional level will significantly increase the competitiveness of both individual enterprises and the country in general.

3. Methodology and results

The methodological basis of the research is general theoretical methods of scientific knowledge, dialectical method, systems analysis, fundamental provisions of management theory, mathematical economic modeling and forecasting, concepts of sustainable development. We also used monographic and dialectical methods to outline the genesis of the ecological market theory; methods of comparative and structural analysis, index method, ranking method, grouping, modeling – to assess the level of development of the environmental market in Ukraine; graphic method – for a visual representation of the dynamics of activities.

In the developed countries of the world, the environmental market has been formed long now that ensures the development of the economy and society. The world has accumulated a wealth of experience that indicates the vital need to develop a market for environmental services and significant real benefits for companies operating on it.

According to the organizations that keep the statistics on the production and sale of organic products (IFOAM, FiBL, International Public Association "BIOLan Ukraine", LLC "Organic Standard"), the area of certified organic lands and farms in Ukraine is increasing every year. Thus, the area of agricultural land allocated for organic production has increased from 164.4 thousand hectares in 2002 to 385 thousand hectares in 2019, and the number of certified (according to international

standards) producers for the study period has increased by 20 times (from 31 to 617, respectively) (Figure 1).

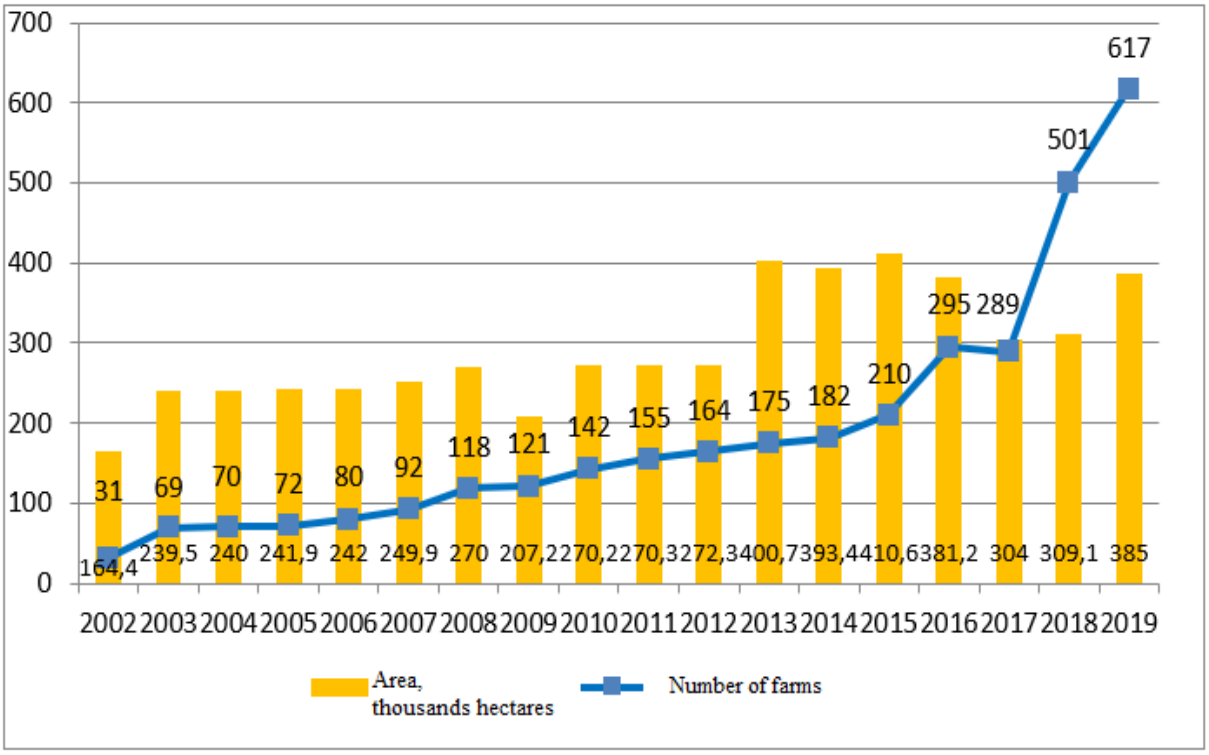

Figure 1. Number of certified organic farms and land area in Ukraine in 2002-2019. [17]

In November 2020, 722 organic market operators were registered; 114 of them have processing as a certified activity, and 64 of them do a shelf-ready packing. In 2020 significantly increased the number and stabilized the areas of organic processing and refining, this figure is the 24th and in comparison with the last year increased by 60% [17].

Taking into consideration the experience of European countries on the development of "green" economy, the priority areas of "green" growth in Ukraine include: the formation of programs to improve energy efficiency, development of renewable and alternative energy; introduction of resource-saving technologies and environmentally friendly production; creating a favorable investment climate for the development of "green" business; introduction of ecological innovations in order to ensure the ecological security of the country; development of the environmental market and creation of an information base on the provision of relevant services [18].

To identify the factor of relationship between the volume of organic products consumption on the domestic market (dependent variable - y) and the number of certified producers of organic products, the area of agricultural land allocated for organic production, the capacity of the organic market (independent variables - x), we built a regression model of organic products consumption in Ukraine.

The first step to create a regression model is to identify the nature of the relationship between the dependent variable and every independent ones. The scatter plot of and the number of certified producers of organic products shows a linear relationship between these factors (Figure 2). This is confirmed by the value of Pearson correlation coefficient, which determines the degree of linear relationship between two variables. Pearson's coefficient for *y* and x1 is 0.930123, and shows that the relationship between these factors by 93.0123% is due to the linear form with a positive slope.

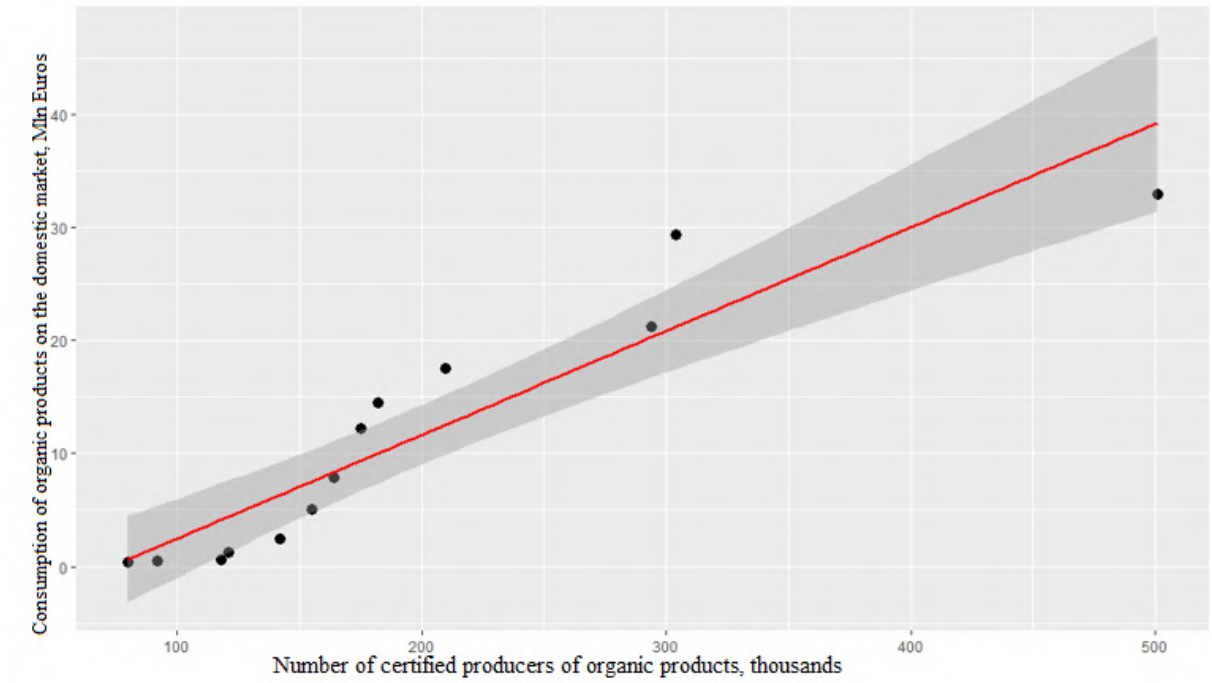

Figure 2. The scatter plot of consumption of organic products and the number of certified producers of organic products.

The scatter plot between the consumption of organic products on the domestic market and the area of agricultural land allocated for organic production shows the lack of strong linear relationship between these variables (Figure 3). This is confirmed by the value of Pearson coefficient that is 0.407105. The relationship between y and x 1 is present, but not linear.

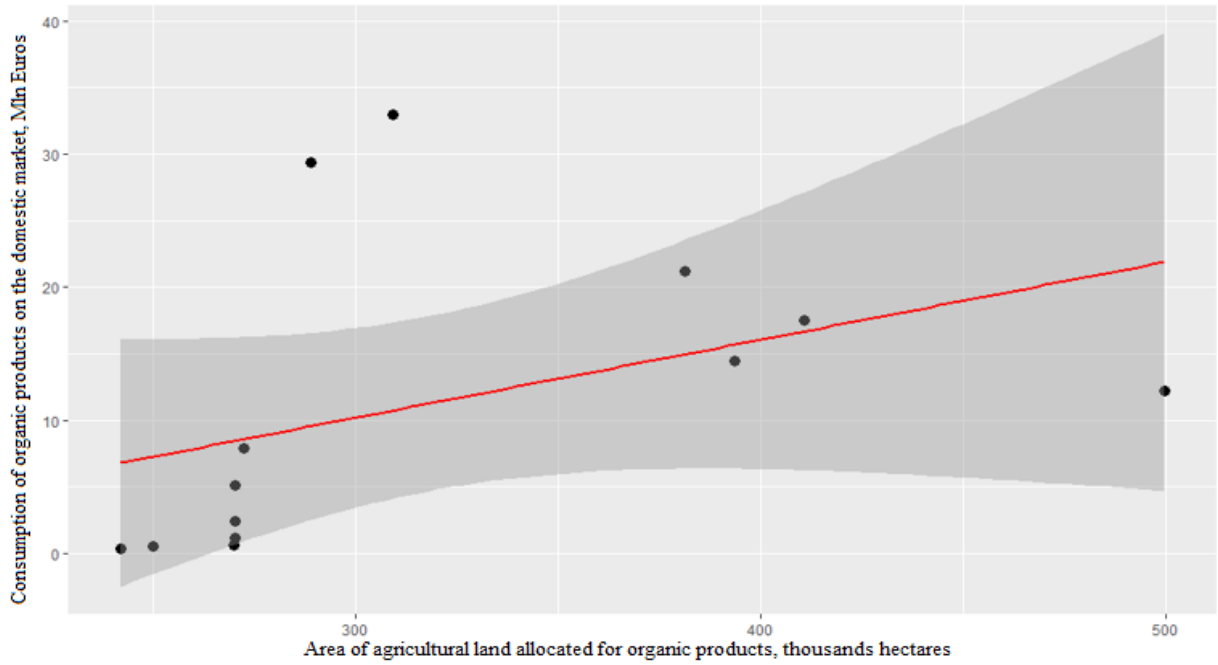

Figure 3. The scatter plot of consumption of organic products and the area of certified organic lands.

The highest value of Pearson coefficient (0.651988) is achieved if the relationship between the variables is as follows: ln (y) ~ ln (x2). At 65.1988% the relationship between the volume of consumption of organic products and the area of agricultural land allocated for organic products is explained by the percentage increase of two values, but not the nominal ones.

The shape of the scatter plot of consumption of organic products and the capacity of the organic market in Ukraine (Figure 4) indicates a linear relationship between these factors. Pearson's correlation coefficient is 0.964837 and shows the relationship between these factors by 96.4837% is due to the linear form with a positive slope.

The initial regression model of organic products consumption in Ukraine is as follows:

$$y = 53{,}3882 + 0{,}0177x_1 - 10{,}1355\ln(x_2) + 1{,}4683x_3. \quad (1)$$

To optimize the appearance of the model or to confirm that this model is the most optimal, we used the inverse method of sequential elements rejection by comparison of the adjusted coefficient of determination.

The second step to create a regression model is to study the model for the need to include a constant number. The adjusted coefficient of determination for the model with a constant is 0.9761, for the model without a constant is 0.9818. A higher value of the adjusted coefficient of determination indicates a stronger linear relationship between the data.

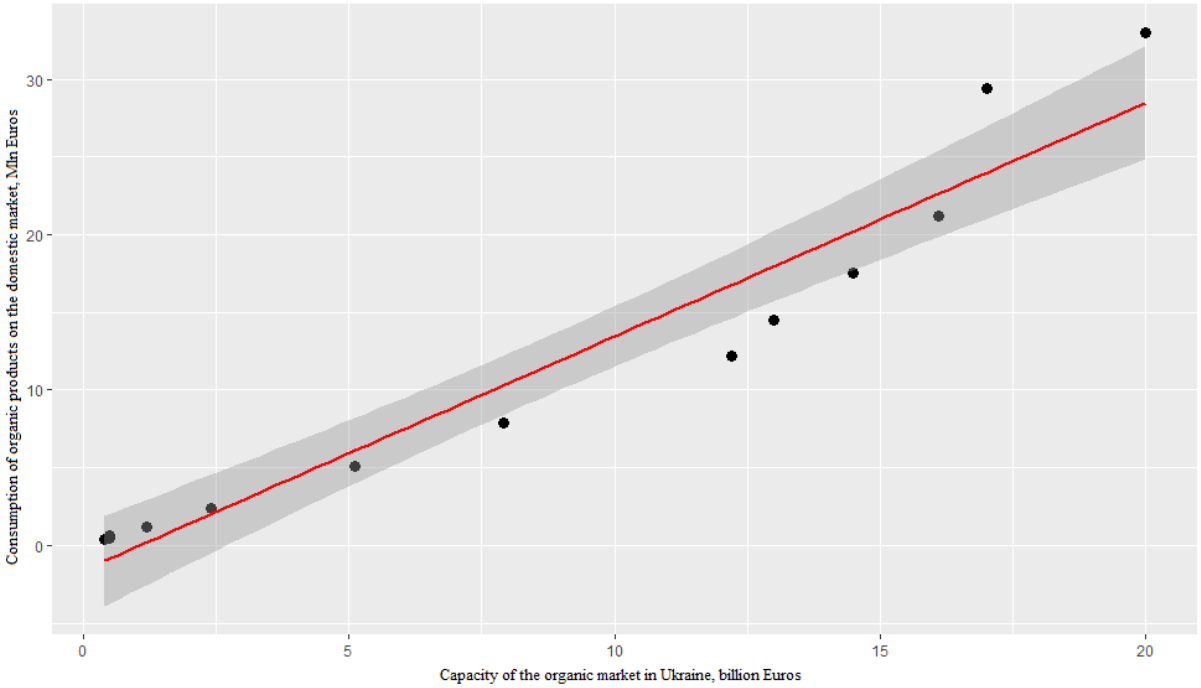

Figure 4. The scatter plot of consumption of organic products and capacity of the organic market.

The third stage to optimize the regression model involves the search for the inclusion two of the three independent variables in the model. Comparative characteristics of models of consumption of organic products are given in Table 1.

As we can see, the highest value of the adjusted coefficient of determination in the model with the three variables without a constant number, therefore the use of the inverse method of model selection is stopped. The most optimal for the three analyzed variables is the following model:

$$y = 0.0369x_1 - 0.8239\ln(x_2) + 1.0235x_3. \quad (2)$$

Table 1. Comparative characteristics of models of organic products consumption.

	model0	model1	model2.1	model2.2	model2.3
(Intercept)	53.388 * (22.664)				
x1	0.018 (0.012)	0.037 ** (0.010)		0.012 (0.012)	0.091 *** (0.011)
ln (x2)	-10,136 * (3,957)	-0.824 ** (0.217)	-0.318 (0.240)		-1.129 * (0.449)
x3	1,468 *** (0,232)	1,023 *** (0.162)	1,523 *** (0,126)	1,162 *** (0,236)	
R- squared	0.982	0.986	0.968	0.966	0.931
N	13	13	13	13	13
Significance : *** = p <0.001; ** = p <0.01; * = p <0.05					

Compiled by the authors.

We used the Ramsey test to check for missing variables. The Ramsey test coefficient is 4.003. The initial data of the test of missed data show that at the reliability level of 99% and 95% the model does not include 2 additional variables. At the reliability level of 90% the hypothesis of the presence of missed factors is rejected, p - value is an acceptable value.

For the analyzed model, the coefficient of determination is 0.9860, the adjusted coefficient of determination is 0.9818. The linear relationship between the independent variables (the number of certified organic producers, the area of agricultural land allocated for organic production, the capacity of the organic market) and the dependent variable (consumption of organic products in the domestic market) is more than 98% linear. According to the value of F-statistics, the model is significant, p-value = 1,435e-19. The residual standard error is 2,103. The coefficients for the variables x_1 and ln (x_2) are significant with a reliability level of 99%, the coefficient for the variable x_3 is significant with a reliability level of 99.9%.

The summarized characteristics of the model of organic products consumption model1 are given in Table 2.

Table 2. Summarized characteristics of the model of organic products consumption model1.

Call : lm (formula = y ~ x1 + ln (x2) + x3 + 0)				
Residuals :				
Min	1Q	Median	3Q	Max
-1.6217	-1.2254	-0.5958	0.3485	5.4561
Coefficients :				
	Estimate	Std . Error	t value	Pr (> | t |)
x1	0.03689	0.01016	3,630 th most common	0.00462 **
ln (x2)	-0.82393	0.21656	-3,805 th most common	0.00346 **
x3	1.02350	0.16246	6,300 th most common	8.91e-05 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 " 1				
Residual standard error : 2.103 on 10 degrees of freedom				
Multiple R - squared : 0.986, Adjusted R - squared : 0.9818				
F- statistic : 235.2 on 3 and 10 DF, p- value : 1.435e-09				

Compiled by the authors.

Therefore, the values of the coefficients near the independent variables allow us to make the following conclusions:

− as the number of certified producers per farm increases, the consumption of organic products increases by 36.89 thousand Euros under other constant conditions;

− as the area of agricultural land allocated for organic production increases by 1 thousand hectares, the consumption of organic products decreases by 0.82% under other constant conditions;

− as the capacity of the organic market increases by 1 billion Euros, consumption of organic products increases by 1.02 million Euros under other constant conditions.

For coefficients near variables other than point ones, interval forecasts are investigated. At the reliability level of 95%, the coefficient near the variable x_1 ranges from 0.0142 to 0.0595; the coefficient near the variable ln (x 2) ranges from -1.3065 to -0.3414; the coefficient near the variable x 3 ranges from 0.6615 to 1.3855 (Table 3). The capacity of the organic market in Ukraine by the value of the regression model is shown graphically in Figure 5.

Table 3. Confidence intervals of coefficients near independent variables.

	2.5%	97.5%
x1	0.01424161	0.05952941
ln (x2)	-1.30645998	-0.34140712
x3	0.66151369	1.38548274

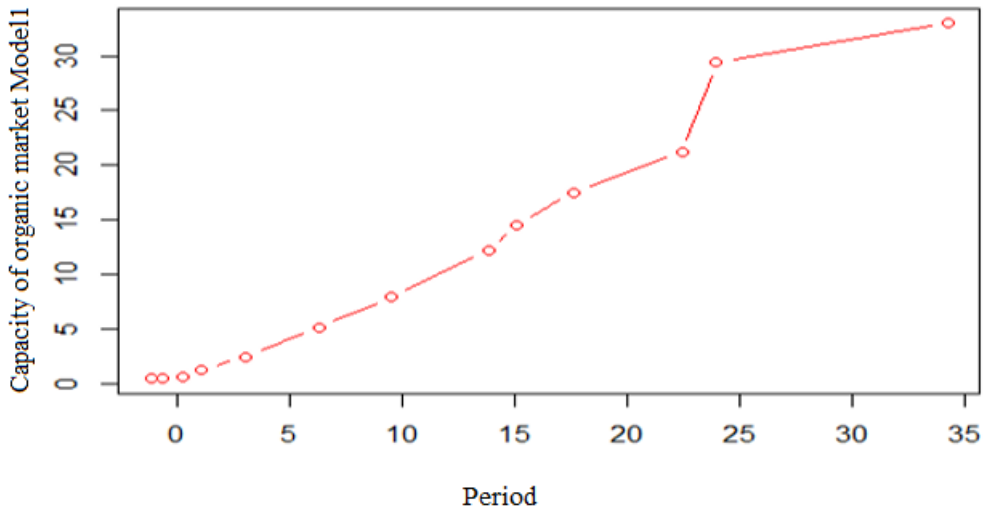

Figure 5. The capacity of organic market in Ukraine by the value of the regression model.
Compiled by the authors.

The research shows that the development of the organic sector in Ukraine requires an active public policy. In November 2020, the parliament of Ukraine adopted amendments to the law "On State Support of Agriculture of Ukraine" and other laws on the functioning of the State Agrarian Register and improving state support for agricultural producers (№ 3295), which provide three areas of state support producers of organic production: the budget allocation of subsidies per unit of arable land or a head of cattle; reimbursement up to 30% of the cost of organic production certification; reimbursement up to 30% of the cost of purchases allowed for use, fertilizers, seeds, feed [19]. To implement these areas of state support for organic production, it is necessary to create a national Register of organic products producers.

Further development of entrepreneurship in Ukraine without sufficient consideration of environmental factors may lead to a greater increase in the environmental burdens and the inability to organize the organic production. Under these conditions, the main direction of maintaining the natural base is the implementation of effective measures in the nature management system and the active development of various forms of environmental business. Therefore, we believe that enterprises, communities, businesses need to develop the following conceptual competitive advantages:

– to conduct an ecological audit of territories, management systems, enterprises, technologies and virtually all types of natural resources;
– to improve business reputation and image;
– to increase the investment attractiveness in the regions;
– to form motivational mechanisms for the introduction of ecological innovations;
– to create safer working and living conditions for the population in communities;
– to increase the consumer confidence;
– to introduce e-technologies, logistics, social networks for sales and services;
– to organize a full cycle of waste management;
– to contribute to production costs savings, sales and services;
– to use the resources and energy rational;
– to reduce the environmental problems;
– to reduce taxes and cut down on the environmental fines.

The development of the environmental market in Ukraine is hampered by the following factors: lack of a clear government environmental program; insufficient stimulating effect of taxes, fees and fines; local bureaucracy; inconsistency of economic policy implementation; low ecology culture of production and society; lack of training centers for training.

The scientifically-applied bases of the organization and manufacture of organic production and rendering of the corresponding services are proved on the basis of methodological bases of development and regulation of the environmental market (Figure 6).

The basis for substantiation of scientific and applied principles is the formation of regulatory framework, definition of socio-environmental and economic instruments and mechanisms for creating a system of environmental goods and services production, measures and incentives to be implemented, control and monitoring of natural resources.

Recently, the legal framework pays more and more attention to greening. It contributes to the formation of the environmental market that is defined as part of the overall market environment, characterized by competitive exchange of all that aims to preserve, restore and rational use of the environment, improve people's lives and environmental protection.

In our opinion the main tools for implementing and scaling the organization and production of organic products are:

– adoption of new legislative and regulatory documents that motivate the development of the environmental market in Ukraine;
– implementation of the EU-Ukraine Association Agreement and the development of intersectoral partnership and attraction of investments as a result;
– assessment of the strategies, programs and plans impact on the state of the environment;
– informatization of the economy, formation of online services, improvement of the permitting system in the field of rational environmental management;
– dissemination of the environmental audit activities, development of the environmental management systems for food safety systems and their certification;
– educating the population to distinguish environmental labeling as the cheapest tool for selling environmental products and providing services;
– environmental insurance services in the agro-industrial complex;
– development of technical regulations, standardization and accounting in the field of nature management and environmental safety of agricultural products and services;

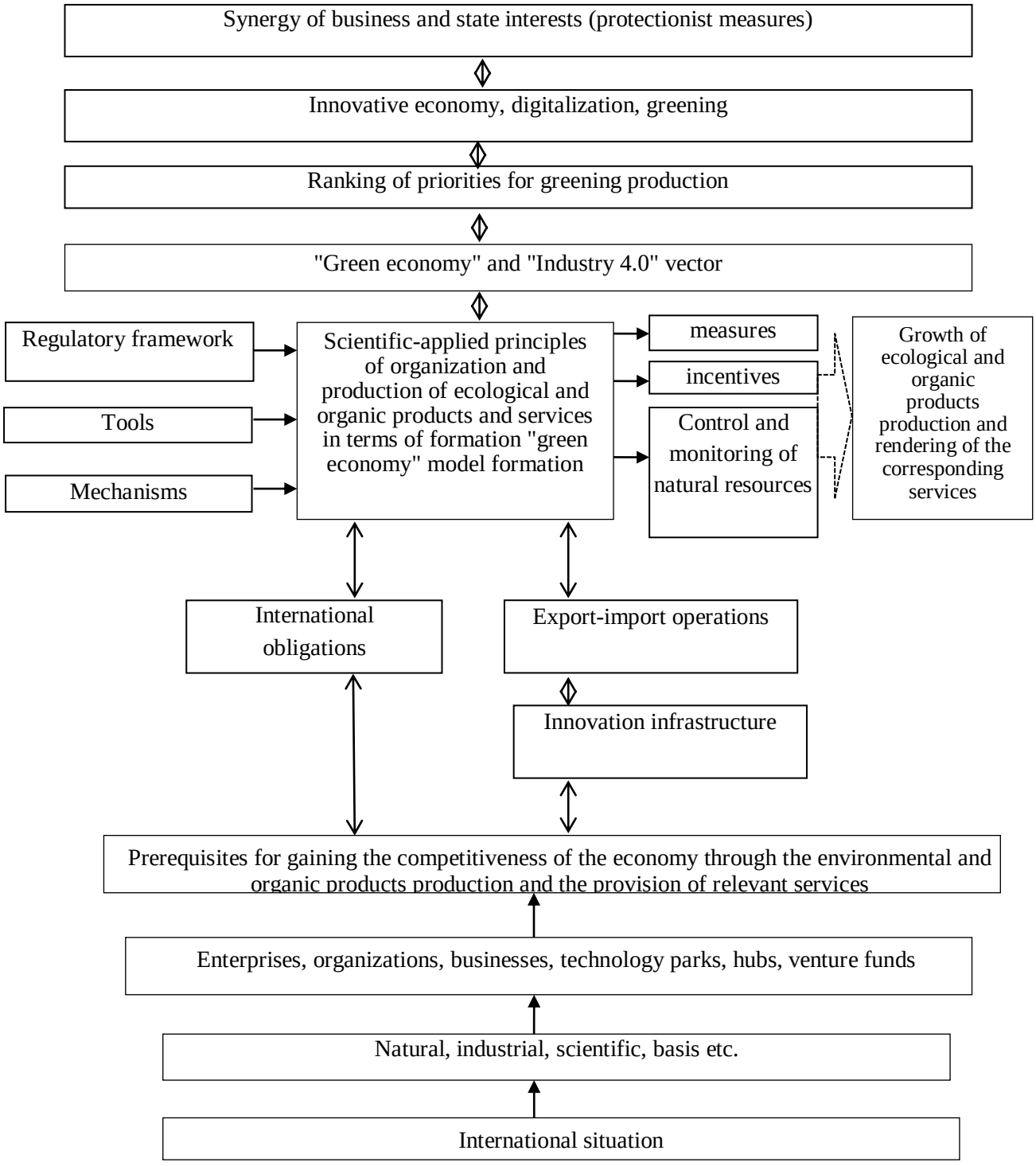

Figure 6. The scientifically-applied bases of the organization and manufacture of ecological and organic production services in terms of "green economy" model formation.
Compiled by the authors.

– systematic education at all levels according to the Life cycle methodology of ecological products production and provision of services;

– stimulation by economic and financial mechanisms and tools of farming, small and medium business;

– environmental monitoring and control in the field of nature management as a natural basis for the environmental products and services production;

– digitalization of production cycles from production, logistics to preservation of quality and terms of realization and delivery of ecological production and rendering of services;

– e-chipping of products, individual orders;

– development of partnerships between sectors of the environmental market and involvement all stakeholders in the planning and implementation of policies (executive authorities, private sector, producers, scientists, NGOs, local governments).

4. Conclusions

In order to improve the organizational and economic support of environmental market regulation, there are proposed modern tools which intends the consolidation of stakeholders and government; diversification of economic activities in the environmental market; application of the cluster approach; introduction of the emissions trading system; use of project management models; attracting grant funding, fundraising and crowdfunding that will help to activate the business environment, create new niches in the market and attract investment.

Therefore, the development of the environmental market depends on the formation of public demands for environmental works, services, goods, equipment, technology, quality environment and regulated system of nature management. This is a common task assigned to the state, public and business systems of environmental management at all levels in the context of European integration. Ukraine has a great potential for the development of the environmental market that in its turn will increase the competitiveness of domestic enterprises in European markets. Further research on the development of the environmental market in Ukraine should be focused on the study of its individual sectors - environmental goods, services and technologies in particular.

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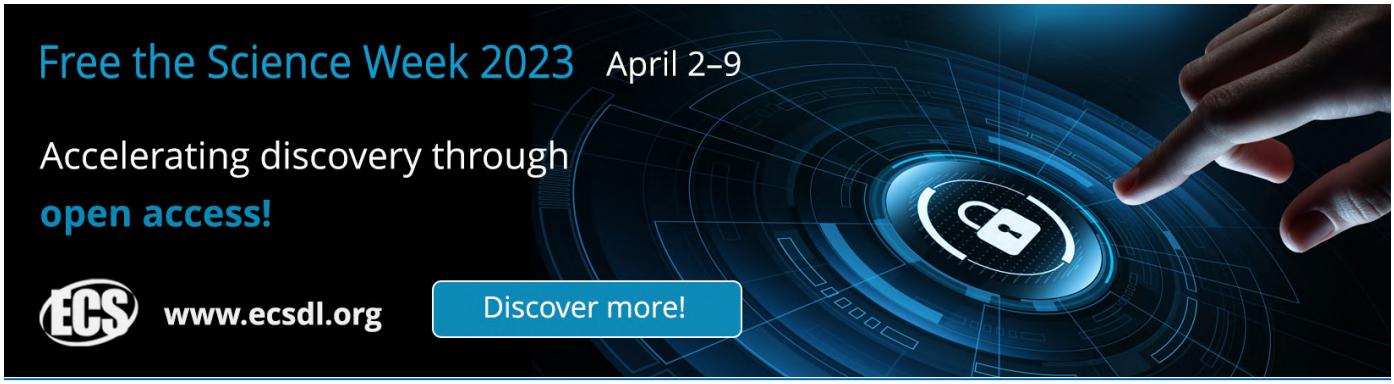
Spatial management of enterprise resource supply adaptation in circular economy conditions



Spatial management of enterprise resource supply adaptation in circular economy conditions

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Abstract. The article considers the analytical approach to the spatial management of the adaptation of the enterprise economic potential in circular economy. The research is based on the dependence of economic potential management systems on its level at the enterprise. The spatial management of economic potential adaptations requires the use of a comprehensive approach to the assessment of its level. The comprehensive approach includes a combination of methods of the factor analysis, the method of principal components and correlation and the regression analysis. The authors propose summary indicators of the components of economic potential that maximally reflect the adaptation of enterprises to modern conditions of economic management. On the basis of the correlation and regression analysis the integral indicator of economic potential evaluation has been calculated, the implementation of which will allow to build an effective system of spatial management of adaptation of economic potential of the company in circular economy. The practical value of the obtained results consists in substantiation of the spatial management of adaptation of the enterprise economic potential in conditions of circular economy by means of the suggested methodology of calculation of the economic potential level.

1. Introduction

Transformations in the economic space of companies' activities cause positive and negative configurations in their economic potential. According to the research of modern scientists [1-6], enterprises and their subsystems of the development support need to adapt to transformational processes through different approaches to management: adaptive, anti-crisis, spatial, innovative, resource, etc. At the same time, it is the economic potential that is the most sensitive subsystem of ensuring the activities of the enterprise, which without an appropriate level of adaptations will not perform the functions of an enterprise development belonging to it in the economic space. The spatial management of an enterprise requires considering its individual systems of economic potential, economic security, business processes, etc. through the prism of the space of their functioning and development. Accordingly, the adaptations of the economic potential, as the key system to ensure the development of enterprises in the strategic circle, should be provided by the tools of spatial management, especially in circular economy.

2. Critical literature review

The problems of adapting the enterprises economic potential and accordingly its adaptive management to the conditions of a competitive environment, transformations to neo-industrial transformations and digital trends have been studied by Akimova L. et al [1], Yaremko A. [2] Titicalo V. [3] Protsenko A. [4], Kwilinski A., Kuzior A. [5]. In the work of scientists Prokhorova V. et al [6] an algorithm for forming a strategy of financial potential of machine-building enterprises is described and the influence of factors reflecting risks, as well as certain features of implementing such a strategy and conditions for adapting to changes to maximize income is determined. Vovk O. et al [7] investigate methodological approaches to the diagnosis of the development of enterprise modernization potential as a component of economic potential, the results of which can be used to assess the adaptation of economic potential in a circular economy. Such studies are prerequisites for the emergence of theories of spatial management of adaptation of the enterprises' economic potential.

The functioning of enterprises, the particularities of their economic potential and resource supply in a circular economy are the object of scientific research: Tulchynska S. et al [8], Tkachenko V. et al [9], Raiput S., Sing S. [10], Shkurenko O. [11], Korhonen J. et al [12], Jesus A. et al [13], Kuzior, A. et al [14]. However, all the reviewed works have their own peculiarities on the functioning of enterprises, their economic potential and the formation of their spatial management in a circular economy. Tulchynska S. et al in their works [8] substantiate the principles of enterprises as part of the development of eco-industrial parks that are part of achieving sustainable development and the circular economy paradigm. That is, the article defines the prerequisites for spatial management of tne enterprise development as part of eco-industrial parks. Rajput S., & Singh S. [10] define the relationship between the digital transformation of industries and circular economy in the context of a supply chain adaptation. Tkachenko V. et al [9] explore the possibility of managing enterprises through the prism of accounting marketing risks as part of the economic potential to increase competitiveness and profitability of enterprises, thus determining that marketing risks have an impact on the adaptation of the enterprise economic potential to the circular economy conditions. Consideration of marketing risks in spatial management of adaptations of economic potential of the company can be as a part of management of market-productive element of economic potential of companies.

Thus, the leading research of enterprise activity in conditions of circular economy and its influence on the management of adaptation of economic potential is carried out in different areas, which are reflected in the adaptation of the components of the economic potential.

3. Methodology and results

Spatial management of the adaptation of economic potential and enterprise resource supply in the circular economy environment requires a combination of different methods for modelling economic processes, because it is necessary to take into account the properties of the determinant. Such properties may include: adaptability, spatiality, constancy of changes, innovativeness, alternative capabilities of economic potential, complexity, systematicity, cyclicality, etc.

The newest model of the economic space - circular economy - will allow to develop and realize the innovation potential of economic subjects at macro and micro levels, which will lead to the transition to a new type of economic development. This will ensure the formation of a dynamic structure, capable of conducting continuous in time and economically successful in achieving their strategic goals under the constant influence of the external environment factors, while maintaining the signs of integrity and balance of the socio-economic system [11]. That is, the circular economy creates conditions for the formation of economic potential at the enterprise level, which is aimed at the innovative development of the country's macrosystem and, accordingly, requires adequate management tools, which will take into account the features of the external space of enterprises.

The efficient spatial management of the adaptation of the economic potential is based on the assessment of the condition of economic potential through the definition of the integral indicator of economic potential in circular economy, the methodology of which is presented in Figure 1.

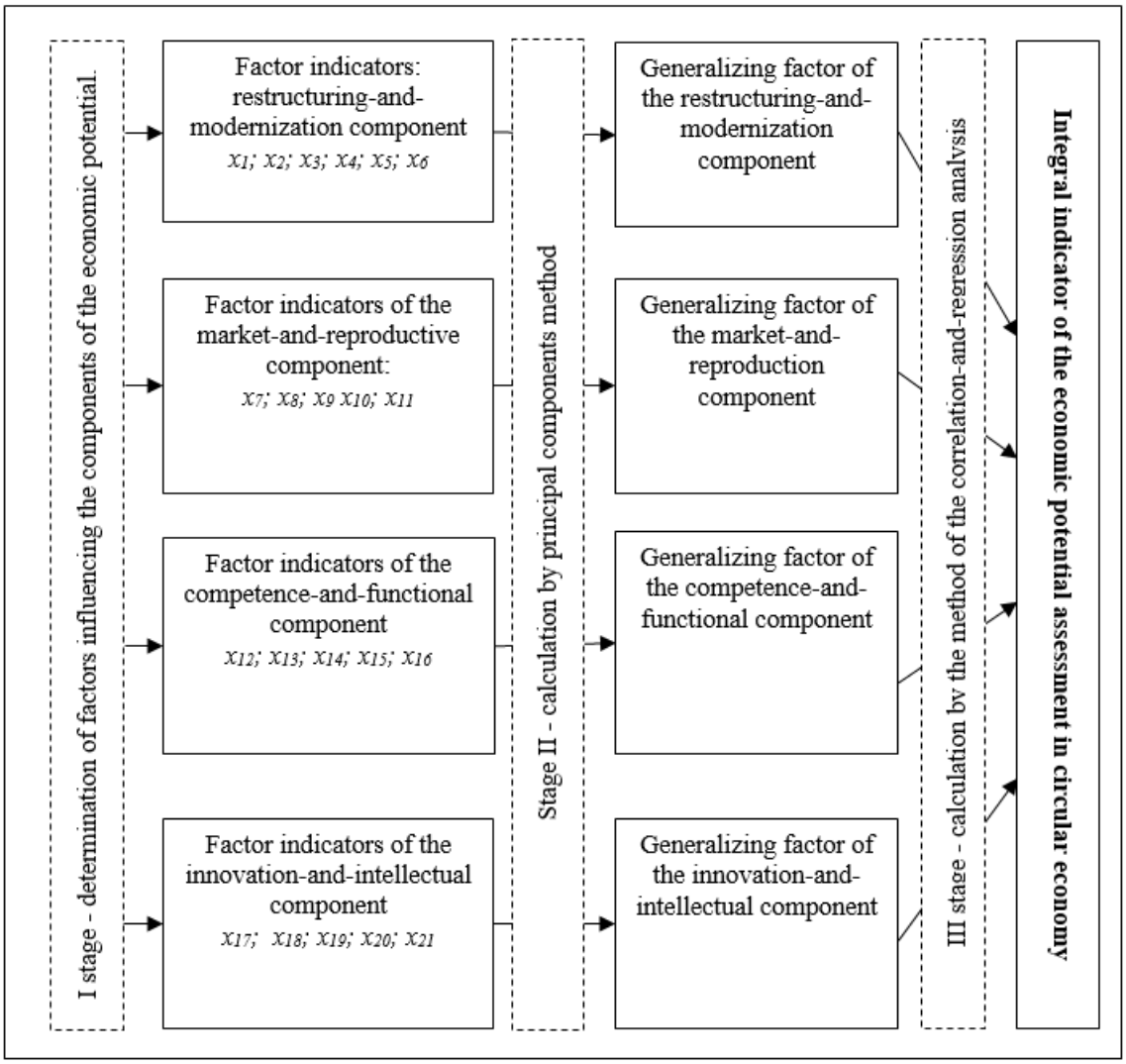

Figure 1. Theoretical and methodological approach to the calculation of the economic potential level in conditions of circular economy using methods of principal components and correlation-and-regression analysis in spatial management of adaptations.

In a circular economy, the calculation of an integral indicator of economic potential and resource endowment involves three stages:

Stage I - identification of factors influencing the components of the economic potential;

Stage II - calculation by the principal component method;

III stage - calculation by the method of correlation and regression analysis.

On the first stage it is necessary to define the main factors of influence on the components of the enterprise economic potential. Circular economy and features of its environment for the activities of enterprises, as well as processes of adaptation to them allows to identify the following components of the element of economic potential of the enterprise: restructuring-modernization, market-production, competence-functional and innovation-intellectual [3]. Each component of the economic potential is influenced by factors, which are essentially a set of indicators. We refer to them: x_1 - coefficient of autonomy; x_2 - coefficient of own capital maneuverability; x_3 - coefficient of the ratio of own and borrowed capital; x_4 - coefficient of provision with own circulating assets; x_5 - coefficient of the ratio of accounts receivable to accounts payable; x_6 - coefficient of long-term debts; x_7 - return on assets; x_8

- return on own capital; x_9 - product profitability; x_{10} - receivables turnover ratio; x_{11} - accounts payables turnover ratio. Accordingly, the factor indicators of the restructuring-modernization component of the economic potential are x_1, x_2, x_3, x_4, x_5, x_6; the market-reproducing component of the economic potential x_7, x_8, x_9, x_{10} and x_{11}; the competence-functional component: x_{12}, x_{13}, x_{14}, x_{15} and x_{16}; the innovation-intellectual component x_{17}, x_{18}, x_{19}, x_{20}, x_{21}.

At the second stage, the calculation of generalized indicators of the components of the economic potential with the method of principal components, which allows to apply the first principal component to construct generalized indicators in the form of a linear combination of factor attributes with weight coefficients, characterizing the relationship between the factor attributes and the component:

$$f_1 = 1/\lambda_1(a_{11} \cdot x_1 + a_{21} \cdot x_2 + ... + a_{n1} \cdot x_n), \quad (1)$$

where f_1 - the first principal component; - λ_1 eigenvalue, which corresponds to the 1st principal component; a_{11} - specific weight of the 1st component in the 1st variable; x_n - factor attributes, $_{1, 2}$, ..., $_n$.

This method allows to switch from description of a set of measurable attributes to their description by a smaller number of maximally informative variables reflecting the most essential properties of the economic potential of machine-building indicators. In order to determine the maximum informative variables that will affect the generalized indicators of the components of the enterprise economic potential, we will use the method of correlation. On the example of the correlation matrix of the impact factors on the restructuring-modernization component of the economic potential (Table 1) we see that the values of the coefficients x_3 and x_6 have a value of less than 0.2, i.e. and it is the coefficient of the equity ratio and borrowed capital and the coefficient of long-term debt can be excluded from the further study because of the weak relationship with the resultant indicator.

Table 1. Correlation matrix of the impact factors on the restructuring and modernization component of the economic potential of enterprises

Indicators	x_1	x_2	x_3	x_4	x_5	x_6
x_1	1					
x_2	0,419247	1				
x_3	0,696877	0,191653	1			
x_4	0,695073	0,776051	0,469522	1		
x_5	-0,4873	-0,9921	-0,22578	-0,7752	1	
x_6	0,27786	0,269317	0,34948	0,43145	-0,27292	1

In order to move to the principal components, we determine the eigenvalues of the correlation matrix. Note that the first and second principal components (factor 1, 2) explain 81% of the total variation. Then it is necessary to determine the eigenvectors of the correlation matrix, which characterize the relationship between the variables and the main components (factors). The share of the first component in the total variance of the set of indicators is 55,40%, the second - 25,73%. Total two components explain 81,13% of the total variation, which testifies to a high degree of factorization.

Having determined the interrelation of the main factors with the initial variables, the following conclusions can be made. Component F1 includes such indicators as the coefficient of autonomy (x_1), the coefficient of equity flexibility (x_2), the coefficient of provision with own circulating assets (x_4). The second component F2 is characterized by such indicator as the ratio of accounts receivable to accounts payable (x5). If we take the total variance as one, the contribution of each of these

components will be about 0.60 and 0.40. These values can be taken as the component weights. The control sum of these weights would be 0.6+0.4=1.

The weights α_{ij} are calculated by the formula:

$$a_{ij} = \frac{c_{ij}\left|d_{ij}\right|}{\sum c_{ij}\left|d_{ij}\right|} \quad (2),$$

where dij - factor loadings;

c_{ij} - contribution of the *j-th* component to the total variance of the set of indicators of the *i-th* attribute.

Having calculated the weight coefficients, it is possible to present the generalizing index of the restructuring-modernization component of the economic potential I_{RM}, which is a component of the integral index of assessment of the economic potential under the conditions of structural-and-organizational and adaptive-and-harmonization transformations of the machine-building enterprises, determined by the formula (3):

$$I_{RM} = 0{,}184 \cdot x_1 + 0{,}193 \cdot x_2 + 0{,}222 \cdot x_4 + 0{,}4 \cdot x_5. \quad (3)$$

The interpretation of the components' influence on the generalized indicator of restructuring-and-modernization component of the economic potential is as follows: the greatest influence on the generalized indicator has the ratio of accounts receivable to accounts payable, its increase by 1% will increase the generalized indicator by 40,0%, an increase in the coefficient of provision with own funds will increase the generalized indicator by 22,2%, an increase in the equity flexibility ratio by 1,0% will increase the generalized indicator of the economic potential.

Other generalizing indices of the economic potential of the enterprises are calculated similarly to the index of restructuring and modernization component of the economic potential I_{RM} and have the form:

the generalizing indicator of the market and production component

$$I_{MR} = 0{,}47 \cdot x_7 + 0{,}29 \cdot x_8 + 0{,}24 \cdot x_9. \quad (4)$$

the cumulative indicator of the competence-and-functional component

$$I_{CF} = 0{,}22 \cdot x_{10} + 0{,}34 \cdot x_{11} + 0{,}21 \cdot x_{12}. + 0{,}23 \cdot x_{15} \quad (5)$$

the cumulative indicator of the innovation-and-intellectual component

$$I_I = 0{,}4 \cdot x_{17} + 0{,}29 \cdot x_{19} + 0{,}31 \cdot x_{20}. \quad (6)$$

On the third stage of defining of the economic potential level in the circular economy, the integral index of assessment of economic potential (AEP) is calculated using the method of correlation and regression analysis on the basis of the calculated summarizing indices

$$I^{n}_{EP}(t) = -0{,}08 + 0{,}03 I_{RM} + 0{,}25 I_{MR} + 0{,}19 I_{CF} + 0{,}54 I_I \quad t = 1,...,36 \quad (7)$$

where *t* is the number of levels of dynamic series.

The interpretation of the influence of the components on the integral index of the assessment of the economic potential is as follows: the greatest influence on the integral index has the generalizing index of the innovative-and-intellectual component, if it is increased by 1%, the integral index of the economic potential will be increased by 54,0%, the increase of the generalizing index of the market reproducing component by 0% will lead to the increase of the integral index by 25%, the increase of the generalizing index of the competent and functional component by 1,0% will promote the increase of the integral index. Thus, the calculations show a necessity of introducing the spatial management of the economic potential adaptation, because the determinants of dependences are of an external character and correspond to modern tendencies of the circular economy formation.

According to the obtained results it is possible to suggest measures for the spatial management of the adaptation of the enterprises economic potential in the conditions of circular economy which are presented in figure 2.

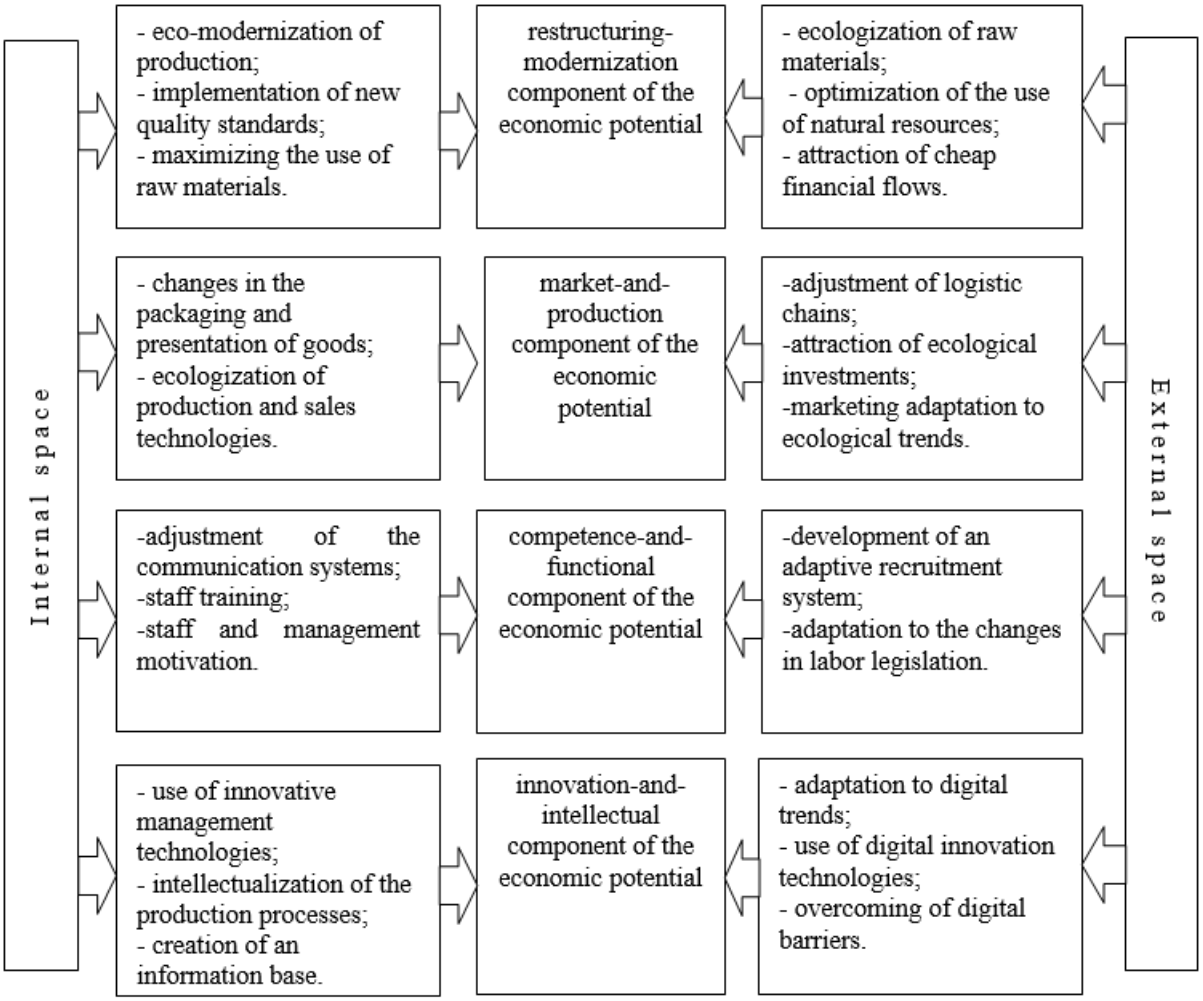

Figure 2. Priority areas of the economic potential adaptation in circular economy under spatial management

Approaches to ensure spatial management of adaptation of the enterprises' economic potential under the conditions of circular economy developed in accordance with the components of the economic potential of the enterprise, which will maximize their effects in accordance with the specific area. We assume that the spatial approach involves internal and external influence of spaces on the adaptation of the enterprises' economic potential.

