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RESEARCH OF GREEN INNOVATION OF COMPANIES OF COUNTRIES WITH DIFFERENT LEVELS OF TECHNOLOGICAL DEVELOPMENT OF PRODUCTION

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Abstract:
In the conditions of the transition to higher technological systems in the conditions of the implementation of the Sustainable Development Goals, the companies of the world face the question of effective management of green innovative development in their economic activities. The goal of the research is the formation of effective organizational and economic support for green innovations of companies of countries with different levels of technological development of production. This research contains: to describe the known positions of scientific schools regarding the managerial aspects of green innovations of companies of the world; to form the economic support of this administration, by developing an assessment of the potential of green innovations of companies of the world (the data of the Global Innovation Index Report were taken as a source of empirical data), to form criterion values of the potential of green innovations of companies of the countries for the purpose of their clustering. The research methods used include: system method; bibliometric analysis; method of assessing competitiveness; criterion method; method of generalization. The objects of evaluation include companies from five countries of Central and Eastern Europe. The main results of the study include: development of management theory; forming an assessment of the green innovation potential of companies from countries of the world with different levels of technological development of production (the data of the Global Innovation Index Report were taken as a source of empirical data); formation of criterion support for the results of evaluation of the green innovation potential of the countries' companies. The conclusions of the study should include establishing the actualization of managing green innovations by companies of the world by involving the results of the assessment of the green innovation potential of companies of the world to the formation of the criterion values of this assessment in order to make effective management decisions on the part of all interested stakeholders. For further scientific research, to focus on the formation of effective communication links between different groups of stakeholders, the basis of this scientific direction is the criteria developed by the authors to ensure the level of green innovation potential of companies of countries in order to make effective decisions on the part of stakeholders (state bodies, investors, manufacturers, suppliers, clients, financial institutions) regarding organizational, social, economic support of green innovations of companies of countries with different levels of technological development of production. This study can be useful for the governments of countries in the development of international and national programs for the innovative development of the economy in terms of the implementation of the Sustainable Development Goals; to company managers when forming strategic and tactical plans for green innovative business development; to students and scientists in the implementation of scientific and educational programs.

Key words: *management, green innovation, companies, technological development, assessment, criteria*

INTRODUCTION

The introduction of ecologically oriented goods and services, which have high added value and manufacturability, by the companies of the world is becoming more and more actualized. It should be noted that green (ecological) innovations [1] are focused on reducing the use of raw resources, introducing renewable materials, reducing the level of waste and their recycling in order to increase the economic life of goods or services and innovations that meet the of Sustainable Development Goals. At the level of implementation of European initiatives, there is the EU4Environment program [1], the purpose of which is financial support for the formation and promotion of green innovation strategies of representatives of small and medium-sized businesses in countries. These strategies are also aimed at assessing the potential of business entities to implement environmental innovations at all stages of the added value chain of environmentally friendly goods and services.

When studying the issues of green innovation management measures of companies of countries of the world with different technological development of production, one should pay attention to the research of the index of innovation of the countries of the world, which was formed by scientists Dutta S., Lanvin B., Rivera León L. and Wunsch-Vincent S. [2]. This index shows the level of innovation in the work of the countries of the world, but does not reflect the level of green innovations in the economic work of the companies of the world. Therefore, the focus of the study is aimed at the development of an effective organizational and economic toolkit of green innovations of the companies of the countries of the world, which is aimed at making effective management decisions for all interested stakeholders and makes it possible to assess the level of innovative implementation of environmentally oriented goods and services by companies of countries with different levels of technological development of production.

The main goal of the research is the formation of effective organizational and economic support for green innovations of companies in countries with different levels of technological development of production. The scientific hypothesis of the scientific research - in the conditions of different technological development of the production of the companies of the world, there is a need for effective management of ecologically oriented innovative development in order to increase their market positions, competitiveness and economic efficiency due to the promotion of their green innovations.

LITERATURE REVIEW

Investigating the problems and prospects of managing the innovative development of companies in countries with different levels of technological development, it is necessary to note different scientific views on the solution of this scientific problem. The scientific direction of searching for publications is social sciences, and the field of knowledge taken into account in the scientific direction is social and behavioral sciences.