4. Conclusions

The study presents a method for calculating of the economic potential level under the conditions of circular economy with the use of methods of main components and the correlation-and-regression analysis for simple management of adaptations. Accordingly, the formula for calculating the economic potential level of the enterprise under the conditions of circular economy indicates, that enterprises were able to adapt to modern digital and resource transformations, because their economic potential is most influenced by the innovative and intellectual factors (54%). Along with this, the factors of market and investing components influence of the economic potential level by 25%. Therefore, the circular economy formation determine the nature of spatial management of adaptation of the enterprises' economic potential, because these very components of the economic potential, most sensitive to changes

in the external environment have the greatest impact on the potential level (in general, a change of 1% of these factors will cause an increase/decrease in the economic potential by 79%). The suggestions for measures to ensure broad management of adaptation of the enterprises' economic potential under conditions of circular economy. For practical activities, the significance of the conducted research and its results: justification and optimization of simple management of enterprise economic potential adaptation in a circular economy through the use of the proposed theoretical and methodological approach to the calculation of the level of economic potential of an enterprise.

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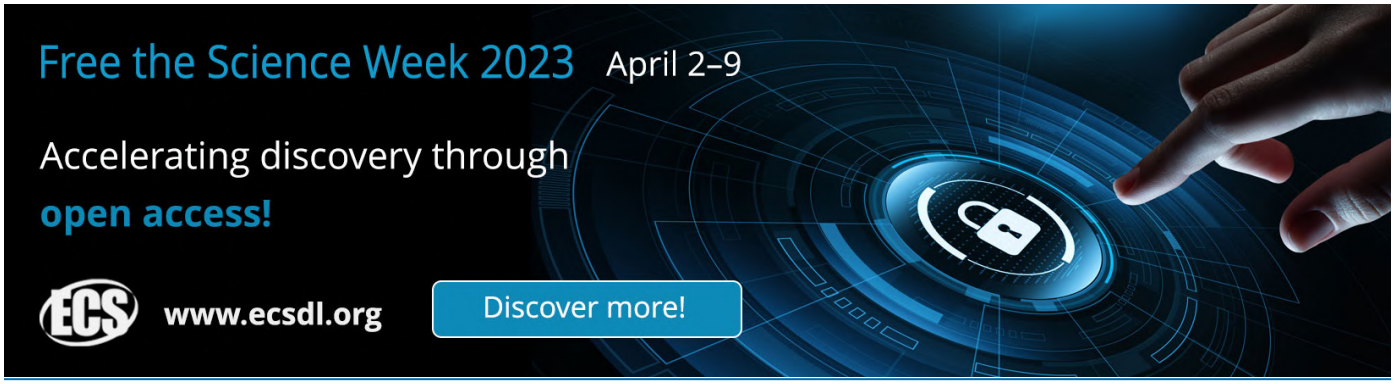
Solid waste market: cross-country analysis



Solid waste market: cross-country analysis

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Abstract. Intensive consumption of natural resources causes man-made changes in the environment, which result in deteriorating living conditions and threaten the existence of human civilization. Today, the problem of environmental pollution is an environmental catastrophe of a global nature that needs to be urgently addressed. To identify the factors influencing the state of solid waste management in different countries, several indicators were selected that describe the environmental situation, its level of economic development, education, and comprehensive development of society. The built regression models and the interpretation of their parameters indicate the need to consider three elements of the strategy to improve the management of solid waste: 1) promoting economic development, including innovative waste processing technologies; 2) improving the legal framework for the industry; 3) raising the educational level and environmental awareness of the country's population.

1. Introduction

Intensive consumption of natural resources causes human-made environmental impacts, which result in deteriorating living conditions and threaten the existence of human civilization. Today, the problem of environmental pollution is an environmental catastrophe of a global nature that needs to be addressed urgently. After realizing all the dangers of household waste pollution, some countries have already taken necessary actions in this direction, but the situation is changing rather slowly. Disorders in the collection, storage, disposal, and recycling of household waste cause significant damage to the environment and increase the area of land where waste constantly accumulates. In modern conditions, the main way of disposal of household waste in Ukraine is to bury it in landfills or dumps. Almost 450 million tons of waste are generated in Ukraine every year, of which no more than 3% is recycled. The area of landfilled waste exceeds that of the country's nature reserve fund. According to rough data, about 30 billion tons of household waste are concentrated in landfills. However, if up to 60% of glass, paper, plastic and other waste is recycled in civilized countries, in Ukraine, unfortunately, this issue remains open and relevant.

The legal framework for solid waste management in Ukraine is cumbersome, confusing, and difficult to implement. There are currently too many laws and regulations that are not truly enforced. Ukrainian

legislation should be simplified and optimized by adapting to EU directives. The existence of a waste hierarchy is an EU requirement for the organization of waste management.

The impact of the consequences of environmental pollution on human health, the state of the ecosystem, as well as climate change contributed to the emergence of a new trend in scientific research to find effective tools for reducing the anthropogenic burden on the environment, which led to the choice of the research topic. Considering the difficult situation that has developed in Ukraine today regarding the handling of household waste, both at the public and grassroots levels, it is advisable to change key approaches – to make a transition from waste disposal to reducing its generation, introducing waste sorting, recycling and its reuse. To implement the optimal model of waste management, it is advisable to use the best global practices, which are written down in clear policies at the legislative level.

2. Theoretical background

Consideration of the solid waste market requires clarification of some definitions related to its operation. The market in the most general sense is a set of economic relations between the subjects of the economic system all bound up through the exchange of goods and services using the financial and credit mechanism. Most economic processes are carried out thanks to the market. This is a specific form of economic relationship that connects different entities. Signs of the modern market are competitive mechanism, economic freedom, mobility of resources, informatization and digitization of business processes, autonomy of market subjects, globalization of economic relations, etc. Modern market structure is one of the elements of another, more complex system of management – mixed economy, which includes the actual market relations, numerous regulatory institutions, legal system, market infrastructure, the state of public consciousness [1; 2; 3]. To better understand the microeconomic aspects of the solid waste market, we conducted a study on it to determine whether it belongs to a certain type of market structure. Thus, the market for solid waste, like most existing industries – is a combination of competition and monopoly and belongs to the markets of monopolistic competition. An essential aspect of monopolistic competition is the differentiation of products with a fairly large number of suppliers and almost unlimited opportunities for new firms to enter the industry. The degree of product differentiation is low and depends on brands, proper product quality, and advertising. Consumers can distinguish the products of different companies on the market thanks to this differentiation. Thus, the demand for the products of an individual firm is not completely elastic, even though it remains highly elastic. This means that firms have some market power and can vary prices (very limited though) without the risk of losing all buyers.

Now we'll find out the characteristics of the solid waste market in terms of the objects of this market. According to the Law of Ukraine [4], waste is any substance, material or object that is formed in the process of production or consumption, as well as goods (production) that have completely or partially lost their consumer properties and are not suitable for further use at the place of their formation or discovery, and which their owner disposes of, intends to dispose of or must dispose of by recycling or other means. Household waste (solid, large, repair, liquid, except for the waste related to production activities of enterprises) – is waste that is generated in the process of human activity in residential and non-residential premises and is not used in the place of their accumulation. Municipal Solid Waste (MSW) includes cardboard, newsprint, packaging or consumer paper, all kinds of containers (wooden, glass, metal); any articles of wood, metal, leather, glass, plastic, textiles, and other materials that have become obsolete or have lost their consumer properties; broken household appliances – garbage, as well as agricultural and municipal food waste. In Ukraine, 4% of household waste is sorted, the rest is incinerated or taken to landfills [5].

First off, it should be noted that the solid waste market has a complex structure. It includes the production of waste, i.e., the component that unites individuals and legal entities whose activities lead to the generation of waste. In general, waste management is the actions aimed at preventing its generation, collection, transportation, sorting, storage, treatment and processing, disposal, neutralization, etc., including control of the progress of these operations and monitoring of waste disposal sites.

Waste collection includes removal, accumulation, keeping it in specially designated areas and sorting. The next component of the solid waste market is their storage – temporary placement in appropriate places or facilities (before their disposal). An important place in this structure belongs to the market of services for the transportation of solid waste, i.e., their transportation from places of formation or storage to places or objects of processing, recycling, or burial. According to the current legislation of Ukraine, the provider of household waste removal services is determined on a competitive basis by the local self-government body in accordance with the procedure established by the Cabinet of Ministers of Ukraine. The provider must conclude an agreement with consumers on waste management services and is obliged to conclude agreements on the provision of services for processing and disposal of household waste with entities that provide such services in accordance with the rules of improvement of each city. Treatment (recycling) of waste involves the performance of any technological operations that include a change in the physical, chemical or biological properties of waste in order to prepare it for environmentally safe storage, transportation or further disposal. Waste utilization – means using it as secondary material or energy resource [6; 7; 8]. Disposal is understood as the implementation of operations with waste that do not lead to their complete removal but contribute to the neutralizing waste – reduction or elimination of the danger of waste through mechanical, physio-chemical, or biological treatment. The final stage of the life cycle of waste is its burial, i.e., the final placement in landfills (dumps), so that leaving it in specific places or facilities would not have any harmful effects on the environment and human health exceeding established standards long-term. According to the current legislation, the market of solid waste in Ukraine can be classified as official and illegal (shadow) market, which is prohibited by law. It is a continuation of the shadow economy and belongs to unauthorized economic activity. This practice exists mainly in landfills, where individuals sort garbage and transfer it to economic entities that take it for recycling. Thus, there is a concealment of irregular earnings and tax revenues.

Legislation on waste consists of the laws of Ukraine “On Environmental Protection”, “On Ensuring Sanitary and Epidemic Safety of the Population”, “On Radioactive Waste Management”, “On Scrap Metal”, “On Housing and Communal Services”, “About chemical sources of current”, “On veterinary medicine”, “About withdrawal from turnover, conversion, utilization, destruction or further use of low-quality and dangerous products”, the Subsoil Code of Ukraine, and other regulations. The main objectives of waste legislation are to define the basic principles of state policy in the field of waste management; legal regulation of relations that are related to the activities in this area; determination of the main conditions, requirements and rules for environmentally friendly waste management, as well as a system of measures related to organizational and economic incentives for resource conservation; ensuring the minimum generation of waste, expanding their use in economic activities, preventing the harmful effects of waste on the environment and human health.

According to Article 33 of the Law of Ukraine “About Waste” [4] storage and disposal of waste is carried out in accordance with environmental safety requirements and in such ways as to ensure maximum use of waste or establish transfer of it to other consumers (except for burial). It is prohibited to mix or bury the waste for the utilization for which there is an appropriate technology in Ukraine.

3. Materials and methods

Waste management statistics are difficult to collect and even more difficult to synthesize. Lack of measurements in many parts of the world, as well as lack of standard measurement methodologies, reporting systems and even waste definitions and classifications have hampered past attempts to develop waste-related environmental indicators that are reliable enough to facilitate global comparisons. Existing data sources include survey data from the United Nations Statistics Division, OECD data as well as regional and national reports. As a working hypothesis of the study, it was suggested that several indicators have a significant impact, namely: GDP per capita, Human Development Index – HDI, Literacy Rate (LR), Stringency of Environmental Regulations (SER).

To test the working hypothesis about the dependence of the quality of solid waste management in the country on the level of its economic development, human development index and strictness of

environmental regulation, several statistical analyzes were conducted (descriptive, correlation, regression, cluster) on features of samples that varied from 99 to 128. One of the indicators selected for determining the integrated environmental performance indicator (EPI), namely Waste Management (WM), was chosen as the dependent (explanatory) variable (regression). In most cases, we used the Gross Domestic Product (GDP), the Human Development Index (HDI), and the Stringency of Environmental Regulations (SER) as independent variables in the analysis [9; 10]. At the initial stage, some types of analysis also considered the level of literacy of the population and the Environmental Performance Index (EPI) in the country.

4. Empirical results

In order to identify the factors influencing the state of solid waste management in different countries, a number of indicators were selected that characterize the environmental situation, its level of economic development, education and comprehensive development of society.

One of the indicators of the integrated index of the ecological state in the country, namely Waste Management, was chosen as an effective feature in our analysis. The indicator shows the share of generated solid waste that is collected and treated in a controlled manner. This indicator has been included in the EPI since 2020 as a new indicator covering an important issue of sustainable development. Before 2020, the EPI did not have any methodologically consistent data on how countries handle solid waste. Uncontrolled waste disposal pollutes the air, water, soil and increases the risk of pathogens and toxic substances affecting human health. Improperly disposed waste also causes climate change due to methane emissions and, under certain circumstances, can threaten biodiversity. The new waste management indicator tracks the destination of waste as an indicator of the direct impact of waste on the environment. This indicator shows the share of household and commercial waste generated in the country that is collected and treated in a way that allows us to control environmental risks. This parameter considers waste as “controlled” if it is treated, recycled, anaerobically digested, incinerated or disposed of in a sanitary landfill. A score of 100 indicates that a country controls 100% of its waste sustainably, while a score of 0 indicates that a country is unable to control any of its solid waste or collect and report data on it.

The Human Development Index around the world has been chosen as one of the independent variables. Human development is determined by the growth of human opportunities provided by the provision of rights and freedoms, public respect for the individual, political freedom, and a healthy environment. One of the basic choices is financial well-being, but it is not an all-encompassing goal. The development of human potential is the goal and criterion of social progress and economic growth, while the fundamental opportunities for human development are long and healthy life, the acquisition of knowledge (education) and access to means of ensuring a decent standard of living.

The Human Development Index is an integrated assessment of a country’s civilization that aggregates Life expectancy index, Education index, and the GDP index per capita. This indicator calculates the average level of achievement of the country in the field of basic capabilities. HDI includes three key dimensions of human development [10]:

1) Long and healthy life is measured by life expectancy. The closer the value of this index is to 1, the closer the country is to achieving the average life expectancy of 85 years, which for the time being remains a dream for the population of any country;

2) Access to education is measured by the expected years of schooling of children of school age and the average age of the adult population. The closer these indices are to 1, the closer this country is to full literacy and youth enrollment;

3) Decent living standards – measured by the volume of gross domestic product per capita, taking into account the level of prices in the country. This component of the human development index is the most difficult to compare. The statistical services of the countries measure GDP according to the International System of National Accounts (SNA) in the national currency, i.e., to compare the values of this indicator between countries it is necessary to convert them into the same currency. This can be

done in two ways: at the official exchange rate or by comparing in dollars the set of several hundred goods and services that make up the market basket.

The first method is unacceptable, because the official exchange rate is often a declared ratio of currencies, which has no real economic basis. Comparisons by the second method are made based on very complex and long (2-3 years) comparisons, because of which the indicators of GDP as a whole and per capita are calculated according to real purchasing power (PPP – purchasing power parity). No more than 60-80 countries participate in the Program of International Comparison. The value of GDP in purchasing power parity for other countries is calculated by the World Bank and the University of Pennsylvania.

Unlike other components of the human development index, the income index has its own method of rationing. As for other components of human development, its maximum and minimum values were determined ($40,000 and $100 of purchasing power parity). But in the concept of human development there is a concept of declining value of higher incomes, i.e., having some funds, a person can use them with a positive effect on development – to acquire better education, improve nutrition, living conditions etc., but it also can be negative – drug use and more. Thus, the HDI indicator for each country shows how much effort it needs to make to achieve certain goals: an average life expectancy of 85 years, full literacy and full coverage of youth education and a level of average annual income per capita, $40,000 at the purchasing power parity of the national currency. These goals are closer if the value of HDI is closer to one.

Another indicator selected as an independent variable is Literacy rate, adult total (% of people aged 15 and above). The level of education of the adult population is defined as the share of literate people aged 15 and older. Education index (of certain people is the ratio between the number of educated people and the total population. This ratio is expressed as a percentage).

GDP per capita was used as an indicator of the well-being of the population. GDP at purchasing power parity per capita (real GDP) – is a measure of product output per capita in dollars of constant purchasing power, while eliminating the impact of inflation. Higher real GDP per capita is an indicator of a higher standard of living. The level of real GDP per capita in a country allows you to make comparisons with other countries and find out which category they belong to – developed or developing.

The value of the Stringency of Environmental Regulations (SER) is taken from the Travel and Tourism Competitiveness Report published by the World Economic Forum under the Aviation and Travel Partnership Program. This index (SER) is one of the 90 indicators used to calculate the Travel and Tourism Competitiveness Index (TTCI). Data for the SER are obtained through a survey conducted by the World Economic Forum on a scale of 1 to 7, where answer 1 corresponds to the lowest score and answer 7 – the highest possible score [11; 12].

The EPI 2020 report, prepared by researchers from Yale and Columbia Universities, included 133 countries in the ranking of the quality of the indicator of solid waste management. Quantitative values of this indicator vary in the maximum possible range from 0 to 100. The first five places are occupied by Colombia, the Netherlands, Denmark, Sweden, Singapore. Among the top ten – seven European countries. Afghanistan, Madagascar, and Mozambique received the lowest scores.

Ukraine with 73.1 points occupies a relatively high 45 position. Russia is ranked 122nd with 3.2 points. Among the countries of the former Soviet republics, our country ranks second, slightly behind Belarus. Among the 20 countries of Eastern Europe, Ukraine is in the middle of the ranking list.

For the comparative analysis of countries on the complex of all the above indicators, estimates and indices we used one of the options for graphical analysis, namely iconographic. In Figure 1 star-shaped icons are depicted, illustrating the significant variability of countries on six indicators.

The shape of the icon of our country shows that in these respects Ukraine is like a number of Eastern European countries – Poland, Hungary, Slovakia, Croatia.

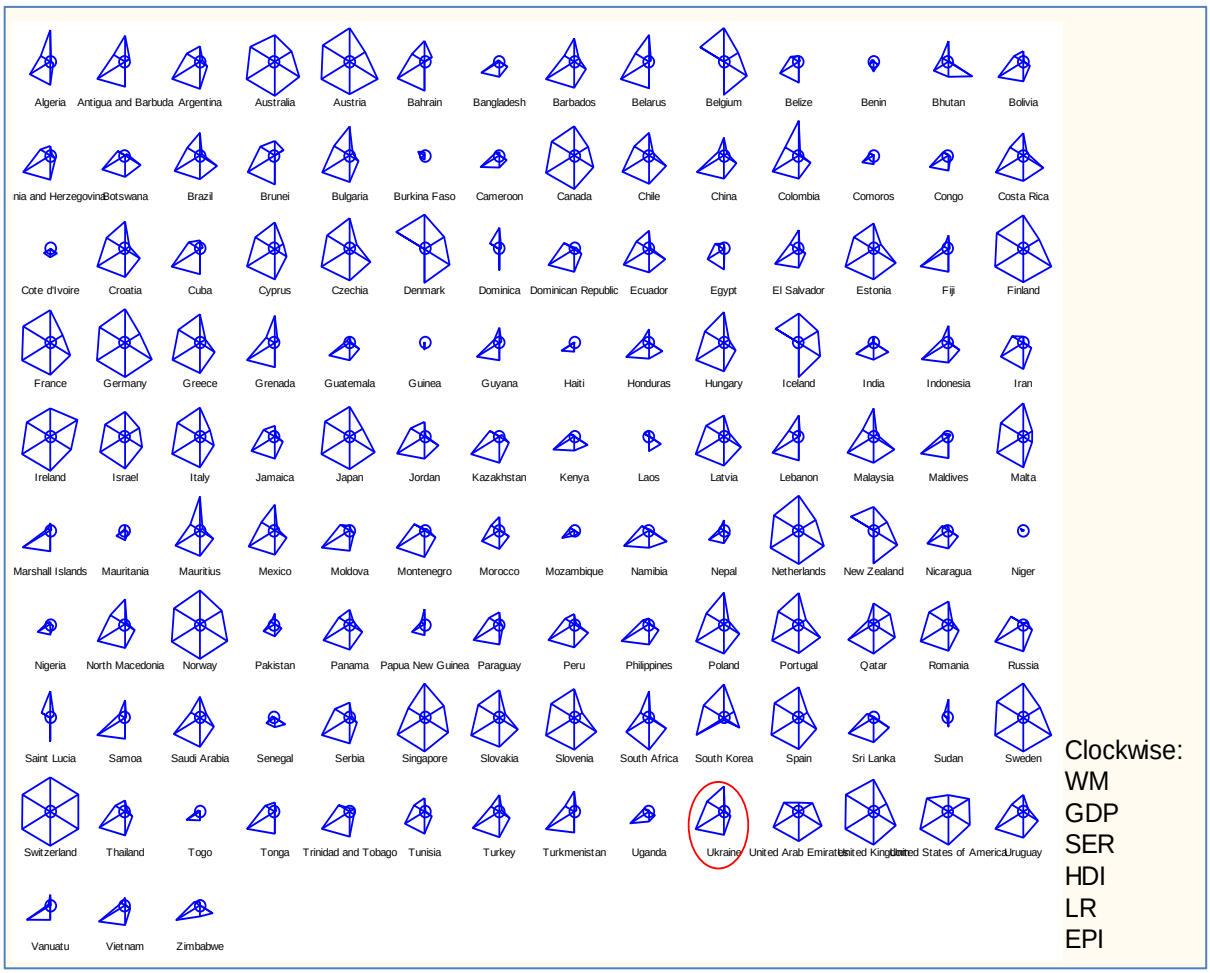

Figure 1. Iconographic characteristics of countries on a set of environmental and socio-economic indicators

Correlation analysis revealed a significant direct relationship between the quality of household waste management in the country (WM) and variables GDP, SER, HDI, LR, EPI (Table 1).

The highest WM correlation coefficient was found with EPI (r = 0.795). And this makes sense because WM is one of the indicators of integrated EPI. Among other variables, it is worth noting approximately the same closeness of the relationship between WM and GDP, SER and HDI (r = 0.632-0.696) and slightly weaker with LR (r = 0.533). However, according to the Chaddock scale, in both cases this connection is characterized as significant.

To better visualize the form of the relationship between the dependent and independent variables, a matrix of scattering diagrams and histograms is constructed (Figure 2). As we can see, the relationship between the indicator of the quality of household waste management in the country and the indicators of its economic development and literacy of the population is probably better to approximate using a nonlinear function, while between WM and other variables – using linear. It is also worth paying attention to the histograms of the distribution of values of the analyzed variables. They indicate certain deviations of their actual distribution from normal.

Table 1. Relationship between the quality of household waste management (WM) and variables GDP, SER, HDI, LR, EPI

Variables	WM	GDP	SER	HDI	LR	EPI
WM	1,0000 (N = 128)	**0,6324** (N = 128)	**0,6399** (N = 104)	**0,6962** (N = 128)	**0,5333** (N = 121)	**0,7951** (N = 128)
GDP	**0,6324** (N = 128)	1,0000 (N = 129)	**0,7739** (N = 104)	**0,6986** (N = 129)	**0,4326** (N = 122)	**0,7997** (N = 129)
SER	**0,6399** (N = 104)	**0,7739** (N = 104)	1,0000 (N = 104)	**0,6581** (N = 104)	**0,4600** (N = 99)	**0,7126** (N = 104)
HDI	**0,6962** (N = 128)	**0,6986** (N = 129)	**0,6581** (N = 104)	1,0000 (N = 129)	**0,8028** (N = 122)	**0,8095** (N = 129)
LR	**0,5333** (N = 121)	**0,4326** (N = 122)	**0,4600** (N = 99)	**0,8028** (N = 122)	1,0000 (N = 122)	**0,6261** (N = 122)
EPI	**0,7951** (N = 128)	**0,7997** (N = 129)	**0,7126** (N = 104)	**0,8095** (N = 129)	**0,6261** (N = 122)	1,0000 (N = 129)

Note: coefficients significant for $p < 0.05$ are highlighted in bold

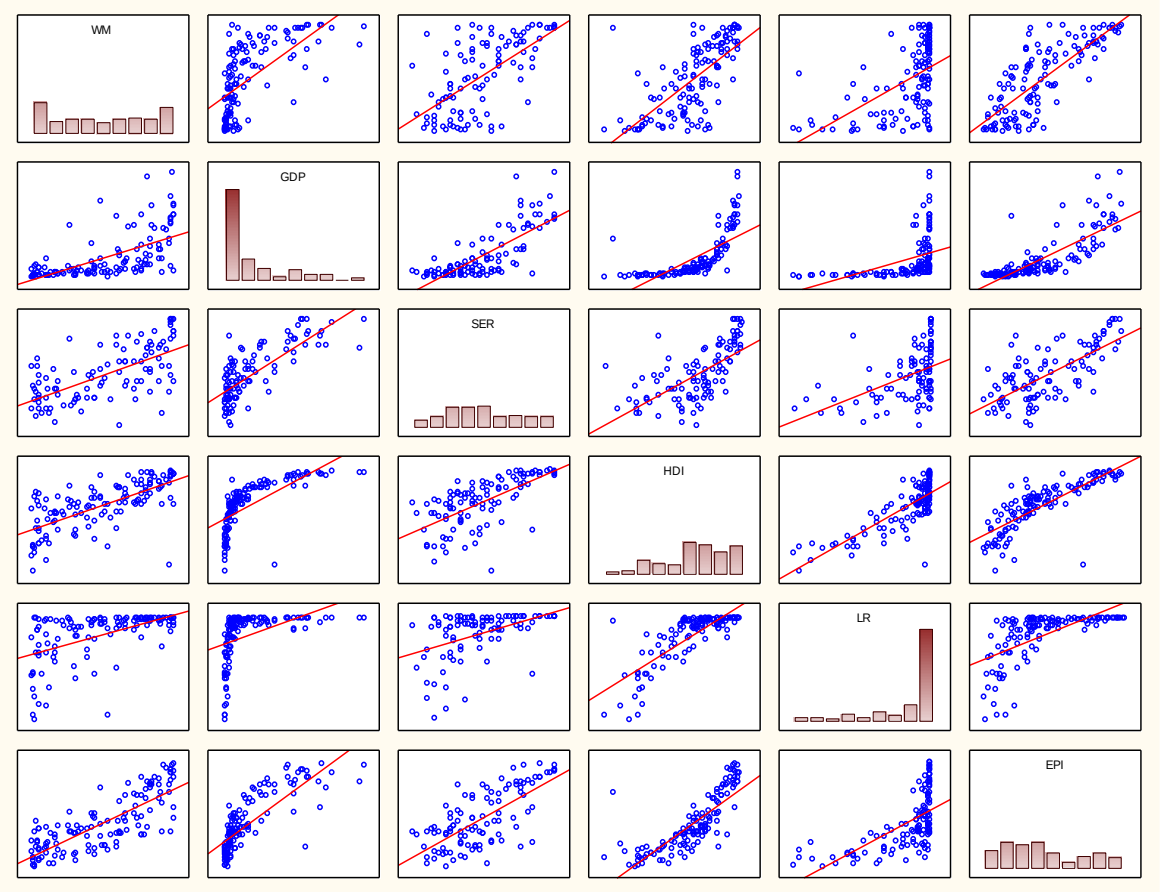

Figure 2. Scattering diagrams and histograms of the distribution of values of target variables

The result of the regression analysis was the construction of several one-factor regression models that describe the form of dependence of the resultant feature (waste management) on certain independent variables (Table 2).

As we can see, all constructed models (nonlinear 1 and 4) and linear (2 and 3) are adequate and estimates of their parameters are significant. The share of variation of the dependent variable (the level of quality of solid waste management), which in most cases is significant is explained by the variation

of the independent variable (41-56.7%). Only for the fourth model the coefficient of determination is low (0.243). Although in general this model approximates empirical data well. Regression coefficients in these models show that an increase in GDP per capita by 1% leads to an increase in the quality of solid waste management in the country by 0.2 points. Increasing the level of environmental regulation by 1 point can increase the level of WM by 22.2 points, and the increase of human development index by 0.1 leads to increase of WM by 16.5 points.

Table 2. Results of one-factor regression analysis of target variables

Model's N	Model's analytical form	Sampling (N countries)	Criteria of adequacy and significance of model parameters			
			R^2	Fisher's F-test	The value of p < for	
					inter-cept	regression coefficient (b)
1	WM = -130,3 + 20,1 ln GDP	104	0,567	133,7	<0,0001	<0,0001
2	WM = -41,9 + 22,2 SER	104	0,410	70,7	0,0005	<0,0001
3	WM = -73,0 + 164,7 HDI	128	0,485	118,5	<0,0001	<0,0001
4	WM = -255,207 + ln LR	121	0,243	38,1	<0,0001	<0,0001

Note: $F_{table.0,01}(1,102) = 6,90$, $F_{table.0,01}(1,119) = 6,81$

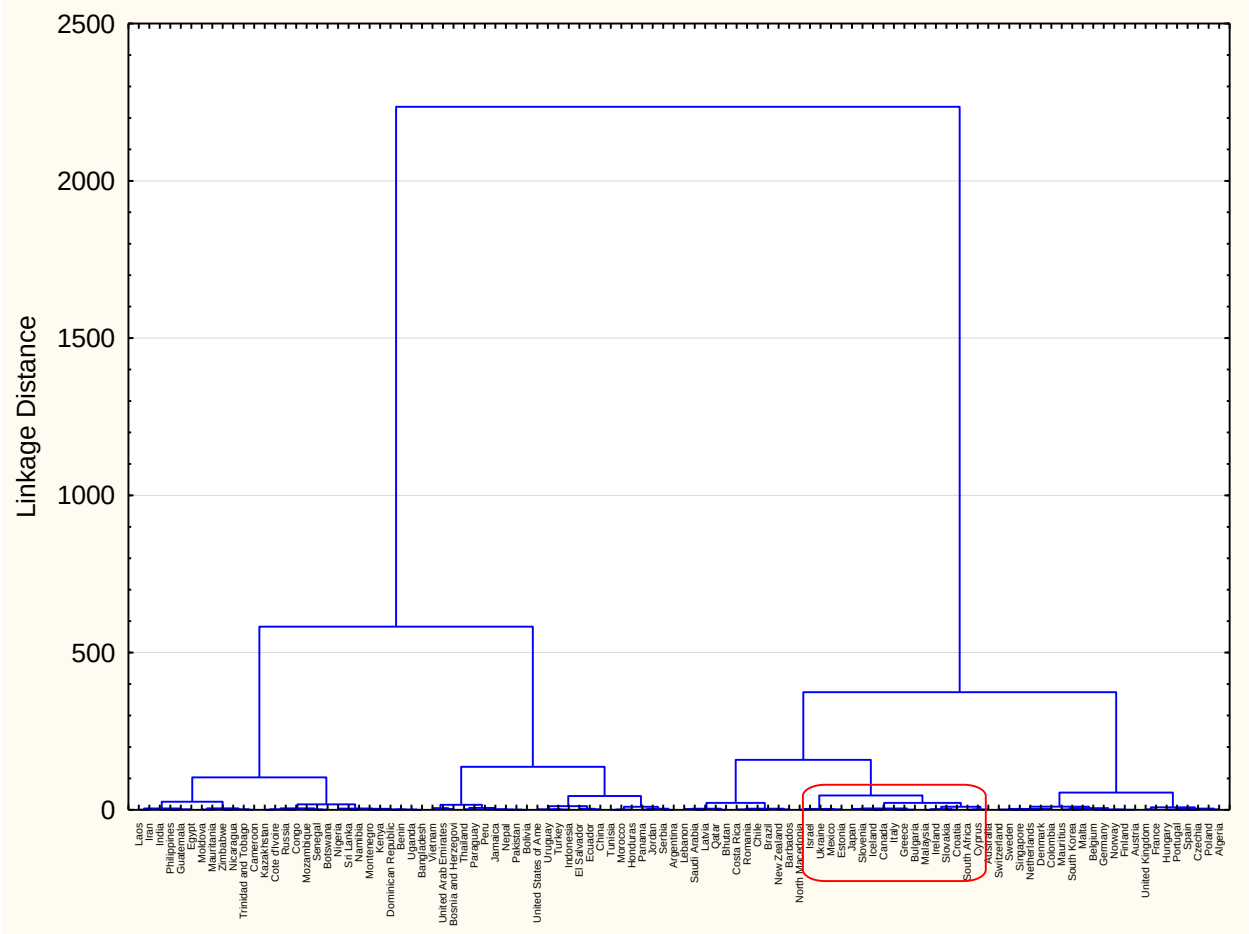

Figure 3. Dendrogram of cluster analysis of countries by 6 target characteristics

To compare the countries according to the set of considered indicators, an agglomerative hierarchical cluster analysis was performed, because of which a dendrogram was constructed (Figure 3). As we can see, all countries are grouped at a distance of 300 by a set of six studied characteristics into four clusters,

each of which in turn is divided into two subclusters. Ukraine belongs to the second subcluster of the third cluster (in the figure marked by a red line) along with 16 other countries, including Israel, Mexico, Estonia, Japan, Slovenia, and others.

5. Conclusions

The solid waste market in Ukraine as of now develops mainly in the inertial scenario (processing rates are at the level of 7-8%, while the volume of solid waste exported to existing and new landfills is increasing). Despite this, an innovative scenario is slowly being implemented, which involves the use of the latest waste recycling technologies. Under the implementation of the innovative scenario of solid waste management in Ukraine by 2030 in large agglomerations (Kyiv, Lviv, Donetsk, Dnipropetrovsk, Kharkiv and others), it will be possible to achieve about 50% processing with the introduction of separate collection of as many factions as possible, including complex processing and incineration of waste along with energy production. This scenario also addresses the problem of environmentally safe disposal of non-recyclable waste and the closure as well as reclamation of overcrowded or hazardous landfills.

The success of reforms in the field of household waste management depends significantly on the support of the population. Citizens need to develop an environmentally friendly way of thinking and change their behavior towards a culture of waste management. The importance of this factor determines the importance of cultivating a careful attitude to resources and the environment. The legal framework for solid waste management is cumbersome, confusing, and difficult to implement. Too many laws and regulations are currently in place that are not being enforced. Ukrainian legislation should be simplified and optimized by adapting to EU directives. In terms of solid waste management, Ukraine is in the top third of the list in the world ranking of countries, ranking 45th and significantly ahead of almost all former Soviet republics.

According to a visual iconographic analysis of countries on six characteristics that reflect socio-economic and environmental development, Ukraine is approaching the countries of Eastern Europe. We have established a statistically significant direct connection between the level of solid household waste management and the level of a country's economic development, HDI and SER.

The built regression models and the interpretation of their parameters indicate the need to take into account three elements of the strategy to improve the management of solid waste, namely: 1) promoting economic development, including innovative waste processing technologies; 2) improving the legal framework for the industry; 3) raising the level of education and environmental awareness of the country's population.

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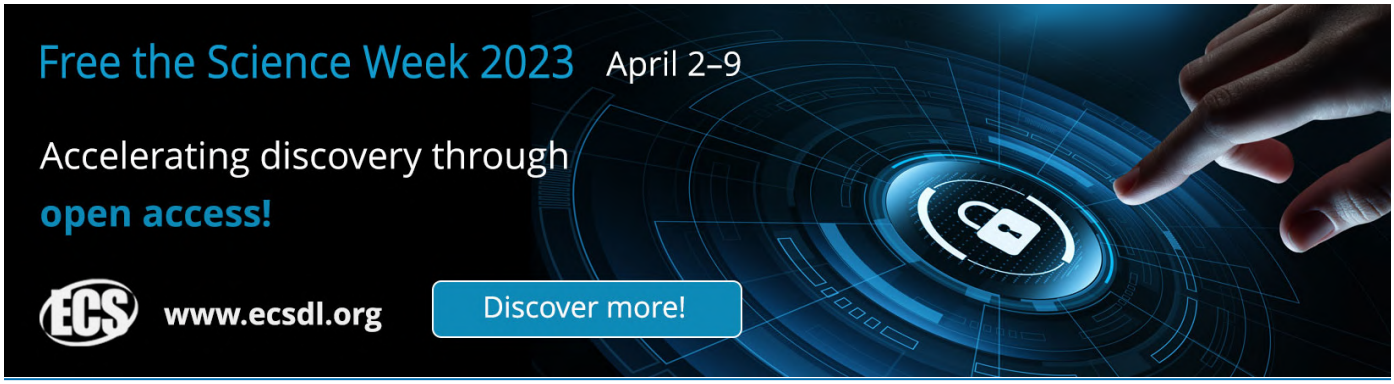
Financial and economic mechanism of the regulation of sustainable development of economic entities in a circular economy: institutional dominants



Financial and economic mechanism of the regulation of sustainable development of economic entities in a circular economy: institutional dominants

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Abstract. The article defines that to create an effective system of financial and economic regulation of the system-vector development of economic quiddity in the conditions of the circular economy it is necessary to define reserves, which contain a system of measures and methods of determining the potential capacity to develop in accordance with the real opportunities of economic entities of the energy sector in conditions of uncertainty, that allows to make well-grounded and well-balanced management decisions. It is determined that the methodical approach to determining the impact of target parameters of financial and economic condition on the level of the system-vector development of economic entities of the energy sector in the conditions of the circular economy, based on the use of financial-economics identification of the system-vector development of economic quiddity, considering the diversity, nonlinearity of target parameters of financial and economic activities and the convergence of their institutional dominants. This allows to determine the weighting of statistical indicators of financial condition, which reflects the parametric data of ranges of factors-indicators of impact on the level of financial-economics support of the system-vector development of economic quiddity in the conditions of the circular economy.

1. Introduction

Modern conditions of institutional and structural transformations in the economy of Ukraine determine the necessity of improvement of financial and economic aspects of regulation of the system-vector development of economic quiddity in the conditions of the circular economy. Since regulation of system-vector development of economic quiddity in the conditions of the circular economy plays development role in of competitiveness of our country. However, in today's conditions there are a significant number of problems and factors that make it impossible to operate the system economically, develop it, implement a strategic and relevant mission and achieve its systemic and adaptive goals. Significant depreciation of fixed assets, partial loading of general production capacities, increased dependence on external borrowing capital, low level of motivational management

function, tension of organizational climate, outdated management methods are the main factors slowing the system-vector development of economic entities of the energy sector, gradually reducing their level of financial and economic security.

2. Critical literature review

The issues of regulation of the system-vector development of economic quiddity in the conditions of the circular economy were investigated by such scientists, including O. Arefieva, A. Batura, J. Bezuhla ,T. Koryagina, T. Belyalov, A. Oliynyk, I. Gryshova, R. Khabibullin, V. Prokhorova and others. However, the theoretical-scientific and methodical-applied bases of the given issue remain not sufficiently investigated and need more thorough study.

3. Methodology and results

The energy sector is a relevant sector in the area of climate change not only in our country but also in other countries of the world, since it accounts for about 60% of the total national greenhouse gas emissions. Reducing the intensity of carbon emissions in the energy sector of Ukraine is a dominant task in achieving strategic goals in the system of regulation of the system-vector development of economic quiddity. Economic value is the economic dominant associated in energy sector with the unity of the economic utility of the good and the economic costs of production, which affects the increase in profits in the strategic-adaptive period. Because the availability of affordable energy has always been a strategic goal to meet human needs, increase life expectancy and improve living conditions. But there is another, negative, side of energy, which has an adverse effect on humans and the environment. In 2020, Ukraine ranks 60th out of 180 countries in terms of environmental pollution ranking (figure. 1).

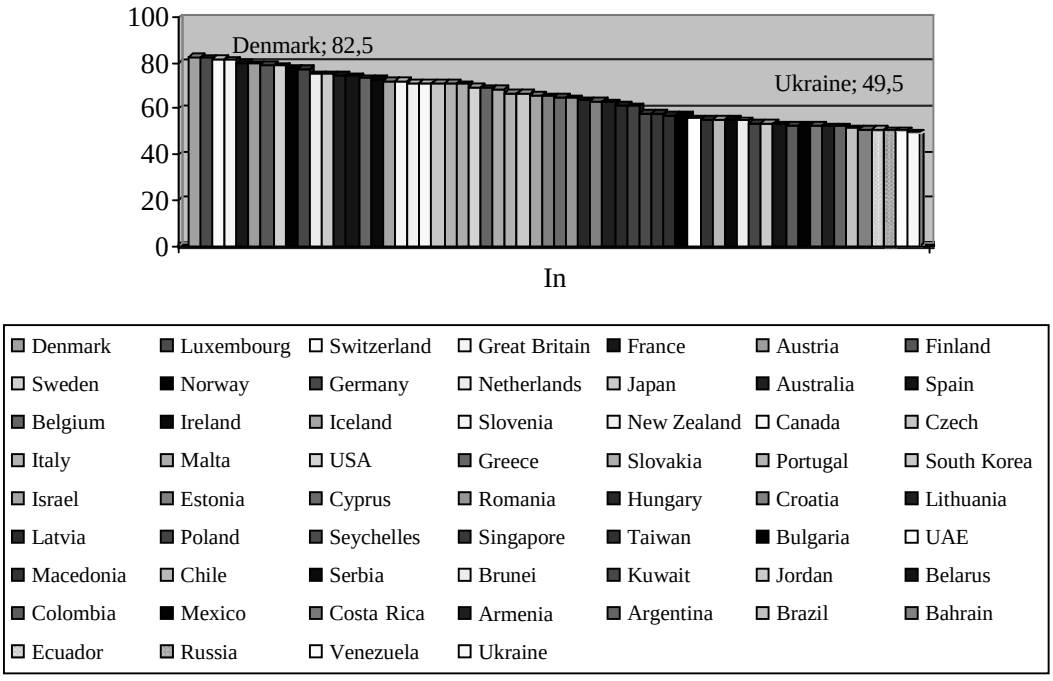

Figure 1. Ukraine is in the ranking of countries by the level of environmental pollution [8, 9, 11].

The dominant forms of influence of the energy sector on the environment of our country are defined in the following [1]:

1) The total amount of energy Ukrainians get through the use of non-renewable resources.

2) Pollution of the atmosphere of our country: Thermal effect, emission of gases and dust into the atmosphere.

3) Contamination of Ukraine's hydrosphere: Thermal pollution of reservoirs, emissions of pollutants.

4) Contamination of the electricity sector in the transportation of energy resources and waste disposal, in the production of energy by economic entities of the energy sector.

5) Contamination by radioactive and toxic wastes of the environment by economic entities of the energy sector.

6) Change water-based regime of hydroelectric power plants and, as a result, pollution on the territory of the watercourse.

7) Formation of electromagnetic fields around the lines of electric transmission by subjects of economy of power industry.

Thus, when investigating the cognitive aspects of regulation of system-vector development of economic quiddity in the conditions of the circular economy, it is necessary to pay-attention to creation of conditions for realization of potential financial and economic reserves of activity. From the point of view of creation of relevant conditions of development it is proposed to concentrate on creation of resource base, which covers formation of intellectual resources and managerial competences; formation of informational and analytical resources; formation of material resources; formation of intercoordination of relations between organizational structure lines and creation of normative-legal basis of regulation of financial and economic activity in the direction of progressive development of economic subjects (figure 2).

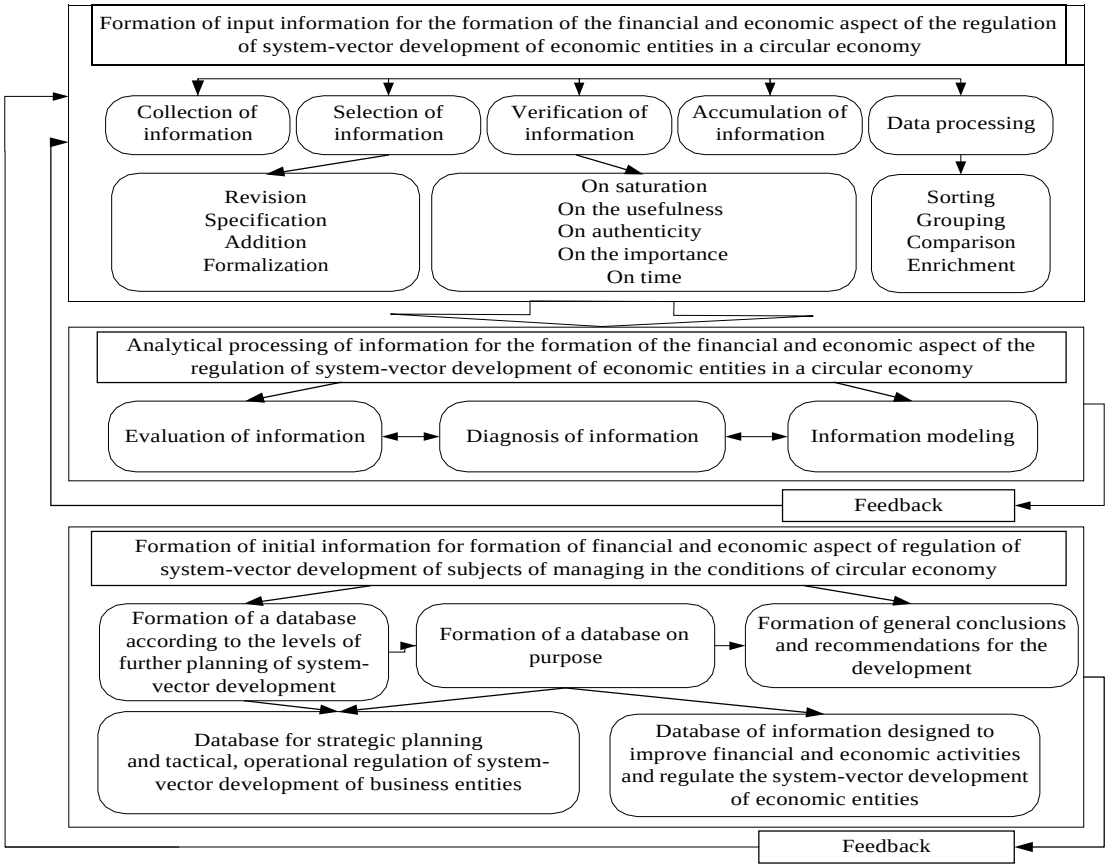

Figure 2. Information-analytical regulation support of the system-vector development of economic entities of the energy sector: financial and economic aspect.

The general approach to determining the impact of the financial and economic parameters on the level of the system-vector development of economic quiddity of the circular economy is based on the use of financial and economic identification of the level of the system-vector development of economic quiddity, taking into account the diversity of the target parameters of financial-economics activity and their convergent institutional dominants [3-4]. This allows to determine the gross factor of importance of statistical indicators of financial condition, which reflects parametric data of ranges of changes of factors-indicators of influence on level of financial-economic support of the system-vector development, which is an objective basis for building a mechanism of regulation of the system-vector development of economic quiddity in the conditions of the circular economy (figure 3) taking into account their institutional indicators and parametric data of the range of changes in financial and economic factors of influence.

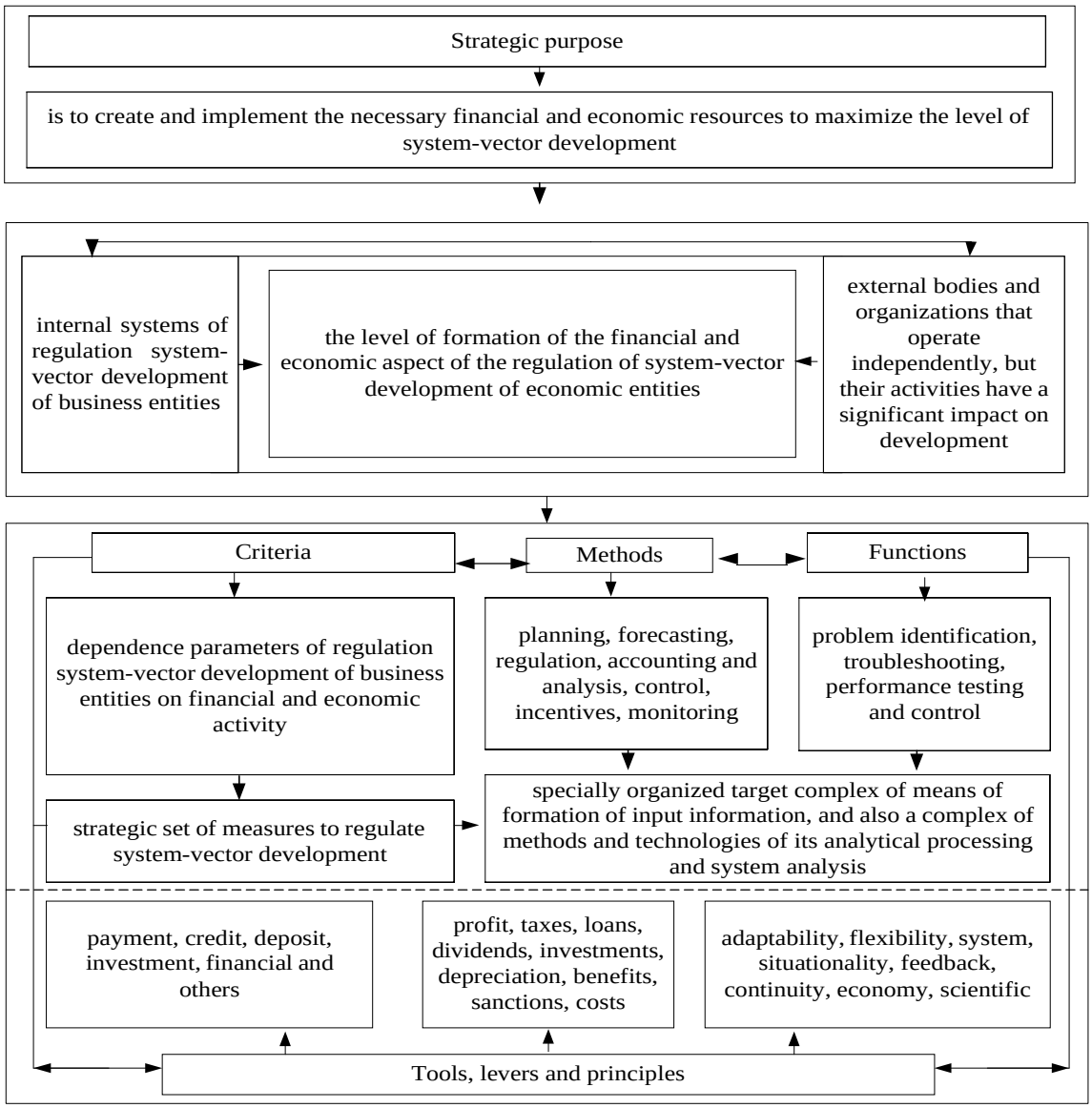

Figure 3. Mechanism of regulation of the system-vector development of economic quiddity in the conditions of circular economy.

The assessment of efficiency of financial-economics regulation of the system-vector development of economic quiddity in the conditions of circular economy is proposed to be carried out by calculation of the generalized indicator of effectiveness of instrument processes Y_{takt}, which is the sum of values of partial indicators adjusted on the gross factors.

Partial indicators of efficiency of instrumental production processes consist of monitoring base of system-vector development of production stage of financial and economic cycle. At that, the sum of the gross multipliers at partial indices should be 1, and the absolute value of each of them should be reflected the value of the individual index in the aggregate score [1, 5]. Among the seven proposed indicators, the higher priority in assessing the effectiveness of the vector system as an important business management function have a net sales profitability, a change in profitability under the influence of turnover and profitability of management of production processes, in connection with which the weight multipliers at these variables should be equal to 0.2 - 0.1.

Thus, the quantitative assessment of the effectiveness of regulation of system-vector development of the production stage of the financial and economic cycle is determined as follows:

$$Y_{takt} = 0.1I_{OA} + 0.1I_{OS} + 0.1I_{VP} + 0.2R_{NPM} + 0.1R_{OIM} + 0.2\Delta R^{OB} + 0.2R_{OAZ}, \quad (1)$$

where I_{OA} – an integrated indicator of current assets;
I_{OS} - an integrated indicator of fixed assets;
I_{VP} - an integrated indicator of the efficiency of the use of gross profit;
R_{NPM} – net profitability of sales;
R_{OIM} – operational profitability of products;
R^{OB} – change in profitability under the influence of vector development;
R_{OAZ} – profitability of management of financial-economics activities.

The integrated indicator of current assets is calculated proceeding from indicators of return of current assets (table 1) :

$$I_{OA} = \sqrt{B_{OA} \cdot R_{OA}}, \quad (2)$$

B_{OA} - indicators of return on current assets;

R_{OA} - profitability of income from ordinary activities before tax.

Table 1. Integrated indicator of the efficiency of the use of current assets of economic entities (forecast indicator).

Year	Financial and economic influence			Production influence				Parametric-vector influence	
	B_{OA}	R_{OA} (%)	I_{OA}		B_{OA}	R_{OA} (%)	I_{OA}		B_{OA}
1st year	1.36	1.20	1.28	1st year	1.36	1.20	1.28	1st year	1.36
2nd year	1.32	2.13	1.67	2nd year	1.32	2.13	1.67	2nd year	1.32
3rd year	1.43	6.12	2.96	3rd year	1.43	6.12	2.96	3rd year	1.43

The integral indicator of the effectiveness of the use of fixed assets (I_{OC}) (table 2) reflects the conditional average economic effect in the form of revenue from realization, profit from basic activity and productivity of the use of labor capital, which is on every hryvnia of expenses invested in fixed assets.

The calculation formula of this indicator is as follows:

$$I_{OC} = \sqrt[3]{FO_{OS} \times R_{OS} \times EF_{OS}}\ , \quad (3)$$

FO_{OS} – the fund-raising of fixed assets;

R_{OS} – profitability of fixed assets of economic entities in the energy sector;

EF_{OS} – level of efficiency of fixed assets economic quiddity.

Table 2. Integral indicator of efficiency economic quiddity (forecast indicator).

Year	Financial and economic influence				Production influence				Parametric-vector influence	
	FO_{OS}	R_{OS} (%)	EF_{OS}		FO_{OS}	R_{OS} (%)	EF_{OS}		FO_{OS}	
1	1.41	0.22	0.59	1	1.41	0.22	0.59	1	1.41	
2	1.84	0.27	0.62	2	1.84	0.27	0.62	2	1.84	
3	2.39	0.34	0.62	3	2.39	0.34	0.62	3	2.39	

The use of this indicator for the analysis of financial and economic activity gives an opportunity to assess the synergistic intensity of the economic effect caused by the expediency of using material and labor capital to determine the level of regulation of the system-vector development of economic quiddity in the conditions of the circular economy.

The integral indicator of the efficiency of the use of gross profit ($I_{BП}$) is proposed to calculate as the average geometrical following three indicators: net proceeds from the sale of products in the calculation of 1 UAH of wages (together with the calculations) (EF_{ZP}); profitability of expenses on wages (including social measures) on profit from operational activity to taxation (R_{ZP}) and adjusting multiplier, which takes into account the share of administrative and administrative expenses (d_{az}) and expenses on sales (d_{zs}) in operational expenses of economic entities of the energy sector (table 3):

$$I_{BП} = \sqrt[3]{EF_{ZP} \times R_{ZP} \times (1 - d_{az} - d_{zs})}\ . \quad (4)$$

The proposed indicator reflects the conditional average economic effect in form of realization revenue, profit from the main activity, which accounts for each UAH of expenses for payment of labor of the main production personnel – direct producers of products of economic entities of the energy sector (workers, IPCS, workers involved in technical servicing of production processes, etc.).

Net sales profitability (R_{NPM}) is a general indicator of production processes (financial and economic activity) and takes into account the full impact of the range of sold products, price policy, capital structure and financing of economic entities of the energy sector on their profitability.

Table 3. Integrated indicator of efficiency of use of gross profit of economic entities of the energy sector (the forecasted indicator).

Year	Financial and economic influence				Production influence				Parametric-vector influence			
	EF_{ZP}	R_{ZP}	d_{az}		EF_{ZP}	R_{ZP}	d_{az}		EF_{ZP}	R_{ZP}	d_{az}		EF_{ZP}	R_{ZP}	d_{az}
1s	7.88	0.27	0.12	1	7.88	0.27	0.12	1	7.88	0.27	0.12	1	7.88	0.27	0.12
2	8.698	0.39	0.11	2	8.698	0.39	0.11	2	8.698	0.39	0.11	2	8.698	0.39	0.11
3	9.55	0.42	0.10	3	9.55	0.42	0.10	3	9.55	0.42	0.10	3	9.55	0.42	0.10

This indicator shows the amount of net profit generated by each UAH of net income of economic entities of the energy sector (table 4).

Table 4. Net profitability of sales of economic entities of the energy sector (forecast indicator)

Year	Financial and economic influence	Production influence	Parametric-vector influence
1	0.02	0.56	0.26
2	0.01	0.35	0.17
3	0.01	0.06	0.18

The indicator of operational profitability of the production (R_{OIM}) allows to assess the possibilities of economic entities of the energy sector to reproduce and expand their production processes in the form of pure return of the total investments consumed and shows the total efficiency of the system-vector development, which influences internal production processes and operations directed at production. The operational profitability index is one of the best instruments for determining operational efficiency and demonstrates the ability of management to obtain profit from production and sales costs (table 5).

Table 5. Indicator of operational profitability of products of economic entities of the energy sector (forecast indicator).

Year	Financial and economic influence	Production influence	Parametric-vector influence
1	0.04	0.77	0.39
2	0.06	0.88	0.34
3	0.054	0.07	0.46

The rate of change in profitability under the influence of vector development reflects the level of control of financial and economic efficiency of production processes of economic quiddity, i.e. the expediency of intensification of business activity and related structural changes in the production consumption of resource base in the system-vector development (table 6).

$$DR^{об} = \frac{OII}{OS + ONOA - VOA} - OR_A, \quad (5)$$

where OS – average cost of fixed assets;
$ONOA$ – average value of the balances of normalized working capital;
VOA – the amount of absolute release of current assets as a result of accelerating their turnover;
OR_A – operational profitability of assets.

Table 6. Indicator of change in profitability under the influence of vector development of economic entities of the energy sector (forecast indicator).

Indicator	Financial and economic influence			Production influence				Parametric-vector influence	
	1	2	3		1	2	3		1
$DR^{об}$	0.15	0.18	0.21	$DR^{об}$	0.15	0.18	0.21	$DR^{об}$	0.15

The data obtained testifies to the positive dynamics of indicator changes in profitability under the influence of the vector development of economic entities of the energy complex. Financial and economic management profitability index is an indicator of the profitability of the system-vector development of economic entities of the energy sector, whose functions include coordination of internal and external financial and economic processes (table 7).

Table 7. Profitability indicator of management of financial and economic activity of economic entities of the energy sector (energy indicator).

Year	Financial and economic influence	Production influence	Parametric-vector influence
1st year	0.2	-0.79	1.76
2nd year	0.3	-1.19	2.26
3rd year	0.32	-0.61	3.12

Partial indicators of efficiency of instrumental financial and economic processes are the monitoring base of system-vector development, which influences production stages of the economic cycle.

Assessment of effectiveness of regulation of system-vector development of the production stage of the financial and economic cycle is proposed to be carried out by calculation of the generalized indicator of efficiency, which is determined by partial indicators of influence adjusted on the gross factors (table 8).

Table 8. Indicator of efficiency of regulation of system-vector development of the production stage of the financial and economic cycle of economic entities of the energy sector (forecast indicator).

Year	Financial and economic influence	Production influence	Parametric-vector influence
1st year	Moderate (2)	Conservative (1)	Aggressive (3)
2nd year	Moderate (2)	Moderate (2)	Aggressive (3)
3rd year	Moderate (2)	Moderate (2)	Aggressive (3)

According to the calculated general indicator, the effectiveness of regulation of system-vector development of production stage of the financial and economic cycle of economic entities of the energy sector was determined by the following scale: 1 point – crisis level of system-vector development caused by inefficient management of production processes; 2 points are the pre-crisis (critical) level of system-vector development, which testifies to significant shortcomings in the system of management and control of production processes or operations; 3 points are the normal level of system-vector development achieved as a result of the acceptable rigidity and adaptability of the internal system of regulation of business entities of the energy sector.

4. Conclusions

In order to create an effective model of financial and economic regulation of system-vector development of economic quiddity in the conditions of the circular economy it is necessary to define reserves, which contain a system of measures and methods of determining the potential capacity to develop in accordance with real opportunities of economic quiddity in conditions of uncertainty, that allows to make well-grounded and well-balanced management decisions. Since the creation and maintenance of the necessary level of development for effective functioning of economic entities of the energy sector provides for realization of all functional mechanisms of financial and economic potential formation on the way to making effective management decisions. Based on the fact that climate is based on individual perception, which can change with changes in the situation and the emergence of new information, it is possible to conclude that the management climate of economic entities of the energy sector is a dynamic indicator, which serves as an effective source of business activity improvement and a source of management capacity improvement. In accordance with the

peculiarities of the potential and reserves of regulation of their system-vector development during the relevant period, aimed at the increasing level of regulation of financial-economics aspects of management by reforming general strategies and tactics. For example, for economic entities of the energy sector with low level of regulation of system-vector development in the financial and economic aspect, the optimal level of regulated development, which should be oriented at forming strategic goals and setting of the planned indicators of activity, is the average level of the potential of financial and economic activity. For an enterprise with an average level, this is an average progressive level of potential. Only economic entities whose financial and economic potential exceeds the average progressive level and is the closest to the maximum level of regulation of system-vector development can be oriented to the maximum level of potential of system-vector development.

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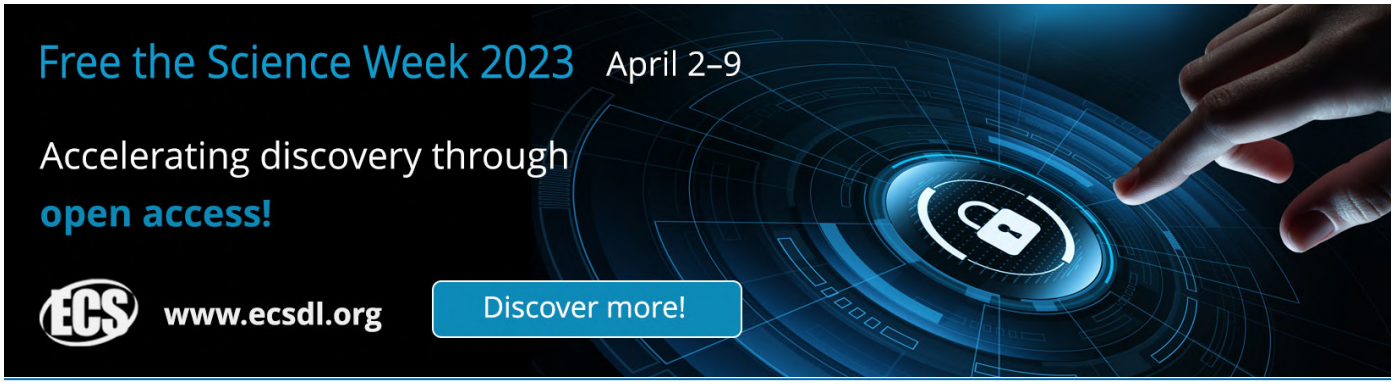
The paradigm of emergent qualities of education management as a scientific and technological platform for sustainable development



The paradigm of emergent qualities of education management as a scientific and technological platform for sustainable development

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Abstract. In this paper the factors influencing sustainable development were identified. The influence of emergent qualities of education management on stable development is highlighted. The analysis of the rating of countries by the level of education, the human development index was carried out. A cognitive map-review of systematized factors of influence on the development of education in the modern socio-economic environment has been constructed. Economic-mathematical models that describe trends in indicators of the impact of emergent qualities of education management on sustainable development and testify to a fairly stable relationship between the factors influencing the stable development of education management have been constructed. It is proved that the emergent qualities of education management have a direct impact on the creation of a scientific and technological platform in Ukraine as an effective mechanism for partnership and interaction between education, science and business.

1. Introduction

The global disruption in education caused by the COVID-19 pandemic is unparalleled and its impact on learning is very serious. The crisis has halted the education system around the world: school closures have forced more than 1.6 billion pupils to study independently. Although almost every country in the world offered distance learning opportunities for pupils and students, the quality and coverage of such initiatives varied greatly and at best partially replaced full-time education. Now educational institutions remain closed to millions of children and young people, and millions of applicants for education at different levels will never return to education. Evidence of the detrimental impact of the closure of educational institutions demonstrates a terrible reality: learning losses are significant, which affects the most marginalized children and young people.

UNESCO called for a new public contract in the field of education as part of a historic report on the future of education. The practical experience that humanity has gained as a result of the global pandemic has shown that teachers, pupils, students and their parents were not prepared for such challenges. At this time, the issue of new education, education that transforms people who can transform society and build a better future, is becoming urgent.

UNESCO has called for the conclusion of a new social contract in the field of education as part of the historical report on future education [1].

Together, educators should strive to transform education systems so that pupils of all ages receive support, so that they can take care of each other and the planet, and create more peaceful, just and sustainable societies.

Ukraine is the largest European country by area with a population estimated by the state statistics service 41,588,354 people as of January 1, 2021. Today about 70% of Ukrainian residents have a higher education. However, the potential of higher education is not fully used by society and the economy. So, according to the overall rating "The Good Country Index", which indicates how much each of the 153 countries does good for the planet and the human race through their policies and behavior, in 2020 Ukraine ranked 76th, while the closest geographical neighbors and countries that are direct competitors in the educational services market are significantly higher, namely Poland – 31st, and Germany – 5th.

It should be noted that this is not the first time that Ukraine ranks 1st in the "Contribution to the Development of Science and Technology" component of this rating, Poland – on the 13th place, Germany – on the 23rd, and Great Britain – on the 5th, but it should be noted that such a high place of Ukraine is explained by a significantly lower level of GDP per person than the results of the development of science and technology [2]. Higher education is in high demand and this is confirmed by the indicator of high-tech employment, which is a component of the global innovation index [3]. Analysis of sources [2-4] showed that in 2020 the global innovation indicator of Ukraine was 37.3% and Ukraine ranked 32nd. However, a number of European countries have a significantly higher indicator of this index. The UK ranks 7th with the Global Innovation Index at 49.2%, Germany is 17th with 45.2%, and Poland is 28th with 39.5%.

2. Critical review of the literature

The integration of the national economy, in particular domestic energy companies, into the global economic space is a complex and unpredictable process, because it is difficult to ensure its effective functioning, especially sustainable development. Research on the conceptual foundations of sustainable development of energy companies is an extremely relevant issue today. The unpredictability of socio-economic phenomena, global turbulence and the emergentness of the national economy complicate the solution of this problem.

It is necessary to identify and monitor the latent manifestations of emergent qualities of education management as a scientific and technological platform for sustainable development, the formation of which takes place in the context of constant and not always effective reforms. The modern socio-economic environment is characterized by turbulence, the presence of economic threats and dangerous socio-economic phenomena that simultaneously threaten their sustainable development.

The study of the theoretical foundations of manifestations of unpredictable directions of sustainable development of subjects of entrepreneurial activity and business, the economic nature of which is determined by the formation and activation of emergent qualities of education management, forms organizational and economic support for quantitative and qualitative changes in the strategic aspect. Timely identification of emergent negative qualities of education management of subjects of economic processes and systems and their effective direction will enable their sustainable development. Elucidating the emergentness characteristics and features of non-additive (emergent) qualities of education management will become the basis for social development and the development of the educational environment for identifying and timely directing strategic guidelines for sustainable development. Determining the

effectiveness of the direction of emergent qualities of education management in the national economy and the economic system at the microlevel will be a prerequisite for a model forecast of the functional potential of these systems.

The methodology of sustainable development processes is the object of research by a significant number of domestic and foreign scientists.

Many factors affect sustainable development, among which special attention should be paid to the quality of education management.

In the literature on management, commercial activity and marketing, it is classically customary to divide it into factors of internal and external environment, as well as factors of direct and indirect influence [5-9]. In modern conditions, the number of factors and their nature is being transformed. For example, with the development of information technology and logistics, each organization has the ability to increase or decrease the impact of individual factors.

Both the external and internal environment include many different components. Thus, the internal environment includes, according to M. Mescon, M. Albert and F. Hedowry [11], the goals of the organization, material and labor resources, size, horizontal and vertical division of labor, technical equipment, internal information, organizational culture and other elements. G. Levitt has the same opinion paying attention to the systemic nature of the organization and formulating the concept of "Levitt's Diamond", which lays in the relationship of four components: tasks and missions; technologies; structure; people [12].

For the effective functioning of the enterprise, the implementation of tasks is related to the set goals, which requires providing employees with specialties and qualifications. The sustainable development of companies is constrained by the lack of the necessary professionals. The main concern of a modern enterprise is the selection of professionals and the help of capable managers.

It should be noted that without high-quality education management, there will be no professionals in any field of activity, and therefore it is necessary to pay special attention to the emergent qualities of education management as a scientific and technological platform for sustainable development.

Analysis of literature sources has shown that today much attention is paid to complex systems that are characterized by emergentness, as a manifestation of the property of system integrity in the brightest form, that is, the presence of any system of such properties that are not inherent in any of its elements, considered separately outside the system. In general, emergentness (from the English ‘emergent’ – suddenly appearing, suddenly popping up) is the appearance of properties of a whole that are not additive to the properties of the parts included in it, that is, properties that do not follow from the properties of its parts. However, as practice shows, today there is no single definition of the concept of "emergentness", different scientists interpret it following no particular pattern [6-12].

It is most appropriate to define emergentness as a result of the occurrence between the elements of the system of the ability to tune in to a more productive, efficient nature of work and respond in time to respond to changes in both the external and internal environment, which provide a significant increase in the overall effect than the sum of the effects of individual independent elements of the system.

Emergent qualities of education management are manifested in the form of the feature of innovation and innovative features. The feature of the innovation has versatile and diverse characteristics that lead to rapid changes in both products, goods produced by enterprises and educational services provided by teachers, or there is a gradual improvement of these results of enterprises' activities. Due to the emergent features of innovations, the company gains relative stability for the purposes of sustainable mass production. An innovative feature is characterized as a breakthrough in the main product technology, through innovative processing that solves the main issues of development and processing. Due to emergent innovative features, society experiences technological normality through goods and services, or the compliance of technologies

with modern requirements of life and business model. Innovative processing in the concept of circular economy is also considered [9].

The processes of activation of emergent properties are a driving force for the mechanism of innovation introduction and promotion, which allows companies to select and measure the needs of the market and consumer at each stage of the life cycle for the expediency, timeliness, clarity and compliance of innovations [10].

3. Methodology and results

Currently, higher education in Ukraine is publicly available and the level of higher education coverage of the population of the traditional official age of study reaches 83 %, which allowed Ukraine to take the 14th place in the Global Innovation Index 2020, while according to this component of the Global Innovation Index, Great Britain ranks 34th and the indicator is 60%, Germany is on the 28th place (70.2%), Poland has the value of this component at the level of 67.8% and occupies the 34th place. Most researchers believe that a significant advantage of Ukraine is equal access to education for both women and men. The share of working women with higher education and scientific degrees in the total number of employees in Ukraine is one of the largest in the world-30.4 % (the 3rd place). In other countries selected for comparison, this indicator is much lower. So in the UK – 23.4% of working women have higher education and a scientific degree and it ranks 16th, Poland ranks 25th, since 21.1% of working women have higher education and a scientific degree – 21.1 % (25th), Germany-13.5 % (51st) [3].

Analysis of the data in Figure 1 shows that 47 countries have a high level of education among the countries studied, out of which 15 countries, namely: Germany, Norway, Great Britain, Finland, Iceland, New Zealand, Australia, Ireland, Denmark, Sweden, the Netherlands, Slovenia, Belgium, Switzerland, the United States of America have an index of 0.9 or higher.

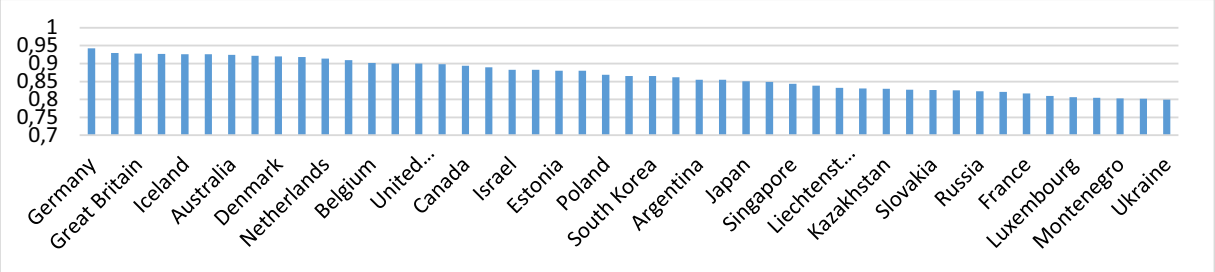

Figure 1. Rating chart of a country with a high level of education.

Countries with an education index of 0.8 to 0.9 include Lithuania, Canada, the Czech Republic and other countries. It should be noted that Ukraine closes this list with an indicator of 0.8.

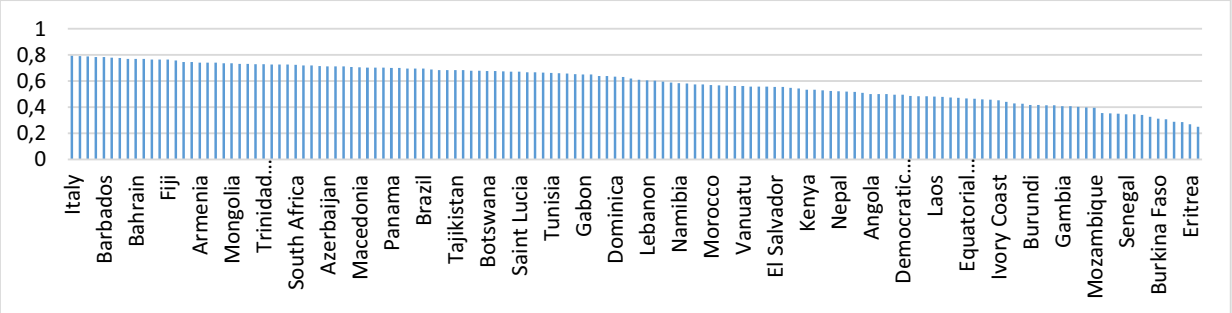

Figure 2. Rating graph of countries with medium and low levels of education.

Analysis of the indicators in Figure 2 showed that Italy, which is a highly developed country and is among the 10 most developed countries in the world, has an education index of 0,793 and Cuba of 0.79. The lowest indicators are in such countries as Mali (0.286), Eritrea (0.269), Niger (0.249).

The authors investigated an up-to-date (periodically updated in accordance with the latest research results) list of countries of the world and administrative territories without state status, ordered by the Human Development Index. Current data is presented as of 2019 and published in December 2020. Figures 3-6 show the ranking of countries classified into four categories according to the accepted gradation shown above.

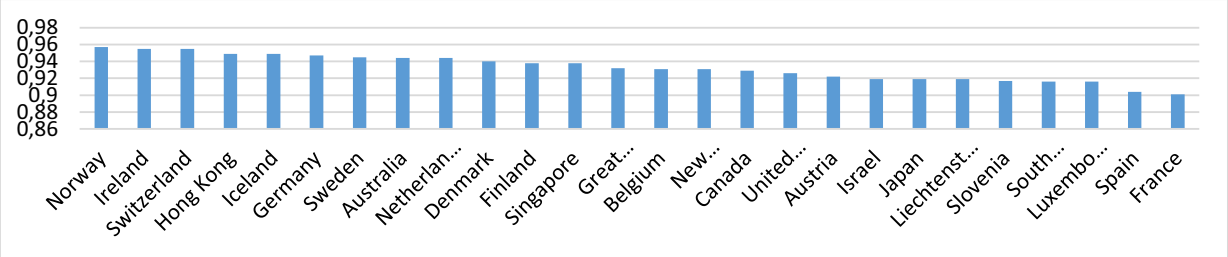

Figure 3. Ranking of countries with a very high level of the Human Development Index.

Analysis of the Human Development Index of countries that have a very high level showed that no country has this indicator at the level of the maximum value of 1. Norway, Iran, Switzerland have the highest level. According to this gradation, such countries as Luxembourg, Spain, and France have the lowest level among countries that have a very high level of the Human Development Index.

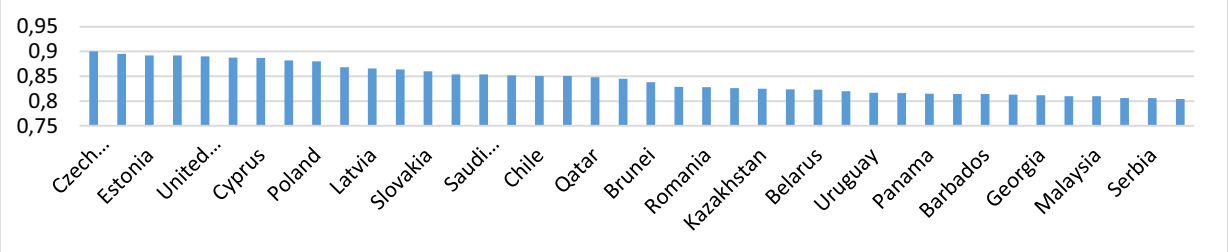

Figure 4. Rating of countries with a high level of the Human Development Index.

Analysis of the Human Development Index of countries with a high level showed that the Czech Republic, Estonia, and the United Arab Emirates have the highest level. According to this gradation, such countries as Georgia, Malaysia, and Serbia have the lowest level among countries with a high level of the Human Development Index.

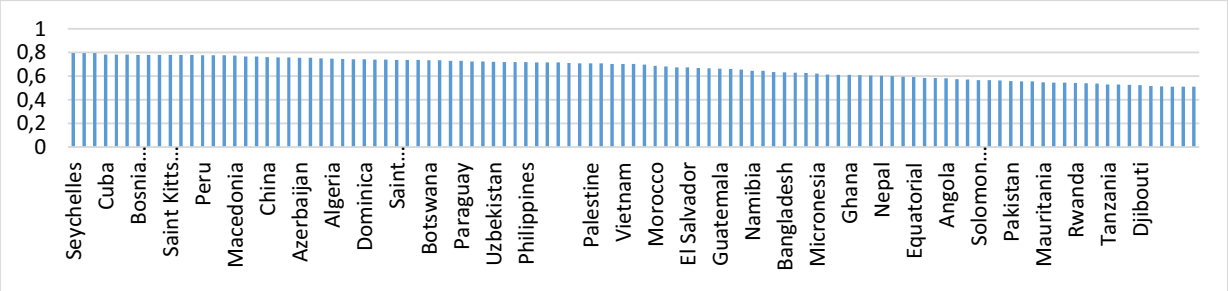

Figure 5 – Ranking of countries with an average level of the Human Development Index.

The studies have shown that most of the countries studied have an average level of Human Development Index, namely Cuba, Albania, Iran, Sri Lanka and others. It should be noted that the part of the data provided by national statistical organizations is not always reliable, as some governments knowingly embellish the situation in their countries, and the statistics shown in Figure 4 are somewhat questionable.

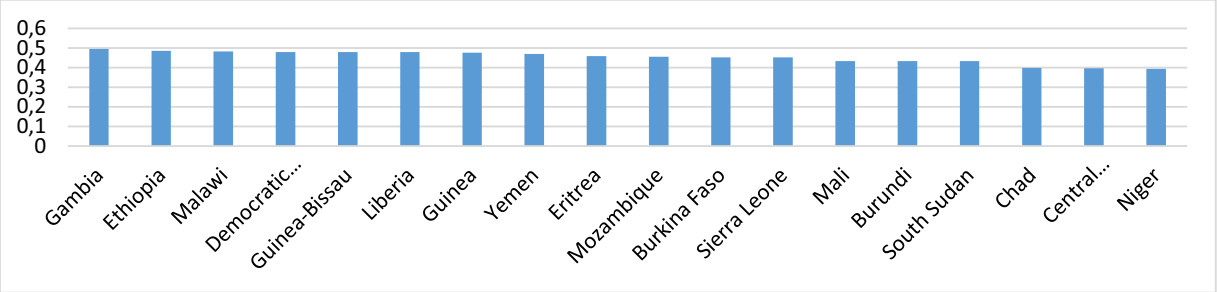

Figure 6. Rating of countries with a low level of the Human Development Index.

The studies have shown that countries such as The Gambia, Ethiopia, the Democratic Republic of the Congo, Guinea-Bissau, Liberia and others have a low level of Human Development Index.

So, the studies have shown that modern world socio-economic processes indicate an increasing role of education in all spheres of public life, including having a significant impact on sustainable development.

Without any exaggeration we can say that education plays and will play a crucial role in sustainable development. It is due to education that a modern information society is formed, as well as an integral system of resource conservation of social production.

In modern conditions, the sustainable development of the energy industry is determined by an increase in the scientific and technological component, the development of intellectual capital, and a high level of competitiveness due to the widespread introduction of innovations.

Today, the development of Ukraine is impossible without a conscious acceptance of the priority of ensuring an effective balance of economic, environmental and social development. The energy industry is one of the key global changes in this direction, since the progressive increase in capacity based on outdated technologies and worn-out fixed assets leads to an increase in the negative impact on the ecology of regions and countries, and the qualitative restructuring of the sector structure is long-term and investment-intensive. Ukraine, as a state, supports the course of building a circular economy and ensuring inclusive development.

Recently, the importance of education and the level of its management have significantly increased, which is advisable to understand the system of making managerial decisions that will ensure the high-quality functioning of an educational institution in modern environmental conditions. At the same time, it is important that management allow the educational institution to adapt or counteract certain factors that affect the development of education and its competitiveness. It is clear that educational institutions are fundamentally different from enterprises. However, in our opinion, they can significantly increase the efficiency of their activities if they adopt management tools. Figure 7 shows a cognitive map overview of systematized factors influencing the development of educational institutions on those that contribute to the development of educational institutions, and those that slow it down.

The priorities of the functioning of the innovative economy are the availability of highly educated employees capable of innovative work [16, 22-28]. To solve the tasks set for the effective development of educational institutions, it is necessary to use the tools of modeling processes. The main stages of economic modeling are:

- defining the essence of the economic process and setting the task;
- choosing a method for solving the problem;

- analysis of quantitative and qualitative parameters of the task set in relation to the object of research;
- study of relationships between model elements;
- building an economic model, solving the problem;
- analysis of model results, implementation of forecasts [17].

Econometric models are a type of economic and mathematical models that are used to estimate the parameters of the research object using mathematical statistics methods.

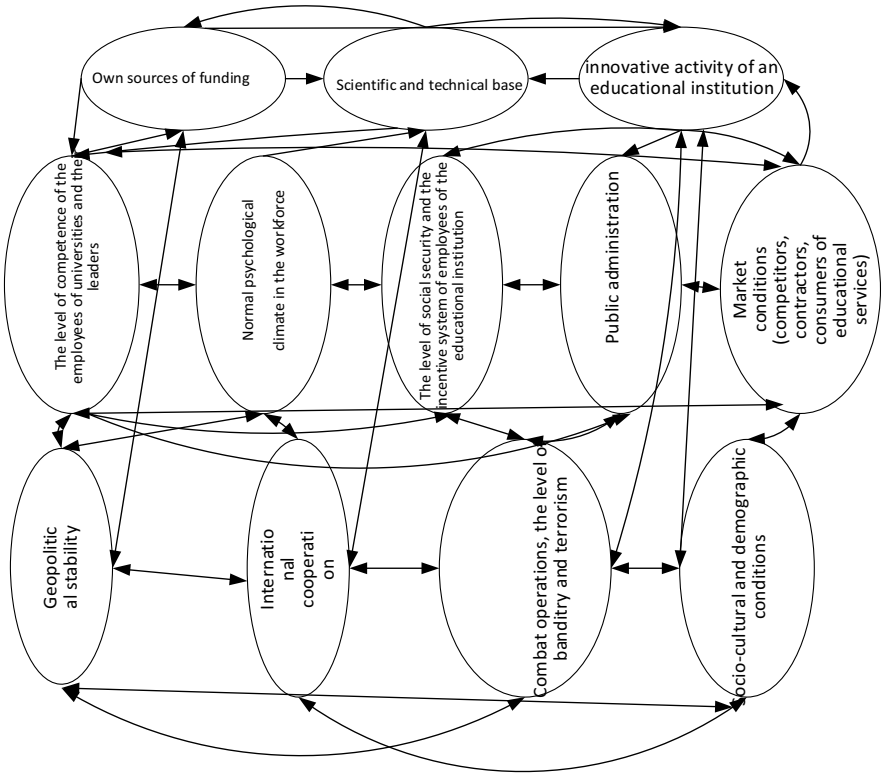

Figure 7. Cognitive map overview of systematized factors influencing the development of education in the modern socio-economic environment.

In the econometric model, one of the main approaches to studying the relationship between factors of influence is correlation-regressive analysis. It is a set of methods that determine the type of equation for the factors under study and calculate their parameters (regressive analysis). Regression models establish a linear relationship between variables. The tightness of the relationship between variables in an equation or equations and their significance is also determined using correlation analysis [18].

In order to study the processes and factors of influence of emergent qualities of education management on sustainable development, it is advisable to apply methodological developments of scientists and economists on the construction of Trend models for predicting the main development processes [19]. According to the State Statistics Service of Ukraine [20], the Ministry of Finance of Ukraine [21], a certain number of indicators that have an impact on sustainable development were selected for the study. From the

presented array of statistical data, indicators of the most significant impact of emerging qualities of education management on sustainable development are selected for further research (Table 1).

Table1. Factors of influence of emergent qualities of education management on sustainable development.

Name	Influence factors
X1	Number of population, thousand people
X2	Average life expectancy at birth, both sexes, years
X3	Expenditures of the consolidated budget for the development of the state, UAH bln.
X4	Consolidated budget expenditures on education, UAH bln
X5	Graduates of specialists in ZVO III-IV levels of accreditation, thousand people
X6	Trained (graduated) skilled workers, thousand people
X7	Number of scientists, persons
X8	Amount of organizations performing research and development, number of organizations
X9	Share of enterprises implementing innovations, %
X10	Economically active population aged 15-70, thousand people
X11	Employed population aged 15–70, thousand people
X12	Unemployed population aged 15-70, thousand people
X13	Average monthly salary, UAH
X14	Labor productivity of human funds, USD/person
X15	Population migration between Ukraine and other states, increase (decrease), thousand people
X16	Expected duration of study, years
X17	GDP of Ukraine, million USD
X18	GDP per capita in USA, USD

Note: formed by the authors on the basis of data (the State Statistics Service of Ukraine. Economic activity of the population of Ukraine, 2020; the Ministry of Finance of Ukraine, 2020) [20, 21]

For certain factors of influence of emergent qualities of education management on sustainable development, trend lines are constructed using various types of approximating dependence (linear; logarithmic; polynomial of the 2nd, 3rd and 4th degree; power). The forecast values were calculated using the Microsoft Excel package. The selection of trend models was carried out taking into account the value of the coefficient of determination (R^2). For further studies, the following factors of influence and their predictive values were selected, which had high values of the coefficient of determination in the range of 0.8-0.9.

In general, a multi-factor correlation and regression model that reflects the relationship of factor features to the resulting indicator (Y) and is used for economic analysis has the following form:

$$Y = f(X) + u, \quad (1)$$

$$Y = a0 + a1*X1 + a2\ X2 + a3\ *X3 + \ldots + an\ *\ Xn + u, \quad (2)$$

where Y - dependent variable;

X – independent variable;

a0, a1,… an – unknown parameters of the regression model (a coefficient that determines the strength of influence of factors, i.e. independent variables on the Y indicator;

u – a vector of random variables (errors) [18].

In general matrix form the econometric model is presented as follows:

$Y = AX+u$,

where A is a matrix of model parameters of size m×n
Y – a dependent variable parameter matrix;
X – a matrix of parameters of independent variables;
u – a matrix of random variables.

Table 2 shows models describing trends in indicators of the impact of emerging qualities of education management on sustainable development

Table 2. Models describing trends in indicators of the impact of emerging qualities of education management on sustainable development.

Influence factors	Models	Determination coefficient R2	Estimated values, years 2022	2023	2024	2025	2026
Number of population, thousand people	Y1=-345,1X+49783	0,95	41231	41100	40878	40581	40121
Average life expectancy at birth, both sexes, years	Y2=9E-05X4-0,0012x3+0,059x2-0,7985x+68,387	0,92	71,88	72,05	72,34	72,54	72,61
Expenditures of the consolidated budget for the development of the country, UAH bln	Y3=1,1124x3-17,99x2+128,5x-0,1198	0,97	2765,5	3382,7	3456,27	3512,83	3582,47
Consolidated budget expenditures on education, UAH bln	Y4=0,14689x3-2,989x2+16,999x-3,898	0,96	403,15	462,32	482,1	501,20	543,83
Specialists graduated from universities of III-IV levels of accreditation, thousand people	Y5=-0,79852x2+37,954x+3,1212	0,92	360,53	348,68	345,81	331,32	328,24
Trained (graduated) skilled workers, thousand people	Y6=0,0029x4-0,25341x3+7,121x2-49,787x+573,01	0,92	120,44	119,21	117,99	117,24	116,88
Number of scientists, thousand people	Y7=-8159ln(x)+325315	0,97	47009	45483	43124	42024	41545
Amount of organizations performing research and development	Y8=-2,141x2+48141x+1198,8	0,87	567	462	354	256	198
Economically active population aged 15-70, thousand people	Y10=-498,98x+20194	0,85	14297	14392	13985	13002	12878
Average monthly salary, UAH	Y13=108,1x2-301,29x+13,992	0,92	16128	17958	18450	18342	19450
Expected duration of study, years	Y16=-0,03011x2+0,2698x+14,725	0,93	15,6	14,6	14,3	13,1	13

As we can see in Table 2, in the near future, when calculating forecast values, some indicators are characterized by a downward trend, which will negatively affect the development of education.

Table 3. Econometric models of education management development.

Models	Correlation coefficient R	Determination coefficient R2	Normalized R-square	Fisher's criterion F	Approximation error
Y1=0,1583+0,1872X1+0,2402X8+0,1968X10+ 0,1005X13+0,2705X16	0,968	0,815	0,723	10,1	0,012
Y2=0,15041+0,5238X7+0,2781X12+0,4239X1 3+0,3728X17+ 0,1105X18	0,951	0,811	0,711	11,2	0,017
Y3=0,3717+0,1658X2+0,5362X8+0,51708X11 +0,4101X15+0,3471X17	0,810	0,671	0,651	12,1	0,018
Y4=0,2357+0,3453X1+0,2061X4+0,4753X7+0, 2443X10+0,1763X13	0,929	0,713	0,645	10,1	0,016
Y5=0,15484+0,17584X1+0,04578X4+0,26183 X11+0,1956X15+05748X14	0,899	0,715	0,671	10,0	0,015

This indicates the need to step up state regulation and improvement measures efficiency of reproduction and development of the country's education management. High values of the coefficient of determination R^2 indicate a significant close relationship between the dependent variable Y and the independent variable X. The results of calculations using standard MS Excel software are shown in Table 3. Econometric modeling of the influence of factors on the development of educational management is carried out and correlation and regression models are constructed.

4. Conclusion

The paper defines the factors of influence of emergent qualities of education management on sustainable development, on the basis of which economic and mathematical models are constructed that describe trends in indicators of the influence of emergent qualities of education management on sustainable development. Economic and mathematical models of education management development are also constructed. The constructed economic and mathematical models indicate a fairly stable relationship between factors affecting the development of education management. The authors came to the conclusion that the emergent qualities of education management have impact on the creation of scientific platforms in Ukraine as an effective mechanism for partnership and interaction between education, science and business, which in the future will make it possible: improve the competitiveness of the main sectors of the economy; to combine education, science and business in the process of creating and developing advanced technologies; to concentrate state and private sector funds on solving the problems of scientific and technological and innovative development; to identify future needs in the field of training highly professional personnel in demand by the market; to encourage the participation of business structures to act as customers of

educational and scientific institutions and research organizations, as well as investors in promising scientific and technological developments.

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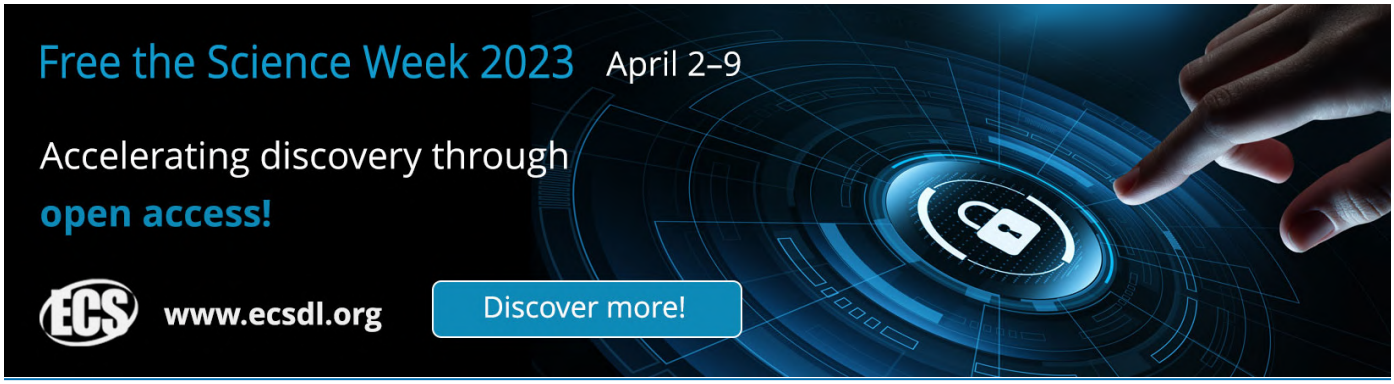
Corporate management of sustainable development goals as a driver for solving global environmental problems



Corporate management of sustainable development goals as a driver for solving global environmental problems

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Abstract. The article devotes the study of the environmental responsibility of automotive enterprises from the point of view of solving global environmental problems. The authors mainly focus on the issues of financial stability, which determines enterprises' ability to realize sustainable development goals (SDGs). The synthesis of scientific approaches allows for generalizing and developing theoretical foundations for understanding the role of finance and investment in achieving SDGs. The authors proposed a methodology for analyzing the influence of financial stability on the possibilities of realizing SDGs and carried out its approbation on the example of automobile enterprises. In general, the authors identify the main challenges, trends, and problems of financial support for the implementation of sustainable development goals, which allows setting key objectives for the near future. According to the analysis results, an algorithm for sustainable development management was proposed, which differs in complexity and multilevel approach. The role of automotive corporations in shaping the eco-environment in their countries requires further research.

1. Introduction

The aggravation of global environmental problems highlights the task of implementing sustainable development goals at all levels of society: international, national, and corporate [1].

It is essential, in this case, to provide the necessary amount of funding. According to UNCTAD, 5-7 trillion USD are needed annually to finance the SDGs) [2], but there is a general gap in SDGs funding due to public finance deficits and corporate finance constraints, which are an important component of these processes. According to Bloomberg, the value of global assets combined with ESG criteria will exceed 53 billion US dollars by 2025. This process is quite dynamic, as ESG assets amounted to 22.8 in 2016 and 30.6 trillion US dollars in 2018 [3].

Corporations should become more and more active participants in the implementation of SDGs because, in focus on sustainable economic results, they disturb the balance of the environment and are major polluters. So, 224 companies represent 72% of annual global industrial GHG emissions [4]. In addition, the issues of sustainable development management are left out of consideration in many

more companies. Hence the study of the positive experience of leading corporations is of great scientific and practical importance.

There is WBCSD [5] established in the context of accelerating the transition to a sustainable model of development through corporate initiatives. It includes more than 200 leading companies coordinating efforts to ensure success and sustainability.

The activities of leading companies to achieve SDGs acquire comprehensive characteristics and are carried out, including through foreign divisions in the global dimension. It includes a set of projects that will promote to the education of an ecologically responsible society that benefits biodiversity (from Develop human skills in harmony with nature and Develop biodiversity education up to promote local interaction and the creation of a responsible society) [6].

The success of the 2030 Agenda [7] depends on the use of tools to manage corporations' economic, social, and environmental aspects, the functioning of territories and cities, and the direction of society as a whole. The paper [8] 0offers a comprehensive study of the promotion of sustainable development goals. The authors point out the existence of significant gaps in current research and emphasize the need to apply systemic thinking to achieve SDGs.

In [9] the authors summarize the challenges and obstacles to the implementation of SDGs and propose a practice-oriented approach, outlining the key challenges for scientists on sustainable development.

A systematic approach to the implementation of SDGs and tools for its application proposes in [10]. In general, the authors' vision bases on prioritizing SDGs and mobilization of available resources. On this basis, it is proposed to investigate the best experience in the formation of environmental responsibility and the development of relevant strategies.

The need for deep research summarizing effective practices, along with systematic studies of specific measures to implement SDGs in business schools, is emphasized in the paper [11].

Thus, the study of the implementation processes of SDGs should be based on multilevel, integrated, systematic approaches and focus on the dissemination of positive experiences and effective practices.

Boffo R. and Patalano R. [12] note that despite progress in implementing ESGs, there is a need to intensify continued endeavours by policymakers, investors, and all stakeholders. Many companies are still too superficial about the goals of sustainable development. Therefore, as noted in [13]0, achieving the Agenda 2030 requires more significant changes in business behavior. It is important to apply a new way of thinking about the environmental responsibility of business structures in the future. It requires a holistic approach to interaction with sustainable development goals, in which all internal subsystems must transform. The key issue here is sustainable financing [12], which has increased significantly in recent years, but income indicators have been volatile, raising questions about the real impact of SDGs on productivity.

Corporate governance has some experience in achieving the SDGs and forming sustainable financial support for greening processes. Still, this study focuses on generalizing the experience of automotive companies, and it is appropriate for several reasons.

1. The environment is significantly affected not only by the production activities of car companies but also by their products. 15% of total CO2 emissions are provided by transport, in the particular automobile [14].

2. According to IEA experts [15], there will be a doubling of global transport (in passenger-kilometers) and a 60% increase in the number of car owners due to population growth and income by 2070. Such an increase in demand can be offset solely by reducing emissions from passenger vehicles, i.e., through technological innovation and increasing electric vehicles production.

3. Orientation of global energy to achieve zero CO_2 emissions by 2070 (according to the IEA scenario [15]) involves the gradual cessation of emissions from all types of vehicles. Although emissions from certain types of vehicles will not be completely eliminated by 2070, their significant reduction is expected in many regions of the world [16].

4. Automobile companies are quite active and among the pioneers to start large-scale implementation of SDGs at the corporate level, as evidenced by a comparison of the dynamics of production and CO_2 emissions per unit of output. Thus, there was a gradual reduction in the amount of CO_2 emissions per unit of output (by 4.15% per year) comparing to growth in the production of the automotive industry during 2009-2018 (by 5% per year) [16].

This means that the increase in car production, which is generally observed around the world, is partly due to an increase in the production of cleaner cars. Thus, this indicates a generally positive trend in the implementation of SDGs by car companies.

Some companies representing the automotive industry are market leaders and set trends in the public vision of spreading the concept of sustainable development [17]. Governments, consumers, and investors are also pushing car companies to changing technology, products, and culture in the context of fully transforming sustainability goals into strategic development priorities for the industry as a whole.

The choice of the studied enterprises is based on their significance in the global car market. The key players operating in the global automotive industry are Volkswagen AG (Germany), Toyota Motor Corporation (Japan), General Motors (US), Ford Motor Company (US), Nissan Motor Corporation (Japan), Fiat Chrysler Automobiles (US) and others.

Without claiming to study all the factors, we will focus on determining the importance of forming an effective financial management system to implement SDGs using the experience of the above automobile companies.

The paper [12] reveals the characteristics of sustainable financing. The authors note that investments in the goals of sustainable development are determined by the desire of investors not only to obtain economic results from such investments, but also to make a positive impact on the environment.

Investments and innovations are key factors of progress in business development, and therefore the implementation of SDGs requires consideration of these emphases in the management process. Businesses need new innovative approaches to solving current environmental problems that correlate with SDGs [18]. The solution of existing problems and challenges depends on investment activity of enterprises, i.e., their ability to produce innovations on an ongoing basis. Sustainable innovation is very important, as implementing SDGs can lead to deteriorating financial results and financial instability.

This, in turn, can significantly limit the capacity of enterprises to finance investment and innovation, and thus effectiveness in the field of environmental responsibility. The same companies with unstable financial results do not have the opportunity to maintain adequate financial support for environmental goals. In other words, a stable financial position, sustainable investment is the basis for the implementation of SDGs [19]. That is why incorporating SDGs into the financial management system is relevant and needs research.