The scientist Sineviciene L. et al. [3] studied the economic costs in the economic and innovative work of companies in countries with a transition economy and the third technological system of production, which is important in the construction of effective monitoring of green innovations. Scientist Dimitrova V. et al. [4] investigated the personnel aspects of the implementation of green innovations at machine-building companies of a country with a transition economy, which produced ecologically oriented products for hydroelectric power plants, which makes it possible to understand the personnel aspects in the management of green innovations. Scientist Wang J. et al. [5] studied the logistical and innovative development of agricultural companies that produced ecologically oriented products of countries with developed, transition and developing economies, which corresponds to the third, fourth and fifth technological order and makes it possible to emphasize the importance of a higher level of technological order in increasing manufacturability and innovativeness of the agrarian complex. Scientist Häußermann J.J. [6] investigated responsible innovations in the field of production and sale of hydrogen to vehicle owners in Germany, which makes it possible to expand the area of influence of green innovations on their responsible use. Scientist Wang H. et al. [7] in his work investigated the effectiveness of green innovations in the work of Chinese companies, this makes it possible to economically substantiate the need for the introduction of green innovations in the work of companies in the world. Scientist Winarsih Fuad K. et al. [8] considered the influence of green innovations in the production of products on the financial effects of companies' work, which increases the economic significance of the introduction of green innovations for various groups of stakeholders, primarily investors, banking institutions. Scientist Zambanini M.E. et al. [9] noted the relationship between the implementation of the Sustainable Development Goals and the production of food packaging, this is important when establishing the environmental sustainability of innovations in the production process of companies.

Scientist Rufo M. [10] considered environmental norms in the production of chemical goods as a component of encouraging innovations in the field of careful consumption of these goods, which makes it possible to form a customer orientation towards environmentally-oriented goods and ecological production. Scientist Akyazi T. et al. [11] noted the importance of innovative competences in the formation of synergy between the environmental norms of production and its energy efficiency in the work of manufacturing companies of the European Union. The importance of technological innovations in the production of environmentally friendly goods and services by companies of countries is also indisputable in the implementation of the Sustainable Development Goals, scientist Ahmad M. et al. [12] considered the combination of technological innovations, fiscal policy, openness of the economy to environmental sustainability in the work of companies. Researcher Sivakumar A. et al. [13] determined the importance of implementing innovation monitoring in health care institutions, which characterizes the

assessment of the implementation of the Sustainable Development Goals in the health care sector. Researcher Xu X. et al. [14] noted the need to consider green finance in the innovative activities of air carrier companies in China, which notes the high investment attractiveness of green innovation projects at the national and international levels. It should be noted that the implementation of the processes of decarbonization of production and transport by companies is relevant in the implementation of the Sustainable Development Goals, the scientist A. Raihan [15] studied the contribution of economic development, renewable energy sources, technical progress and forestry by Uruguayan companies with the aim of becoming a carbon-neutral country by 2030 year. Scientist Coccia M. [16] noted the importance of the influence of technological systems on the innovative work of companies in countries that produce environmentally-oriented goods, which makes it possible to increase the popularization of green innovations in countries with higher technological systems. Scientist Li D. et al. [17] examined the scientific intensity of innovations in energy sector companies of countries with developed economies, this makes it possible to note the importance of scientific works in the implementation of innovations in energy sector companies for the purpose of implementing directions of alternative energy as a component of the implementation of the Sustainable Development Goals. Scientist Udeagha M.C. et al. [18] investigated the role of financial decentralization in the processes of decarbonization of South African manufacturing companies, which makes it possible to establish new innovative approaches to the financial management of green technologies in countries with a high level of technological development of production. Important in establishing a high level of technological development of production and its compliance with environmentally-oriented directions of innovative work of the company is also the study of the role of artificial intelligence in the implementation of secondary waste processing, these aspects were considered by the scientist Gumersindo F. et al. [19] in his scientific work.

The processes of globalization by the G7 countries in the context of the implementation of green innovations are a modern direction of movement towards the implementation of the Sustainable Development Goals, these processes were studied in work [20] by Akram R. et al. Scientist Zhang P. et al. [21], considered the impact of technological innovations on renewable energy in the countries of East Asia, which makes it possible to determine the actualization of green innovations in the work of energy generating companies. Scientist Jie G. et al. [22] investigated the effects of environmental regulation by country governments and business representatives when implementing environmental innovations by companies, which expands the understanding of the need for green innovations at the state and corporate levels in countries with different levels of technological development of production. Scientist Han D. et al. [23] investigated the elements of the circular economy in the implementation of innovative startups by companies of countries with developed and developing economies, which makes it possible to consider innovative approaches of green recycling in company projects. Scientist Shahzad M. et al. [24] proved the interaction of knowledge management and corporate green innovations in the economic activity of companies, this allows to focus attention on the management of information support for the implementation of green innovation projects by companies of countries of the world with different levels of technological development of production.