Given all the above, this research of sustainable development and financial sustainability using the example of automobile corporations will have both scientific-theoretical and practical significance.

This study aims to study the financial support processes for the implementation of SDGs by automotive corporations from the position identification challenges, trends, and positive experiences.

Taking into account the main goal of the article, we consider it necessary to solve the following specific tasks: to summarize the scientific views of scientists on the problems of sustainable development and its analysis; to explore best practices in the management and financing of SDGs on the example of car companies.

2. Methodology

The issue of methodological support for the analysis of sustainable development of enterprises, on the one hand, has a strong base in the form of a number of works [20-26], from a different perspective, the problem of ensuring stable operation of the enterprise is difficult to predict because it is caused by external factors that are difficult to regulate. In modern conditions, there is a further complication of the external environment in terms of challenges, respectively, the method of analysing the sustainable

business development, identifying the key factors for sustainable development, remains relevant, and the emphasis on financial stability is quite logical.

2.1. The logical basis of the methodology.

It is necessary to form a structural and logical scheme of causal relationships between key components of sustainability and their impact on financial stability in order to substantiate a possible algorithm for analysing the sustainability of enterprise development, which would combine the advantages of existing methodological approaches and allow real research, especially with an emphasis on financial aspects (Figure1).

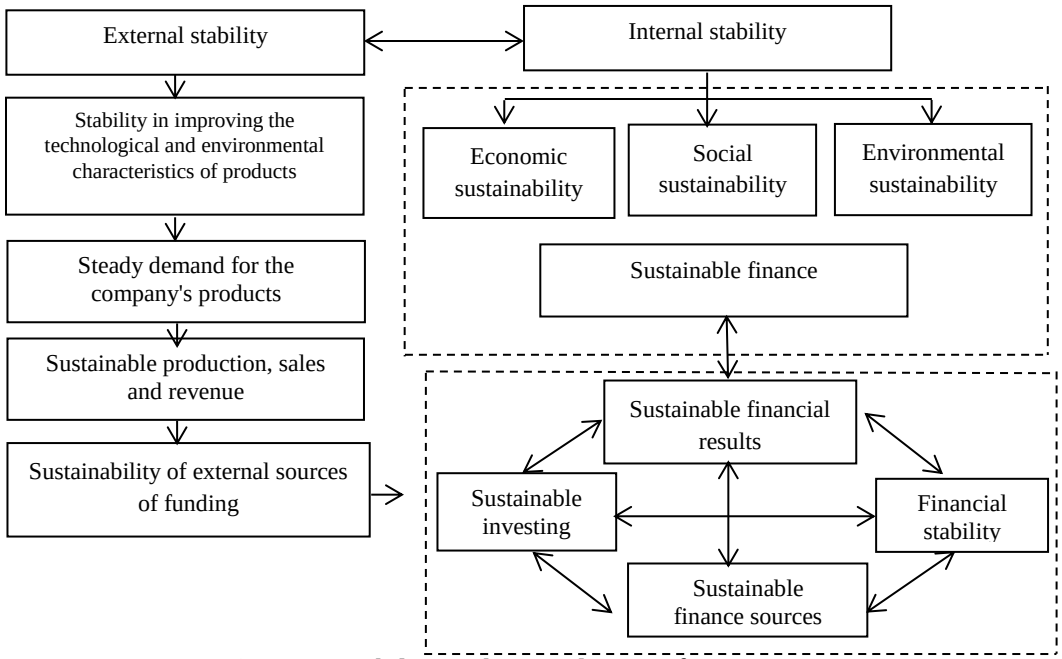


Figure 1. Stability in the coordinates of its various types.
Source: developed by the authors

The condition for ensuring sustainable development in terms of environmental, economic, and social goals is the development of the company's internal potential by the requirements of the external environment. A crucial precondition for achieving the goals of sustainable development is the company's sustainable technological development, which is the basis of their ability to ensure sustainable development of innovation potential and product renewal.

If the market is characterized by the stable dynamics of demand, the manufacturer can hope for stable sales, and hence stable production. Sustainability in sales allows the company to receive stable income and provides financial stability. Based on a sufficient level of financial stability, the company focuses on achieving the full range of goals and finances them at the required level. Sustainable development as the development of economic, ecological and social vectors allows obtaining improved product performance on a regular basis, and therefore meeting consumer demand or even shaping it.

In this study, the authors focus on determining financial stability through the sustainability of production activities. Other sources of financial resources such as loans and government loans are not taken into account.

Focusing on sustainable development goals, which are discussed in this article in the framework of sustainable development management with an emphasis on corporate finance, requires the separation of integrated methods of sustainable development of the enterprise: analysis of the sustainability of financial resources and investment sustainability analysis of financial performance.

The purpose of analysing the impact of SDGs on corporate finance is to determine the company's ability to provide adequate funding for the implementation of the whole set of SDGs and evaluate the results of these actions from the standpoint of economic, environmental and social characteristics.

2.2. The proposed algorithm for analysing the implementation of SDGs into account financial stability.

A comprehensive understanding of the concept of "sustainable development" allows outlining the main directions of analysis and considering financial aspect by highlighting additional important points (Figure 2).

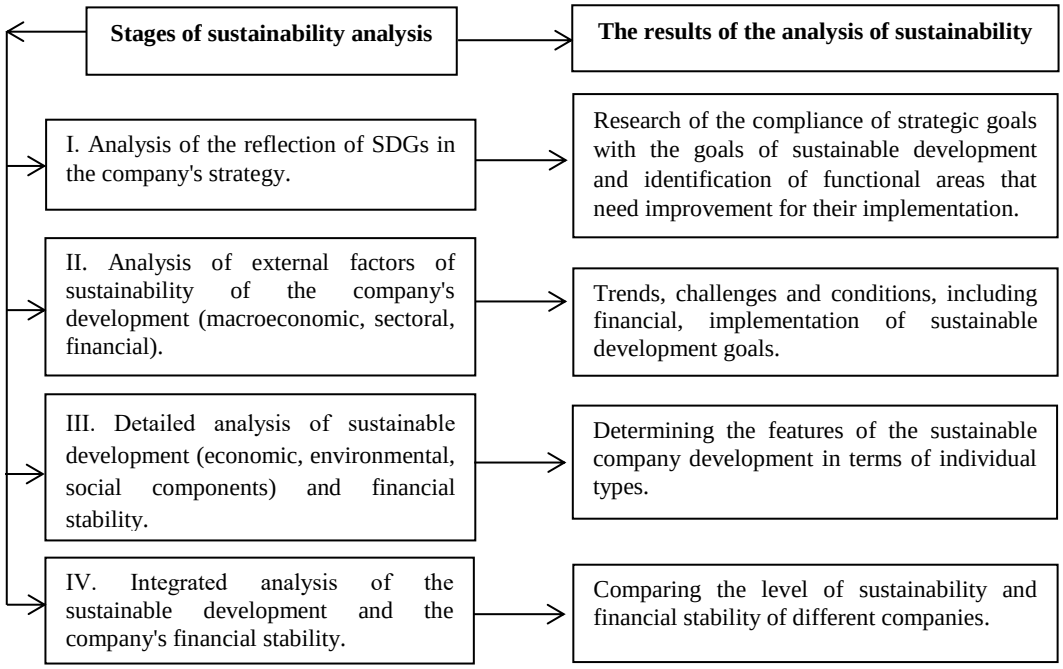


Figure 2. Stages of the analysis of sustainable enterprise development with an emphasis on financial stability.
Source: developed by the authors

The emphasis on financial stability determines the need to specify its components in forming analytical information and the definition of significant trends.

The ability of the enterprise to form stable financial resources from internal and external sources allows for sustainable investment, which generally characterizes the enterprise's financial condition as stable, and ultimately allows obtaining stable financial results.

Thus, the company's sustainable development concept is inextricably linked to its financial potential because the acquired capacity and opportunities to increase it are a practical basis for restoring the state of equilibrium in the development process.

To ensure a complete analysis of sustainable development, it is necessary to systematize indicators that will form an appropriate information base. Since the quantification of environmental and social sustainability and even comparison with the economic component is a complex process, using indicators with different measures. In addition, there is a significant problem of forming a set of unified sustainability indicators because there are no requirements for Sustainability Reporting, and companies that compile such reports independently determine the list of indicators and their units of measurement.

The issue of systematization of sustainable development indicators is revealed in detail in the works [20-23], in which the authors presented the complete list of indicators. Various companies use a fairly wide range of indicators and international agencies; however, there is a problem of unification of

the set of indicators and their comparability. In this study, we limit ourselves to those indicators that most of the studied automotive companies most often use and therefore allow for analysis.

As we consider the goals of sustainable development and the quantitative indicators that characterize them, in comparison with financial stability, the set of indicators should be expanded by: indicators that characterize the stability of financial resources, investment stability, financial stability, and stability of financial results. These indicators are formed based on existing methods of analysis of financial stability [27-30].

Such system of indicators should become an effective tool for managing the enterprise's sustainability and give a comprehensive view of the financial condition, organizational efficiency, use of modern equipment and technology, and use of market position in achieving strategic and tactical development goals. The analysis of indicators can determine the initial situation at the enterprise, strengths in comparison with competitors, and substantiate the direction of the achievement of the set strategic purposes. To analyse the stability, the authors systematize and introduce a list of key indicators (Table 1).

Table 1. Key performance indicators of integrated assessment of sustainable development.

Economic sustainability	**Social sustainability**	**Environmental sustainability**
Total Sales (millions of units)	Employees	Energy consumption of production
Vehicle production (consolidated)	Male/Female	(absolute) (Electricity, Heat, Fuel
Market share	Top Management Positions	gases)
Revenue	(Male/Female)	Energy consumption (specific)
Assets	Total Salary Hires	Energy Intensity (MWh/vehicle)
Fixed assets, % of assets	Newly-hired employees	Water Intensity (M3/vehicle
Intangible assets, % of assets	Average period of employment	Waste Intensity (kg/vehicle)
Productiveness	Total Turnover Rate	CO_2 emissions per unit produced (in
Assets ratio	Ratio of basic salary and remuneration	tons/unit
Capital Investment, % of Revenue	of women to men (base salary only)	VOC emissions (in kg/vehicle, in
R&D Expenses, % of Revenue	Employees who feel personal growth	tonnes/year)
	Total expenses for social contribution	Environmental protection costs
	activities	(Investments, Operating costs)

Financial sustainability			
Stable of financial resources	Sustainable investing	Stable financial position	Stable financial results
Internal (sales revenue)	Capital investing	Liquidity	Net Income, EBIT, EPS,
External (loans)	R&D expenditure	Profitability	EVA, MVA, ROI, ROA
	Environmental protection	Market valuation	
	costs (investing)		

Source: [20-23, 27-30, 31-33]

An essential source of information on the sustainable development of the enterprise is the report on sustainable development. An increasing number of companies are starting to compile a Sustainable Development Report. Reporting on sustainable development helps the users understand the company's business model and its impact on society and the environment better. Both detailed and integrated analyses can be performed using the indicators presented in the reports. This approach is proposed in [34]. The authors propose a classification of single indicators (on operational and strategic levels) and combined measures.

SDGs are quite multifaceted, combining both quantitative and qualitative development targets in economic, environmental, and social components.

The presented indicators allow to carry out both the detailed and the complex analysis of the stability of development of the enterprise. The analysis of the presented indicators allows comparisons with competitors and to define critical characteristics of lag in the cut of separate components of stability. In addition, based on a set of indicators (X_n^i), it is advisable to calculate integrated indicators (index of sustainability of economic development ($p_{ij}{}_{econ}$), index of sustainability of environmental development ($p_{ij}{}_{ecol}$), index of sustainability of social development ($p_{ij}{}_{soc}$). We need integrated indicators because we can determine the connection between the components of sustainability. Through the calculation of the corresponding partial integral indices, it is advisable to determine the generalized integrated sustainability index (I_{sust}).

Financial indicators (X_n^{fin}) can be used to calculate the integrated index of financial stability (I_{sust}^{fin}). Monitoring the enterprise's development in terms of sustainability components is important in understanding the progress of implementation of SDGs and opportunities for their implementation through financial stability. The structural and logical scheme of the survey of sustainability indicators (economic, ecological and social) with the indicators that comprehensively characterize financial stability is presented in Figure 3.

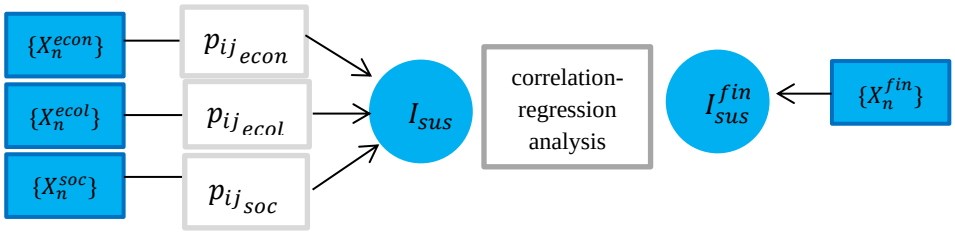


Figure 3. Research Model.
Source: authors

The following important issue is the choice of information processing methods.

In general, the following basic methods is recommended to use in the study to characterize the stability of economic processes using quantitative and qualitative indicators: structural and logical analysis (to find out the factors of enterprise sustainability); economic and statistical analysis (to establish dynamic changes and analyse the main trends of the main indicators of sustainable development); methods of economic-mathematical modelling, correlation, and regression analysis (for composite (consolidated) analysis of large data sets to assess latent indicators of sustainable development of enterprises and further calculation of the integrated index, as well as to establish close relationships between individual types of stability and financial indicators); the abstract-logical method is used to summarize the results and formulate research conclusions.

For any indicator presented in the table, authors have a dynamic range of values, and therefore for their processing, authors use two approaches: from the standpoint of the achieved level in absolute values and from the standpoint of stability of dynamics in relative terms - to determine trends in the studied processes.

The analysis at a certain point in time allows to compare sustainable development indicators of enterprise with other competitors and identify challenges by the components of sustainability that exist. The analysis in dynamics allows to establish the efficiency of the processes of transformations caused by the implementation of sustainable development purposes and their reflection in other economic and financial indicators. The study of the stability of the dynamics is carried out using the indicators presented in [35-37]. In this article, to determine the stability of the dynamics, will be used the following indicators:

The percent relative range (PRR) – reflects the relationship between the minimum and maximum increments, i.e. allows you to determine the stability of the absolute values of indicators (can be calculated as an index and in percent):

$$PRR = \frac{X_{max} - X_{min}}{\frac{(X_{max} + X_{min})}{2}} \times 100\% \qquad (1)$$

where X_i – the specific meaning of the variable feature (X_{max}, X_{min} – maximum and minimum value);

$\overline{X}$ – the average value of the sign.

Coefficient of variation (ύ), which is the standard deviation ratio to the mean value of the sign:

$$\acute{\upsilon} = \frac{\sigma}{\overline{X}} \times 100\% \qquad (2)$$

where σ – dispersion.

Analysis ύ is carried out taking into account such scale:

to 10% – slight variation;

10-25% – significant variation;

> 25% – significant variation.

$$\sigma = \sqrt{\frac{\sum(X_i - \overline{X})^2}{n}} \quad (3)$$

n – the average value of the sign.

To carry out an integrated assessment of the enterprise stability and the calculation of complex indicators, it is necessary:

1. To standardize the values of selected and systematized indicators [38]:

$p_{ij} = \frac{x_{ij} - \bar{x}_j}{\sigma_j}$, where x_{ij} – the value of indicators of stability (assessment by species classification of stability), $i = \overline{1,m}$ – the amount of research periods, $j = \overline{1,n}$ – the amount of indicators, $\bar{x}_j = \frac{1}{m}\sum_{i=1}^{m} x_{ij}$ – average value of the indicator, $\sigma_j = \sqrt{\frac{\sum_{i=1}^{m}(x_{ij} - \bar{x}_j)^2}{m}}$ – standard deviation of the indicator, which ensures the alignment of variances and values of indicators.

2. To calculate the integrated indicator of stability:

$$I_{sust} = \sqrt[3]{p_{ij}{}_{sociology} + p_{ij}{}_{economy} + p_{ij}{}_{ecology}} \quad (4)$$

where $p_{ij}{}_{sociology}$ – standardized value of social sustainability, $p_{ij}{}_{economy}$ – standardized value of economic sustainability, $p_{ij}{}_{ecology}$ – standardized value of environmental sustainability.

At this stage, it is also advisable to use the distance method to compare the indicators of the analysed enterprises (divisions) with the reference indicators. The distance method [39] is relevant for strategic analysis of the level of enterprise sustainability operating in a particular industry, as it allows for identifying the differences in terms of different types of sustainability and targets for further development strategy. As a reference, we will accept the conditional enterprise with the best values of the presented indicators.

A slightly different approach is proposed using relative indicators. At the same time, we should once again turn to the concept of stability.

The concept of "sustainability" should be clarified when choosing the methods of information processing for the purposes of analysis. Its understanding is the basis for the choice of criteria for the interpretation of sustainability indicators.

According to [40], «stability is a property of the system S to coincide in terms of {Ss} before and after changes {C}, which are caused by the action of a set of factors {F}». Among the main types of stability, there are such types of stability as inertia, symmetry, adaptability, homeostasis, delayed, and compositional stability.

The development of the system, respectively, is a sequence of its states, which are determined by both quantitative indicators and qualitative characteristics. The trajectory of economic indicators can be characterized by the development in terms of characteristics «slowly-fast» or cyclically, but we can determine how progressive it is based on the additional information, including in terms of the traditional triad of components.

Emphasizing the concept of «sustainability» in analytical terms, i.e. considering its manifestation as a fixed dynamics of indicators, we propose to consider sustainable development as a development with a value that characterizes the dynamics of a particular indicator as a constant value. Theoretically, sustainable development is a process of improving the internal qualitative subsystems when the growth of quantitative values of indicators is an almost constant value. When the quantitative value of the increase has increasing indicators, it is an accelerated development.

$$T\%_t^{n(i)} = \frac{X_t^{n(i)}}{X_{t-1}^{n(i)}} \quad (5)$$

where $T\%_t^{n(i)}$ – change in the percentage of the n-th indicator of the i-th component (environmental, economic, social) stability at time t.

Accordingly, the condition for sustainable growth is a positive and constant value of the studied indicators. Achieving such a situation in practice is impossible, which means that the characteristics of sustainable development are more meaningful than mathematical:

A positive trend for the economic and social components is the positive dynamics (increase) of key indicators over a certain period of time. Regarding the environmental component, a sign of positive dynamics is a decrease in the absolute values of indicators at a steady pace.

Accordingly, the procedure of normalization of indicators, i.e. reduction to a comparable form, should be used to determine the integrated indices.

Economic sustainability	Sociological sustainability	Ecological sustainability
$\{X_n^{econ}\}$	$\{X_n^{soc}\}$	$\{X_n^{ecol}\}$
stability conditions		
$100 < T\%_t^{n(i)} \cong const$	$100 < T\%_t^{n(i)} \cong const$	$100 > T\%_t^{n(i)} \cong const$
positive trend		
$T\%_{t-1}^{n(i)} < T\%_t^{n(i)}$	$T\%_{t-1}^{n(i)} < T\%_t^{n(i)}$	$T\%_{t-1}^{n(i)} > T\%_t^{n(i)}$
Financial sustainability		
$\{X_n^{fin}\}$		
Stable of financial resource	Sustainable investing	Sustainable investing	Stable financial results
positive trend		
$T\%_{t-1}^{n(i)} < T\%_t^{n(i)}$		

At this stage, it is also advisable to use the distance method to compare the indicators of the analyzed enterprises (divisions) with the reference indicators [39]. Also in the process of analyzing the sustainability of enterprise development and the balance of stability of individual species, it is advisable to use correlation-regression analysis [41]. In this study, it is planned to use the Pearson correlation coefficients r_p and Spearman correlation r_s.

At the last stage, to compare the enterprise's sustainability on the integrated index and the enterprise's financial stability, it is advisable to use OLS (Linear) Regression [36, 41]. The ordinary least square method is a mathematical description of the dependence of one variable on another. Therefore, it allows to summarize the results of generalized indices of sustainable development and partial indices (economic, environmental, and social sustainability) compared to the financial stability index.

In general, the presented analysis algorithm, which provides for the use of both a set of metrics and integrated indices, allows to identify key trends in the effectiveness of the implementation of SDGs compared to key indicators of financial stability.

3. Results

Sustainable development goals, formally or indirectly, have been the basis of long-term corporate governance and the development of appropriate strategies for automotive corporations for a long time. This experience is vital because automotive corporations, on the one hand, have significant achievements and devote significant resources to sustainable development, and on the other hand, even in recent years, they have been constantly facing the issues of adverse environmental impacts and development instability.

The purpose of analysing the sustainability of the studied automotive companies is to determine the main trends in the processes of resource, in particular financial support and the realization of SDGs.

3.1. Analysis of the sustainability of automotive companies.

In order to determine the best experience in the realization of SDGs, we will further compare the experience of the studied corporations. At the same time, we will analyse the sustainability of development in general from the perspective of the triad of components, conduct the analysis of the financial potential of the studied corporations to determine financial opportunities in order to increase costs to ensure SDGs.

The study of the sustainability of automotive corporations was conducted over two periods of 2008-2010 (crisis period) and 2011-2020.

3.2. Research of the general indicators of stability.

The first indicator of the sustainability of companies is the dynamics of production volumes (Figure 4).

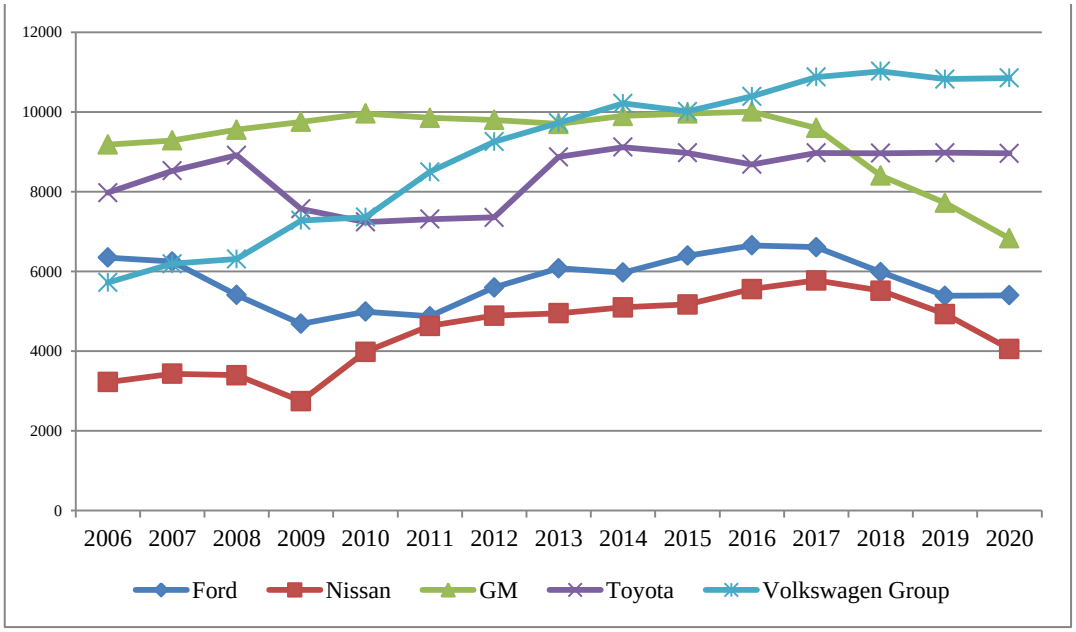


Figure 4. Sustainability of production of selected automotive manufacturers.
Sources: [42-46]

The presented data indicate generally unstable dynamics of production in all surveyed enterprises. During 2006-2020, the average annual production dynamics in terms of enterprises were Volkswagen Group - 104.81%, Nissan - 102.7%, Toyota - 101.1%, Ford - 99.2%, General Motors Company - 98.04% (Fig. 4). That is, not all car manufacturers have a general tendency to increase production. Ford and General Motors did not reach the pre-crisis level in 2020. Particularly volatile dynamics were observed during the crisis of 2008-2010 and in recent years under the influence of Covid-19.

Thus, automakers can use the potential for dynamic development of the car market due to the environmentally responsible trend, which is clearly formed under the influence of consumers, governments, and other stakeholders due to growing demand for electric vehicles only by investing in this area.

3.3. Research of economic, ecological, and social components sustainability of enterprise development.

Analytical study of environmental, social, and economic components has some difficulties from the standpoint of forming the information base because the company began to form reports on sustainable development on a systemic basis not so long ago. TESLA, for example, only started compiling a report on sustainable development in 2019, although environmental trends in the industry generally determine its activities. The experience of General Motors Company starts since 2009, and Toyota since 2002. Therefore, conducting a fully coordinated and comprehensive study of these issues is quite a challenge.

There will be considered the key achievements and guidelines for further sustainable development of the studied automotive companies using individual indicators and processing those using distances (Appendix A).

The presented board in the generalized form allows comparing the level of stability of enterprises' development on separate components and from the perspective of separate indicators. Understanding the type and level of lagging in terms of individual indicators and a component of sustainable development in general allows determining the content of measures, the implementation of which will maximize the focus on best practices in the industry.

Generally, the studied enterprises have a comparable level of sustainability of development, despite some differences in terms of individual components. Each of the surveyed corporations actively participated in attaining a climate-neutral footprint worldwide by 2050 at the latest. The realization of this and related goals requires not only the cooperation of corporations with business and society but

also the performance of the driver's functions in the formation of the eco-environment in their countries. Companies shape the values of sustainable development and try to spread them in society.

The ambitious goals of sustainable development concern, first of all, environmental responsibility, require corporations to mobilize all resources and thus to develop human resources and strengthen economic potential.

The importance of social sustainability and proper attention to it is based on simple logic: socially stable working conditions, economically appropriate forms of remuneration, opportunities for self-realization, and career growth through professional development are the basis of creativity and creativity of employees that promotes innovation, and hence environmental and economic sustainability.

The development of digital technologies will raise the role of the professional workforce, as there will be the elimination and improvement of jobs. In the context of increasing the level of social stability, car companies are actively working in the context of all these areas.

3.4. Financial sustainability analysis of automobile manufacturing enterprises.

Concluding on the inevitability of further movement of automotive corporations to increase the level of sustainable development, it is necessary to analyze their financial stability and determine the financial potential for further sustainable development goals.

To analyse the financial stability in the dynamics, we use several indicators that characterize the stability of financial resources, the stability of investments, the consistency of the financial status and results (Appendix B).

Revenues of enterprises, as the central financial resource of activity, are characterized by unstable dynamics. Their magnitude was affected by both the crisis of 2007-2010 and the pandemic of 2019-2020. The average annual dynamics of the last decade is only slightly higher than in the crisis period. In general, during the study period from 2006 to 2020, the authors can note a gradual increase in revenues of Toyota and Volkswagen, and only their tenfold increase over the period from 2014 to 2020 on the example of Tesla. Thus, some analogies can be drawn. It should be argued that all automotive companies should use the growth potential of demand for electric vehicles to increase income sustainability.

The highest level of dynamics (instability) is an indicator of profit in all surveyed companies. First, that the crisis of 2007-2010 affected American companies more significantly, while Volkswagen worked with profits, and Toyota and Nissan had losses in only one of the crisis years (2009 and 2008, respectively). The year 2020 of all companies, except Tesla, is characterized by a decrease in profits and even entering the loss zone (Ford and Nissan). Tesla, which operated at a loss during 2008-2019 and made a profit for the first time in 2020, demonstrates a fundamentally different performance.

Despite the instability of the leading financial results (income and profit), car companies are actively financing the development of the economic base of their activities, as evidenced by the dynamics of assets. Thus, from 2009 to 2020, GM's assets grew by 72 percent, for the period from 2006 to 2020, respectively: Volkswagen 3.3 times, Toyota - almost twice, Nissan - 48%. Only Ford had a decrease in total assets. Tesla, whose assets increased 400 times in 2009-2020, demonstrates an outstanding example of dynamic development. The company, established in 2003 in an industry where other representatives have a long history, established competition and achievements, on the idea of achieving sustainable development goals, identifies trends in innovative development of other enterprises and demonstrates the extra-dynamics of production capacity. However, the scale of Tesla's activity is in a different weight category.

The amount of working capital for each company should have its optimal value and allow the core business to operate smoothly is unstable in the Volkswagen Group, General Motors, Tesla. However, the Current Ratio went beyond the allowable value (1) only in some years.

Since SDGs require long-term financing, it is vital to consider the debt/equity ratio, which allows establishing the potential of the company's financial leverage based on the study of the ratio of debt and equity (Table 2). If the most acceptable ratio is 60% of borrowed capital and 40% of equity (ratio = 1.5), the data of the surveyed enterprises indicate excessive financial dependence on external sources.

The indicators of Toyota correspond to the optimal value (and throughout the study period); in other companies, the values are twice or more times higher than recommended. This indicates that the financial stability of the surveyed enterprises is not at a high level.

Table 2. Summary of the leading indicators of financial stability in terms of the periods 2006-2010 and 2011-2020.

Company	**Revenue**		**Total Assets**		**Net Working Capital (average annual value)**		**Curent Ratio (average annual value)**		**Debt/equity ratio**		**ROI (average annual value)**	
	2006-2010	2011-2020	2006-2010	2011-2020	2006-2010	2011-2020	2006-2010	2011-2020	2006-2010	2011-2020	2006-2010	2011-2020
Volkswagen Group	106.9	104.8	111.8	108.4	13.4	6.7	1.16	1.04	3.75	2.96	8.4	10.2
General Motors	92.5	99.2	-	105.5	2.5	3.0	1.13	1.07	1.29	3.73	8.7	0.03
Ford	95.6	100.1	87.9	105.0	73.3	59.8	1.97	2.92	-66.43	7.68	1.4	5.2
Tesla	224.3	191.7	-	171.6	0.0	1.3	1.31	1.31	0.17	4.12	-40.2	-19.4
Toyota	104.9	103.2	107.9	104.2	8.9	6.4	1.08	1.04	1.74	1.64	75.4	7.5
Nissan	98.4	101.5	101.8	103.7	14.5	35.4	1.34	1.60	2.37	2.42	6.3	14.3

Sources: authors' calculations

The increase in costs for implementing environmental goals does not lead to a significant deterioration in the dynamics of financial income.

Several companies, in particular Volkswagen and Toyota, provide information on Environmental protection costs (investment and operating costs) in their Sustainability Reports. However, the allocation of financial resources for sustainable development is also reflected in other financial flows, in particular, capital investment, R&D investments. Investments in fixed assets include the purchase, first of all, of more modern and therefore energy-efficient equipment, and R&D investments are the costs of developing new products with better environmental performance. Thus, it is difficult to single out those aimed at achieving SDGs. Therefore, the total amount of investment should be considered as investment in the company's development, which is entirely directed at achieving the SDGs.

The next important step in the analysis of financial encouragement for the SDGs realization is to study the level of sustainability of enterprises in terms of individual types in comparison with indicators of financial stability using the OLS Regression method. Table 3 presents the results of this analysis.

Table 3. Analysis of the financial stability ratio and components of sustainable development of the enterprise.

Company	Financial sustainability and Economic sustainability	Financial sustainability and Ecological sustainability	Financial sustainability and Social sustainability
Toyota	$y = 0.0007x^2 + 0.056x + 87.106$ $R^2 = 0.693$	$y = 1.5273x^2 - 294.24x + 14256$ $R^2 = 0.230$	$y = 0.1302x^2 - 24.129x + 1204.2$ $R^2 = 0.341$
General Motors Company	$y = 0.0004x^2 - 0.0052x + 95.384$ $R^2 = 0.640$	$y = -0.4079x^2 + 78.861x - 3733.3$ $R^2 = 0.039$	$y = 0.1174x^2 - 26.444x + 1543.5$ $R^2 = 0.303$
Volkswagen Group	$y = 0.0003x^2 + 0.1032x + 97.423$ $R^2 = 0.668$	$y = 0.022x^2 - 7.2409x + 605.58$ $R^2 = 0.1103$	$y = 0.0007x^2 - 0.24x + 119.99$ $R^2 = 0.515$
Ford	$y = -0.0003x^2 + 0.1648x + 86.587$ $R^2 = 0.967$	$y = 0.0017x^2 - 0.8402x + 188.23$ $R^2 = 0.035$	$y = 0.1961x^2 - 40.079x + 2147.2$ $R^2 = 0.248$

Sources: authors' calculations

In general, the average level of correlation between financial and economic sustainability should be noted, the links between financial and social sustainability are slightly below the average, and the links between financial and environmental sustainability are insignificant. This state of affairs indicates the

importance of sustainable development goals, the progress in achieving which car companies provide regardless of the stability of financial resources and results.

The final stage of this investigation was a simile of indices of financial stability and the integrated index of sustainability of the studied automotive companies, calculated for the period from 2007 to 2019 (Figure 5).

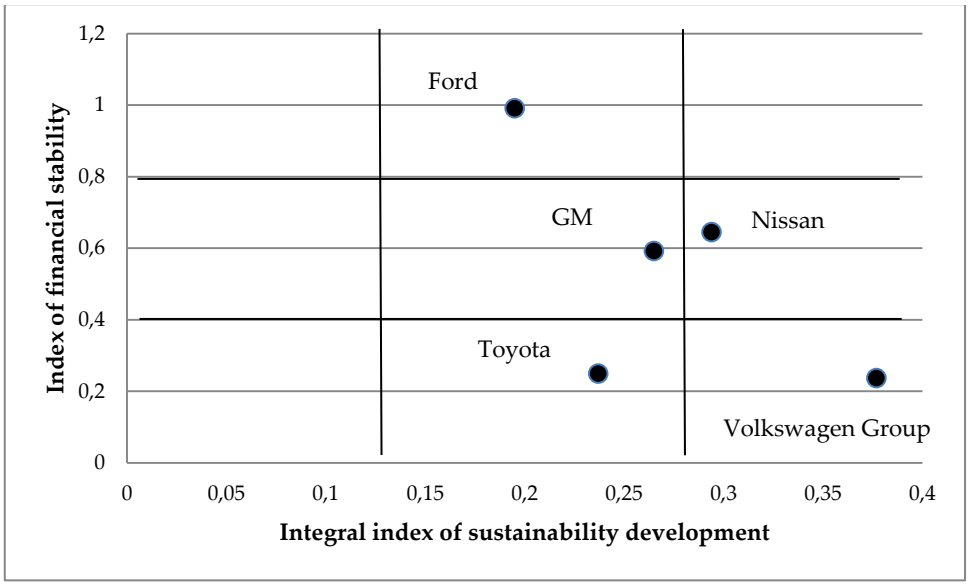


Figure 5. Sustainability of enterprise development in comparison with financial stability.
Sources: authors' calculations

The smaller the value of the generalized indices of stability, the less variability the studied indicators show.

The presented results of comparing the stability of integrated indices of sustainable development in comparison with the generalized index of financial stability, conducted using the example of car companies, reflect the following main trends:

firstly, all surveyed enterprises show progress in environmental and social sustainability, but the dynamics of both actual and integrated indicators indicate a low level (slight variation) against the background of relatively high financial instability;

secondly, the studied automobile enterprises differ in the sustainability development level (taking into account the components) and financial stability. Volkswagen Group and Nissan are showing more progress in ensuring sustainable development against the background of low and medium levels of financial stability. Ford has the lowest level of sustainability index against the background of the highest level of financial instability.

thirdly, the calculations of the correlation between indicators of sustainable development (economic, environmental, and social components) and financial stability showed a low level of dependence. This means that enterprises implement SDGs against the background of different levels of variability of financial stability.

Such trends formulated based on calculations confirm Hypothesis 1 on the best results in the implementation of SDGs of companies with a higher level of financial stability. Indeed, enterprises that have a higher level of financial stability simultaneously have higher absolute indicators and positive dynamics in the components of sustainable development of the studied enterprises, particularly economic and social.

Considering investments (indicators for one employee are taken for the analysis), the authors see the following tendencies during the studied period: R&D investments are gradually increasing; investments in fixed assets, given the level of capital intensity and capital adequacy of employees, tend to decrease.

All surveyed automotive companies are increasing investment, including investment in innovation. Only vital funding for innovation allows companies to research all necessary areas to ensure compliance with market requirements: safety, efficiency, environmental friendliness, design, disposal. That is, the realization of SDGs depends on the enterprise ability to have a high innovation performance and activity.

The amount of investment directed to the goals that include sustainable development is influenced by such quantifiable factors as the amount of enterprise income (x1); its level of profitability (x2); economic potential (value of assets) (x3); the amount of working capital (because it is difficult to finance long-term projects in case of inadequate current liquidity) (x4); profitability of previously implemented projects (ROI) (x5); the ratio of the borrowed assets and equity (x6).

The study of the closeness of the relationship was conducted using these indicators as characteristics of key factors.

This model represents the relationship between the investment (performance indicator) and indicated factors:

$$Y = f(x_1, x_2, x_3, x_4, x_5, x_6) \quad (6)$$

Given that these factors affect the performance indicator, assuming they are not interrelated, it is appropriate to use the correlation-regression methods.

The correlation analysis (Appendix C) shows that the dynamics of investment in the studied enterprises depend on income and economic potential, but not on other financial condition indicators. This means prioritizing investment financing and, therefore, the importance of ensuring long-term sustainable development goals.

The world's leading car companies manage the goals of sustainable development of society, which have several levels of implementation: at the strategic level (the goals determine the content of sustainable development strategies); at the functional level (they are embodied in specific targets, formed under the environmental, social and economic components); at the operational level (provide for the formation of a set of detailed activities and tools to achieve the objectives).

In order to fill the processes of sustainable development management based on the generalization of scientific approaches and taking into account the positive experience, a comprehensive approach to sustainable development management was proposed through the separation of conceptual, strategic, operational, and analytical levels.

4. Conclusion

The world's leading car companies carry out financial management taking into account the SDGs, which have several levels of implementation: at the strategic level (the goals determine the content of sustainable development strategies); at the functional level (they are embodied in specific targets, formed under the environmental, social and economic components); at the operational level (provide for the formation of a set of detailed activities and tools to achieve the objectives).

Based on the systematization of existing methodological approaches to sustainability analysis, the authors propose to consider sustainability as the ability of the system to achieve goals, as a balance of internal resources, as stability of interaction with the external environment, and as an adaptation of the business model.

To study the processes of financial support for sustainable development, the authors formed a method of analysis. The novelty of the work is an attempt to consider indicators of sustainable development of the enterprise in the view of economic, environmental, and social objectives, and also from the standpoint of financial stability.

The procedure for analysing the sustainability of enterprises is proposed to be carried out at the following main stages: overview of the reflection of SDGs in the strategy, analysis of external factors of sustainability, comprehensive and integrated analysis of sustainability with an emphasis on financial stability. The article systematizes the indicators of economic, environmental, social, and financial sustainability, based on which it is advisable to perform a sustainability analysis.

Exploration of SDGs realization by automotive companies allows identifying the main sustainability challenges and determining the key trends in developing strategies regarding sustainable development.

SDGs adopted by automotive companies under the Global Agenda are a real challenge in terms of environmental responsibility, as their achievement requires efficiency in the field of innovation and proper investment.

Since the development of companies is influenced by factors of the internal and external environment, this paper analyses the influence of trends in the world economy. The external global environment creates clear environmental, social and economic challenges for internal sustainability subsystems. Moreover, although the dynamics of the global economy have a medium level of impact on the sustainability of automotive enterprises in the end, as the analysis shows, there is a clear synchronization of development dynamics in the short term, especially during crises.

Because the crisis in the global economy, no matter what the root cause is, is displayed in the financial system and the activity's progress, the SDGs' realization is always related to financial stability. The financial condition of automobile enterprises during the crisis in the economy is unstable. The examined enterprises received state support in one form or another. However, sustainable development goals are being funded properly. Transformations in the automotive industry are becoming an essential factor and even a driver in the SDGs realization, as they directly relate to production technologies and the technical characteristics of cars.

The analysis of the sustainability of development provides for defining tendencies in the current stage of development of leading automotive companies:

firstly, there is an unstable dynamics of production volumes in general, but with a gradual increase in production of electric vehicles, accompanied by the improvement of business models of enterprises;

secondly, there are some differences between the studied enterprises in the characteristics of social and environmental sustainability, despite the similarity of the targets;

thirdly, the ratio of different subsystems of financial stability, which the authors give as an example of car companies, has the following general characteristics: relatively stable financial resources - stable investments - financial stability - varying financial results.

As the analysis showed, the selected companies have unstable financial resources and financial results but progress in achieving the key sustainable development goals.

Understanding these trends will provide an opportunity to improve financial management mechanisms and approaches, including at the regional and state levels.

All of this calls for further research on the question of the effect of ecological responsible on the socio-ecological area.

Appendix A

Table A1. Scoreboard of key indicators of sustainable development of automotive corporations

Indicators	Absolute values of indicators					Values of indicators after processing using the distance method				
	General Motors	Volks wagen	Toyota	Ford	Nissan	General Motors	Volkswagen	Toyota	Ford	Nissan
Economic sustainability										
Market share, %	7.07	10.7	10.79	6.58	5.95	0.66	0.99	1.0	0.61	0.55
Fixed assets	34.4	50.5	54.1	48.0	34.6	0.64	0.93	1.0	0.89	0.64
Capital Investment per employee, in US dollar	45739	24507	35740	30870	35020	1.0	0.54	0.78	0.67	0.77
R&D Expenses per employee, in US dollar	41460	24640	28400	38170	35927	1.0	0.59	0.68	0.92	0.87
Index of Economic sustainability						*0.83*	*0.76*	*0.87*	*0.77*	*0.71*
Social sustainability										
Number of learners, in % of employee	42.6	31.5	26.4	33.2	12.3	1.00	0.50	0.62	0.78	0.29
Training hours per employee	10.73	11.7	9.3	8.7	4.3	0.92	1.00	0.79	0.74	0.37
Hours per leaner	25.1	23.2	25.6	24.2	26.0	0.97	0.89	0.98	0.93	1.00
Employees who feel personal growth, %	79.6	81.2	82.1	80.2	79.5	0.97	0.99	1.00	0.98	0.97
Index of Social sustainability						*0.96*	*0.85*	*0.85*	*0.86*	*0.66*
Ecological sustainability										
Energy intensity, in	2.13	2.18	1.81	2.14	2.08	0.82	0.79	1.00	0.82	0.85

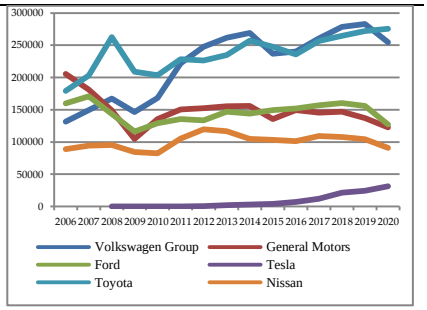
MWh/vehicle										
Waste volume per unit, in kg/unit	42.2	44.8	46.2	43.45	41.9	0.99	0.93	0.90	0.96	1.00
CO_2 emissions per unit produced	0.62	0.436	0.387	0.58	0.51	0.40	0.87	1.00	0.50	0.68
VOC emissions, in kg/vehicle	2.55	1.59	1.66	2.15	2.34	0.40	1.00	0.96	0.65	0.53
Water Intensity, M3/vehicle	4.17	3.74	4.1	4.2	4.81	0.89	1.00	0.90	0.88	0.71
Index of Ecological sustainability						*0.70*	*0.92*	*0.95*	*0.76*	*0.76*
Index of Sustainability Development						***0.83***	***0.84***	***0.89***	***0.80***	***0.71***

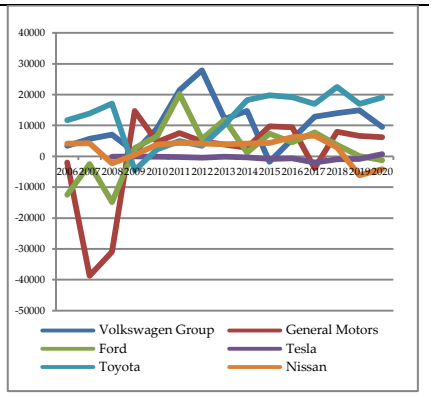
Sources: authors' calculations

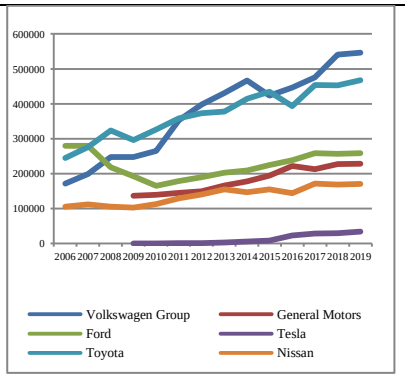
Appendix B

Table B 1. Dynamics of the main indicators of sustainability of development

Company	2015	2016	2017	2018	2019	2020	Trends
Revenue, in million US dollars							
Volkswagen Group	236696	240427	260739	278537	282947	254600	
General Motors	135725	149184	145588	147049	137237	122485	
Ford	149558	151800	156776	160338	155900	127144	
Tesla	4046	7000	11759	21461	24578	31536	
Toyota	247834	235745	256653	264415	272031	275355	
Nissan	103514	101173	108996	107560	104168	90885	
Net Income, in million US dollars							
Volkswagen Group	-1755	5692	12833	13967	14947	9519	
General Motors	9687	9427	-3880	7916	6581	6247	
Ford	7373	4589	7731	3677	47	-1279	
Tesla	-888	-674	-1962	-976	-870	690	
Toyota	19777	19195	17029	22445	16945	19100	
Nissan	4347	6170	6722	2872	-6175	-4217	
Total Assets, in million US dollars							
Volkswagen Group	423844	453409	477204	541082	546639	567853	
General Motors	194338	221690	212482	227339	228037	235194	
Ford	224925	237951	258496	256540	258537	267261	
Tesla	8067	22664	28655	29740	34309	52148	
Toyota	434341	393649	453376	452774	467432	484660	
Nissan	155115	144201	171315	168722	170571	156185	

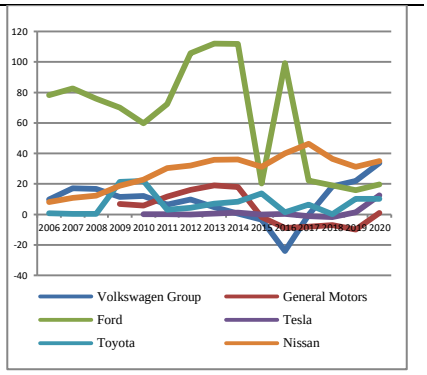






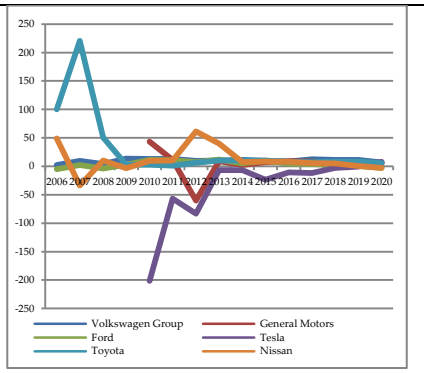
Net Working Capital

Volkswagen Group	-3,44	-24,12	-0,31	18,39	21,88	33,74
General Motors	-1,81	-8,98	-8,15	-6,95	-9,92	1,01
Ford	20,25	99,18	22,2	19,08	15,92	19,55
Tesla	-0,03	0,43	-1,11	-1,68	1,43	12,47
Toyota	13,83	1,38	6,34	0,18	10,29	10,24
Nissan	31,31	40,04	46,39	36,51	31,17	35,06



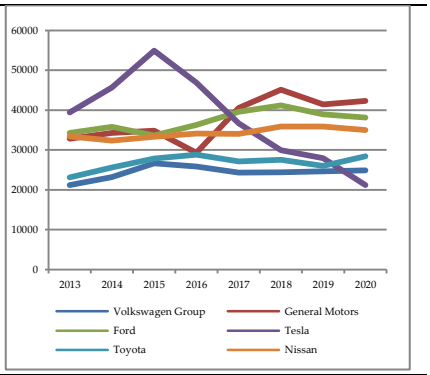
ROI

Volkswagen Group	9.6	8.2	12.1	11	11.2	6.5
General Motors	7.26	9.07	8.21	4.02	4.67	5.21
Ford	10.07	4.28	3.72	2.3	0.42	-3.06
Tesla	-23.7	-10.5	-11.5	-2.66	-0.39	7.81
Toyota	10.11	7.82	7.4	8.52	8.32	5.7
Nissan	8.19	7.99	5.83	5.04	0.61	-2.76



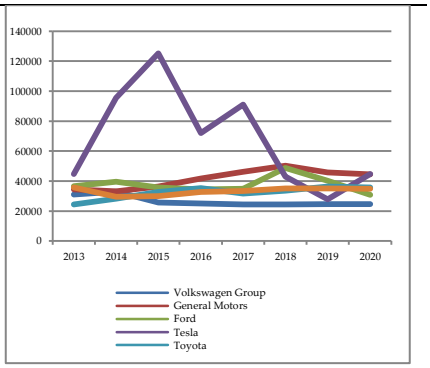
R&D expenditure per employee, in US dollars

Volkswagen Group	26679	25857	24345	24437	24640	24879
General Motors	34884	29333	40556	45087	41460	42330
Ford	33668	36318	39604	41206	38950	38170
Tesla	54909	46901	36705	29908	27970	21200
Toyota	27846	28863	27156	27502	25990	28400
Nissan	33289	34084	34048	35927	35890	34980



Investments in fixed assets per employee, in US dollars

Volkswagen Group	25757	25071	24280	24364	24507	24600
General Motors	36294	41777	46111	50289	45739	44500
Ford	35678	34328	34896	48713	40168	30870
Tesla	125211	71983	90962	43020	27740	44760
Toyota	32639	35340	31719	33666	36340	35740
Nissan	29978	32618	33333	35020	35120	34770



Sources: [42-47]

Appendix C

Table C 1. The results of correlation analysis

Volkswagen Group						
	y	x1	x2	x3	x4	x5	x6
y		0,968	-0,35	0,977	0,06354	-0,5546	-0,3156
x1			-0,44	0,9862	0,099714	-0,60213	-0,36573
x2				-0,352	-0,02744	0,299116	-0,07851
x3					0,192891	-0,60952	-0,4012
x4						-0,01119	-0,27183
x5							0,32999
x6							

General Motors Company						
	y	x1	x2	x3	x4	x5	x6
y		0,2765	-0,198	0,56651	-0,3134424	-0,3638775	0,619941
x1			-0,830	-0,3476	0,1292765	0,1156681	0,0126298
x2				0,1745	-0,00743	-0,25731	-0,03397
x3					-0,77639	-0,02905	0,772513
x4						-0,23424	-0,70161
x5							0,006876
x6							

Toyota						
	y	x1	x2	x3	x4	x5	x6
y		0,8284	0,6397	0,58273	-0,2519216	0,2764967	-0,4219992
x1			0,9115	0,89829	-0,3380505	0,0241881	-0,7331428
x2				0,8223	-0,54207	0,161549	-0,64513
x3					-0,18496	-0,23604	-0,90118
x4						-0,36349	0,168723
x5							0,284665
x6							

Nissan						
	y	x1	x2	x3	x4	x5	x6
y		0,8446	0,3224	0,87792	0,5731495	-0,2289875	0,3422739
x1			0,6898	0,8906	0,5251836	-0,2927152	0,4128872
x2				0,4511	0,550077	0,104498	0,018077
x3					0,557861	-0,51678	0,413806
x4						0,089118	-0,0117
x5							-0,35341
x6							

Ford						
y	x1	x2	x3	x4	x5	x6
y	0,8472	-0,356	0,82722	-0,5764233	-0,7214181	0,4712286
x1		-0,207	0,89162	-0,3557031	-0,878311	0,5644874
x2			-0,38	0,324326	0,33132	0,173779
x3				-0,54678	-0,88928	0,189962
x4					0,348716	0,007346
x5						-0,30435
x6						

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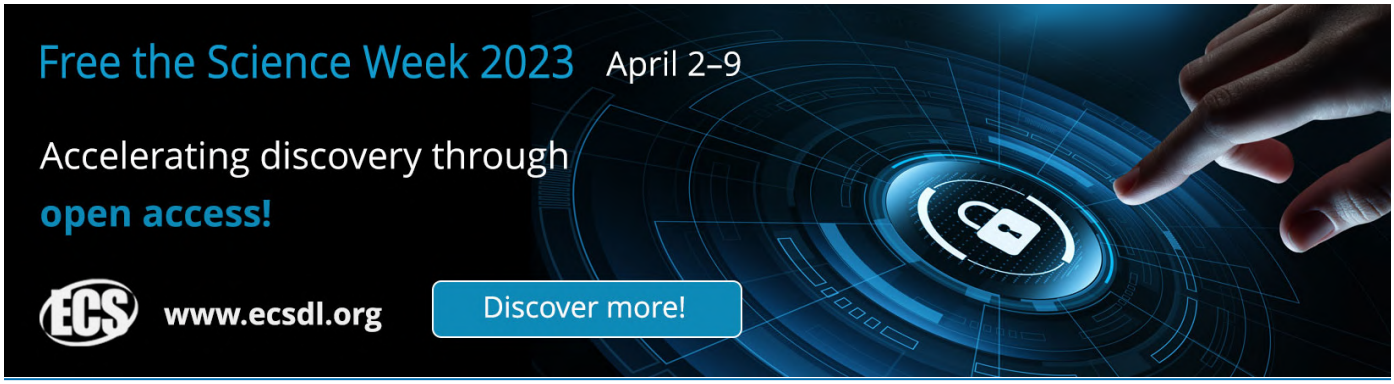
Education in the concept of circular economy in times of global crises



Education in the concept of circular economy in times of global crises

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Abstract The article shows the relevance of transition to a cyclical economy in the society under the influence of global crises. Two hypotheses were proposed. Firstly, the formation of environmental values in Ukrainian society can be traced, which can create the basis for the transition of society to a circular economy model. Secondly, the important role of education in the implementation of the concepts of sustainable development and the circular economy has been confirmed, since it ensures the formation of environmental and economic consciousness, value orientations and social culture, trains specialists and develops the economy, in particular cyclical economy. To assess the hypotheses, the following were used: an online survey of representatives of the educational community. The results showed: 1) insufficient awareness of respondents about the nature of the circular economy; 2) the value of protecting the ecology of the region and the understanding of the importance of environmental protection in Ukrainian society are weak; 3) The most important problems include economic problems, but at the same time, environmental problems of the territories. An analysis of the scientific literature and coverage of foreign practical experience made it possible to determine the ways of developing education in support of sustainable development, the "green" and cyclical economy, the reorientation of higher and postgraduate education towards the training of specialists in the cyclical economy. The results can be useful in the formation and adaptation of educational and environmental strategies.

1. Introduction

The transition of society to the Fourth Industrial Revolution is accompanied by the spread of the global economic crisis, exacerbation of the global environmental, social, and political problems of mankind. In 2021, the population growth rate increased significantly, reaching 1.23%, the population amounted to 7.851 trillion. persons, which is more than projected by 53.8 million people [1]. The growth of the Earth's population deepens upon the problem of limited non-renewable natural resources. In addition, strong

marketing activity, behavioral economy, market principles of interaction of economic entities have led to the separation of business interests from public, rapid growth of production and consumption, as well as increased economic inequality. Existing economic models and concepts of development are not able to solve these problems, which are beginning to get out of control. The world community seeks to prevent collapse. The European Commission has approved a new Circular Economy Action Plan, which includes measures aimed at: making organic products the norm; empower consumers and public buyers, focus on sectors where cycle potential is high and which use the most resources, such as electronics and ICT, batteries and vehicles, textiles, plastics, packaging, construction and buildings, water and nutrients, food; provide less waste [2].

The fundamental basis of human development after the Fourth Industrial Revolutions should become the concepts of circular economy, social entrepreneurship and climate-neutral economy. Education, culture and the development of spirituality play a crucial role in the effectiveness of the implementation of these concepts.

2. Critical literature review

In recent years, many studies have been conducted to the development of circular economic. The current economic crisis related to the COVID-19 Pandemic is an economic and environmental downturn. For most countries, the impact of the dynamics of economic growth on the level of air pollution is one or two years behind. The level of air pollution changes simultaneously with the change in GDP growth per capita in 28% of countries of the world [3].

Crisis situations have given impetus to finding effective ways out of them, restoring economic, environmental and social processes. in particular the appeal to the concept of cyclical economy. This movement is also reflected in scientific publications. For example, Per Klevnäs, Alexandra Kulldorf, Per-Anders Enkvist (2019) believe that «the transition to a circular economy can make a significant contribution to the EU's priorities for sustainability, jobs and environmental protection, while opening up great opportunities in purely economic terms - both short-term incentives and long-term productivity» [4].

In a number of scientific works attention is paid to the study of the concept of cyclical economy, defining its essence, ways of effective transition to its functioning. Thus, a study by J. Kirchherr, D. Reike, M. Hekkert based on an analysis of 114 definitions of the circular economy, revealed: its basic principles, systemic perspectives, goals, activators / enablers. A study by these authors found that: 1) the circular economy is often portrayed as a combination of measures to reduce, reuse and recycle; 2) the goal of the circular economy is often considered economic prosperity, then the quality of the environment; and to a lesser extent, the impact on social justice and future generations; 3) among the activators of the cyclical economy are business models and consumers [5].

The analysis of scientists' works allowed to reveal approaches to defining the essence of cyclical economy as: 1) **model of economic development**, based on the rational use of resources and their restoration [6]; 2) **an alternative to the traditional, linear economy**, based on three principles of «3R»: reduction of consumption, reuse and recycling (reduce, reuse, recycle) [7]; 3) **industrial system** that is restored or regenerated by design and construction [8]; 4) **economic model**, in which both the outcomes and the actual processes of resource supply and production are organized in such a way as to increase human well-being and efficiency of ecosystems [9].

At the same time, research related to the introduction of a cyclical economy highlights such an impact factor as education. In particular, when analyzing the state of research on the problems of the circular economy according to the search platform «Web of Science» it was found that among the publications in 2016 on this issue, 2.8% belong to the field of education [10]. Currently, attention to the role of education in building a cyclical economy in different countries is growing because «education is a significant potential for sustainable development of society. Its role consists in forecasting, forming and developing

the professional competence of future specialists throughout their lives, developing an energy-saving style of professional activity» [11].

A number of researchers believe that the concept of circular economy is a new stage in the development of the concept of sustainable development and green economy. [12]. Education plays a significant role in these concepts.

Thus, back in March 2005, the European Economic Commission (EEC) at the UN adopted the document «UNECE Strategy for Education for Sustainable Development». Therefore, a significant number of publications are devoted to the impact of education on sustainable development and its reorientation [13,14,15,16,17].

A number of scientific papers emphasize that the transition to a circular economy requires a sufficient number of specialists with relevant competencies (quality). Therefore, the role of higher education institutions for the specialists training at the request of society, the economy, employers [18,7,19,20].

A study by Finnish researchers points to the critical problem that more than two-thirds of adults with vocational education and training have poor or no problem-solving skills in technology-rich environments, and that more than one-fifth of these adults are at risk [21].

A number of scientific works outline educational approaches, tools, learning technologies in higher education, which will accelerate the transition to a circular economy, in particular: the development of incubators in a circular economy [19]; development of special courses for students on cyclical economics [22]; introduction of an educational module created in collaboration with industry and academia [23]; introduction into the educational process of tasks related to the analysis of products that claim to be cyclical processes [24]; study the economics of the cycle (CE) with the help of a serious game In the Loop [25].

A systematic review of the literature and epistemological perspectives on the level of maturity of the circular economy and bioenergy research in the fields of education and communication by Spanish scholars has revealed that the scientific literature is limited and still in its infancy [26].

Reviewing research allows us to formulate new hypotheses and expand the scope of research.

Hypothesis 1. Ukrainian society is at the stage of forming a system of values, which can lay the foundation for the transition to a model of a circular economy.

Hypothesis 2. Education as a social institution has a significant impact on the implementation of the concepts of sustainable development and cyclical economy, because it ensures the formation of environmental and economic awareness, values, culture of society, and higher and postgraduate education - the training of specialists..

3. Methodology and results

An empirical study was conducted to identify the awareness and readiness of representatives of the educational environment to carry out the processes of the cyclical economy.

To study the readiness of Ukrainian society to implement a circular economy, a sociological study was conducted. The organization and conduct of the study included three stages:

Stage 1. collection of primary sociological information;

Stage 2. the stage of information processing;

Stage 3. analysis of the received information, generalization of conclusions, preparation of the recommendations. with the StatSoft's software package «Statistica»

The social survey was conducted in January 2021. It was attended by 74 respondents who are representatives of the educational environment (higher education, teachers, educators, teachers, scientists), of whom: 35% - aged 41-50 years, 23% - aged 31-40 years, 20% - at the age of 18-20 years, 9% - 21-30 years, 13% - over 60 years. The study was conducted using an online survey using the Google Forms tool. Objective: to study the readiness of society to implement the model of circular economy in conditions of global crises.

The questionnaire contains questions on awareness and understanding of the essence of the cyclical economy; determining the place of economic and environmental problems in crisis conditions; readiness to participate in the processes of sustainable development, green and cyclical economy; the importance of social, family, socio-economic, environmental values.

The results of a sociological survey show that representatives of the educational environment (for example, the Kharkiv region, Ukraine) are not sufficiently aware of the nature of the circular economy (38.9% of respondents said they know nothing about it, 29.2% - heard something about it, however, they do not have a clear idea, 30.6% believe that they understand what we are talking about. This indicates that the importance of the transition to a new ecological model of the economy is not yet fully formed.

According to the Circularity GAP report 2021 circularity in our world is trending down (8.6%), not up [27]. On the one hand, this is due to the fact that with the introduction of the circular model of the economy, large corporations must begin to reduce production and at the same time invest in improving their product and packaging. On the other hand, the population must be aware of and support this concept of human preservation. An online survey shows that the majority of respondents see the purpose of their work as income (70.8%), creating a comfortable living environment (66.7%), self-development and interaction with people (65.3%); creation of a useful product for people (48.6%). Respondents were not directly related to entrepreneurial activity, so they noted the development of business and their own projects much less often (23.6%).

Also, 62.5% of respondents believe that entrepreneurs should increase the economic efficiency of their activities, receive more income, pay taxes, assistance - this is a matter for the state. According to 47.2% of respondents, it is necessary to deduct part of the profits for socially important matters, and 45.8% - that it is also necessary to deal with the preservation of the environment. This indicates that society is in the process of realizing the importance of social and green entrepreneurship, however, it is obvious that the basis for significant dissemination and support of this area has not yet been laid. This is confirmed by the ranking of the value system (figure. 1).

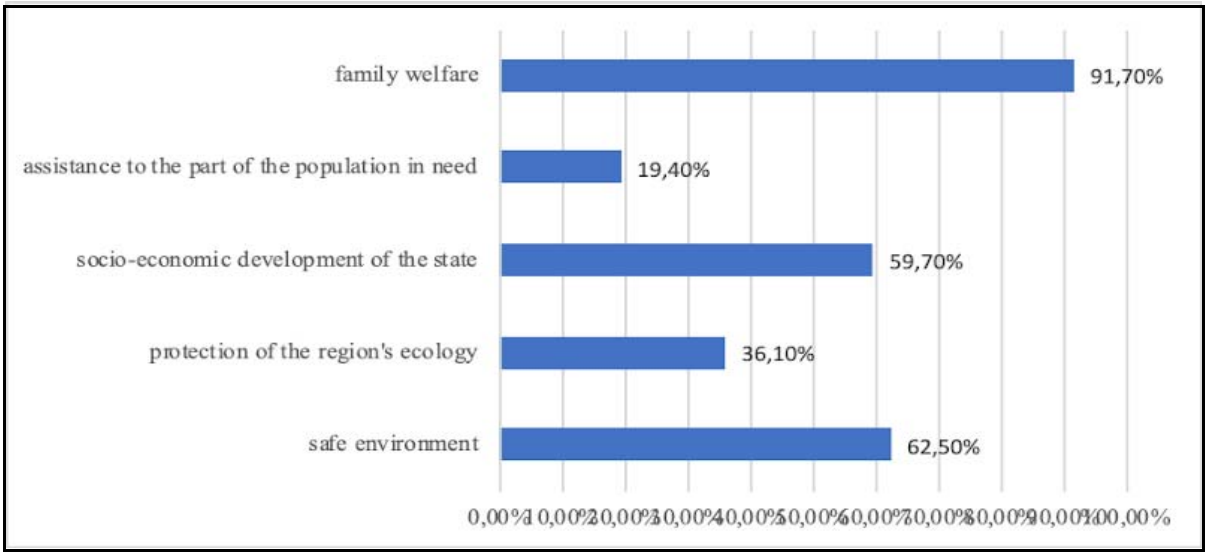

Figure1. Aassessment the importance of the values in Ukrainian society.

As can be seen from Fig. 1, the greatest value among 91.7% of respondents is the well-being of the family. The protection of the region's ecology is the least important for the educational environment (36.1%) and the assistance of the part of the population in need.

The analysis of the results of the social survey of the representatives of the educational environment of Ukrainian society was carried out based on descriptive statistics using the STATISTICA program package (Table 1).

Table 1. Significance of problems for Ukrainians (representatives of the educational environment) in conditions of global crises (1 - the least significant, 5 - the most acute).

Variable	Valid N	Mean	Median	Mode	Frequency of Mode	Std.Dev.	Skewness	Kurtosis
Economic problems	72	14.4	13.0	13.0	2	16.395	1.62	2.89
political instability, life-threatening;	72	14.4	13.0	13.0	2	15.773	1.63	2.93
high corruption;	72	14.2	14.0	14.0	2	13.31	1.37	2.15
intensive migration of the population of Ukraine;	72	14.2	15.0	Multiple		5.80	-0.59	-1.07
education crisis, online education;	72	14.2	14.0	Multiple		5.40	-0.80	0.59
ecological condition of territories	72	14.2	14.0	Multiple		7.98	1.21	1.55

As can be seen from Table 1, on average, the greatest value among people is economic problems and political instability, life-threatening. The distribution of the survey results for more blocks of problems has a right-hand bias, as evidenced by the asymmetry coefficient (the largest for economic problems (1,62), political instability - 1.63 and 1.21 - ecological condition of territories). In addition, the ecological conditions of the territory are more important than the issues of education and migration in Ukraine.

An important stage in the implementation of the circular economy model is not only awareness and awareness of the importance of environmental behavior of society, but also the willingness to change the norms of behavior and habits. The results of the survey on the readiness to sort garbage are presented in figure. 2.

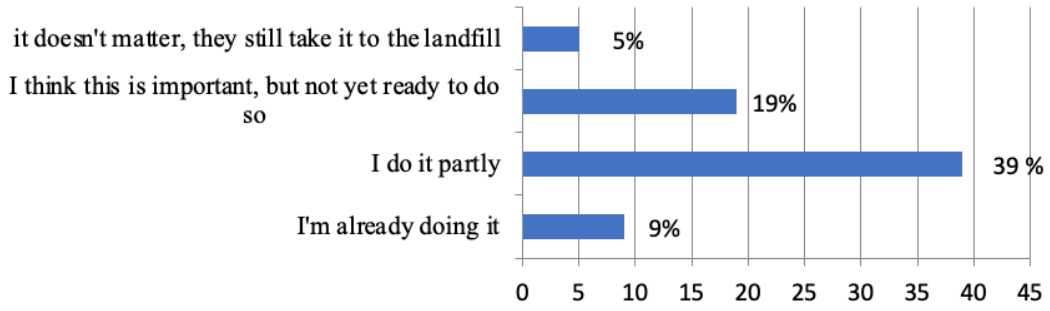

Figure 2. Assessment of your readiness to sort garbage.

As can be seen in Figure 2, the results of a social survey have shown a lack of willingness of Ukrainians to participate in the recovery of products, but only 12.5% of respondents are already sorting garbage, 54% - does it in part, 22% - think it's important, however, are not ready to join the garbage sorting process. The results of the empirical study indicate a lack of awareness of the educational environment (not the economic sector) about the nature and processes of cyclical economics. At the same

time, there is an understanding of the need of the economic sector to invest in minimizing the negative impact of production on the environment, take care of the region's ecology, create a safe environment, and willingness to take responsibility and participate in the preservation of natural, resource and social potential.

To move to a circular model of the economy, society must develop values, norms, patterns of behavior, skills, experiences related to a culture of sustainable development, environmental protection, and the reproduction of resources. The solution of these issues is facilitated by the orientation of education as a social institution in general and at all its levels in particular) preschool, general secondary, pre-professional higher, higher, vocational, postgraduate. «Education is a significant potential for sustainable development of society. Its role is to predict, shape and develop the professional competence of future specialists during their lifetime, to develop an energy-saving style of professional activity» [11].

Analysis of scientific sources revealed successful experience in this area of Europe (Poland, Germany, Finland, etc.), China. This issue is also relevant in Ukraine.

To transition and implement the concepts of sustainable development and cyclical economy, scientists and practitioners propose:

- addressing this issue at the state and legislative levels by including education in national strategic plans, programs and roadmaps for sustainable development, green economy, cyclical economy [28];
- introduction into the strategy of education development, in particular higher education, in addition to supporting the direction of sustainable development, also supporting the transition to a circular economy;
- dissemination of measures in the field of education to implement the principles of the circular economy: the formation of society's worldview, the formation of leadership competencies, exchange of experiences and best practices, providing the necessary infrastructure [29];
- to introduce in institutions of higher education the training of specialists in a fundamentally new direction for Ukraine, namely specialists in circular economics [11];
- modernization of the existing professional training of future specialists-economists, diversification of educational programs in the specialty «Economics» in the context of the tasks of global sustainable development, development of «green» and cyclical economy. For example, updating the content of educational «Business Economics», «Agribusiness Economics», «Economics and Economic Policy», «International Economics» [30]. Study by future specialists of the latest technologies and methods of prevention and prevention of environmental catastrophes [28], processes and procedures for closed-loop production;
- directing educational and training processes in preschool, general secondary and higher education institutions on the development of ecological and economic culture of students, formation of values, norms of behavior for conservation of natural resources, the culture of waste disposal, knowledge of recycled goods, experience in using them. Formation of worldview, the idea of the state of the environment, economic thinking on the rational use and distribution of material, technical, human resources, harmonization of human and nature. Fostering a sense of belonging to the environment and dependence on its consequences;
- modernization of methods, technologies and methods of teaching, taking into account the possibilities of IT education, the use of distance learning, gaming technology and educational software products;
- introduction of basic modules on sustainable development, «green» and cyclical economy in the advanced training system of pedagogical workers in the system of postgraduate education;
- development of educational environment and infrastructure by involving higher education institutions in techno- and science parks, creation of FabLab- and startup centers on the basis of ZVO to attract research and teaching staff, students to create and use closed-loop technologies, product processing;

- realization of interaction of links: «production, business» - «education» - «science» - «sphere of professional activity»;
- providing a holistic and focused approach to education for sustainable development, covering curriculum content, learning outcomes, teaching methods, educational environment development, and building green economies and societies [31].

Implementation of the strategy of sustainable development and training of new generation economics in higher education can be carried out according to several models: a) disciplinary (thematic) - the introduction into the educational process of a separate discipline to study the basics of sustainable development and cyclical economy; b) interdisciplinary - training based on the study of related sciences in terms of sustainable development, «green» and cyclical economy; c) educational - the implementation of economic, environmental, national, multicultural, labor, moral and ethical education of higher education; d) system - the development of all components of the educational environment of higher education [32]; e) saturation of the educational environment of universities with examples of energy, resource-saving, reproductive, processing technologies, partnership of stakeholders of sustainable development and cyclical economy (managers, teachers, graduates; scientists; representatives of industry and business) and implementation of projects based on the best practices (i.e. project «Nature is society»).

The implementation of these areas and educational activities will facilitate the transition to a cyclical economy.

4. Conclusions

Thus, one of the ways out of the global crisis of today (economic, environmental, social) in many countries is the transition to a cyclical economy.

The analysis of literature sources revealed the wide attention and diversity of approaches to determining the nature and definitions of the circular economy. In particular, scientists consider the category of cyclical economy as: a model of economic development; alternative to traditional, linear economy; industrial system that is being restored or regenerated; economic model aimed at ensuring economic prosperity, efficiency of ecosystems, human well-being.

Also, a review of scientific papers revealed that one of the important levers for the introduction and development of a cyclical economy is education. This is due to the need for specialists in cyclical economics for its implementation and effective implementation, the formation of consciousness, values, culture of economic and environmental behavior, willingness to participate in the conservation and reproduction of resources. But such works are currently insignificant.

The relevance of the role of education in addressing the issues of effective implementation of the cyclical economy was confirmed by our empirical study. The survey of representatives of the educational environment of non-economic specialties revealed: 1) insufficient awareness of the essence of the circular economy (only 30.6% - believe that they understand what we are talking about); 2) weak formation of the value of environmental protection in the region (36.1%) and insufficient understanding of importance of dealing with environmental protection by business entities (45.8%; 3) among the most significant problems are economic and political, but at the same time, among the least significant the ecological condition of the territories, educational and migration problems were revealed; 4) insufficient readiness to participate in the processes of recovery of production products, as only 12.5% of respondents are already sorting garbage, 54% - does so in part.

These results indicate the need for more active formation of basic knowledge, values, norms of behavior, responsible environmental, economic and social culture and responsibility.

Based on the analysis of highlighted international practical experience and scientific literature, the ways of education development in support of sustainable development, cyclical economy, reorientation of higher and postgraduate education to train specialists in cyclical economics are identified.

The limitation of this work is the quantitative and qualitative composition of the target group of empirical research, which mainly included representatives of the educational environment of non-economic specialties. The direction of further research will be the study of readiness and experience in the transition to a cyclical economy of future and current economists.

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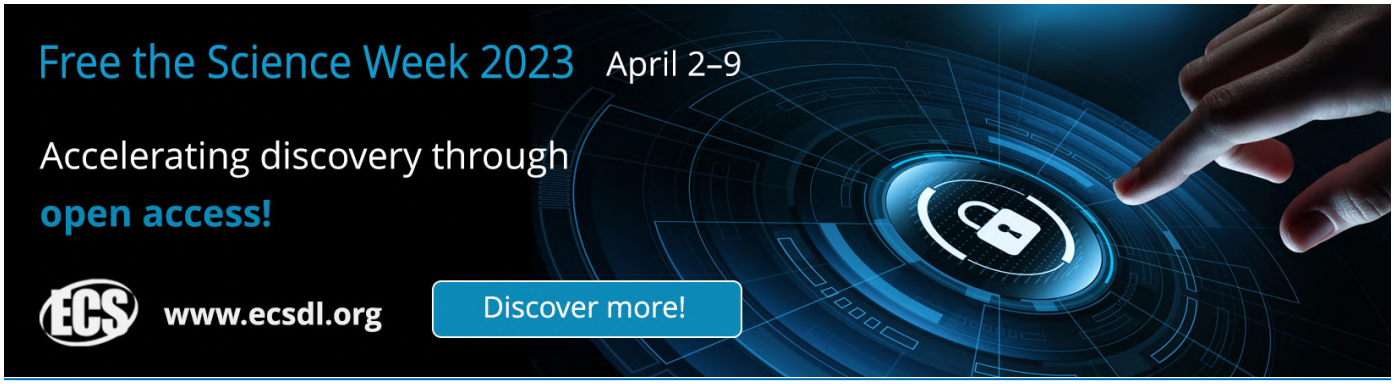
Approaches for assessing the public administration activities in the field of ensuring sustainability



Approaches for assessing the public administration activities in the field of ensuring sustainability

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Abstract. Paper has tried to find a balance between the traditional role of public administration (transparency, efficiency, information symmetry and other values of common European administrative space) and the new role since the European Green Deal (2020) and public procurement reform (2014) as a policy tool for promoting green growth. It has been argued that Green Public Governance Efficiency can be assessed according to inputs and outputs. The information can be organised into several categories: Investment in Environmental governance, public institution energy consumption and green public procurement. Some variables can be waged as outputs: sustainable development growth index (SDGI), consumer engagement in green governance and the achievement of Green Public Procurement (GPP) criteria. It is difficult to arrive at conclusions about a need for appropriate instrumental variables. Despite the limitations, these are valuable in light of how Public Administration can contribute to environmental protection and long-term growth.

1. Introduction

Implementing national policies in sustainable growth requires systematic monitoring and coordination, considering the rapid changes in the world and economic space. Specific monitoring of a country's sustainable development should be carried out through the collection and further analysis of detailed factual data, thereby co-authoring a state agency to ensure the country's sustainable growth. This field of study is sometimes referred to as green governance. According to some authors [1, 2], green governance is a long-standing social, economic, and ecological sustainability.

However, the existing research has some limitations in representing an overview of how environmental indicators are produced, applied and circulated and demonstrating the power of indicator culture for ecological governance and decision-making [3]. The data provided is called "indicators" in the scientific literature, and the parameters used to create the relevant data (indicators) are called "criteria".

The difference between criteria and indicators is pronounced. The indicator expresses a quantitative characteristic of the criterion, a feature when assessing a particular phenomenon, process or situation. The evaluation criterion may include several indicators, which can be expressed in digital format, orally or in writing – the so-called “quality indicators”.

Thus, we observe the identification of criteria and indicators in specific scientific works on sustainable growth. Besides, the state’s sustainable growth is directly related to quantitative economic indicators, i.e. we can say that the criteria of sustainable development are currently its constituent features defined in the relevant recommendations of the relevant Ministry. In contrast, indicators are

quantitative economic data describing this criterion. For example, one of the state's criteria for sustainable growth is sustainable foreign growth, which includes sub-criteria: transparency of the economy, export coverage of import, import within domestic consumption, and trade conditions. In turn, those sub-criteria have the following indicators: volume of export of goods and services, million US dollars, the share of the total export of chemical and related industries, import of goods and services, million hryvnias, etc.

There is the question, along with the one mentioned before: how do we have to assess the efficiency of implementing public management? On the one hand, the question seems to be very easy – you need to create a system of criteria for assessing sustainable growth, formulate (calculate) a list of indicators according to those criteria, and then calculate the actual situation – if the obtained data differs from the standard data to a greater extent, then the country is in the right direction, if not – then the activities to ensure sustainable growth should be adjusted.

This has been previously assessed only to a minimal extent because further research does not adequately cover the connotation and extension of green governance [4].

We offer to study this issue, considering the effectiveness of public authorities' activities, which are the entities authorised to implement the state policy within specific components of sustainable growth. In our opinion, this approach has a right to exist because it allows us to find the root cause, which could lead to a negative final result in the form of a formally defined quantitative indicator of sustainable growth.

We can say something else – the implementation of organisational and authoritative powers by public authorities creates the basis for the establishment, development and change of economic relations, which ultimately entails a change in quantitative indicators of the state's economy (price index, transportation of goods, the number of products, the amount of money supply, etc.). The evaluation of the efficiency of public management in the field of sustainable growth can be carried out as an assessment of the effectiveness of public administration in the area of sustainable development (figure 1), which has several aspects: constitutive and law-enforcement, which, in turn, consists of enforcement and law enforcement elements.

Thus, the general scheme of evaluating the efficiency of national policy in the field of sustainable growth of Ukraine, in our opinion, is as follows:

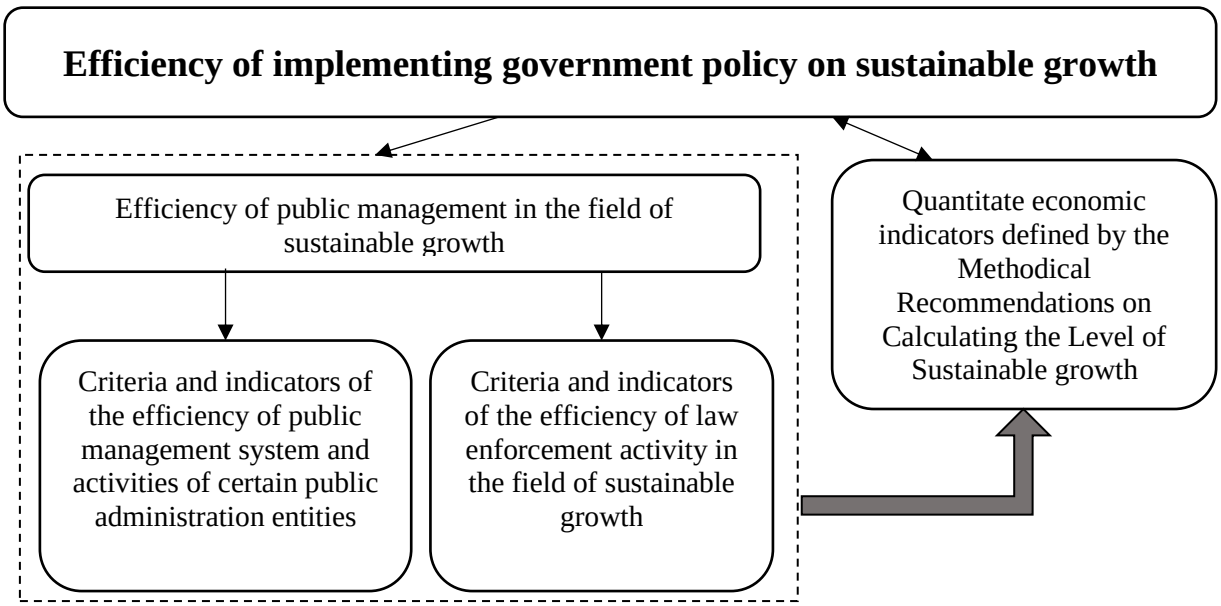

Figure 1. Components of assessing the efficiency of government policy on sustainable growth.

2. Comparative analysis for assessing the public administration activities in the field of ensuring sustainable growth

Despite decades of research, this continues to be debated among some developing countries on how to combine economic and social benefits and the principles of green economic development. Some key questions and notions still need to be discussed in the literature about self-assessment of public administration in the context of reaching goals of sustainable growth. A more systematic and theoretical analysis is required for Green public governance efficiency (GPGE), which constitutes a significant element for achieving sustainable growth because it puts more muscular general stress on sustainable development.

The problem can be addressed by constantly rising energy consumption in developing countries and they're becoming the world's largest consumers of the world due to rapid urbanisation and industrial development [5].

Under resource constraints, GPGE is defined as achieving higher management performance with minimal environmental costs. A thorough survey of the GPGEs of developing countries has shown the characteristics of economic development in some countries and, as a result, has contributed significantly to the world's long-term growth.

It is appropriate to refer to the international experience of assessing the parameters of public administration activities to ensure sustainability, which undoubtedly strengthens our conclusions and propositions.

Let's talk about the indicators of sustainable growth in the Republic of Kazakhstan. The scholars include GDP, the share in the industrial production of manufacturing, the share in the industrial production of machinery, investment, research costs, the percentage of new types of products in production within the mechanical engineering output, the share of people with incomes below the subsistence level, life expectancy, income gap between 10% of the richest and 10% of the poorest groups, crime rate, the ILO unemployment rate, annual inflation rate, domestic and foreign debt, budget deficit [6,7].

At the same time, coal causes a much higher CO2 emission factor than gasoline and natural gas. Considering the dominant position of coal in Germany, Ukraine, Kazakhstan and Poland, it would be tough to change such dependency; increasing pressure on CO2 emissions and air quality management is expanding these countries' wider regional and economic conditions. It is expected to affect the development of the economy. Most public authorities are evaluated in two directions: 1) operational evaluation of the efficiency; 2) evaluation of the performance.

Operational assessment is implemented according to the following units [8] (figure 2):

Figure 2. Main stages of assessing the efficiency of government policy on sustainable growth.

The implementation of Green Public Governance is assessed in terms of purely economic indicators. It includes the internal activities of authorised state authorities in the field of economy and the direction of interaction with civil society. It should also be noted that the data indicating the effectiveness of the government policy in each area are the results of opinion polls, international polls and ratings.

Let's carefully analyse the international ratings of countries related to the analysis of their economic development and sustainability. We can also say that they are not limited to purely financial quantitative data because sustainable growth, according to experts, is directly related to other spheres of state activity, particularly the process of green public administration and public procurement. Therefore, those evaluation systems should be considered in detail.

Green open data (GOD) and public procurement (GPP) are critical priorities in EU sustainable growth. However, there needs to be more clarity between the discretion given to public buyers within the existing voluntary GPP regime and the role of open data as a mechanism to improve compliance with the environmental goals of member countries. Questions still need to be answered: Do you need green available data for Open Data Maturity Report? And why does GPP still mean that it is a voluntary tool and it is up to Member States and their contracting authorities to implement it?

The Behavioural Study on Consumers' Engagement in the Circular Economy (2018) is a well-known study conducted in the EU. The actual involvement in the practice of the circular economy was pretty low. The majority of consumers (64%) have not repaired the product, but a significant percentage have never improved the product in the past (36%) and/or have rented/leased or purchased a used product (~ 90%). The authors found that one of the reasons for their low involvement in the practice of the circular economy is that consumers lack information on product durability and repairability, and well-developed markets (used products, rentals), leasing, sharing, etc.) showed that there might be no services, etc.). [9].

When analysing foreign practices of sustainable growth assessment, it is possible to find a fascinating fact that the concept of "sustainable growth" is quite commonly adapted to the individual and is described by the term "Sustainable Development Growth (SDG)". Researchers say that SDG is a new indicator designed to facilitate the study and analysis of the roadmap for achieving sustainable development by 2030 and beyond. The average SDG Index score slightly declined in 2021, partly due to slow or nonexistent recovery in poor and vulnerable countries [10].

The SDG Index assesses each country's overall performance concerning the 17 SDGs, with the same weight given to each goal. The score indicates the country's position between the worst result (score 0) and the target value (score 100). Dashboards and trend arrows identify further action priorities and indicate whether a country is on track based on the latest trend data to reach its goals and goals for 2030. Two-thirds of the data comes from official statistics, and one-third from non-traditional statistics such as research centres, universities and non-governmental organisations. SDG indexes published after 2015 have been peer-reviewed [11] and statistically audited by the European Commission.

3. Discussion

The above testifies to the fidelity of our chosen direction for forming criteria and indicators of the Green Public Governance Efficiency. Therefore we should offer their list according to the relevant areas. Another promising finding was that the impact of green governance on CO2 emissions increases and help reduces emissions [12].

The data is analysed from different points of view, such as municipal solid waste (MSW) generation, employment rate, capital formation, gross domestic product (GDP), population density and, for the first time, sulphur oxide (SOx), nitrogen oxide (NOx) and greenhouse gases (GHG) emissions from the waste sector for the relevant countries. [13].

Because we were interested in creating a system of criteria for assessing public administration, we considered only standards and indicators of the efficiency of general management areas of sustainable growth:

1.1. Regulatory provisions for the formation of government impact on sustainable growth. Proper organisation of the entire system of sustainable development depends on the completeness and quality of this component. First, we should talk about a more clear consolidation of sustainable growth as the critical

cocriticalnent of national security, adopting strategies and concepts in this area, and relevant laws. It is also essential to enshrine the powers of agencies and their officials in regulatory acts to implement public management in sustainable growth, etc. The leading indicators of this criterion are the number and quality of relevant regulatory acts. Regulatory provisions should also include the availability of departmental plans and programs to ensure the country's sustainable growth.

1.2. Organizational provision of public management in this sphere. Indicators of this criterion are the quantity and quality of the system of authorised entities of public administration and their structural units that have the authority to form and implement general management and regulatory acts on sustainable growth.

1.3. Human resourcing of public management in the field of sustainable growth. Indicators of this criterion are the presence of a clear staff structure, the number and quality of vacancies in the forms of authorised entities, the specialisation of specific units, the availability of professional development programs, staff selection, adaptation, and social protection. An important indicator of human resourcing is the availability and quality of programs to assess the business qualities of personnel responsible for implementing regulations in sustainable growth, socio-psychological climate, and interpersonal relations.

1.4. Direct implementation of public policy. Indicators of this criterion are the purposefulness of the state agency, the subordination of its activities to the purpose and objectives of ensuring sustainable growth, and compliance of measures with statutory and institutional regulatory acts. Clear direction of the action of public administration makes it possible to ensure the organizorganisationalion properly, i.e. to delineate the internal powers of departments, offices and their officials, as well as the forces of all subjects in the sustainable growth system.

Another aspect of purposefulness is the achievement of purposes and indicators of national or regional programs in sustainable growth by state authorities. This indicator is due to the requirements of proper regulatory provision for forming and implementing public management in sustainable growth – the development of strategic and program documents on this issue. Performance indicators determine the degree of achievement of such programs and strategic purposes and performance indicators (fulfilled, partially fulfilled, not fulfilled).

Another indicator of the implementation of public management in the field of sustainable growth according to this criterion is the time spent on administrative management decisions, as well as their quality, validity and clarity. It is also advisable to assess the consequences of such choices: contributed to the achievement of purposes, did not affect the achievement, etc.

1.5. Interaction of authorised entities during the policy-making process with civil society. The assessment within the framework of this criterion is carried out according to the following indicators: 1) the quantity and quality of green public services; 2) organisation of work with appeals of citizens and legal entities, behavioural study on consumers' engagement; 3) transparency of public administration entity, which is expressed in delivering green open data.

1.6. Informatization of the implementation of the public sustainability policy. Indicators of this criterion are the availability of information systems and software products necessary for the quality performance of set tasks, the depth of coverage of the management system by information technology, automation of daily management operations and internal administrative processes, quantitative indicators of the information security system of public policy systems for collecting, transmitting and processing statistical information in the area of activity of the relevant state agency, etc.

1.7. Logistical support for the implementation of the public sustainability policy. This type of support indeed affects the effectiveness of public management, achieves planned goals realistically, helps preserve and strengthen the staff, etc. The leading indicators of logistical support include the number of funds allocated for the activities of authorised entities of such implementation; current and capital costs for the maintenance of logistical facilities; the number of adequately equipped workplaces, the number of personal computers, communications, stationery, network and similar Internet equipment, the amount of money and resources directed to the social support of staff, it's training, professional development, retraining, foreign internships.

1.8. The assessment of Green Public Procurement (GPP) criteria. The last survey showed that the EU GPP criteria for four product groups from 20 are not up to date [14]. The requirements should be re-evaluated to consider technological advances in the market.

4. Conclusions

Based on the conducted scientific analysis of approaches for assessing the public administration activities in the field of ensuring sustainability, it is expedient to formulate the following conclusions:

Sustainable growth indicators in the modern economic and legal literature are quantitative data characterising the state of the national economy in its various constituent elements: financial, industrial, and investment spheres. At the same time, we believe that the efficiency of implementing the public sustainability policy should be linked to the effectiveness of state authorities' activities, which are the entities authorised to implement public management in specific components of sustainable growth.

The peculiarity of the suggested approach is that the efficiency of the public sustainability policy can be carried out as an assessment of the Green Public Governance Efficiency, which has several aspects: constitutive and law-enforcement. Thus, the criteria and performance indicators of authorised public management entities in the studied area affect the quantitative indicators of sustainable growth.

Green Public Governance Efficiency standards include regulatory provisions on sustainable growth design and government policies, organisational conditions on government policies on sustainable growth, and people for implementing government policies on sustainable development. It should include resources and direct implementation of state policies. The field of national sustainable growth, the interaction of national policy-licensed institutions in the area of sustainable development with civil society, the state of informatisation of national policy in the field of sustainable growth, sustainable growth Logistical support of national policy in the area of green public procurement, rediscovery of standards.

Due to the lack of data, it took much work to estimate all the various factors that influenced the questions in the survey, given the long-term implications. We couldn't address the issue of endogeneity and concurrency because we needed the proper instrumental variables. Despite the above limitations, this paper can provide helpful information for assessing green public governance's effectiveness and enhancing environmental and social growth.

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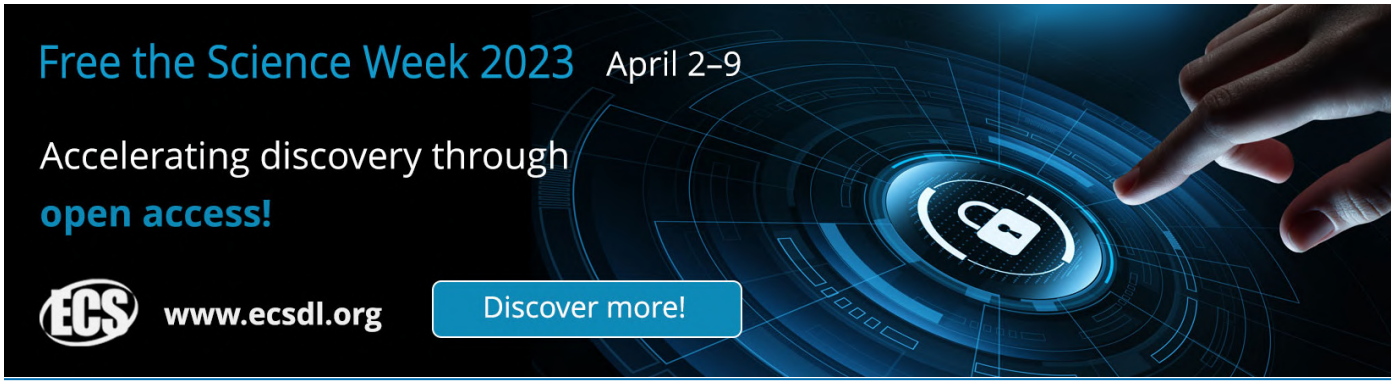
Structural changes in Ukraine's electricity generation and their impact on the reduction of CO_2 emissions



Structural changes in Ukraine's electricity generation and their impact on the reduction of CO_2 emissions

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Abstract. The purpose of the study is to assess the state of and structural changes in Ukraine's electricity generation and their impact on the reduction of carbon dioxide (CO_2) emissions. For the investigation, data from the International Energy Agency and the National Power Company Ukrenergo were used. The study analyzes the trends in Ukraine CO_2 emissions by economic sector, the trends in the country's electricity generation and electricity generation capacities, the structure of electricity generation capacities by type of flexibility and presents the calculations of the integral coefficients of structural changes in the electricity generation capacities and electricity generation by type of flexibility. The study also examines how the structure of the energy sector of Ukraine has changed in terms of electricity generation. For this purpose, the structure of the Ukrainian electricity generation capacities and electricity generation by generation type is considered and the integral coefficients of structural changes in the electricity capacities and electricity production by generation type are calculated. Based on the study results, it is determined that, over the considered period, the decrease in Ukraine's electricity generation was more significant than the decrease in its generation capacities, which has led to a corresponding reduction in CO_2 emissions in the country; the structural changes in the electric power industry of Ukraine were not adequate to the structural changes in the country's economy, which has led to a shortage in flexible capacities but also resulted in the reduction of CO_2 emissions due to a decline in electricity generation.

1. Introduction

One of the most pressing global problems of mankind is the increase in emissions of greenhouse gases, primarily, carbon dioxide (CO_2), and the resulting climate change. The largest emitters of carbon dioxide are China and the United States, accounting together for more than 40 % of the global CO_2 emissions.

In order to solve this problem, world leaders have concluded a number of international agreements providing for the reduction of CO_2 emissions [1]. Ukraine has also undertaken ambitious commitments to significantly reduce greenhouse gas emissions.

It should be noted that different sectors of the economy exert different impact on the environment in the form of carbon dioxide emissions with industry, energy, and transport being the leaders. Currently, global energy-related CO_2 emissions are the major contributors to climate change [2]. The largest CO_2 emitter among the Ukrainian economic sectors is industry with the major share accounted for by the electric power industry [3; 4]. In view of Ukraine's obligations to significantly reduce greenhouse gas emissions, the implementation of this decision cannot but affect the country's economy precisely because industry (energy) is its main economic sector. The situation is complicated by Ukraine's

undertaking significant obligations with its fuel and energy complex technologically unprepared for such changes.

Under these conditions, it is necessary to analyze how exactly the current situation and structural changes in Ukraine's electricity generation affect the reduction of carbon dioxide emissions, and whether further decarbonization of the national economy is possible without hindering the socio-economic development of the country.

2. Critical literature review

The most important studies on the problem of reducing carbon dioxide emissions in the energy sector are being carried out by: International Energy Agency (IEA), US Energy Information Administration (EIA) and the World Energy Council (WEC). Expert researchers are also developing directions for overcoming climate and energy problems.

Antimiani A et al [5] consider the risks of implementing the EU strategy to mitigate climate change by reducing greenhouse gas emissions and the impact of climate policy on competitiveness. The authors prove that this impact can be quite serious and, therefore, informed decisions on the elaboration of a decarbonization policy are required.

The need for a balanced decarbonization policy, accounting for support for high-tech industries, is also noted by Gryshova I et al [6], Kyzym M et al [7; 8; 9].

Pollitt [10] analyzes the prospects for development of the global carbon market as a central issue in reducing greenhouse gas emissions. The focus of the study is to figure out what policies should be implemented to support global decarbonization.

Veysey J et al. [11] investigate the possibilities for Mexico to reduce greenhouse gas emissions. The authors found that the ambitious national goals of reducing greenhouse gas emissions in the country contradict the latest trends in the field of energy and emissions in general and substantiate the need for decarbonization of the country's power sector along with changes in its transport sector.

Research by P Ekins, P Drummond and J Watson [2] examines various emission reduction technologies to identify the best mixes of policies for reducing greenhouse gas emissions. Optimal power generation portfolios are determined through the EU electricity investment model with consideration for various expansion and decarbonization scenarios.

In study [3], the authors analyze the current state of and trends in greenhouse gas emissions in world leading countries and Ukraine and their impact on the environment. The analysis conducted by the authors prove that the situation with greenhouse gas emissions in Ukraine has significantly improved. However, the improvement is not the result of an effective state policy for decarbonizing the economy and of the country's transition to low-carbon development. The main reason for the reduction of technogenic load on the environment in Ukraine is the largest economic downturn and de-industrialization [3; 7].

Therefore, world countries pay special attention to the problem of decarbonization in forming their energy policies. In view of this, both scientists and practitioners note the need for a balanced and well-reasoned approach when making decisions on the state decarbonization policy. Such decisions should be based on corresponding calculations and analysis of the situation in the sectors involved in the decarbonization.

Thus, *the purpose* of this study is to assess the state and structural changes in Ukraine's electricity generation and their impact on reducing carbon dioxide emissions.

3. Methodology and results

According to the international obligations, Ukraine conducts statistical observations, systematic monitoring of greenhouse gas emissions and prepares reports in compliance with the requirements of the UN Framework Convention on Climate Change [12]. Statistical reporting on environmental pollution [13; 14; 15] contains information on emissions of a wide range of pollutants into the atmosphere, but greenhouse gases are not presented separately. Only since 2018, carbon dioxide

emissions have been singled out as a specific item in the statistical reporting [14]. The most up-to-date data on greenhouse gas emissions are available on the official website of the IEA [16].

Data on the total greenhouse gas emissions by individual sectors (according to the IEA [16]) are given in Table 1 (currently, the IEA website contains only data up to 2019).

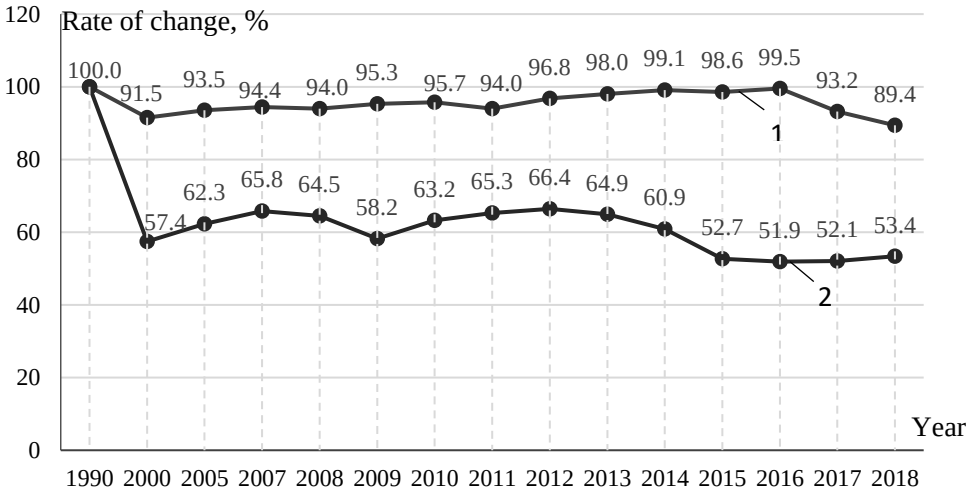
Table 1. Behavior of Ukraine CO_2 emissions by economic sector, mln tonnes.