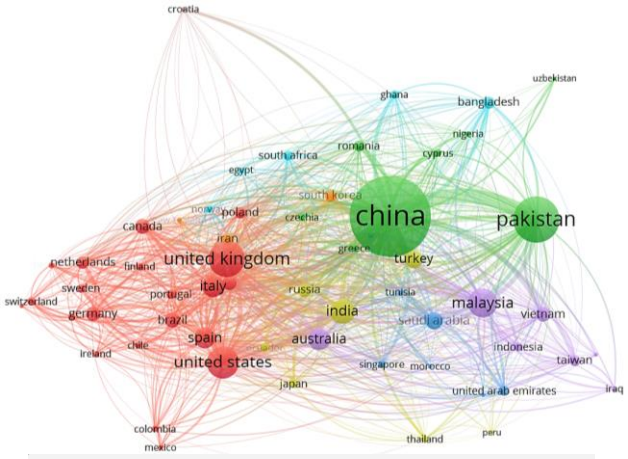
It is also necessary to emphasize the importance of management mechanisms that help promote green innovations, and this is primarily a system of supply and distribution of material, human, and financial resources, which are necessary for the implementation of green innovations. This issue was investigated by scientist Jing L. [25] et al. In his scientific work. Researcher Wang J.Z. et al. [26] established the dependence of the increase in prices for conventional carbon products on the intensification of the implementation of green investments in countries with a low level of technological development of production and the third technological order, this makes it possible to understand the importance of intensification of the implementation of green innovations as an element of replacing traditional types of fuel and energy in work companies. The design and management of solutions at the initial stages of the implementation of green innovations by companies is a component of the effective management of the entire life cycle of green innovations, these aspects were studied by the scientist Pizzol L. et al. [27] in his scientific work. Scientist Chen W. et al. [28] studied energy transitions from low to high levels of technological development of production during the implementation of technological innovations of companies, including in the environmental sphere, this makes it possible to understand the nature of green innovations of companies when changing technological structures.

Research and development of theoretical provisions of green innovation of companies of countries is the basis for understanding the theory of management and innovation, scientist Chaparro-Banegas N. et al. [29] studied citations and formed clusters of works by scientists from the USA, China, Germany, and Canada regarding the coverage of green innovations in scientific literature. Scientist Mahjoub L.B. [30] investigated the role of the influence of green innovations on the implementation of the Sustainable Development Goals in the context of the movement of foreign labor migrants in companies of Saudi Arabian, this allows us to understand the relationship between labor migration processes and the implementation of green innovations by companies in the Middle East. Research on the implementation of green innovations in companies producing solar panels in India was conducted by the scientist Batool K. et al. [31] in his scientific study highlighting the main modern trends of green innovations in countries with transition economies.

The main assumptions of the bibliometric analysis of green innovations of the companies of the countries is to study a large array of input data that relate to scientific

publications on the researched topic in order to improve the quality of the literature review of this scientific research and taking into account geography, citations, authorship of publications on this topic. When using bibliometric analysis using VOSviewer 1.6.19 software, it was processing databases of the dimensions.ai platform [32] (2500 scientific publications). Among the main criteria for selecting input data for literary sources of the *dimensions.ai* and *lens.org* platforms is the possibility of researching scientific publications that are indexed by various databases, not only the main Scopus and Web of Science.

When processing keywords (green innovations, companies, countries, management, technological development of production), the following results were established (see Fig. 1).



Create Map

Verify selected countries

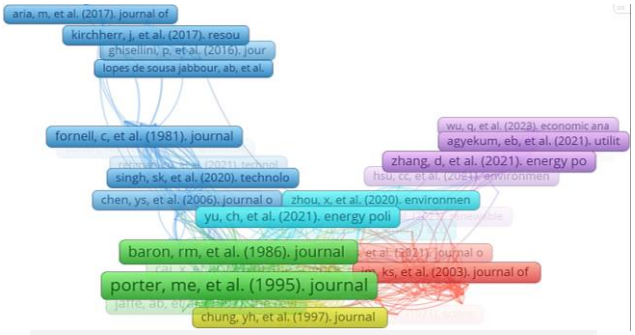
Selected	Country	Documents	Citations	Total link strength
☑	china	1572	19082	35760.83
☑	pakistan	220	3707	15333.93
☑	united kingdom	166	3188	10554.59
☑	united states	129	2733	8735.45
☑	malaysia	105	1222	7714.25
☑	india	91	1438	5962.61
☑	australia	71	1621	4916.76
☑	italy	75	1193	4915.90
☑	spain	80	1049	4656.00
☑	turkey	55	1292	3714.17
☑	saudi arabia	46	639	3430.45
☑	canada	43	842	2762.43
☑	vietnam	43	1211	2739.30
☑	brazil	52	531	2718.30
☑	germany	50	827	2676.32
☑	france	38	370	2626.03
☑	russia	38	538	2253.56
☑	netherlands	33	726	2138.88
☑	bangladesh	25	354	2015.36