Economic sector	Year									
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Electricity and heat generation	333	191	133	129	123	90	101	83	88	80
Industry	195	98	81	75	61	42	38	31	36	35
Transport	55	33	27	31	34	23	24	25	25	27
Buildings	52	52	41	37	35	23	23	22	22	17
Agriculture	22	5	3	8	4	4	5	4	4	4
Energy	24	13	7	9	7	4	4	3	3	3
Total	689	396	295	291	267	188	198	171	182	170

Source: [16]

Let us investigate the state and structural changes in the electric power industry of Ukraine and their impact on the reduction of carbon dioxide emissions in the country.

In 2018, Ukraine's electricity generation capacities decreased by 10.6 % compared to 1990, and by 2.1 % compared to 2000 (Figure 1).



1 – electricity generation capacities; 2 – electricity generation

Figure 1. Trends in Ukraine's electricity generation capacities and electricity generation in 1990-2018.
Source: developed by the authors

At the same time, the volume of the Ukrainian electricity generation in 2018 compared to 1990 decreased by 46.6 % and compared to 2000 – by 4.0 %, this trend persisting. Thus, currently, there is a significant amount of standby electricity generation capacities in the country.

The state of generation capacities by type of electricity generation is reflected by the following data:

1. In 2018, the capacities of nuclear power plants (NPPs) of Ukraine amounted to 107.8 % compared to1990 and 115.9 % compared to 2000. At the same time, the volume of electricity generation by the country's NPPs was 110.7% in relation to 1990 and 110.9% in relation to 2000.

2. The capacities of Ukraine's thermal power plants and combined heat and power plants (TPPs and CHPs) in 2018 amounted to 80.1 % compared to 1990 and 88.9 % compared to 2000. At the same time, the generation of electricity by TPPs and CHPs of the country amounted to 27.2 % and 69 .4 % in relation to 2000.

3. The capacities of the Ukrainian hydroelectric power plants and pumped storage power plants (HPPs and PSPs) in 2018 amounted to 131.9 % compared to 1990 and 2000. At the same time, the generation of electricity by HPPs and PSPs in the country amounted to 99.1 % compared to 1990 and 92, 2 % compared to 2000.

4. In 2018, Ukraine's capacities of renewable energy sources (RES) amounted to 200 % compared to 2012, and the increase in electricity generation from them over this period amounted to 316.7 % [7].

The classification of Ukraine's electricity generation capacities and electricity generation by flexibility is given in Table 2.

Table 2. Classification of Ukraine's electricity generation capacities and electricity generation by flexibility.

Type of flexibility	Source of electricity generation
Non-flexible	Nuclear power plants
Partially flexible	Thermal power plants and combined heat and power plants
Flexible	Hydroelectric, wind, solar power plants, and other electricity generation facilities

Source: developed by the authors

The structure of Ukraine's electricity generation capacities by type of flexibility in 2000 and 2018 is presented in Figure 2.

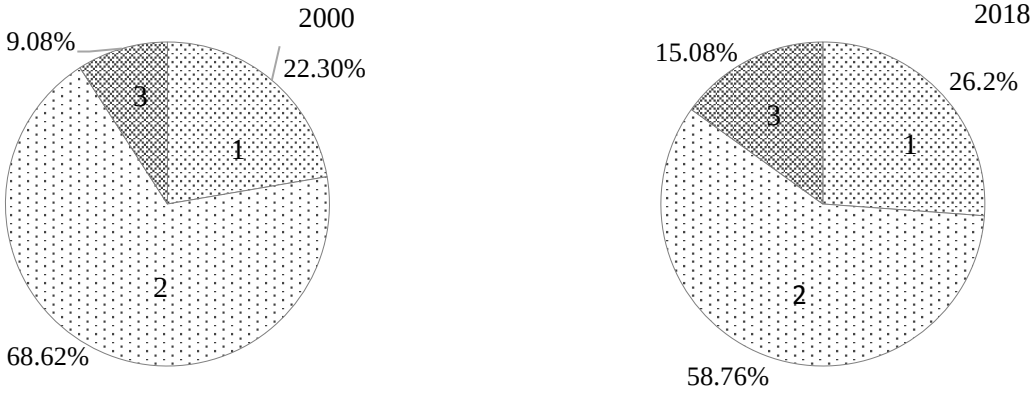


Figure 2. Structure of Ukraine's electricity generation capacities by type of flexibility in 2000 and 2018.
Source: developed by the authors

Over the studied period, the share of Ukraine's flexible electricity generation capacities increased by 6.01 %, that of non-flexible capacities – by 3.85 %, while with partially flexible capacities a decrease by 9.86 % was observed.

Figure 3 shows the increase (decrease) in the share of Ukraine's electricity generation by type of flexibility.

As can be seen, in Ukraine, the generation of electricity from non-flexible and flexible generation types increased by 10.32 % and 2.18 %, respectively; but, in case of partially flexible generation, a decrease by 12.50 % was observed.

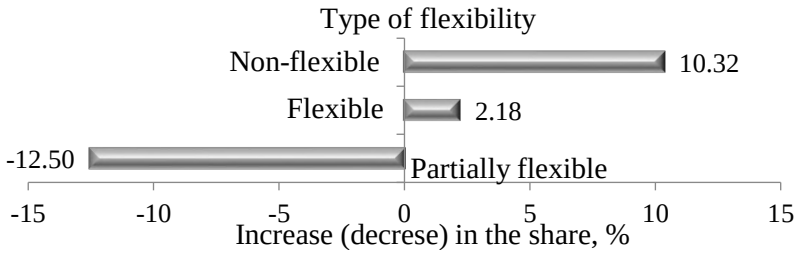


Figure 3. Increase (decrease) in the share of Ukraine's electricity generation by type of flexibility in 2000-2018.
Source: developed by the authors

The United Nations Industrial Development Organization (UNIDO) states that the most common meaning of structural change refers to long-term and persistent shifts in the sectoral composition of economic systems [17]. This study proposes to define "structural change in electricity generation" as a quantitative characteristic of the magnitude of shift in electricity generation due to changes in various types of generation.

The magnitude and direction of the structural change of the *i-th* type of electricity generation in Ukraine's economy for the Δt – th period ($I_i^{\Delta t}$) is calculated using the following index [18; 19; 20]:

$$I_i^{\Delta t} = \frac{d_i^{t2} - d_i^{t1}}{d_i^{t1}}, \quad (1)$$

where d_i^{t1} and d_i^{t2} denote the share of the *i-th* generation type.

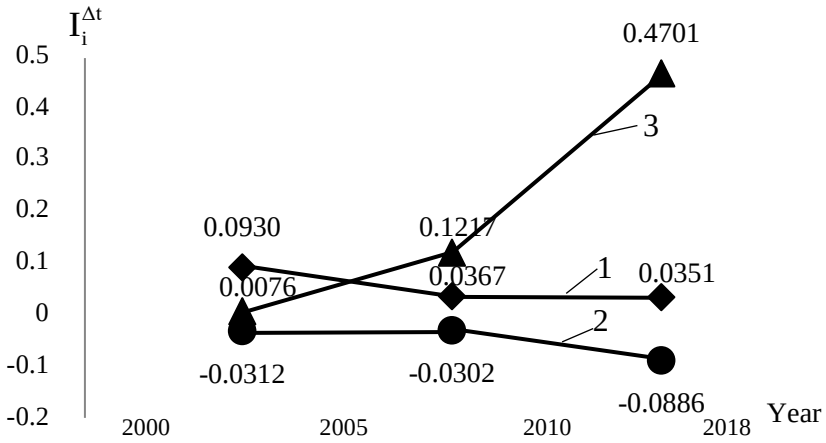
Table 3 shows the calculations of structural changes in Ukraine's electricity generation capacities and electricity generation by type of flexibility for the period 2000-2018.

Table 3. Calculations of structural changes in Ukraine's electricity generation capacities and electricity generation by type of flexibility.

Type of flexibility	Share, %				Difference in the shares, %				Index of structural change ($I_i^{\Delta t}$)			
	d_{2000}	d_{2005}	d_{2010}	d_{2018}	$d_{2005} - d_{2000}$	$d_{2010} - d_{2005}$	$d_{2018} - d_{2010}$	$d_{2018} - d_{2000}$	$I_i^{2000-2005}$	$I_i^{2005-2010}$	$I_i^{2010-2017}$	$I_i^{2000-2018}$
Capacities												
Non-flexible	22.3	24.4	25.3	26.2	2.07	0.89	0.89	3.85	0.0930	0.0367	0.0351	0.1728
Partially flexible	68.6	66.5	64.5	58.8	-2.14	-2.01	-5.71	-9.86	-0.0312	-0.0302	-0.0886	-0.1437
Flexible	9.08	9.15	10.3	15.1	0.07	1.11	4.82	6.01	0.0076	0.1217	0.4701	0.6616
Generation												
Non-flexible	45.1	47.7	47.2	55.4	2.62	-0.52	8.22	10.32	0.0580	-0.0109	0.1743	0.2289
Partially flexible	48.2	45.5	45.8	35.7	-2.68	0.25	-10.08	-12.50	-0.0556	0.0056	-0.2202	-0.2594
Flexible	6.7	6.8	7.0	8.9	0.06	0.27	1.85	2.18	0.0091	0.0394	0.2633	0.3250

Source: developed by the authors

Figure 4 shows the trends in structural changes in Ukraine's electricity generation capacities by type of flexibility in 2000 - 2018.

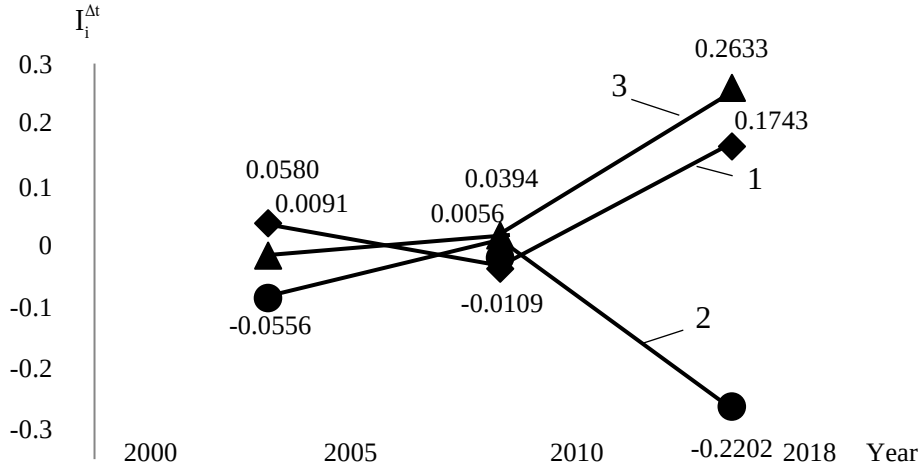


1 – non-flexible; 2 – partially flexible; 3 – flexible

Figure 4. Trends in structural changes in Ukraine's electricity generation capacities by type of flexibility.
Source: developed by the authors

Figure 4 demonstrates that positive structural changes occurred in terms of flexible generation capacities (0.4701) and non-flexible ones (0.0351), while negative shifts were observed in those of partially flexible type (-0.0886).

The trends in structural changes in Ukraine's electricity generation by type of flexibility for 2000 – 2018 are presented in Figure 5.



1 – flexible; 2 – partially flexible; 3 – non-flexible

Figure 5. Trends in structural changes in Ukraine's electricity generation by type of flexibility.
Source: developed by the authors

As can be seen from Figure 5, positive structural changes in Ukraine's electricity generation by type of flexibility occurred in terms of flexible (0.2633) and non-flexible (0.1743) types of generation, whereas with partially flexible generation a decline (-0.2202) was observed.

Table 4 presents the calculations of the integral coefficients of structural changes in Ukraine's electricity generation capacities and electricity generation by type of flexibility.

Table 4. Calculations of the integral coefficients of structural changes in Ukraine's electricity generation capacities and electricity generation by type of flexibility.

Type of flexibility	Square of the difference of the shares, %				Square of the sum of the shares, %			
	$(\Delta d_{2005-2000})^2$	$(\Delta d_{2010-2005})^2$	$(\Delta d_{2018-2010})^2$	$(\Delta d_{2018-2000})^2$	$(\Delta d_{2005+2000})^2$	$(\Delta d_{2010+2005})^2$	$(\Delta d_{2018+2010})^2$	$(\Delta d_{2018+2000})^2$
Capacities								
Non-flexible	4.30	0.80	0.78	14.86	2179.6	2465.6	2645.5	2348.9
Partially flexible	4.60	4.03	32.59	97.21	18250.0	17145.7	15184.5	16224.8
Flexible	0.00	1.24	23.26	36.06	332.0	376.5	642.1	583.6
Total	8.9	6.1	56.6	148.1	20761.6	19987.7	18472.1	19157.3
$\frac{(d_i^{t_2} - d_i^{t_1})^2}{(d_i^{t_2} + d_i^{t_1})^2}$					0.0004	0.0003	0.0031	0.0077
$K_i^{\Delta t}$					0.0207	0.0174	0.0554	0.0879
Generation								
Non-flexible	6.76	0.25	17.64	39.69	8614.7	9008.3	10530.1	10104.2
Partially flexible	6.85	0.27	67.65	106.53	8780.5	8332.1	6635.2	7036.0
Flexible	7.17	0.06	101.56	156.30	181.7	190.6	253.7	243.3
Total	0.00	0.07	3.43	4.75	17577.0	17531.1	17419.0	17383.6
$\frac{(d_i^{t_2} - d_i^{t_1})^2}{(d_i^{t_2} + d_i^{t_1})^2}$					0.0008	0.00002	0.0099	0.0154
$K_i^{\Delta t}$					0.0282	0.0048	0.0996	0.1241

Source: developed by the authors

The behavior of the integral indicators of structural changes in Ukraine's electricity generation capacities and electricity generation in terms of flexibility in 2000 - 2018 is shown in Figure 6.

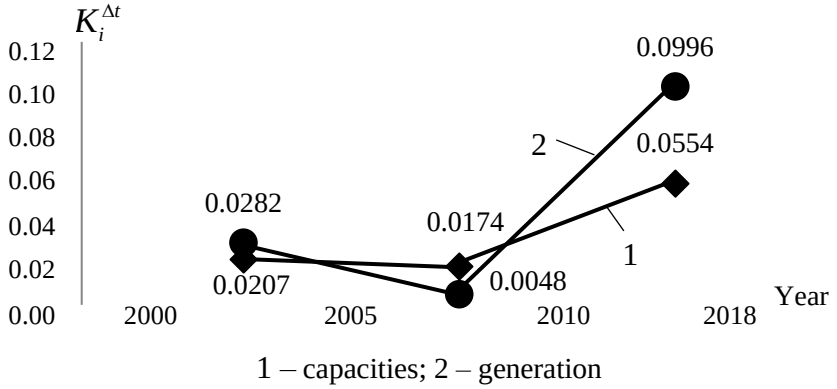


Figure 6. Behavior of the integral indicators of structural changes in Ukraine's electricity generation capacities and electricity generation in terms of flexibility.
Source: developed by the authors

As can be seen from Figure 6, Ukraine's electricity generation in terms of flexibility underwent more significant structural changes than its electricity capacities.

Table 5 presents general characteristics of structural changes in Ukraine's electricity generation capacities and electricity generation by type of flexibility in 2000-2018.

Table 5. General characteristics of structural changes in Ukraine's electricity generation capacities and electricity generation by type of flexibility.

Type of flexibility	Share, %				Rate of changes, %				Structural changes, 2018 in relation to 2000		
	d_{2000}	Rank	d_{2018}	Rank	Absolute	Rank	2018 in relation to 2000	Rank	Index of structural change	Rank	Degree of significance
Capacities											
Non-flexible	22.31	2	26.16	2	3.85	2	117.28	2	0.1728	2	significant
Partially flexible	68.62	1	58.76	1	-9.86	3	85.63	3	-0.1437	3	inconsi-derable
Flexible	9.08	3	15.08	3	6.01	1	166.16	1	0.6616	1	significant
Generation											
Non-flexible	45.10	2	55.42	1	10.32	1	122.89	2	0.2289	2	significant
Partially flexible	48.19	1	35.69	2	-12.50	3	74.06	3	-0.2594	3	significant
Flexible	6.71	3	8.89	3	2.18	2	132.50	1	0.3250	1	significant

Source: developed by the authors

As demonstrated by the data in Table 5, during the period under study, the largest structural changes in Ukraine's electricity generation capacities and electricity generation occurred in terms of flexible electricity generation, respectively 0.6616 (significant) and 0.3250 (significant), and in non-flexible generation, respectively 0.1728 (significant) and 0.2 (significant). As concerns partially flexible generation, over this period, an inconsiderable (-0.1437) decline in Ukraine's electricity generation capacities and a significant (-0.2594) decline in its electricity generation was observed.

This is due to the fact that, firstly, during this period there was no need to increase Ukraine's electricity generation capacities, especially those of non-flexible and partially flexible generation type. Secondly, increasing the actual generation of electricity in the country at the expense of non-flexible electricity generation is inefficient.

Let us analyze how the structure of the energy sector changed in terms of types of electricity generation.

The classification of Ukraine's electricity generation capacities and electricity generation by generation type is as follows (Tbl. 6).

Table 6. Classification of Ukraine's electricity generation capacities and electricity generation by generation type.

Type of generation	Source of electricity generation
Nuclear (NPP)	Nuclear power plants
Thermal (TPP)	Thermal power plants and combined heat and power plants
Hydro (HPP)	Hydroelectric power plants
Renewable energy sources (RES)	Wind and solar power plants, and other electricity generation facilities

Source: compiled by the authors

Figure 7 shows the structure of Ukraine's electricity generation capacities by type of generation in 2000 and 2018.

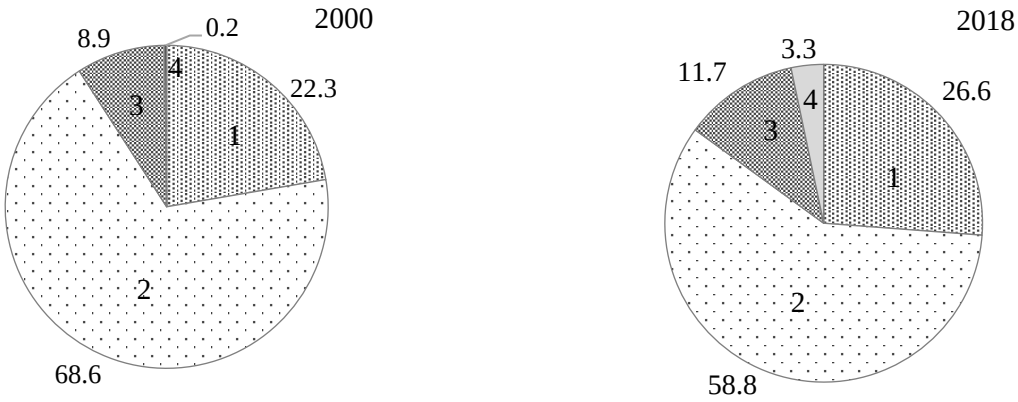


Figure 7. Structure of Ukraine's electricity generation capacities by type of generation in 2000 and 2018.
Source: developed by the authors

As can be seen from Figure 7, the share of TPPs and CHPs in the structure of Ukraine's electricity generation capacities decreased by 9.8 %, while that of other types of generation increased (Fig. 8).

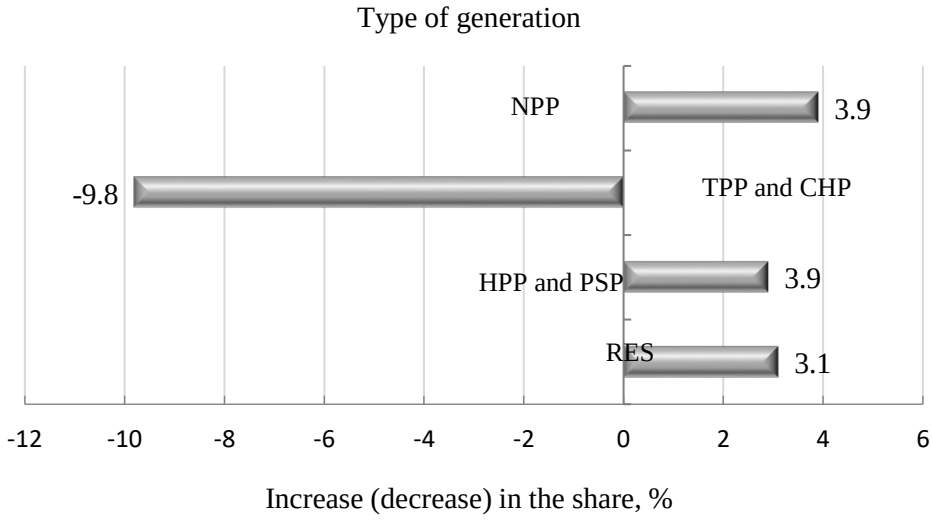


Figure 8. Increase (decrease) in the share of Ukraine's electricity generation capacities by type of generation in 2000-2018.
Source: developed by the authors

The structure of Ukraine's electricity generation by type of generation in 2000 and 2018 is shown in Figure 9.

Figure 10 shows that, compared to 2000, the share of TPPs and CHPs in Ukraine's structure of electricity generation decreased (-12.5%), while the share of all other types of generation increased.

Table 7 contains the calculations of the indices and directions of structural changes in Ukraine's electricity generation capacities and electricity generation by types of generation.

1 – NPP; 2 – TPP and CHP; 3 – HPP; 4 – RES

Figure 9. Structure of Ukraine's electricity generation by type of generation.
Source: developed by the authors

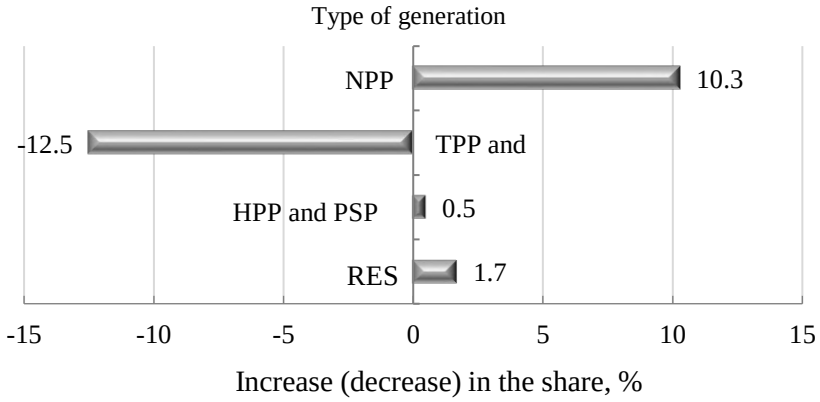


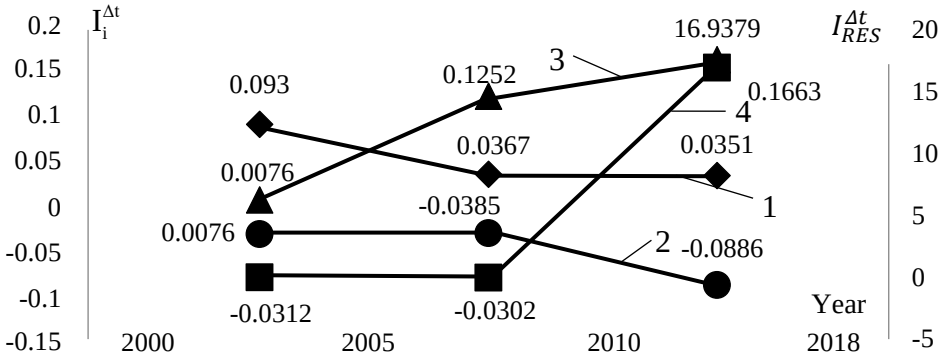
Figure 10. Increase (decrease) in the share of Ukraine's electricity generation by type of generation.
Source: developed by the authors

Table 7. Calculations of the indices and directions of structural changes in Ukraine's electricity generation capacities and electricity generation by types of generation.

Type of generation	Share, %				Difference in the shares, %				Index of structural change ($I_i^{\Delta t}$)			
	d_{2000}	d_{2005}	d_{2010}	d_{2018}	$d_{2005}-d_{2000}$	$d_{2010}-d_{2005}$	$d_{2017}-d_{2010}$	$d_{2018}-d_{2000}$	$I_i^{2000-2005}$	$I_i^{2005-2010}$	$I_i^{2010-2017}$	$I_i^{2000-2018}$
Capacities												
NPP	22.3	24.4	25.3	26.2	2.07	0.89	0.89	3.85	0.0930	0.0367	0.0351	0.1728
TPP	68.6	66.5	64.5	58.8	-2.14	-2.01	-5.71	-9.86	-0.0312	-0.0302	-0.0886	-0.1437
HPP	8.9	9.0	10.1	11.7	0.07	1.12	1.67	2.86	0.0076	0.1252	0.1663	0.3223
RES	0.192	0.193	0.186	3.334	0.001	-0.007	3.15	3.14	0.0076	-0.0385	16.9379	16.3794
Generation												
NPP	45.1	47.7	47.2	55.4	2.62	-0.52	8.22	10.32	0.0580	-0.0109	0.1743	0.2289
TPP	48.2	45.5	45.8	35.7	-2.68	0.25	-10.08	-12.50	-0.0556	0.0056	-0.2202	-0.2594
HPP	6.7	6.7	7.0	7.2	0.01	0.27	0.17	0.45	0.0011	0.0398	0.0248	0.0668
RES	0.0	0.054	0.053	1.732	0.054	-0.001	1.68	1.73	+∞	-0.0153	31.7430	+∞

Source: developed by the authors

Figure 11 presents the trends in structural changes in Ukraine's electricity generation capacities by generation type for the period 2000 - 2018.

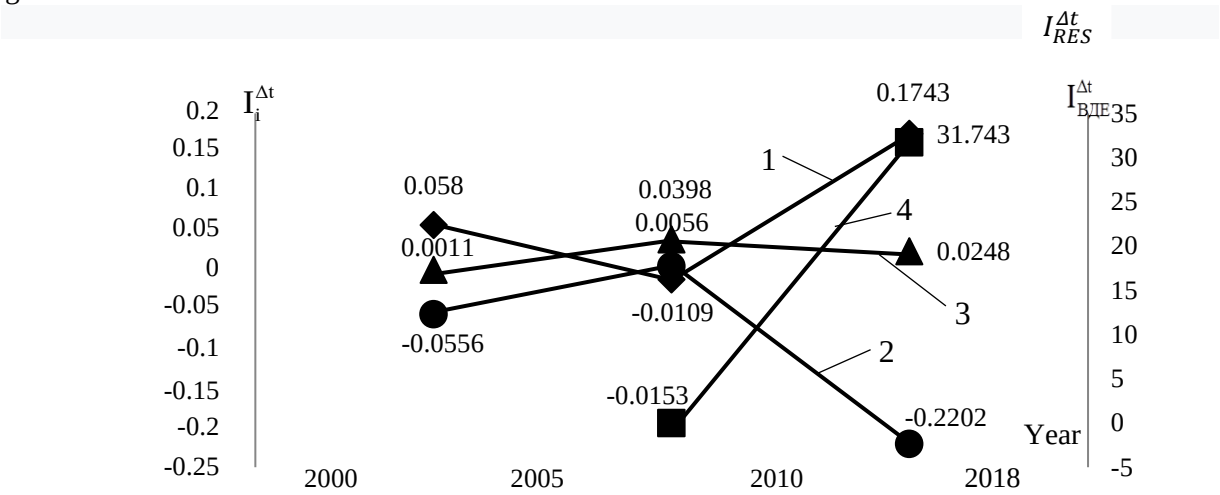


1 – NPP; 2 – TPP; 3 – HPP; 4 – RES

Figure 11. Structural changes in Ukraine's electricity generation capacities by type of generation. Source: developed by the authors

As can be seen from Figure 11, positive structural changes in Ukraine's electricity generation capacities by types of generation occurred in terms of RES and HPP, while a decrease was observed in TPP and NPP.

Figure 12 shows the trends in structural changes in Ukraine's electricity generation by type of generation.



1 – NPP; 2 – TPP; 3 – HPP; 4 – RES

Figure 12. Structural changes in Ukraine's electricity generation by type of generation. Source: developed by the authors

As can be seen from Figure 12, positive structural changes in Ukraine's electricity generation by type of generation occurred in terms of RES and NPP, and a decrease – in terms of TPP and HPP.

Table 8 contains the calculations of the integral coefficients of structural changes in Ukraine's electricity generation capacities and electricity generation.

Figure 13 demonstrates the behavior of the integral coefficients of structural changes in Ukraine's electricity generation capacities and electricity generation by types of generation in 2000-2018.

Table 8. Calculations of the integral coefficients of structural changes in Ukraine's electricity generation capacities and electricity generation

Type of generation	Square of the difference of the shares, %				Square of the sum of the shares, %			
	$(\Delta d_{2005-2000})^2$	$(\Delta d_{2010-2005})^2$	$(\Delta d_{2017-2010})^2$	$(\Delta d_{2018-2000})^2$	$(\Delta d_{2005+2000})^2$	$(\Delta d_{2010+2005})^2$	$(\Delta d_{2018+2010})^2$	$(\Delta d_{2018+2000})^2$
Capacities								
NPP	4.30	0.80	0.78	14.86	2179.6	2465.6	2645.5	2348.9
TPP	4.60	4.03	32.59	97.21	18250.0	17145.7	15184.5	16224.8
HPP	0.00	1.26	2.81	8.20	318.1	362.0	476.2	425.7
RES	0.00	0.00	9.91	9.87	0.1	0.1	12.4	12.4
Total	8.9	6.1	36.2	120.3	20747.7	19973.2	18306.2	18999.4
$\frac{(d_i^{t_2} - d_i^{t_1})^2}{(d_i^{t_2} + d_i^{t_1})^2}$					0.0004	0.0003	0.0020	0.0063
$K_i^{\Delta t}$					0.0207	0.0175	0.0445	0.0796
Generation								
NPP	6.85	0.27	67.65	106.53	8614.7	9008.3	10530.1	10104.2
TPP	7.17	0.06	101.56	156.30	8780.5	8332.1	6635.2	7036.0
HPP	0.00	0.07	0.03	0.20	180.3	187.7	200.0	192.3
RES	0.00	0.00	2.82	3.00	0.0	0.0	3.2	3.0
Total	14.0	0.4	169.2	263.0	17575.5	17528.1	17365.3	17332.5
$\frac{(d_i^{t_2} - d_i^{t_1})^2}{(d_i^{t_2} + d_i^{t_1})^2}$					0.0008	0.00002	0.0097	0.0152
$K_i^{\Delta t}$					0.0282	0.0048	0.0987	0.1232

Source: developed by the authors

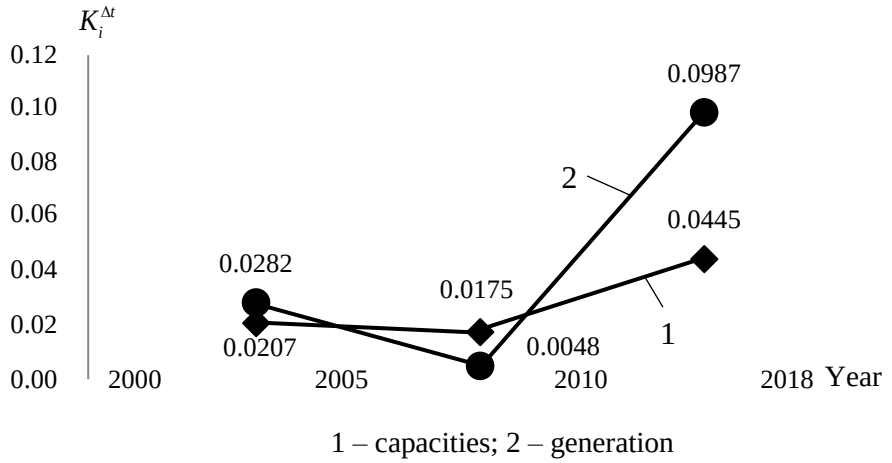


Figure 13. Behavior of the integral indicators of structural changes in Ukraine's electricity generation capacities and electricity generation due to the changes in generation types.
Source: developed by the authors

As can be seen from Figure 13, the largest structural change in Ukraine's electricity generation capacities was 0.0445 (very low structural shift), while the structural change for the entire analyzed period amounted to 0.0796 (low structural shift). The largest structural change in the country's electricity generation that occurred in 2010-2017 was 0.0987 (low structural shift), while the structural change for the entire analyzed period amounted to 0.1232 (low structural shift).

General characteristics of the structural changes in the electric power industry are given in Table. 9.

Table 9. General characteristics of the structural changes in Ukraine's electricity generation capacities and electricity generation by generation type.

Type of generation	Share, %				Rate of changes, %				Structural changes, 2018 in relation to 2000		
	d_{2000}	Rank	d_{2018}	Rank	Absolute	Rank	2018 in relation to 2000	Rank	Index of structural change	Rank	Degree of significance
Capacities											
NPP	22.3	2	26.2	2	3.9	2	117.3	3	0.1728	3	significant
TPP	68.6	1	58.8	1	9.9	1	85.6	4	-0.1437	4	inconsiderable
HPP	8.9	3	11.7	3	2.9	4	132.2	2	0.3223	2	significant
RES	0.192	4	3.3	4	3.1	3	1737.9	1	16.3794	1	considerable
Generation											
NPP	45.1	2	55.4	1	10.3	2	122.9	2	0.2289	2	significant
TPP	48.2	1	35.7	2	12.5	1	74.1	4	-0.2594	4	significant
HPP	6.7	3	7.2	3	0.4	4	106.7	3	0.0668	3	inconsiderable
RES	0.0	4	1.7	4	1.7	3	+∞	1	+∞	1	considerable

Source: developed by the authors

As can be seen from Table 9, the largest structural changes in Ukraine's electricity generation capacities and electricity generation by types of generation occurred in terms of RES, respectively 16.38 (considerable) and +∞ (considerable). Significant positive structural changes in the country's electricity capacities and electricity generation were observed in NPPs, respectively 0.1728 and 0.2289. A significant positive structural change in Ukraine's electricity generation capacities (0.3223) and an inconsiderable positive change in its electricity generation (0.0668) occurred in terms of HPPs. During this period, an inconsiderable negative structural change in Ukraine's electricity generation capacities (-0.1437) and a significant shift in its electricity generation (-0.2594) was observed in TPPs.

General characteristics of the structural changes in Ukraine's electricity generation capacities and electricity generation by flexibility and generation type are given in Table. 10.

Table 10. General characteristics of the structural changes in Ukraine's electricity generation capacities and electricity generation by flexibility and generation type.

Electricity generation	Rate of changes, %				Characteristics			
	Absolute	Rank	2018 in relation to 2000	Rank	Type of flexibility	Degree of significance	Type of generation	Degree of significance
Capacities								
NPP	3.9	2	117.3	3	NF	SSC	NPP	SSC
TPP	9.9	1	85.6	4	PF	-ISC	TPP	-ISC
HPP	2.9	4	132.2	2	F	SSC	HPP	SSC
RES	3.1	3	1737.9	1			RES	CSC
Generation								
NPP	10.3	2	122.9	2	NF	SSC	NPP	SSC
TPP	12.5	1	74.1	4	PF	-SSC	TPP	-SSC
HPP	0.4	4	106.7	3	F	SSC	HPP	ISC
RES	1.7	3	+∞	1			RES	CSC

Source: developed by the authors

Table 10 contains the following abbreviations: NF, PF, F stand for non-flexible, partially flexible and flexible type of electricity generation, respectively.

Thus, we can conclude that, in general, over the studied period, the Ukrainian energy sector underwent significant structural changes related to electricity generation capacities and electricity generation in terms of flexibility and generation type.

Figure 14 shows the distribution of the nuclear power reactors by lifetime.

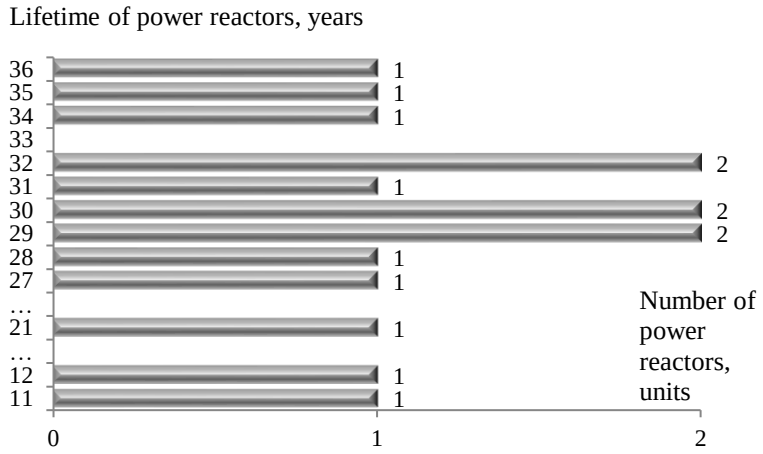


Figure 14. Distribution of Ukraine's nuclear power reactors by lifetime in 2018. Source: [21]

As can be seen from Figure 14, as of the studied year, only three out of 15 Ukrainian nuclear reactors had not exceeded their design life (30 years); for another four reactors, the design life was coming to an end; the rest of the reactors had exceeded the design life (the justified duration of the additional life of nuclear power units is from 10 to 20 years and is determined in each specific case based on the results of a safety reassessment).

Figure 15 presents the distribution of the thermal power units by lifetime.

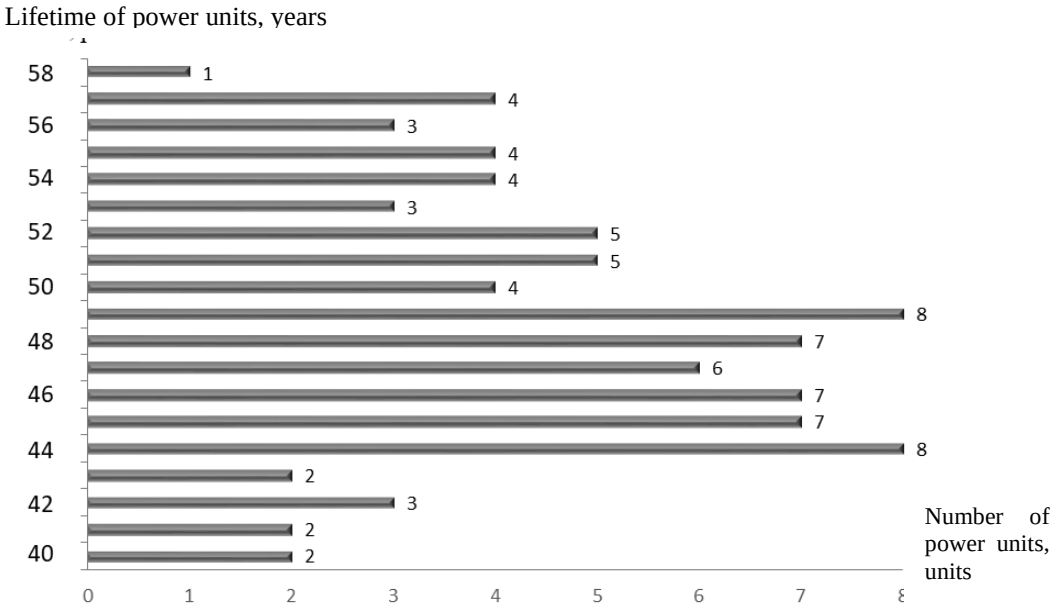


Figure 15. Distribution of Ukraine's thermal power units by lifetime. Source: [22]

As can be seen from Figure 15, as of the year under study, all Ukraine's thermal power units had been in operation for more than 40 years.

Table 11 presents the distribution of Ukrainian HPPs by lifetime.

Table 11. Distribution of Ukraine's HPPs by lifetime in 2020.

Name of the HPP	Lifetime, years
Dniester HES	37
DniproHES-2	40
Kaniv Hydroelectric Power Plant	45
Kyiv Hydroelectric Station	52
Middle Dnieper Hydroelectric Station	54
Kremenchuk Hydroelectric Power Plant	61
Kakhovka Hydroelectric Station	64
DniproHES-1	70

Source: developed by the authors based on [22]

As can be seen from Table 11, as of 2020, Ukraine's HPPs had been operating for over 30 years.

4. Conclusions

Thus, the above study has made it possible to determine the following:

1. The decrease in Ukraine's electricity generation was more significant than the decrease in its generation capacity. This is especially true for thermal generation. As a result, the decrease in electricity generation has led to a reduction in carbon dioxide emissions in the country.
2. Over the analyzed period, in the structure of Ukraine's electricity generation capacities, the most significant decrease occurred in the share of partially flexible capacities (thermal generation). As concerns the volume of electricity generation, there was a decrease in partially flexible capacities (thermal generation) and an increase in non-flexible capacities (nuclear generation).
3. The structural changes in the electric power industry of Ukraine were not adequate to the structural changes in the country's economy, which has led to a shortage of flexible capacities but also resulted in the reduction of carbon dioxide emissions due to a decline in electricity generation.
4. The state of Ukraine's energy generation capacities requires urgent modernization to ensure their safe and uninterrupted operation.

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Clusterization of Ukraine regions according to the integrated index of ecological and economic security in the destructive phenomena conditions

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Clusterization of Ukraine regions according to the integrated index of ecological and economic security in the destructive phenomena conditions

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Abstract. Destructive phenomena conditions, such as the COVID-19 pandemic in 2020, hostilities in Eastern Ukraine and the annexation of the Autonomous Republic of Crimea in 2014, and the Global Financial Crisis in 2008, have significantly affected Ukraine's environmental and economic security. The self-development processes of Ukraine's safety began to slow down, which led to the degradation of the interconnection system between the environment and the economy. The study aims to determine the destructive phenomena' impact on the environmental and economic security level of Ukraine using an improved method of normalised clustering indices to analyse the distribution of Ukraine's regions into homogeneous groups at the level of integrated environmental and economic security. This index is calculated based on stimulating and disincentive normative indicators from 2004 to 2020. With the help of clustering of regions, the adverse effects of destructive phenomena on individual parts and their groups were identified. The obtained results make it possible to track the positive and negative processes of state intervention in the mechanism to ensure the level of environmental and economic security.

1. Introduction

In Ukrainian and World economics, some discussions [2, 5] on the methodology for calculating the integrated ecological and economic security index based on a harmonized assessment of incentive and disincentive factors that affect the overall ecological and economic security of Ukraine. The application of regulation of ecological and economic security of the country is impossible without studying the state of its regions. One of the tasks of such a study is to group regions according to their level of ecological and economic security. In our opinion, this would make it possible to identify the causes of significant differences and disparities between individual regions and offer recommendations for overcoming them.

The study aims to cluster the regions of Ukraine in terms of their ecological and economic security. The integrated index of the region's security level was chosen as the basis for the division of regions into clusters from 2004 to 2020, which, in our opinion, should take into account several factors that unevenly affect the level of ecological and economic security of the region.

2. Related works

The term "security economy" was introduced by American scientists D. Olway, J. R. Golden, and R. Kelly in their book "Economics of State Security" [8].

The American AI Ross [9] made an essential contribution to the definition of the security economy and the identification of its methodological indicators. He referred to the security of political and economic activities as a separate area of research. Similar considerations can be seen in other scholars [1], who, however, did not use the concept of "security economy" but only "political economy of defence". K. Hartley and T. Sunler, believe that in recent years, the defence economy has expanded its field of interest on non-military threats to national security [6].

In the second half of the XX century, the focus of economists and politicians was ecological and economic security. This was facilitated, firstly, by "economic wars" between certain groups of countries and, secondly, by transformation processes in the world economy.

In 1985, at the 40th session of the UN General Assembly, a resolution, "International Economic Security", was adopted [4]. It identified the need to promote international economic security for each country's socio-economic development and progress, and the term "economic security" became "official". The 42nd session of the UN adopted the Concept of International Economic Security [3].

In the world and domestic economics, there is a discussion about the nature, factors, types, and forms of economic security. Some economists among the factors of economic security highlight the uneven economic development, debt growth, environment, hunger, and cyclical fluctuations that destabilize the economic system.

According to Ukrainian legislation “OFNSU”, national safety is the security of active interests of human and resident, community and the country, which guarantee economic sustainability of public, early observation, prevention, and counteraction of real and potential dangers to domestic interests [14].

In our opinion, the ecological and economic security (hereinafter referred to as E&ES) of the region is a state of the region's ecological and economic development, which is characterized by the most total and most rational use of its ecological and economic potential, ability to reproduce, protect from destabilizing factors, strong ties between elements of the regional system. which contributes to the satisfaction of economic, environmental and social interests of the population of the region.

3. Methodology

To calculate the integral index of the E&ES level, we have chosen a set of indicators that fully represent the region's situation (Table 1). In the article we have grouped 25 regions of Ukraine according to the integrated index of E&ES, dividing the entire time into periods:

1. from 2004 to 2008 - the period before the Global Financial Crisis of 2008;
2. from 2009 to 2013 - the post-crisis period and the period before the military intervention of the Russian Federation in Eastern Ukraine;
3. from 2014 to 2019 - the period in the conditions of hostilities in the East of the country and the pre-pandemic period;
4. from 2020 - to the beginning of the period of the COVID-19 pandemic.

The year 2004 was chosen as the base for comparative analysis, as there were no sharp changes in the economic environment this year [13-25]. All statistical indicators have been calculated since 2014 minus the temporarily occupied territories of Donetsk, Luhansk regions, and the Autonomous Republic of Crimea.

Determining the value of E&ES indicators is based on the standardization of indicators, reducing them to one commensurate number - from 0 to 1. To standardize indicators, we distinguish between stimulants and disincentives.

Table 1. Indicators used to calculate the integrated index of the E&ES level.

Indicator	Description of the indicator
Volumes of circulating and re-sequential water use (million cubic meters)	- the amount of savings in freshwater intake through the use of return and re-water supply, including wastewater and collector-drainage water. Reusable use does not include water consumption in municipal and industrial heating systems.
Volumes of polluted return waters discharge (million cubic meters)	- industrial and domestic (municipal) effluents (including mine, mine, reservoir, drainage), and volley discharges entering surface water bodies without treatment or after poor treatment and containing pollutants in quantities that violate the established water quality standards in the control area. These do not include the amount of runoff coming to the filtration fields, storage, terrain, etc.
The capacity of treatment facilities (million cubic meters)	- the maximum amount of return water that can be treated at treatment plants at the end of the reporting period
Adulterant into the atmosphere emissions from stationary sources (thousand tons)	- the total quantity of substances or materials of physical, chemical or biological origin that entered the air basin from immobile sources of contamination, both after passing through dust and gas remedy facilities as a result of insufficient capture and cleaning at immobile pollution sources, and without cleaning from sources
Waste generation of all hazard classes (thousand tons)	- the occurrence of any materials and items formed in the process of manufacture or expenditure, as well as equipment that has absolutely or partly lost their purchaser's properties and has no additional use about the place of their arrangement or detection and which their holder must get rid of by disposal
Disposal of all hazard classes waste (thousand tons)	- use of waste or power resources
Incineration of all hazard classes waste (thousand tons)	- a controlled process of burning of hard, fluid, or gaseous waste at high temperatures
The volume of all hazard classes waste collected during functioning, in especially designated sites or facilities (thousand tons)	- final disposal of waste that is not subject to removal or recycling in peculiarly appointed places for the use of which the resolution of the specially commissioner, central administrative body in the field of waste control has been obtained.
Waste of all classes removed (thousand tons)	- conduct manipulation with waste that does not lead to their disposal: burial in the ground on the land, dumping on especially equipped landfills, disposal
Area of reserves lands and national natural parks (thousand hectares)	- land and water spaces, natural complexes, and objects which have particular environmental, scientific, aesthetic and other values and are allocated to the conservation the diversity of nature, the gene pool of fauna and flora, in general, ecological equilibrium and ensure ground environmental monitoring natural environment

Source: compiled by the authors based on data [13-25].

Stimulants include signs, the quantitative increase of which has a positive effect on the level of E&ES (if $a_{ij} < a_{ei}$):

$$x_{ij} = \frac{a_{ij}}{a_{ei}}, \quad (1)$$

The disincentives include factors whose growth negatively affects the level of E&ES (if $a_{ij} > a_{ei}$):

$$x_{ij} = \frac{a_{ei}}{a_{ij}}, \quad (2)$$

where x_{ij}- a standardized indicator of the state of E&ES for the *i* -th component;
a_{ej}- j-th threshold indicator of the state of E&ES of the component;
a_{ij}- j-th indicator of the state E&ES for the *i* -th component;
$j = 1, \dots,$ n- indicators (signs) based on which the study is conducted;
$i = 1, \dots,$ m- component under study.

The threshold values of the indicators were used to select the maximum value of the proposed indicators of Ukraine's regions for the stimulant indicators and the minimum value of Ukraine's region's proposed indicators for the disincentive indicators.

To group the regions of Ukraine according to the level of their E&ES, we have chosen the method of cluster analysis, which consists in classifying a group of objects according to numerous indicators. This method allows you to create "clusters" or groups of very similar objects.

To classify the regions according to E&ES, we used the method of k-means, developed by G. Steinhaus and S. Lloyd [7]. The algorithm of the method is to minimize the total quadratic deviation of the cluster points from the centre of the cluster and is described by formula (3):

$$V = \sum_{i=1}^{k} \sum_{x_j \in S_i} \left(x_j - \mu_i\right)^2, \quad (3)$$

where: *k* is the number of clusters;
S_i- obtaining clusters, where $i = 1,2, \dots, k$;
μ_i- centers of mass of vectors $x_j \in S_i$.

In our analysis, Euclidean distance was used to construct a distance matrix, which involves the choice of distance metrics. It is the most commonly used measure of distances between objects, which measures the geometric distance between objects in multidimensional space. Euclidean distance can be calculated using formula (4):

$$L = \sqrt{\sum_i (x_i - y_i)^2}, \quad (4)$$

where: x_i- the position of the first object;
y_i- the position of the second object.

Having performed successive calculations of distances between all objects, we constructed a matrix of Euclidean distances. We use the obtained Euclidean distance matrices to divide the regions into four clusters. Statistica 10.0 software was used for grouping.

To classify regions according to the level of E&ES, we have identified four groups of clusters: the first cluster (security status) includes regions with a high level of E&ES; the second cluster (risk status) was formed by regions with a security level above average; the third cluster (threat state) is regions with a level of E&ES below average; fourth cluster (danger status) - regions with the lowest level of E&ES.

The regions belonging to the first cluster are characterized by a state of strengthening E&ES and efficient use of all resources in the region, and the effect of a sustainable response to negative phenomena. The regions of the second cluster are characterized by stable development of the region,

but there are no mechanisms to influence destabilizing factors. The regions of the third cluster are characterized by the inability to prevent the impact of destabilizing factors and the low level of the region's development. The regions of the last cluster are characterized by increasing destabilizing factors and a lack of development mechanisms.

4. Results

Using the formula of the average harmonic weighted for the calculation of the E&ES integrated index through the set of its indicators, we will consider our clustering in the period from 2004 to 2008. The analysis makes it possible to assess the security level of the regions of Ukraine in 2010, which is as follows: the first cluster (security) included three regions; the second (risk) - 2 areas; the third (threat) - 8 areas; to the fourth (danger) - 12 areas. Schematically, the distribution of areas by clusters is shown in Fig.1.

Figure 1. Grouping Ukraine's regions by the level of E&ES in 2004-2008.

Source: compiled by the authors.

According to the level of E&ES in 2009-2013, the regions were distributed as follows: the first cluster (security) included two regions; the second cluster (risk) - 5 areas; the third cluster (threat) - 10 areas; to the fourth (danger) - 8 areas (Fig. 2).

Figure 2. Grouping Ukraine's regions of by the level of E&ES in 2009-2013

Source: compiled by the authors.

The analysis also provides an opportunity to assess the level of E&ES in the regions of Ukraine from 2014 to 2019, which is as follows: the first cluster (security) included two regions; the second cluster (risk) - 7 areas; the third cluster (threat) - 10 areas; the fourth (danger) - 5 areas (Fig. 4).

Figure 3. Grouping Ukraine's regions by the level of E&ES in 2014-2019.
Source: compiled by the authors.

According to the level of E&ES since 2020, the regions are distributed as follows: the first cluster (security) includes two regions; the second (risk) - 6 areas; the third (threat) - 11 areas; the fourth (danger) - 5 areas (Fig. 5).

Figure 4. Grouping Ukraine's regions by the level of E&ES from 2020
Source: compiled by the authors.

The cluster analysis allowed to build the dynamics of changes in the integrated indices of E&ES of different regions of Ukraine in the period from 2004 to 2020 (Fig. 5).

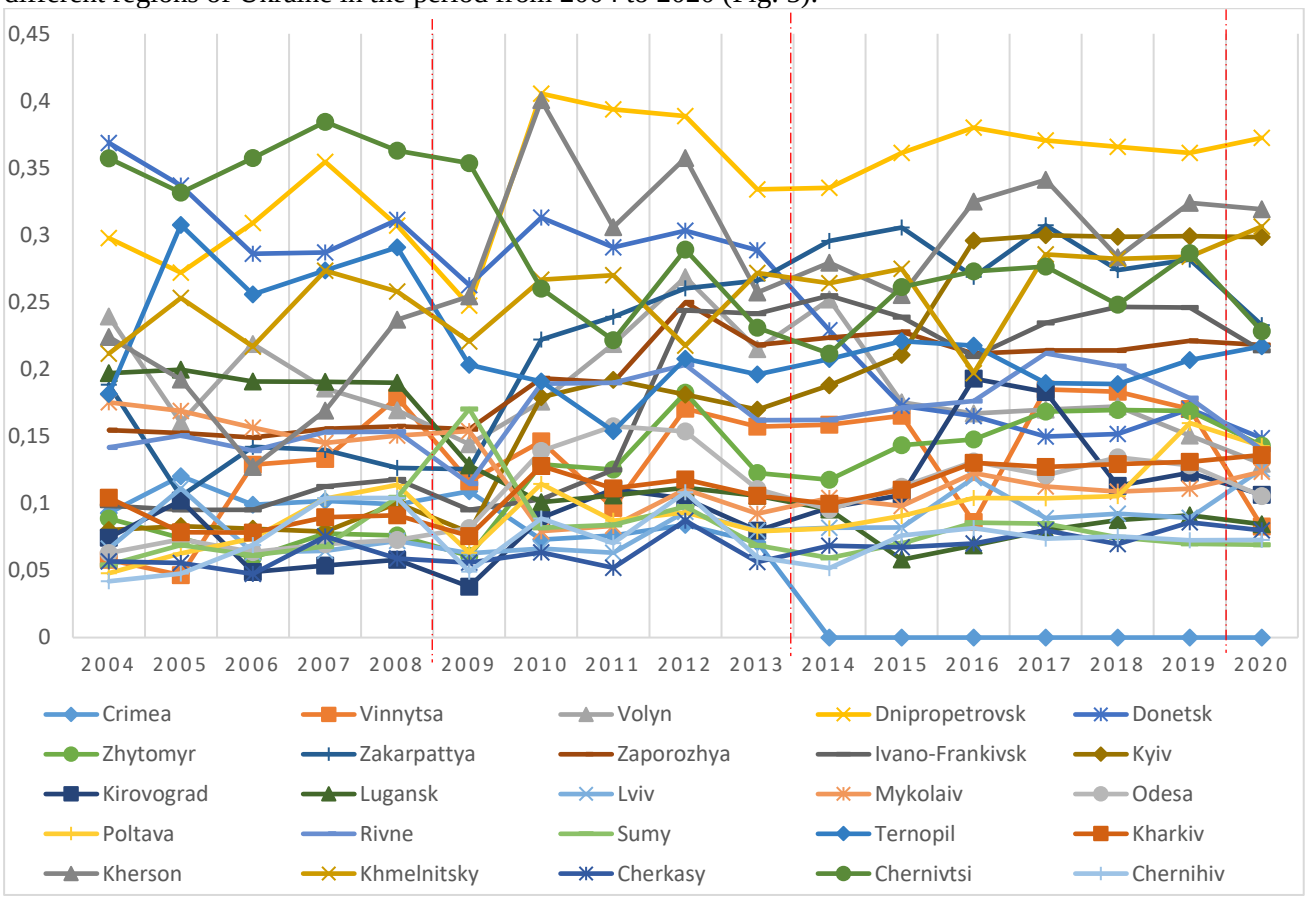

Figure 5. The integrated indicator dynamics of the region's E&ES level in 2004-2020.
Source: compiled by the authors.

In the pre-crisis period of 2004-2008, there was a gradual increase in E&ES compared to 2004 for the Autonomous Republic of Crimea and Vinnytsia, Dnipropetrovsk, Ivano-Frankivsk, and Ternopil regions. A consistently high level of security in the analyzed period was observed in the Chernivtsi region. In contrast to these regions, persistently low levels of security were recorded in Zhytomyr, Odesa, Kharkiv, and Cherkasy regions. A gradual decrease in security compared to 2004 was observed in Volyn and Kherson regions. In other regions, slight fluctuations did not affect changes in the level of E&ES.

Of particular interest is the trace of the direct impact of the Global Financial Crisis of 2008 on the level of E&ES of the regions of Ukraine. Namely, the most significant negative impact of the crisis was on Dnipropetrovsk, Donetsk, Ivano-Frankivsk, Kyiv, Poltava, and Chernihiv regions where the integrated index significantly decreased or led to a move to a lower cluster.

In the pre-war and post-crisis period of 2008-2013, there was a gradual decrease in E&ES compared to 2004 for the Autonomous Republic of Crimea and Donetsk, Luhansk, Mykolaiv, Ternopil, Kherson regions. A stably high level of E&ES in the analyzed period was observed in the Dnipropetrovsk region. In contrast to these regions, a consistently low level of E&ES was recorded in Kirovohrad, Lviv, Poltava, Sumy, Cherkasy, and Chernihiv regions. The level of security with insignificant fluctuations was observed for the rest of the regions compared to 2004.

Of particular interest is the interpretation of the results of the clustering of regions of Ukraine, which does not reflect the negative impact of hostilities in Eastern Ukraine on the level of E&ES in general. However, it should be noted that a significant decrease in the level of security in the Donetsk and Luhansk regions due to military intervention and the inability to calculate the security index for the Autonomous Republic of Crimea due to a lack of official statistics after its occupation.

The post-war and pre-quarantine period of 2014-2019 is characterized by an increase in the region's E&ES for Zaporizhia, Ivano-Frankivsk, Kyiv, Kirovohrad, Mykolaiv, Poltava, and Ternopil regions. The level of security is consistently high for Dnipropetrovsk and Kherson regions. In contrast to these regions, the lowest level of security is characterized by Lviv, Luhansk, Sumy, Cherkasy, and Chernihiv regions. The level of security with insignificant fluctuations was observed for the rest of the regions compared to 2004.

It should be noted that there is a direct impact of the COVID-19 pandemic on the level of Ukraine's region's E&ES. Namely, the most significant negative impact of the corona crisis was on the Vinnytsia and Dnipropetrovsk regions, where the amount of the integrated index significantly decreased or led to a shift to a reduced cluster. Also interesting is the positive impact of the corona crisis on the Lviv and Ternopil regions, which led to the move to higher clusters.

5. Conclusion

The obtained results of Ukraine's regions cluster analysis by the level of E&ES (Fig. 1-5) indicate that the proposed method of clustering allows to group regions into homogeneous clusters according to the integrated indicator of their security.

It should be noted that the new method of determining the threshold values of indicators of stimulant indicators and disincentive indicators has proven its effectiveness. Determining the threshold on the basis of maximum and minimum values avoids errors in the calculations, namely exceeding the unit value of the indicator, which was allowed in previous studies due to the imperfection of the calculation method. Therefore, the application of the proposed method of calculating the threshold values of indicators is promising.

Of particular interest is the interpretation of the results of clustering of regions of Ukraine, which reflects the dual (negative and positive) impact of the Global Financial Crisis of 2008 and the COVID-19 pandemic on the level of regional security. Also, the absolute exclusive direct negative impact on 2 regions due to hostilities in eastern Ukraine.

Comparing the results of the analysis allows us to conclude that in the period from 2004 to 2020 in most regions of Ukraine (60%) there was an increase in the level of E&ES. From a theoretical point of view, this result indicates the consolidation and more efficient use of state resources during the war, which led to increased levels of E&ES of its regions.

However, it is impossible not to note significant disparities in the levels of E&ES of Ukraine's regions, which, from a practical point of view, indicates the unplanned state policy of E&ES and lack of effective mechanisms to respond to security challenges.

In further research, in our opinion, in the described clustering methodology it is necessary to abandon the use of Euclidean distances for each individual year of research. Instead, it is necessary to develop a clear distribution of clusters using harmonious norms of distribution for the ideal situation, which will clearly trace the thresholds of clusters. A clear definition of the thresholds will allow us to further use our proposed methodology for the analysis of security levels for extended time frames.

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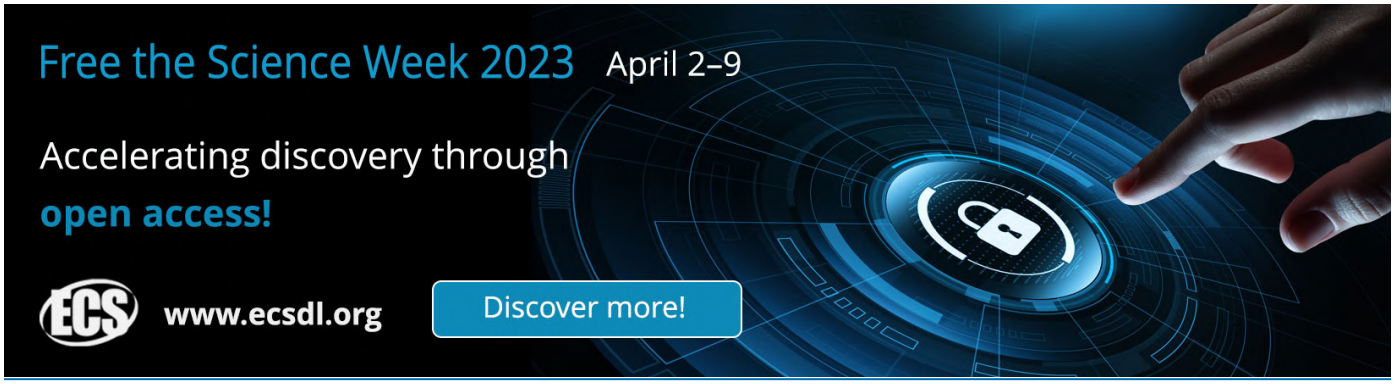
Methodology for assessing the sustainable development of administrative-territorial units



Methodology for assessing the sustainable development of administrative-territorial units

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Abstract. The article considers the existing approaches to understanding the term "sustainable development" and the methodology for assessing sustainable development processes. The problem of lack of a unified methodology for assessing the sustainable development of administrative-territorial units has been identified, which prompted its development. Based on the analysis, a method of assessing the sustainable development of administrative-territorial units has been proposed. The methodology is based on metrics for measuring sustainable development processes, developed by the Institute for Applied System Analysis of the National Academy of Sciences of Ukraine and the Ministry of Education and Science of Ukraine. Improving the existing methodology was to simplify it by developing a single system of parameters based on official statistics. Instead, it was suggested not to use the original data obtained by experts, due to the impossibility of verifying their reliability. For the same reason, it was proposed to abandon the use of weights when calculating the values of indicators and policy categories. Approbation of the improved methodology was carried out on the example of Poltava, Sumy and Kharkiv regions, which are part of the North-Eastern economic region of Ukraine. The calculations confirmed the comparability of the results with the results of other authors in previous studies. The improved methodology, in contrast to existing ones, is different due to its simplicity, versatility and suitability for assessing the sustainable development of any comparable administrative-territorial units. At the same time, further research is needed on the system of baseline parameters for administrative-territorial units for which there are insufficient official statistics, as well as the feasibility of applying weights, provided they are properly justified.

1. Introduction

The issue of searching new ways to develop administrative-territorial units has been relevant at all times and today the discussions on this issue are becoming even more lively. This is due to the fact that at the turn of the XX and XXI centuries, the concept of sustainable development of territories has spread, and thus it quickly became popular in scientific circles. The concept of sustainable development quickly gained widespread popularity in scientific circles. Despite the fact that this theory has both its supporters and critics, it is mainly evaluated as the most balanced and promising theory of the XXI century. It is believed that the further development of human civilization will be determined within the framework of the concept of sustainable development

Today, the ideas and approaches envisaged by the concept of sustainable development are successfully integrated into various spheres of human activity: agriculture [1], land-use [2],

construction [3], education [4] and many others. At the same time, despite its popularity, the concept of sustainable development is one of the most controversial. It relates to different approaches to understanding sustainable development and the need for a universal methodological assessment of sustainable development processes.

2. Critical literature review

The term "sustainable development" was first introduced at the Rio Conference in 1992 as part of the 21st Century Agenda. The content of sustainable development is to meet the urgent needs of humanity and the further development of civilization without creating threats for future generations.

The author of the innovative economic theory of sustainable development, systematically covered in the monograph "Beyond Growth. The Economics of Sustainable Development" is a leading researcher on the economic aspects of environmental pollution, a former World Bank economist Daly H. Based on the definition of the UN Commission and scientific analysis, he interprets the term "sustainable development" as a definition of harmonious, balanced, conflict-free progress of all earthly civilisation, groups of countries (regions, subregions) as well as individual countries of our planet according to scientifically sound plans (methods of systematic approach), when in the process of steady innovative intensive (rather than extensive) economic development of territory positively addresses a range of issues related to environmental protection, eradication, exploitation, poverty and discrimination of each individual and entire peoples or groups, including ethnic, racial or sexual characteristics.

But the main issue is not so much the interpretation of the concept of sustainable development and scientific theories on the possibility of achieving or maintaining it, as the methodology for assessing sustainable development processes for specific regions or other administrative-territorial units. Lately, the following works have been devoted to this issue: Hlavá˘cek P., Kopá˘cek M., Horá˘cková L. [5], Ferova I., Lobkova E., Tanenkova E., Kozlova S. [6], Hryhoruk P., Khrushch N., Grygoru S. [7]. However, the successful application of any evaluation methodology requires a system of relevant parameters. As for the development of a system of parameters to assess the sustainable development of administrative-territorial units today, this issue is complex and controversial. The numerous works are devoted to the solving of this problem: Hák T., Janousková S., Moldan B. [8], Wulfa C., Werkera J., Zappa P., Schreibera A., Schlöra H., Kuckshinrichs W. [9], Dubey S., Sharmabe A., Panchariyab V., Goyala M., Surampalli R., Zhangd T. [10], Raimbault J., Pumain D. [11], Łuczak A., Just M. [12]. Highly appreciating the contribution of scientists in solving these difficult issues, it should be noted that today the question of finding a universal methodology for assessing the sustainable development of administrative-territorial units, as well as the development of a system of parameters is open. In our opinion, in this context the most promising is the metric for measuring sustainable development (MMSD) developed by the research team of the Institute of Applied Systems Analysis of the National Academy of Sciences of Ukraine and the Ministry of Education and Science of Ukraine under the leadership of Academician Zgurovskyi M. According to this methodology, sustainable development is assessed using the appropriate index ($\boldsymbol{I_{sd}}$) on the basis of calculated values of economic ($\boldsymbol{I_{ec}}$), environmental ($\boldsymbol{I_e}$) and social ($\boldsymbol{I_s}$) indices in the space of three relevant dimensions. This index is a vector whose norm determines the level of sustainable development, and its spatial position in the coordinate system (I_{ec}, I_e, I_s) characterises the degree of "harmony" of this development (the degree of harmonisation of sustainable development - $\boldsymbol{\alpha}$) [13].

Although this methodology was developed to assess the sustainable development of the regions of Ukraine, but its strength is the potential for adaptation to the needs of assessing the development of other administrative-territorial entities. Instead, the weaknesses of the methodology include the need to collect large amounts of data that are not available in official statistics, as well as the use of a complex system of weights, mostly determined by experts, and therefore subjective and cannot be verified empirically. The need to simplify the methodology in order to ensure its universality necessitated this study.

3. Methodology

The study has used the method of analysis and synthesis to identify the strengths and weaknesses of the methodology (MMSD) and to find ways to simplify and unify it. What made it possible not to violate the logic of the calculation, to form a system of more accessible indicators, and to refuse to carry out complex calculations that have little significant impact on the final result. The statistical method was used to form a system of parameters and their hierarchical grouping into a system of indicators and policy categories. That made it possible to adjust and standardise the values of parameters with further integration into a single calculation system. The mathematical method and the method of vector calculus were used to calculate the index of sustainable development ($\boldsymbol{I_{sd}}$) and the degree of harmonisation $\boldsymbol{\alpha}$. In particular, the values of indicators, policy categories, and indices were determined by the arithmetic mean formula in a hierarchical sequence. The index of sustainable development ($\boldsymbol{I_{sd}}$) was calculated using the geometric mean formula. The degree of harmonisation $\boldsymbol{\alpha}$ was calculated using the vector calculus formula. The abstract-logical method was used to interpret the results of the study. That made it possible to identify similarities and differences in the calculation results according to the methodology (MMSD) and, proposed by us, the simplified methodology. And also to determine the prospects and potential of further application of the technique.

4. Results and discussion

As for the objects of the study there were selected three regions that are part of the North-Eastern economic region of Ukraine: Poltava, Sumy and Kharkiv. However, despite the fact that in strategic and threatening calculations aimed at assessing the potential and results of regional development, these administrative-territorial units belong to one cluster, in area and especially population they are not comparable. As a result, it often distorts the objective results of the assessment of the potential of each administrative-territorial unit.

Therefore, to assess the sustainable development of selected administrative-territorial units, the mentioned methodology (MMSD) was adapted. Thus, only the parameters published in the official statistical reporting as of 2020 were used. Instead, data obtained by questionnaire or expertise, which could call their reliability into question, were not used. Weights were not introduced during the calculations for the reasons mentioned above. Instead, for the sake of objectivity of the assessment, the parameters were adjusted, where necessary, to take into account the area or population of the administrative-territorial units.

To achieve this goal, we proposed a system of parameters based on the official reports of the Main Departments of Statistics in Poltava, Sumy and Kharkiv regions [14-16].

A necessary step in calculating the integrated index of sustainable development ($\boldsymbol{I_{sd}}$) is the procedure of normalisation of parameters, as all i parameters have different dimensions. Also, they can be multidirectional: there are parameters the increase of which is desirable (stimulators), others are the ones, the decrease of which is desirable (destimulators). The rationing procedure, firstly, converts parameters of different dimensions into dimensionless quantities so that their changes occur in the range from 0 to 1. Secondly, it allows to compare multidirectional parameters, without which it is impossible to form an integrated index [17].

In practice, various methods of rationing are used [18]. All of them are based on the comparison of empirical values of x with a certain reference value. The maximum, minimum, average value of the population [x_1, x_2,...x_n] or the reference (threshold) value of the indicator is used as such a value. The following method of rationing is the simplest and most common:

for stimulators: $$z_i = \frac{x_i}{x_{\max}}, if x_i \in S \quad (1)$$

for distimulators: $$z_i = \frac{x_{\min}}{x_i}, if x_i \in DS \quad (2)$$

where x_i is the value of the indicator for the administrative-territorial unit, x_{max} is the maximum value of the indicator among the administrative-territorial units under study, x_{min} is the minimum value of the indicator among the administrative-territorial units under study [17].

This method was used in the calculation, as the main requirements for rationing are simplicity and adequacy.

Based on the results of the calculations, normalised values were determined for 25 parameters included in the structure of the economic dimension: gross regional product (I_{GRPR}); volume of sold industrial products (I_{VSIP}); agricultural product price index (I_{APPI}); electricity generation (I_{ELGE}); thermal energy production (I_{TEPR}); transportation of goods by all modes of transport (I_{TGAT}); public passenger transport (I_{PPTR}); export of goods (I_{EXGO}); export of services (I_{EXSE}); import of goods (I_{IMGO}); import of services (I_{IMSE}); volume of products sold by small enterprises (I_{VPSE}); number of small enterprises (I_{NSEN}); wholesale trade turnover (I_{WTTU}); retail trade turnover (I_{RTTU}); employment level (I_{EMLE}); average number of full-time employees (I_{NFTE}); average monthly salary (I_{AMSA}); workforce (I_{WOFO}); number of employees involved in research and development (I_{EIRD}); research and development costs (I_{RDCO}); innovation costs (I_{INCO}); the number of industrial enterprises that implemented innovations (I_{IEII}); volume of sold innovative industrial products (I_{SIIP}); capital investment (I_{CAIN}).

The structure of the environmental dimension includes 18 parameters: agricultural land (I_{AGLA}); forests and other wooded areas (I_{FWAR}); built-up lands (I_{BULA}); area of reserves and national nature parks (I_{RNNP}); freshwater taken from natural water bodies (I_{WTNW}); loss of fresh water during transportation (I_{LWDT}); used fresh water (I_{UFWA}); discharged into surface water bodies of contaminated return water (I_{DSWB}); sewage treatment plant capacity (I_{STPC}); emissions of pollutants from stationary sources of pollution (I_{EPSS}); pollutant emissions from mobile sources (I_{PEMS}); waste generation of I-III hazard classes (I_{WGHC}); air protection, climate change prevention (I_{APCP}); return water treatment (I_{RWTR}); waste management (I_{WAMA}); protection, rehabilitation of soil, groundwater and surface water (I_{PSGW}); biodiversity and human habitat conservation (I_{BHHC}); environmental research (I_{ENRE}).

The structure of the social dimension included 28 parameters: coverage of children by preschool education institutions (I_{CCPE}); number of persons in general secondary education (I_{PGSE}); number of persons in vocational education institutions (I_{PVEI}); number of persons in pre-higher education institutions (I_{PPHE}); number of people in higher education institutions (I_{PHEI}); total natural population growth rate (I_{NPGR}); life expectancy at birth (I_{LEBI}); migratory population growth (I_{MPGR}); unemployment rate (I_{UNRA}); dismissal rate (I_{DIRE}); per capita income (I_{PCIN}); household cash expenditure (I_{HCEX}); number of libraries (I_{NULI}); number of people involved in sports (I_{NPIS}); number of tourists served by tour operators (I_{TSTO}); number of registered criminal offenses (I_{NRCO}); general fire information (I_{GFIN}); number of doctors (I_{NUDO}); number of paramedics (I_{NUPA}); number of hospitals (I_{NUHO}); number of hospital beds (I_{NUHB}); number of outpatient clinics (I_{NUOC}); HIV-infected (I_{HIVI}); incidence of malignant neoplasms (I_{IMNE}); incidence of active tuberculosis; (I_{IATU}); housing provision (I_{HOPR}); dilapidated housing (I_{DIHO}); emergency housing stock (I_{EHST}).

In terms of the structure of each dimension, the parameters were grouped in a "hierarchical order" into indicators, and the indicators in turn were grouped into policy categories.

Thus, twelve indicators were identified in the structure of the economic dimension, which fell into four policy categories. The basic needs policy category (I_{BN}) includes four indicators: gross national product (I_{GNP}); industrial and agricultural sector (I_{IAS}); intangible sphere (I_{INS}); transport and transportation (I_{TTR}). The business policy category (I_{BP}) includes three indicators: international trade cooperation (I_{ITC}); small business (I_{SMB}); domestic trade (I_{DOT}). The labor market policy category (I_{LM}) includes two indicators: labor market efficiency (I_{LME}); labor market opportunities (I_{LMO}). The innovation and investment opportunities policy category (I_{II}) includes three indicators: research (I_{RES}); level of innovation (I_{LIN}); investment opportunities (I_{IOP}).

The structure of the environmental dimension identified five indicators that fall into two policy categories. The environmental burden policy category (I_{EB}) includes four indicators: land (I_{LAN}); water

(I_{WAT}); air (I_{AIR}); waste (I_{WAS}). The environmental economic performance policy category (I_{EE}) includes one indicator - capital investment in environmental protection (I_{CIE}).

In the structure of the social dimension, eight indicators were identified that fell into two categories of policy. The human development policy category (I_{HD}) includes four indicators: education level (I_{EDL}); demographic development (I_{DED}); social component of the labor market (I_{SLM}); economic component of human development (I_{ECD}). The quality of life policy category (I_{QL}) includes four indicators: leisure and culture (I_{LEC}); justice and security (I_{JUS}); human health (I_{HUH}); state of infrastructure (I_{STI}).

The value of indicators based on the values of normalised parameters is calculated by the formula of the arithmetic mean:

$$I = \frac{I_{n,1} + I_{n,2} + ...I_{n,k}}{K} \quad (3)$$

where I is the corresponding indicator, I_{n1}; $I_{n1}\ldots$, I_{nk} - first, second, k-th parameter, K is number of parameters [19].

Similarly, the values of policy categories and indices are calculated in a "hierarchical sequence".

The value of policy categories is calculated by formula (3) where I is the corresponding policy category, I_{n1}; $I_{n1}\ldots$, I_{nk} is the first, second, k-th indicator, K is the number of indicators.

The value of indices is calculated by formula (3) where I is the relevant policy category, I_{n1}; $I_{n1}\ldots$, I_{nk} - first, second, k-th policy category, K is number of policy categories.

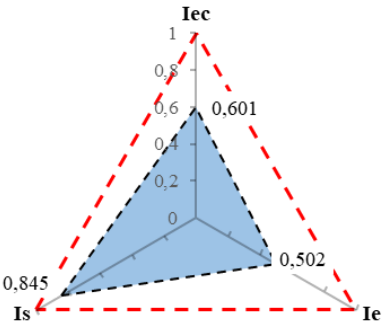
$\boldsymbol{I_{sd}}$ is assessed using a common index ($\boldsymbol{I_{sd}}$) in the space of three dimensions: economic, environmental and social. This index can be considered as a vector whose value determines the level of sustainable development, and its spatial position in the coordinate system (I_{ek}, I_e, I_s) characterises the degree of "harmony" of this development (degree of harmonisation) of sustainable development - ($\boldsymbol{\alpha}$) [13].

The value of the vector $\boldsymbol{I_{sd}}$ in three-dimensional space with coordinates (I_{ek}, I_e, I_s) is found by the formula of the geometric mean.

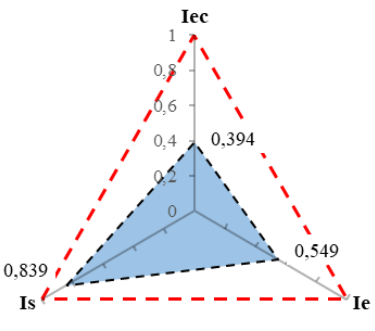
$$I_{sd} = \sqrt[3]{(I_{ek} \times I_s \times I_e)} \quad (4)$$

The equidistant distance of the vector $\boldsymbol{I_{sd}}$ from each of the coordinates (I_{ek}, I_e, I_s) will correspond to the greatest harmony of sustainable development. Approximation of this vector to one of the coordinates will indicate the priority development of the corresponding dimension and neglect of the other two.

Figure 1 shows a comparison in the space of economic, environmental and social dimensions of the profiles of the regions in relation to the ideal model, i.e. to the vector ē with coordinates (1; 1; 1;)



Poltava region



Sumy region

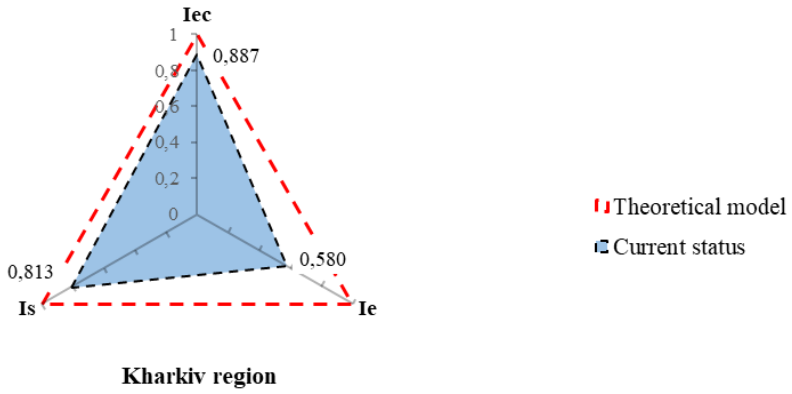


Figure 1. Profile of regions in the space of economic, environmental and social dimensions.
Source: compiled by the authors

The figure shows that the best situation is observed in Kharkiv region, where the coordinates of economic and social dimensions are close to the ideal model, although the coordinate of the social dimension is slightly further than similar coordinates in the profiles of Poltava and Sumy regions. At the same time, in the profile of Sumy region there is a significant deviation from the ideal model in the coordinates of economic and environmental dimensions, although the coordinate of the environmental dimension is slightly closer to the ideal model compared to a similar coordinate in the profile of Poltava region.

According to the angle of deviation of the vector of the index of integrated sustainable development (I_{sd}) from the ideal vector ($\bar{e}$) we determine the degree of harmonisation of sustainable development of regions: $\alpha = arccos \bar{I}_{sd} \wedge \bar{e}$ (Figure 2).

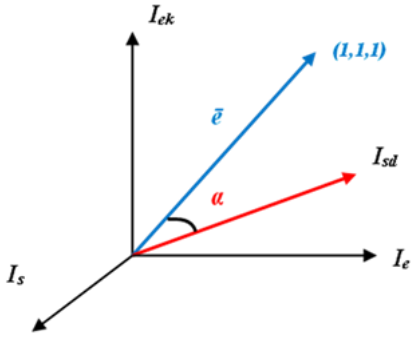


Figure 2. Degree of harmonisation of sustainable development – α.
Source: [13].

From vector calculus it is known:

$$\cos \bar{I}_{sd} \wedge \bar{e} = \frac{I_{ek} + I_e + I_s}{\sqrt{3} \times \sqrt{I_{ek}^2 + I_e^2 + I_s^2}} \quad (5)$$

Therefore, the degree of harmonisation is equal to:

$$\alpha = \arccos \frac{I_{ek} + I_e + I_s}{\sqrt{3} \times \sqrt{I_{ek}^2 + I_e^2 + I_s^2}} \quad (6)$$

According to this formula, the value of α will vary in the range from 0 to 1. In this case, the closer

the value obtained to 0, the more harmonious the development. The results of the calculations are shown in table 1.

Table 1. The results of determining I_{ek}, I_e, I_s, the integral index I_{sd} and the degree of harmonisation α.

Regions	Indices			I_{sd}	α
	I_{ek}	I_e	I_s		
Poltava	0,601	0,502	0,845	0,634	0,218
Sumy	0,394	0,549	0,839	0,566	0,300
Kharkiv	0,887	0,580	0,813	0,748	0,172

Source: compiled by the authors

The results show that the Kharkiv region is developing most harmoniously, whilst Sumy region shows the worst performance.

In general, the results obtained are comparable to the results obtained by the research team led by Zgurovskyi M. [13]. At the same time, we previously conducted a study on the use of simplified methods for assessing the sustainable development of cities of regional importance, which showed the possibility of its application not only for regions but also other administrative-territorial units [20].

5. Conclusion

The conducted research has showed that the simplification of the methodology proposed by the research team under the leadership of Zgurovskyi M. does not significantly affect the final result of the calculation and placement of areas in the ranking. Existing discrepancies are explained by the time of the study and the set of baseline parameters, rather than due to differences in the calculation method.

Instead, the simplified calculation method is universal and can be used to assess the sustainable development not only of the regions of Ukraine, but also of any other administrative-territorial entities. The technique in a form accessible to the general public with the help of integrated quantities allows to display the results of the development of administrative-territorial units. The practicality of the methodology lies in its availability for recording in the form of a computer program, which will greatly facilitate obtaining the values necessary for making sound management decisions and identifying priority areas for development.

At the same time, the question of a set of parameters for evaluation remains open. In practice, it may differ from that proposed. However, in order to effectively apply the methodology and obtain an objective result, the parameters must be derived from the official reporting according to a single system for all objects of evaluation.

Instead, the use of weights in calculating the values of individual indicators and policy categories may be justified provided there is a proper scientific basis and the possibility of determining them empirically.

Applying the proposed methodology has significant potential in local self-government bodies' activities, assessing current problems and determining priority directions for developing territorial communities. Implementing balanced management decisions based on the assessment results will contribute to creating comfortable living conditions and harmonious personality development.

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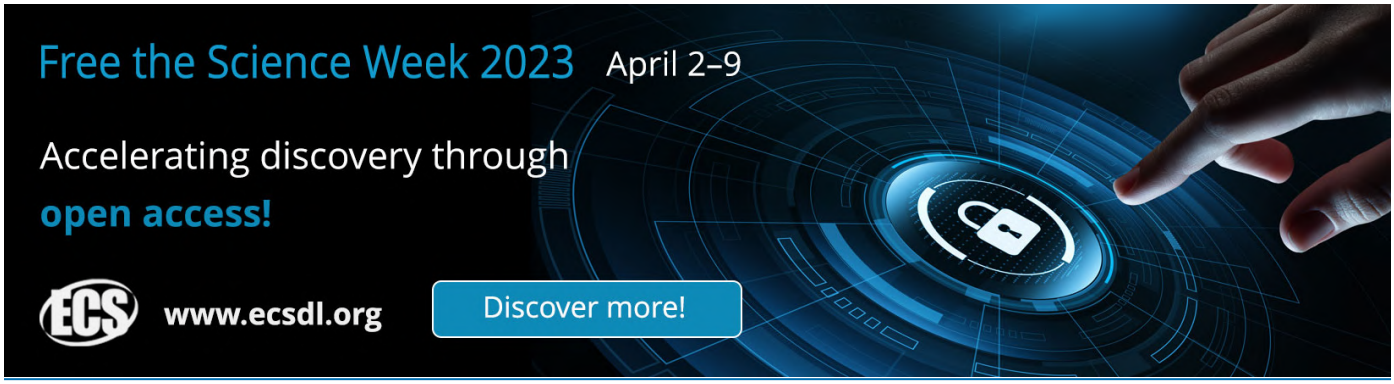
Participatory budgeting as a public mechanism for diagnosing priorities of territorial communities



Participatory budgeting as a public mechanism for diagnosing priorities of territorial communities

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Abstract. The winning projects of participatory budgeting in the cities of Ukraine and Poland are analyzed as a public mechanism for diagnosing the priorities of territorial communities. It is found out that given the unmet basic needs of community representatives (road quality, condition of schools, playgrounds, etc.) involved in participatory budgeting in Ukraine, the strategic goals of local communities are ignored. It has an adverse impact on the need to achieve sustainable development goals based on community potential. It is proposed to establish additional quotas or separate project categories related to the categories of "environment" and "renewable energy" as strategic projects.

1. Introduction

The participatory budgeting mechanism was first introduced in 1989 in Porto Alegre, Brazil. For more than 30 years, this tool has been a trend in the socio-economic development of communities in many countries, which helps to address the most pressing needs of the territorial communities' population, promotes the relationship between government and communities at the local level. A country (city) usually has its model of the public budget, which can be different, but the basis is the model of Porto Alegre. Participatory budgeting (participation budget, public budget) is a new democratic practice for Ukraine, which allows the population to propose projects that will be implemented at the expense of the State Fund for Regional Development based on public consideration and decision-making. It is a public mechanism for diagnosing the priorities and needs of the population. This mechanism for financial decentralization allows attracting additional funds from the budget for community development and helps strengthen its economic security. Participatory budgeting is a process that "allows the participation of non-elected citizens in the conception and/or allocation of public finances" [1].

2. Critical literature review

Public administration is the form of activity of public authorities, manifested in the coordinated influence on specific public relations through specific methods, tools, forms, and aimed at ensuring the public interest [2]. And participatory budgeting is a practical mechanism that can ensure the public interest, as it is based on the desire to build trust between government and the population through the joint development of projects of regional and social importance.

Among the academic community, interest in researching participatory budgeting began with the expansion of democracy, publicity, and decentralization around the world. Different countries with different backgrounds and periods have different solutions. However, the factors of possible positive impact on the development of participatory budgeting are common.

As reported in [3; 4], the proliferation of participatory budgeting in Latin America is due to factors such as the presence of academics, mayors, officials, and advisers at international meetings of successful local government; the intervention of local organized civil society, which is fighting for its adoption; the influence of international organizations that recommend and promote their support and funding; political pluralization, especially of the Latin American Social Democratic parties, and the official promotion of national and regional governments.

Participatory budgets are a space of positive tension between a vision of modern governance built on shared political power, on the one hand, and the action of social and civic movements that usually see participatory budgets as a demand, on the other [5]. A study by the authors [6] on "understanding the dimension of the Participatory Budget, concerning design, experience, social participation in this process, its limits and possibilities" showed that even participatory budgeting with large-scale democratic innovation at the national level is limited in establishment and survival in cities, as they depend on political actors [6]. But in the case of socially responsible behavior of public administration, they could be the driving force in the implementation of the participation budget aimed at meeting not only the basic needs of communities but also the priority needs of the community of a strategic nature. The focus of participatory budgeting on the development of alternative energy sources in a given region, improving waste management, and other goals related to eco-innovation [7], we see as those that need attention in terms of support and government regulation.

The purpose of our study is to analyze the winning projects of participatory budgeting in the cities of Ukraine as a public mechanism for diagnosing the priorities of local communities and develop proposals for possible prioritization of projects of strategic importance.

3. Materials and methods

The initial data for the study were official statistics, official websites of public budgets of Ukraine and Poland, regulations on the Budget of participation of Ukrainian cities, strategies for urban development of Ukraine, scientific literature on the principles of participatory budgeting.

The analysis uses the method of descriptive statistics to compare the categories of winning projects in Ukraine and Poland.

4. Results and discussion

During the research, the winning projects of participatory budgeting for the period from 2017 to 2021 were analyzed – a total of 2262 projects selected by resident cities: Ivano-Frankivsk [8], Odesa [9], Kyiv [10], Chernihiv [11], Dnipro [12] (Table 1). These cities were chosen among others because of their different location: west, east, north, south, and center of the country, which may differ in the projects selected by residents. The selection criteria were also various indices of urban development: in particular, municipal competitiveness index (MCI) (Ivano-Frankivsk (65.41) and Chernihiv (59.96) are cities with a high level of MCI, Kyiv (50.27) has a medium level of MCI, Odesa (36.84) and Dnipro (43.64) have a low level of MCI) [13].

Table 1. Basic data of participatory budgeting in the analyzed cities of Ukraine.

Year	Kyiv			Odesa			Chernihiv			Dnipro			Ivano-Frankivsk		
	Submitted projects	Implemented projects	% implemented	Submitted projects	Implemented projects	% implemented	Submitted projects	Implemented projects	% implemented	Submitted projects	Implemented projects	% implemented	Submitted projects	Implemented projects	% implemented
2017	320	62	19	223	31	14	87	19	22	373	82	22	62	24	38
2018	564	138	25	165	22	13	84	20	24	190	109	57	101	31	31

2019	940	333	35	95	34	36	73	26	36	435	107	25	130	37	28
2020	1578	554	35	131	34	26	69	24	35	505	147	29	146	46	32
2021	1405	351	25	129	41	32	85	21	25	373	82	22	252	62	25

Source: own calculations based on data [8],[9],[10],[11],[12].

There is no national legislation on participatory budgeting in Ukraine. Normative acts are approved by members of the working groups of the Participation Budget, which include representatives of the government, deputies, representatives of public organizations or residents of the city and approved at the local level [14]. Therefore, these cities also have the specifics of the division of all submitted projects by certain types, which are approved by the working group of the Participation Budget (Table 2).

Table 2. Types of projects in the analyzed cities.

City	Types of projects
Kyiv	Small projects (100 000 – 999 999) UAH Big projects (1 000 000 – 3 000 000) UAH
Odesa	Small (1 – 300 000) UAH Big (300 001 – 1 500 000) UAH
Chernihiv	Small (1 – 300 000) UAH Big (300 001 – 1 500 000) UAH
Dnipro	Educational Big (500 000 – 1 500 000) UAH Educational Small (100 000 – 499 999) UAH
	Humanitarian Big (500 000 – 1 500 000) UAH Humanitarian Small (100 000 – 499 999) UAH
	Municipal Small (100 000 – 499 999) UAH Municipal Big (48 000 – 1 500 000) UAH
	Medico-social Small (100 000 – 499 999) UAH
	Information and youth (90 000 – 499 999) UAH
Ivano-Frankivsk	Small educational (1 – 100 000) UAH Great educational (100 000 – 300 000) UAH
	Big other (100 000 – 300 000) UAH Small other (1 – 100 000) UAH
	Repair of small streets (300 000 – 1 500 000) UAH
	Design and estimate documentation prepared by JSC "Ivano-Frankivskgas" for a residential building (1 – 500 000) UAH
	Cultural heritage sites (1 – 1 500 000) UAH

Source: [8],[9],[10],[11],[12].

In turn, all the studied winning projects were divided according to a certain category. Projects based on names, as well as descriptions posted on the Public Budget website, were included in one category or another. Each project was assigned to only one category. In a situation where the task covered many aspects and several categories could be identified, the choice was made in favor of one dominant based on the analysis of the task description prepared by the author (Figure 1). In other words, where it was about a playground or small architecture in the form of benches the code most similar to an accent which was put by the author in the description of the project was chosen (Road, utilities, and transport).

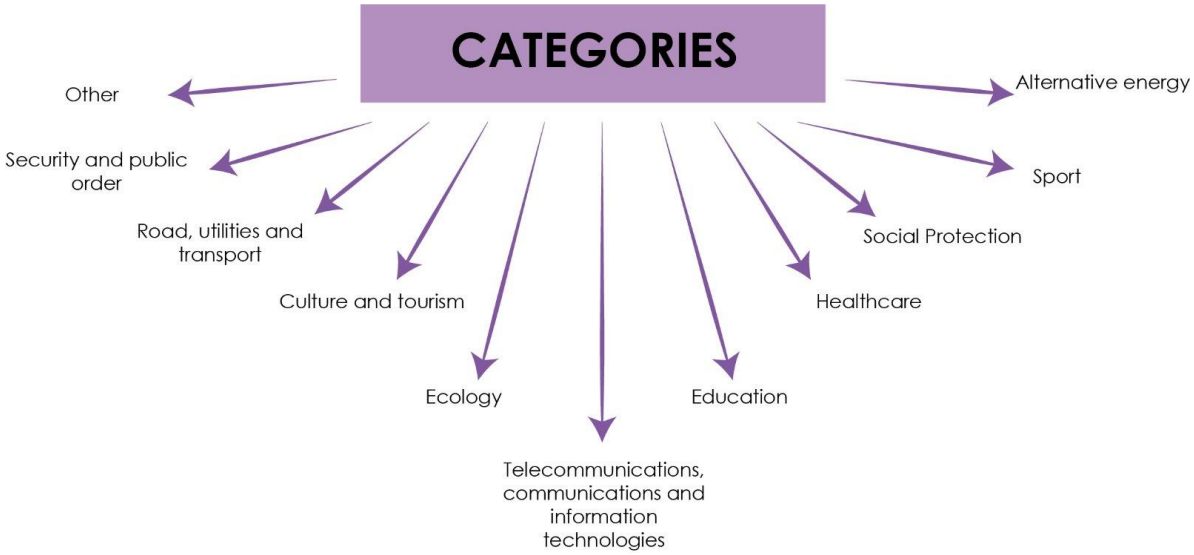

Figure 1. Categories used to analyze the winning projects in the resident cities.

Source: own research

In recent years, there has been a trend of increasing the number of selected projects related to road, communal, and transport facilities (repair of the adjacent territory, replacement of sewerage networks, replacement of windows, etc.) Also, for Ukrainian cities "educational projects" are common, but they are characterized mainly by improving the material and technical base of educational institutions rather than aimed at improving the quality of educational services (Table 3). The analysis shows that with the increase in the size of the city, the percentage of "soft projects" is growing. Sports projects have a significant percentage in Odesa. The city can be called a "city of sports", as the percentage of implemented sports projects is 37%. Chernihiv residents voted 55% for utility projects. "Educational" projects predominate in Dnipro. At the same time, in these cities for 2021, the winners do not have a single project that falls under the category of "ecology". The situation is also difficult in the category of "alternative energy", as only in Dnipro the implementation of such projects amounted to 1%.

Table 3. Breakdown of projects by categories that won the Budget of participation in resident cities in Ukraine, %.

year	**City**	Security and public orde	Road, utilities and transport	Culture and tourism	Ecology	Alternative energy	Education	Healthcare	Social Protection	Sport	Telecommunications, communications and information technologie	Other
a	b	c	d	e	f	g	h	i	j	k	l	m
2017	Kyiv	13	5	5	13	0	**29**	8	3	21	0	3
	Odesa	0	16	13	13	0	13	3	3	**39**	0	0
	Chernihiv	5	**28**	11	0	0	15	0	21	16	4	0
	Dnipro	0	19	10	3	3	**42**	2	0	13	0	8
	Ivano-Frankivsk	1	28	13	2	0	**40**	1	7	8	0	0
2018	Kyiv	4	2	7	1	0	**51**	4	6	20	3	2
	Odesa	18	**32**	14	0	0	9	0	5	22	0	0
	Chernihiv	0	**35**	5	0	0	10	0	25	5	0	20

	Dnipro	3	22	8	9	0	**36**	5	2	14	0	1
	Ivano-Frankivsk	2	30	15	2	0	**34**	4	9	4	0	0
a	b	c	d	e	f	g	h	i	j	k	l	m
2019	Kyiv	14	15	4	4	0	**42**	3	5	12	1	0
	Odesa	3	**38**	14	12	0	7	2	2	22	0	0
	Chernihiv	8	**44**	6	0	0	18	5	6	11	2	0
	Dnipro	3	19	0	5	2	**35**	2	4	8	0	0
	Ivano-Frankivsk	1	**40**	6	2	0	35	0	9	7	0	0
2020	Kyiv	5	18	7	2	0	**53**	2	2	9	1	1
	Odesa	5	**33**	9	0	0	14	2	9	28	0	0
	Chernihiv	1	**42**	10	0	0	8	4	21	11	0	3
	Dnipro	5	29	11	2	0	**43**	3	1	5	0	1
	Ivano-Frankivsk	4	**39**	7	0	0	35	3	3	9	0	0
2021	Kyiv	0	12	7	2	0	**55**	3	3	13	2	3
	Odesa	0	**49**	2	0	0	5	5	2	37	0	0
	Chernihiv	0	**55**	10	0	0	0	1	19	10	0	5
	Dnipro	4	12	2	0	1	**59**	4	6	12	0	0
	Ivano-Frankivsk	0	**39**	5	0	0	**39**	2	6	3	0	6

Source: own calculations based on data [8],[9],[10],[11],[12].

During the seven years of implementation of the public budget in Ukraine, the amount of funds allocated by local governments for the implementation of citizens' projects has increased almost 60 times, and the number of people participating in voting for them has increased almost 110 times [24]. In Ukraine, the history of participatory budgeting dates back to 2015. The practice of the Participation Budget was carried out based on the Polish model. Therefore, it is logical to compare the winning projects of Polish cities, which also have different geographies of location (north, south, west, and east).

Table 4. Breakdown of projects by categories that won the Budget of participation in resident cities in Poland, %

Year	**City**	Security and public order	Road, utilities and transport	Culture and tourism	Ecology	Alternative energy	Education	Healthcare	Social Protection	Sport	Telecommunications, communications and information technologies	Other
2021	Krakow	6	**22**	10	19	5	20	2	3	13	0	0
	Gdansk	7	**36**	13	12	3	11	2	8	8	0	0
	Lodz	5	**25**	11	11	6	15	3	7	10	5	2
	Bialystok	2	**34**	7	8	2	22	2	8	13	2	0

Source: own calculations based on data [15],[16],[17],[18]

In Polish cities, as well as in Ukrainian cities, a significant percentage falls on the category of "Road, utilities and transport" (Krakow 22%, Gdansk 36%, Lodz 25%, Bialystok 34%) and "Education" (Krakow 20%, Gdansk 11%, Lodz 15%, Bialystok 22%) (Table 4). At the same time, in the category "Utilities" 60% are projects related to landscaping and cleaning the city from the garbage.

After analyzing the winning projects, Krakow can be described as “a city in pursuit of greenery”. Against this, the city of Lodz presents itself as a “city of many deficits”, which is reflected in the choice of the people of Lodz. Quite a significant percentage of Polish cities, compared to Ukrainian, account for environmental and alternative energy projects (Krakow (19%, 5%); Gdansk (12%, 3%); Lodz (11%, 6%); Bialystok (8%, 2%)). This is an aspect of project work that has received insufficient attention in Ukraine and requires the development of a response mechanism and the establishment of additional quotas or the separation of categories as strategic projects.

5. Conclusions

Analyzing the study of the Participation Budget as a public mechanism for diagnosing the priorities of Ukrainian and Polish cities, it should be noted that there is some similarity and differentiation of projects that have won due to participatory budgeting. In particular, the cities of Ukraine, first of all, solve urgent problems (improvement of the material and technical base of educational institutions, certain types of activities related to public utilities). On the positive side, a significant proportion of the winning projects, both in Ukrainian and Polish cities, aimed at improving sports infrastructure and recreation areas. What is negative for the cities of Ukraine in terms of the need to achieve sustainable development goals is that, compared to our neighbors, we do not support projects related to waste management, other environmental aspects, and alternative energy.

Strategic public administration is closely linked to the concept of sustainable development, i.e. “development that meets the needs of today without compromising the ability of future generations to meet their own needs” [25]. And despite its popularity, this concept remains a problem in the context of the unambiguous interpretation of politicians, business, and the scientific community [26] and should be defined through the separation of the potential of a particular territorial community in development strategies. Most Ukrainian cities (as community centers) have identified several strategic goals that are a priority for them and correlate with the Sustainable Development Goals. In each of the studied cities, one of such goals is to increase energy efficiency and the introduction of alternative energy sources (Strategic goal B.2. Ivano-Frankivsk) [19], clean environment (Strategic goal B.3. Dnipro) [23], development of ecological transport, development of alternative energy sources (Chernihiv) [22], ecopolitics and environmental protection (Kyiv) [21], energy efficiency, development of alternative energy sources (Odesa) [20].

As each city independently regulates the regulatory framework and sets appropriate quotas for project types, it would be advisable to synchronize the principles of participatory budgeting with the City Development Strategy, in particular, introduce quotas for projects related to waste management, renewable energy development, and more. After all, these projects can ensure the implementation of sustainable development goals set by the UN and supported by the City Strategy. In such a situation, information interaction of public authorities with civil society is necessary, i.e. the implementation of public administration and the development of mechanisms that will give priority to funding projects that contribute to achieving sustainable development goals, which are prospects for further research.

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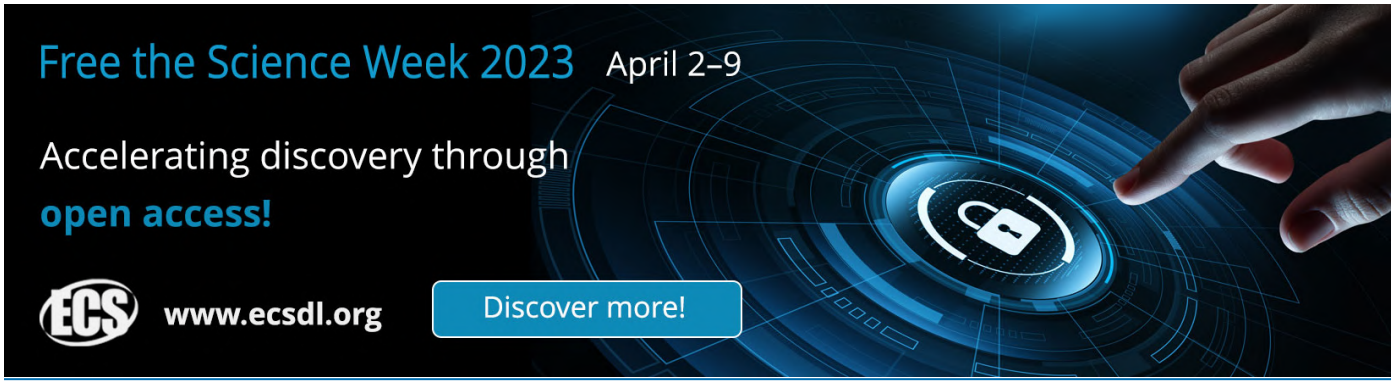
Determination of the competitiveness of cities and districts of the Odessa region



Determination of the competitiveness of cities and districts of the Odessa region

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Abstract. The development of regions, their features and the possibility of a balanced growth of the economy of the regions are relevant for all countries. The ability to evenly and steadily develop the region and use the available resources is the basis of any management strategy. The choice of management model in the development of the region is influenced by a number of factors, among which are the limited resources, the level of development of the region and its general condition, scientific and technological progress, labor resources, transport links and other factors. The purpose of the study is to identify the most progressive and promising for investment areas of the Odessa region and depressive ones, which will allow implementing the region's development strategy more efficiently and taking into account the needs of depressed regions.

1. Introduction

The potential of each region of Ukraine is diverse and unique, but the issues of managing the competitiveness of both the region and individual regions and cities are a priority in the overall development model of countries. Among the main aspects of the formation of models for managing the potential of the region and the development of territorial structures are the following issues: the principle of rational and efficient use of existing advantages, a balanced and reasonable redistribution of resources, taking into account the geographical and economic characteristics of the regions. The uniqueness of each city and region of the country requires certain approaches to management issues, which necessitates a primary analysis and identification of the most promising and depressed areas.

2. Critical literature review

Many scientists study the development of regions and cities. However, the main direction in the study is given to the development of large cities and deindustrialization [1, 2, 3, 4]. Also, a sufficient number of studies are devoted to the study of the development of rural areas and the agro-industrial complex in conditions of economic instability [5, 6].

The role of strategic management in planning the development of territorial associations is noted [7]. Problems were identified: low quality of communications with the authorities and society, non-compliance with the principles of publicity, openness and transparency; unsystematic organization of strategic planning.

In 2021, the USAID Competitive Economy Program of Ukraine, Info Sapiens, the Institute for Economic Research and Policy Consulting conducted the second wave of the study "Competitiveness Index of Ukrainian Cities 2021" (CCM 2021). It covers 45 cities - 24 regional centers that participated in the survey and 21 cities with a population of 73,000 or more.

For ICM 2021, about 9 thousand business entities in 45 largest cities of Ukraine were surveyed. Statistical data, official documents, etc. were also collected and processed. Based on the results of the

ICM 2021, cities were ranked according to the favorable business climate and the effectiveness of economic management.

Odessa was on the last line of the competitiveness rating of Ukrainian cities. This is evidenced by the results of a study of the business climate in 45 cities of the country, published by the analytical center of the Institute for Economic Research and Policy Consulting [8].

According to the published results, the cities of Khmelnitsky, Ivano-Frankivsk, Lviv, Mukachevo, Bakhmut, Ternopil, Vinnytsia, Mariupol, Alexandria, Melitopol and Chernihiv received the highest competitiveness index (CCI). The least favorable business climate was in the Dnieper, Uman, Kherson, Zaporozhye, Cherkassy, Kamensk, Poltava and Odessa.

Turk I. [9] noted that two approaches are used in the development of regions. One is market-oriented and more pragmatic. Local authorities solve problems as they come, coordinating decisions with centralized management. The second approach is more experimental, contains a greater social orientation. Local authorities independently consider problems and try to implement long-term plans and strategies for the development of territories.

The relevance of such research is undeniable. All methods apply the factor of competitiveness in relation to any territorial object and serve as the basis for increasing this factor.

Competitiveness is an economic category that is closely related to both the economic development of an object and its growth prospects. So, "the competitiveness of the region can be ensured only with the maximum implementation of regional interests". Studies of the competitiveness of territories and their associations, cities should precede any development strategy.

3. Materials and Methods

To study the subject and object of research, the method of analysis and synthesis was applied, which made it possible to identify the main factors that affect the competitiveness of cities and districts of the Odessa region. Using the software SPSS, the clustering of the data array was carried out and the most promising and depressed areas were identified. When summarizing the results of the study and drawing conclusions, an abstract-logical method was used.

4. Results and Discussion

Odessa region occupies most of the territory of the North-Western Black Sea region. The population of the region is multinational. A wide access to the Azov-Black Sea basin and to large river highways determines the strategically advantageous position of the region for the development of transport infrastructure. Odessa is the administrative center of the region, one of the largest cities in Ukraine. The city is also an important transport, industrial, cultural and tourist center with a population of over 1 million people. The role of the Odessa region in the maritime complex of Ukraine is also great - about 75% belongs to the ports of Odessa, Yuzhny, Ilyichevsk, Reni, Izmail, Ust-Dunaysk, Belgorod-Dnestrovsky. It should be noted that the Odessa region is known as a recreational and tourist area, a wine-making center.

One of the important factors for the sustainable development of the region, its socio-economic sphere is the strong competitive position of the region. However, the presence of only competitive advantages cannot increase the degree of competitiveness. There is also a need to develop the capacity to make full use of resources and achieving the set economic goals. A stable competitive position requires real opportunities and the use of existing resources as efficiently as possible.

Characteristics of the components of the economic complex of Odessa region:

- Leading positions of the maritime complex in the number of ports in the country
- Logistics functions that are determined by the transport infrastructure of national and international levels
- Concentration of research, design and development potential agro-industrial complex
- Enterprises of chemical, oil refining, mechanical engineering
- Recreational and tourist region of the coastal type
- Active development of construction of residential real estate, infrastructure

An analysis of the volume of products sold in Odessa shows that the largest volume falls on domestic trade, car repair – 46,3% of the total, then industry – 19,9%, transport and warehouses – 9,72%, construction – 13,3%, agriculture, forestry and fisheries – 3,45%, healthcare and social assistance – 1,9%, real estate transactions – 1,7%.

Less than 1% is accounted for by scientific and technical activities.

The geographical position of the city implies the development of other areas, such as recreation, agriculture, and fish farming. However, the presence of a sufficiently large number of ports and transport routes from Europe provides an advantage for the development of trade. [10].

The volume of sold products (goods, services) of enterprises by type of economic activity (Fig. 1).

However the assessment of the current situation of economic development in the Odessa region is not unambiguous, the regions are developed unevenly. The vast majority of enterprises in various areas suffered losses last year due to the Covid 19 pandemic and the instability of the socio-political situation in the country. "The pandemic and the lockdown response have exacerbated pre-existing divisions within cities" [11].

To identify promising and depressed areas of the Odessa region, the analysis of information using economic and statistical methods was carried out. The goal is the distribution by groups (clusters) of districts and cities of the region using the software SPSS (Statistical Package for the Social Sciences).

Statistical analysis using the SPSS package will determine the clustering of cities and districts in the Odessa region. Clustering in statistics is the division of many objects into groups (clusters) according to certain characteristics, which among the group have the greatest similarity, and the maximum differences with other groups.

The similarity is determined by measuring the distance between the components of the characteristics of objects in pairs and is calculated in the selected method of clustering Euclidean distance.

For the calculation, the data of the State website of statistics of Ukraine were used as a database [12].

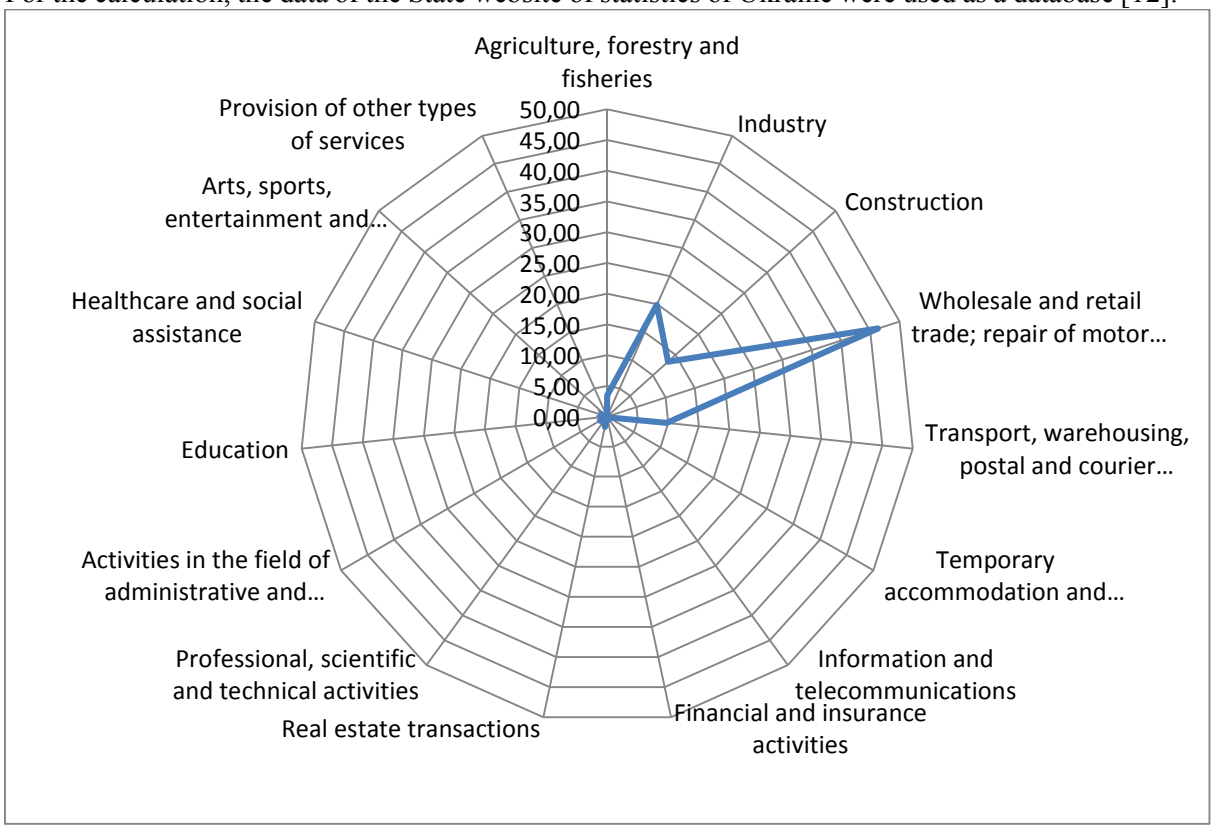

Figure 1. The volume of sold products (goods, services) of enterprises by type of economic activity

Source: formed by the authors

The first stage is the choice of output data and the construction of a mathematical model of the relationship between indicators. For the initial data, we will choose such indicators of the region as (Figure 2).

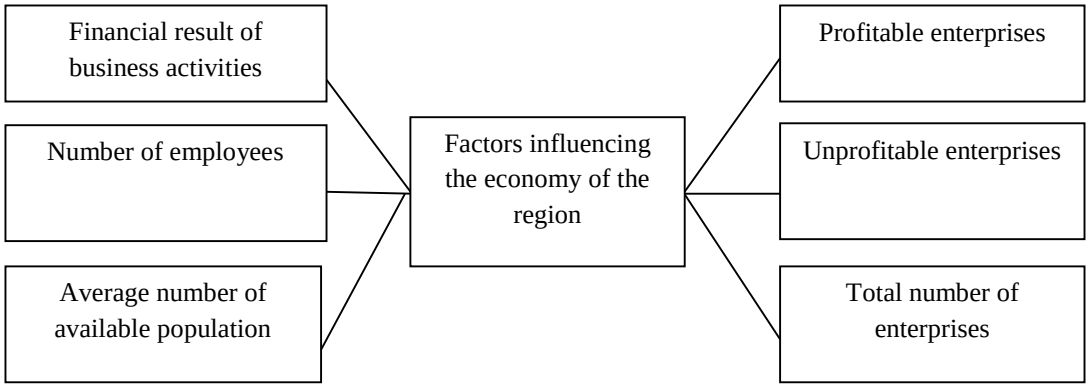

Figure 2. Selected indicators for the economic and statistical analysis of the Odessa region.
Source: formed by the authors

For an objective comparison of heterogeneous indicators, they were standardized using the SPSS software package. A z-standardization transformation in the range -3 to +3 is selected.

Due to the heterogeneity of the initial data for cities of regional significance and districts, it was decided to analyze the cities first, then separately, the districts. An indicator of the financial result of enterprises' activities is taken as a variable value.

Frequency correlations for cities of regional importance are shown in Table 1.

Table 1. Frequency correlations for cities of regional importance

Variable control			X2	X3	X4	X5	X6
X1	X2	Correlation	1,000	1,000	,684	,749	,682
		Significance (two-sided)	.	,000	,134	,087	,136
		degrees of freedom	0	4	4	4	4
	X3	Correlation	1,000	1,000	,684	,749	,682
		Significance (two-sided)	,000	.	,134	,087	,136
		degrees of freedom	4	0	4	4	4
	X4	Correlation	,684	,684	1,000	,995	,997
		Significance (two-sided)	,134	,134	.	,000	,000
		degrees of freedom	4	4	0	4	4
	X5	Correlation	,749	,749	,995	1,000	,993
		Significance (two-sided)	,087	,087	,000	.	,000
		degrees of freedom	4	4	4	0	4
	X6	Correlation	,682	,682	,997	,993	1,000
		Significance (two-sided))	,136	,136	,000	,000	.
		degrees of freedom	4	4	4	4	0

Source: formed by the authors

For the initial data, we will choose such indicators of the region as:

X1 – financial result of enterprises, balance, thousand hryvnia;

X2 – profit-making enterprises, financial result, thousand hryvnias;

X3 – enterprises that received a loss, financial result, thousand hryvnias;

X4 – number of enterprises, units;

X5 – number of employed workers, people;

X6 – average population, persons.

A high level of frequency correlation coefficients between X4 and X5, X6 factors was revealed; X2 and X5; X3 and X5, that is, the entrepreneurial activity of the population, profitability and population have a significant impact on financial results (Table 2).

Table 2. Frequency correlations for districts

Variable control			X2	X3	X4	X5	X6
X1	X2	Correlation	1,000	1,000	,076	,536	-,005
		Significance (two-sided)	.	,000	,701	,003	,979
		degrees of freedom	0	26	26	26	26
	X3	Correlation	1,000	1,000	,076	,536	-,005
		Significance (two-sided)	,000	.	,701	,003	,979
		degrees of freedom	26	0	26	26	26
	X4	Correlation	,076	,076	1,000	,717	,699
		Significance (two-sided)	,701	,701	.	,000	,000
		degrees of freedom	26	26	0	26	26
	X5	Correlation	,536	,536	,717	1,000	,553
		Significance (two-sided)	,003	,003	,000	.	,002
		degrees of freedom	26	26	26	0	26
	X6	Correlation	-,005	-,005	,699	,553	1,000
		Significance (two-sided))	,979	,979	,000	,002	.
		degrees of freedom	26	26	26	26	0

Source: formed by the authors

A high level of frequency correlation coefficients between the factors X6 and X2, X3, X4 was revealed, that is, in the interaction of factors, the population size, profitability, and entrepreneurial activity have a significant impact on financial results.

To classify the settlements of the Odessa region according to these factors, we use hierarchical clustering. To do this, indicators of the proximity matrix for cities of regional significance and districts of the Odessa region were calculated. The proximity matrix calculates the distance between clusters using the Euclidean distance method. The order of agglomeration and dendrograms make it possible to determine the optimal number of clusters. The order of agglomeration for cities obtained by cluster analysis in SPSS using the method of average connection between groups determines the stages of combining objects into clusters, and the coefficients indicate the distance between them.

On fig. 3 and fig. 4 is a graphical representation of the grouping of objects into clusters in the form of a dendrogram.

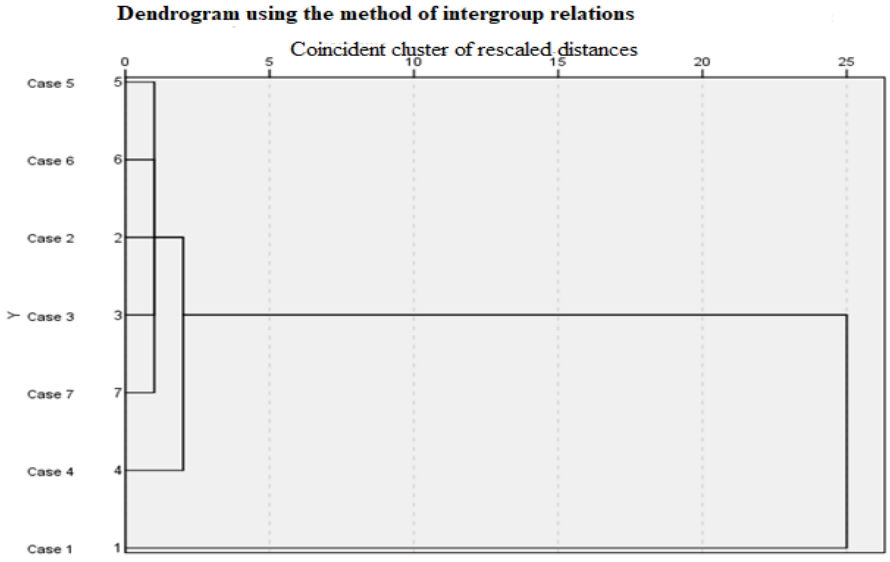

Figure 3. Dendrogram of object grouping into clusters (cities)

Agglomeration was carried out using hierarchical clustering for the districts of the Odessa region. An analysis of the cluster distance gives grounds for conclusions: with the agglomeration of cities in the Odessa region, it makes sense to consider the breakdown into three clusters. The first cluster should

include objects 3.5, 6.7 - that is, the cities of Izmail, Kotovsk, Teplodar, Yuzhnoye; the second includes 2.4 - the city of Belgorod-Dnestrovsky, the city of Chernomorsk; to the third cluster - object 1, Odessa.

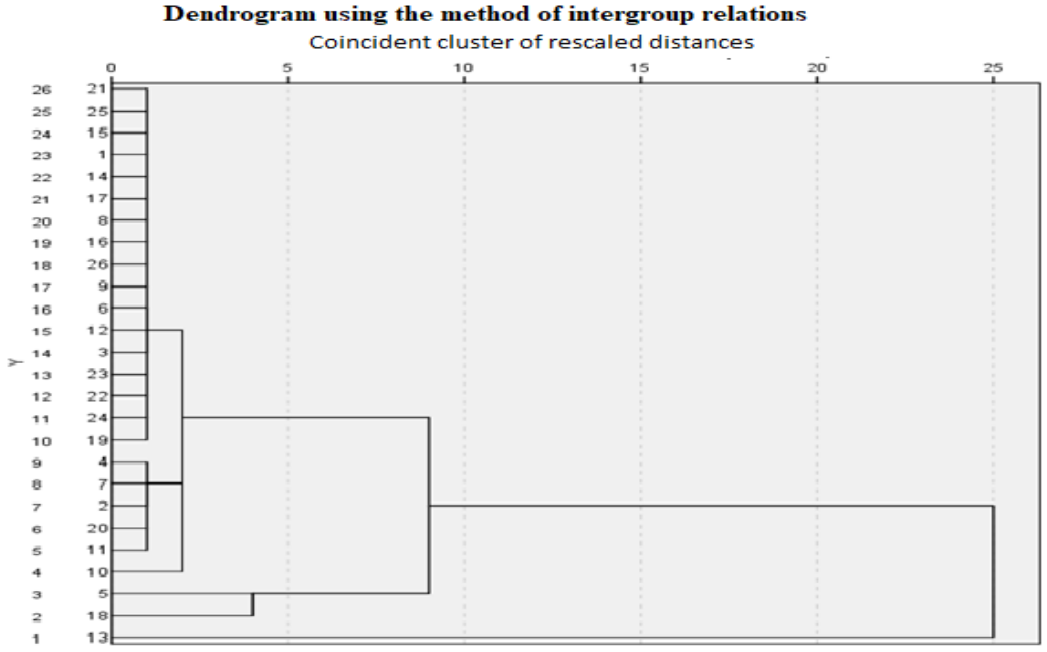

Figure 4. Dendrogram of object grouping into clusters (districts)

The dendrogram and cluster distance group the districts into 4 clusters:

Cluster 1 - 17 districts of Odessa region, to a greater extent, the profitability of enterprises, their small number compared to some;

Cluster 2 – Limansky district, in which enterprises generally received a loss, but there is significant human potential;

Cluster 3 - Ovidiopol district with a negative result of the activity of enterprises, but a large number of existing residents and employees, entrepreneurial activity, confirmed by a large number of registered enterprises, singles out this district in a separate cluster;

4 clusters - 7 districts with low entrepreneurial activity, mostly unprofitable results of enterprises. The distribution of districts by clusters is presented in Table 3.

Table 3. Example of Clustering Cities and Districts

Cluster number	City
1 cluster	Odessa
2 cluster	Belgorod-Dnestrovsky and Chernomorsk
3 cluster	Izmail, Kotovsk, Teplodar, Yuzhne
Cluster number	Districts
1 cluster	Ananyivsky, Baltsky, Berezovsky, Velykomykhailivsky Ivanovsky, Kodymsky, Kotovsky, Krasnooknyansky, Lyubashivsky, Nikolaev, Reniysky, Savransky, Saratsky, Tarutinsky, Tatarbunarsky, Frunzovsky, Shiryaevsky
2 cluster	Limansky
3 cluster	Ovidiopolsky
4 cluster	Artsyz, Belgorod-Dniester, Bilyaiv, Bolgrad, Izmail, Kiliya, Rozdilnyansky

Source: formed by the authors

Clustering of cities and districts of the Odessa region using the SPSS program allows us to conclude that the most promising in terms of further economic development and investment are the objects listed in cluster 1. 2 clusters also have prospects for development, but there is a lack of some indicators. Development outsiders - 3 for cities and 3 and 4 for cluster districts.

5. Conclusion

The results of the study testify to the uneven development of districts and cities of the Odessa region.

The formation of motivational mechanisms for economic relations between regional government bodies and territorial communities should help build the potential of individual regional components.

The balance of intersectoral relations between depressed and progressive regions will reduce the impact of external and internal risks. The development of sustainable development programs for the districts of the Odessa region should take into account the peculiarities of clustering and direct resources to support and further growth of the economy of depressed areas.

Analysis of the cluster distance gave grounds for identifying three clusters of cities in the Odessa region: the first cluster - Izmail, Kotovsk, Teplodar, Yuzhnoye; the second cluster - Belgorod-Dnestrovsky, Chernomorsk; the third cluster is Odessa.

Analysis of the cluster distance gave grounds for the allocation of four clusters of districts of the Odessa region: the first cluster - 17 districts (there is a small number of profitable enterprises); the second cluster is the Limansky district (the vast majority of enterprises are unprofitable, but there is significant human potential); the third cluster is the Ovidiopol district (all enterprises are unprofitable, but a large number of enterprises and residents); the fourth cluster - 7 districts (all enterprises are unprofitable, low entrepreneurial activity).

Clustering of cities and districts of the Odessa region with the help of the SPSS program made it possible to conclude that the first and second clusters are the most promising in terms of further economic development and investment attractive among cities and districts.

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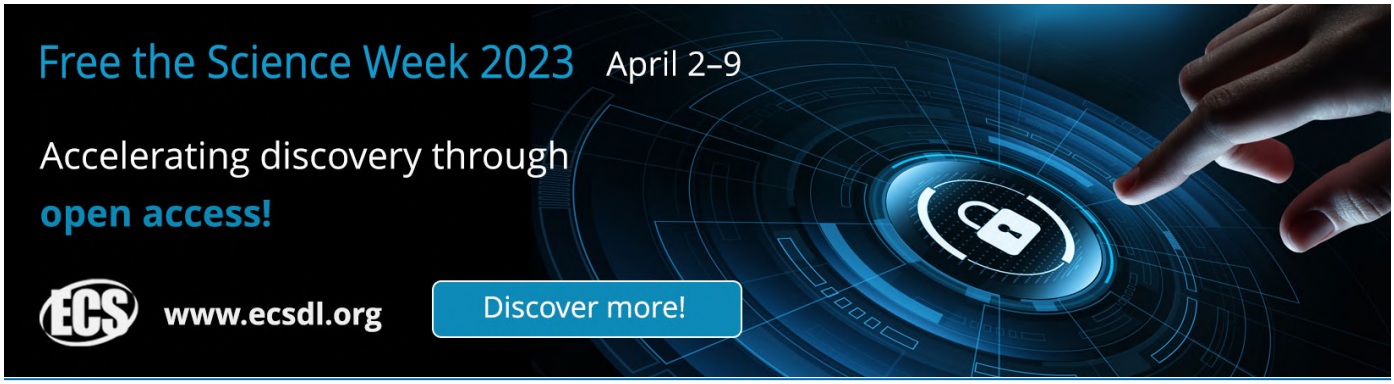
Global trends in the behavior of consumers of retail enterprises in the digital economy



Global trends in the behavior of consumers of retail enterprises in the digital economy

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Abstract. The purpose of the article is to identify the main changes that have taken place in the consumer behavior of retail enterprises under the influence of objective factors such as the transition to the digital economy, the crisis caused by the COVID-19 pandemic, and the transition of all businesses to new conditions of functioning. The authors present the directions of global changes in the motives, intentions, and means of purchase; identify the main drivers for the buyer in the new realities of retail trade. Based on the conducted primary and secondary researches features of consumer behavior both on a global, and regional scale are defined. The article reflects the changes in the channels of purchase of goods by category, as well as an assessment of the factors that cause feelings of consumer insecurity. The problems of Ukrainian trade enterprises are considered, taking into account the peculiarities of the behavior of Ukrainian consumers when making a purchase both physically and online. The problems that have arisen as a result of the COVID-19 pandemic are considered, and, taking into account the opinions of experts, conclusions are made on how retail companies will be able to adapt to the new conditions of the digital economy.

1. Introduction

Consumer behavior has been the basis of marketing concepts for many years, as well as a key research object in retail. An important category for professional analysis is not only consumers and patterns of their behavior, but also an understanding of the needs, preferences, and habits of potential and actual customers.

Along with the digital transformations of the economy, which is characterized by the development of production, trade, technology, and marketing tools, consumers are becoming more influential, more knowledgeable, and sophisticated, and research into modern consumer behavior is becoming increasingly important for retail. Research on retail and ways to attract customers by improving sales methods, services, and product range, is one of the most important aspects of marketing, which improves the overall consumer experience (by promoting a better understanding of modern society as a whole); support retail networks to attract and retain customers.

In 2020, the world economy was hit by severe shocks, primarily due to the COVID-19 pandemic. The epidemiological situation has fundamentally changed the world of marketing and, at the same time, accelerated the introduction of digital technologies in the public sphere. These developments have significantly affected changes in customer needs and preferences, consumer habits, lifestyle, and behavior. The changes affected not only the structure of consumption but also our ways of thinking. The consumer is now considering products and brands from a whole new perspective.

2. Critical literature review

To achieve effective communication with a consumer in a digital economy, retailers need to understand consumers' needs; monitor the main trends, motives, factors influencing the purchasing process; exploretheir capabilities to influence changing consumer demand.

Patterns of consumer behavior have been the subject of marketers' research for a long time. Most consumer research made by retailers focuses on the effects of different types of marketing tools in retail [1]. It is worth noting the classic works of Kotler P. & Keller K. I. [15] on marketing management, which regard the study of consumer behavior as one of the important stages of marketing research, as the consumer considers all alternatives to purchasing taking into account factors such as size, quality, and price.

In studies of Hui SK., Bradlow E.T. & Fader T.S. [12], and Turley L.W. & Milliman R. E. [19] the relevance of studying the characteristics of consumer behavior in shopping malls is noted. Variawa E. [20] analyzed the impact of packaging on the consumers' decision-making process concerning consumer goods, which is directly related to the characteristics of consumer behavior in the field of retail. East R., Wright M. & Vanhuele M. [9] believe that price is a critical marketing element that determines consumer behavior.

According to Dibb S., Simkin L., Pride W.M., Fereell O.C. [5], consumer behavior is an activity that customers engage in as part of decision-making, and this, in a way, is beyond buying at a trading enterprise. Peter J. P. & Olson J. C. [18] argue that consumer behavior is dynamic, as the thinking, feelings, and actions of people and society as a whole change over time. All this confirms the need to comprehensively study consumer behavior influenced by the external and internal business environmentof the retail sector.

East, R., Ang, L. [8]; Fenech T, O'Cass A. [10]; Gurrieri, L., Previte, J., Prothero, A. [11] argue that with the development of digital technologies, the study of consumer behavior patterns when making online purchases has become objective. Important in this regard are the statements of McCole P. et al. [16] and Drennan J. et al. [6] that most consumers consider online shopping risky. Thus, Drennan J., Mort S. G., and Previte J. [6] argue that even shopping online, consumers' risk perception is likely to have a significant feedback attitude and intentions. In terms of expected risk, trust is seen as an important factor in online shoppingthat can reduce the level of expected risk [16].

With the change of economic and social conditions of trade enterprises, the tendencies of consumer behavior have changed, especially in retail [13]; Ozanne, L.K. et al. [17]. Thus, the study of new realities and characteristics of consumer behavior is an important area of marketing in a digital economy.

3. Materials and Methods

The study used the method of dialectics and the graphical method. The method of dialectics was used to define the way how consumer behavior influenced by the external and internal business environment of the retail sector. The graphical method was used to represent the directions of global changes in the motives, intentions, and means of purchase and to identify the main drivers for the buyer in the new realities of retail trade.

Currently, there are changes in the consumer goods industry, processes of creating values for consumers, the formation of strategic and tactical plans of producers and sellers of products, as well as in a restructuring of marketing channels. With the transition to a digital economy, retail enterprises facea variety of challenges, the one is ensuring the availability of goods on the store shelves and effective crisis management of the supply chain. Buyers will increasingly demand the range of retailers to combine quality, efficiency, transparency, and manufacturability.

In such emergencies, it has become difficult for retailers to focus on long-term business planning, and most attention is paid to tracking daily reactions to market behavior. Under the influence of changes in the technological way of life due to the emergence of Industry 4.0, crisis phenomena in the economy due to the pandemic, manufacturers, and retailers faced a "reset" in the

retail industry. Thus, proactive and timely actions under these conditions will maintain and increase market relevance. The high development of modern technologies in trade allowed buyers to safely limit the number of purchases made offline. Considering this fact, we can state that the pandemic was not the cause but the catalyst for change and it only accelerated the inevitable growth of the e-commerce market.

4. Results and Discussion

In larger purchases, there is a trend of quality being more important than price. Brand loyalty is also declining [7]. Value, affordability, and quality have become the main drivers for the buyer to try another brand. Figure 1 shows the main consumer motives when purchasing during a crisis caused by a pandemic.

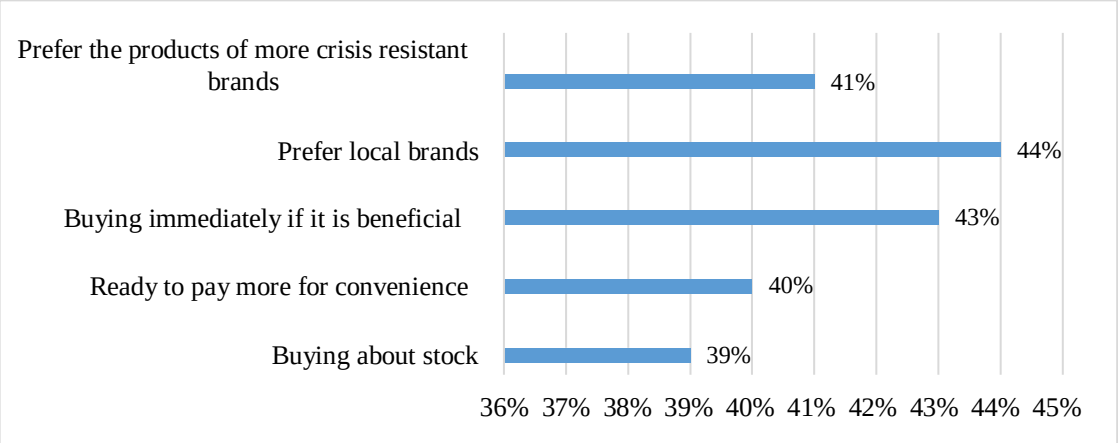

Figure 1. Consumer behavior resulted from the pandemic crisis
Source: Compiled by the authors based on [2, 3, 4]

Consumers are deeply concerned about the impact of the current situation both on their health and on the economy as a whole. Research shows that consumer priorities are more focused on basic needs,hygiene, bacterial protection, and essential products.

Having considered such changes, Nielsen's marketers conditionally divide retailers' product supply into three broad categories, such as product categories that have had increasing demand during Covid-19, which is likely to remain after the crisis (disinfectants for laundry, vitamins, soap, etc.); categories that have grown in the short term since consumers stocked up on them (canned food, toilet paper, etc.); categories that had a drop in sales during the crisis (cosmetics,beverages, etc.).

According to a survey of consumers in the retail sector, more than 60% of respondents began to wash their hands more frequently, 33% – began to use cleaners, 26% – to clean the house, more than 15% of respondents wash clothes more frequently. Given the changes in the needs and consumer sentiments of the population, an increase or decrease in total purchases by individual categories can be noted (Fig. 2).

There is an outbreak of online orders for everyday goods. More than half of Ukrainian consumers note that quarantine has affected their consumer behavior, in particular, the transition to online shopping [14].

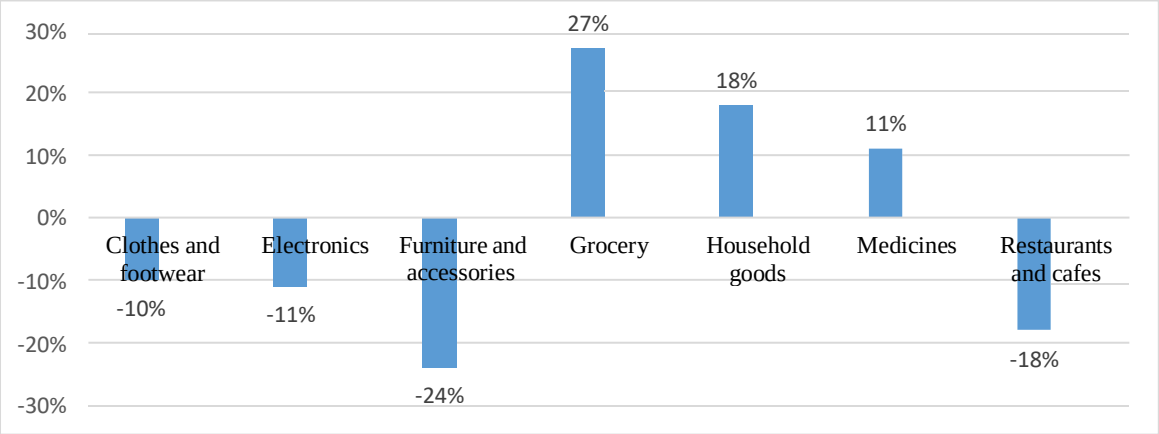

Figure 2. Intentions to increase purchases by product categories
Source: Compiled by the authors based on [3, 4]

Figure 3 presents changes in the ways of consumers purchasing goods by category.

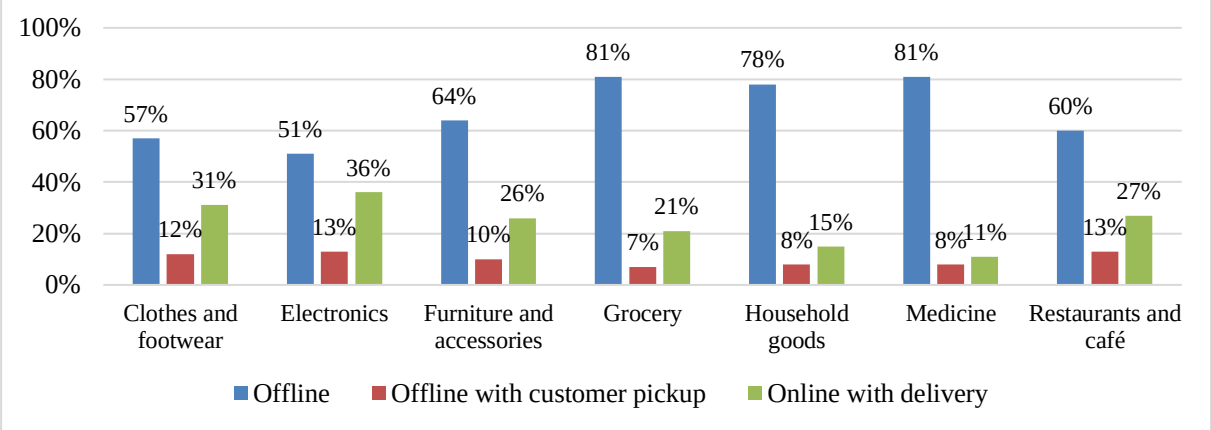

Figure 3. Change of channels of purchase of goods by categories as of December 2020
Source: Compiled by the authors based on [2, 3]

Survey data show that consumers' offline purchases decreased by almost 40%, while the level of costs decreased by 30%. At the same time, the size and frequency of purchases through online servicesincreased by an average of 20%.

A significant proportion of consumers report that the impact of quarantine on their shopping habits increases with the decrease in income (25% of respondents with above-average income said that quarantine affected such habits; this figure among low-income respondents is 43%).

Due to the pandemic and quarantine restrictions, the level of consumer insecurity when visiting public places has significantly increased. By the end of 2020, consumers felt an urgent need for isolation from society. 40% of respondents believe that they risk their health in public places, and 77% informedthat they were uncomfortable being among a large number of people. Figure 4 shows the factors that caused the greatest feeling of insecurity among consumers during 2020.

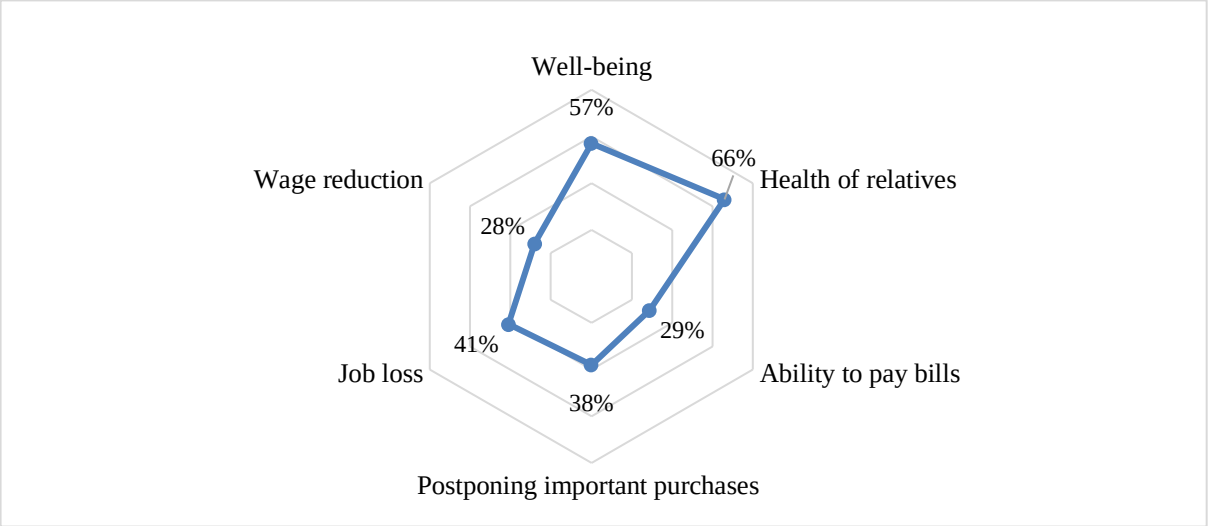

Figure 4. Assessment of the factors that cause consumers' feelings insecurity
Source: Compiled by the authors based on [3]

The share of consumers willing to spend more on shopping for convenience (for example, on product delivery or subscription to services) is the largest among the residents of big urban centers. Half of the respondents are concerned about data protection when shopping online, and with age, the share of concerned consumers increases (40% among consumers aged 16-29 and 57% among consumers over 60).

The pandemic has the greatest impact on the restaurant business and fast-food restaurants, which have experienced more than half reduction of consumers, as well as the cost of ordering in restaurants and fast-food restaurants have also been reduced by almost half. Compared to women, men state they began to spend more on ready meals and food (both in traditional stores and through online orders). Figure 5 presents an assessment of the factors and the level of consumer confidence in them.

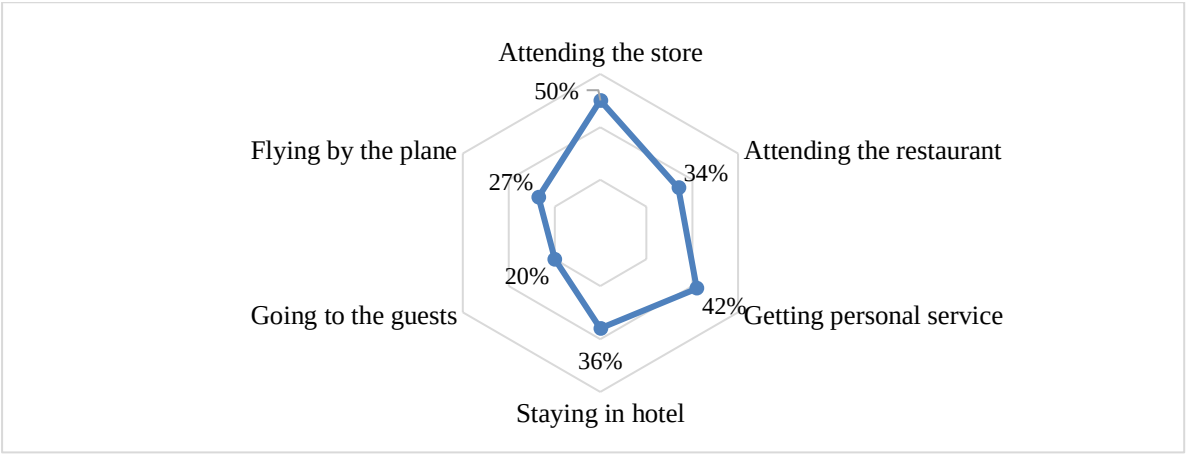

Figure 5. Assessment of factors based on consumer confidence
Source: Compiled by the authors based on [3]

Surveys conducted among Ukrainian consumers have led to certain conclusions. Thus, retail businesses should consider supporting a healthy lifestyle for consumers, buyers, and employees. This strategy may become the main differentiator soon. According to surveys, respondents note the importance of visible security measures, such as additional cleaning and physical barriers. They buy more from companies and brands that demonstrate concern for the safety of customers and care for more hygienic and safe packaging.

Consumers are becoming more attentive to what they are buying; aim at reducing the amount of food waste; shop more economically and buy environment-friendly products. Moreover, due to financial instability, the consumer is more careful about where to spend money. Priority is still given to food, household chemicals, pet food, children's toys, gasoline (Figure 6).

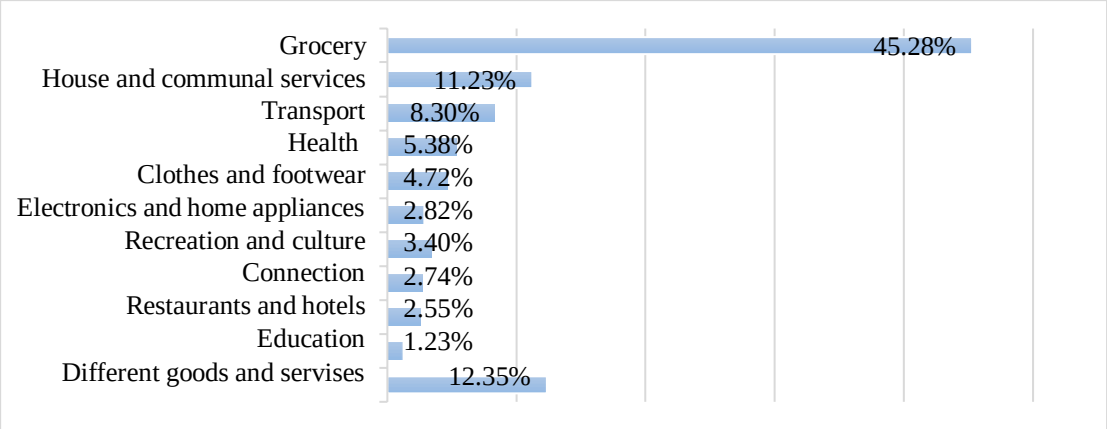

Figure 6. The structure of Ukrainians' consumption on the results of III quarter of 2020
Source: Compiled by the authors based on [2, 4]

Only a small percentage of Ukrainians are willing to spend money on meetings with friends and entertainment; most prefer to save, keep money at home or in a safe box instead of buying real estate or opening a bank deposit in dollars or hryvnia. Such sentiments undoubtedly hold the development of the Ukrainian economy, as citizens of other countries prefer not to keep money at home, rather invest it in real estate or use deposits and other financial instruments.

More than other respondents, Ukrainians aged 45-59 state that they buy more local products, even if their price was higher than usual; buy more brands that have responded correctly to the current situation and have become more likely to buy on credit or by installments in comparison with the before quarantine period. The share of respondents buying food and household chemicals more than necessaryis the largest among the residents of small towns – 28%, while the average is 25%.

The share of Ukrainians living in Kyiv and the Kyiv region and buying more local products, is the highest among all regions of the country (31%, while the average is 25%). The share of consumers who are willing to spend more on shopping for convenience (for example, on product delivery or subscription to services), among the residents of big urban centers is the largest (25%, while the average is 21%). Along with the digitalization of many retail processes, an important facet of consumer behavior is online shopping. One of the peculiarities of the behavior of Ukrainian consumers on the Internet is the spirit of freedom. Thus, 41% of respondents said that they are free to publish their views on economic and social issues on the Internet, while most citizens of other countries say they do not want to share their views.

Citizens of Ukraine also tend to check information, make quick and important decisions and take responsibility for them. Half of the respondents are concerned about protecting their data when shopping online. At the same time, the share of concerned consumers increases with age (40% among consumers aged 16–29 and 57% among consumers over 60). Women are more concerned than men about keeping their data safe when shopping online.

5. Conclusions

The research results indicate the relevance of studying global trends in consumer behavior of retail enterprises influenced by such objective factors as the transition to a digital economy and the spread ofthe COVID-19 pandemic.

The analysis confirms that the epidemiological situation has fundamentally changed the world of marketing and, at the same time, accelerated the introduction of digital technologies in public life.

The study showed that quarantine significantly affected the consumer behavior of Ukrainian consumers. Thus, more than half of consumers switched to online shopping. Consumers shifted their priorities to basic needs and necessities. We determined that the impact of quarantine on the shopping habits of Ukrainian consumers increases with decreasing income.

A significant trend in the behavior of consumers of retail enterprises in the digital economy is the decline in brand loyalty. Value, affordability, and quality become the main drivers for the buyer to try another brand's products.

To achieve effective communication with consumers in a digital economy, retailers must understand their needs; monitor the main trends, motives, and factors that influence the purchasing decision-making;explore their ability to affect changing customer demand.

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