Fig. 1 Bibliometric analysis of scientific schools of countries of the world that research green innovations of companies of countries

Source: constructed by authors via VOSviewer for the scientific schools of countries of the world that research green innovations of companies (Input data: 2500 documents, 2012-2022, Dimensions.ai Database, refined).

China, the United States, Great Britain, Australia, Spain, India, Pakistan, and Malaysia are among the leading countries of scientific schools that research green innovations of the world's countries. This proves the high importance of implementing green innovation projects in the world.

If we highlight the highest number of citations of scientific works that contain research on green innovations of companies of countries, the following results were established during the bibliometric analysis (see Fig. 2).



Create Map

Verify selected cited references

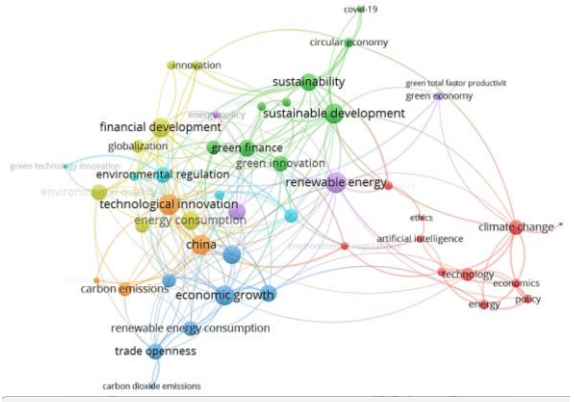
Selected	Cited reference	Citations	Total link strength
☑	porter, me, et al. (1995). journal of economic perspe...	248	246.00
☑	baron, rm, et al. (1986). journal of personality and so...	131	125.00
☑	pesaran, mh (2007). journal of applied econometrics...	85	84.00
☑	hansen, be (1999). journal of econometrics, 93(2), 34...	87	83.00
☑	grossman, gm, et al. (1995). the quarterly journal of ...	85	83.00
☑	tone, k (2001). european journal of operational resea...	80	79.00
☑	cai, x, et al. (2020). the science of the total environm...	80	78.00
☑	jaffe, ab, et al. (1997). the review of economics and s...	76	76.00
☑	rubashkina, y, et al. (2015). energy policy, 83288-300	73	73.00
☑	zhang, d, et al. (2021). energy policy, 153112256	70	69.00
☑	wu, h, et al. (2020). energy economics, 91104880	65	65.00
☑	acemoglu, d, et al. (2012). american economic revie...	66	64.00
☑	yu, ch, et al. (2021). energy policy, 153112255	64	62.00
☑	xie, rh, et al. (2017). ecological economics, 132104-1...	62	62.00
☑	westerlund, j (2007). oxford bulletin of economics a...	62	62.00
☑	lanoie, p, et al. (2008). journal of productivity analysi...	61	61.00
☑	lee, cc, et al. (2022). energy economics, 107105863	58	58.00
☑	chung, yh, et al. (1997). journal of environmental m...	59	58.00
☑	du, k, et al. (2021). energy economics, 98105247	58	57.00

Fig. 2 Bibliometric analysis of citations of scientific works that contain studies of green innovations of companies of countries

Source: constructed by authors via VOSviewer for citations of scientific works that contain studies of green innovations of companies of countries (Input data: 2500 documents, 1981-2023, Dimensions.ai Database, refined).

The founders of the direction of green trends in the innovative activity of companies are representatives of the American scientific school (Porter M. – an American economist, representative of the Harvard Business School), according to the results of processing citations of 2,500 scientific papers. At the same time, it should be noted that the first studies in this issue of competitiveness and the introduction of innovations of ecologically oriented goods were already defined at the end of the 20th century and became popular at the current stage of the development of science.

When using bibliometric analysis, one should add a study of the actualization of keywords with which green innovations of the world's companies are associated (see Fig. 3). This analysis included the processing of 3659 scientific publications from the database of the lens.org platform [33] and the use of VOSviewer 1.6.19 software.



Create Map

Verify selected keywords

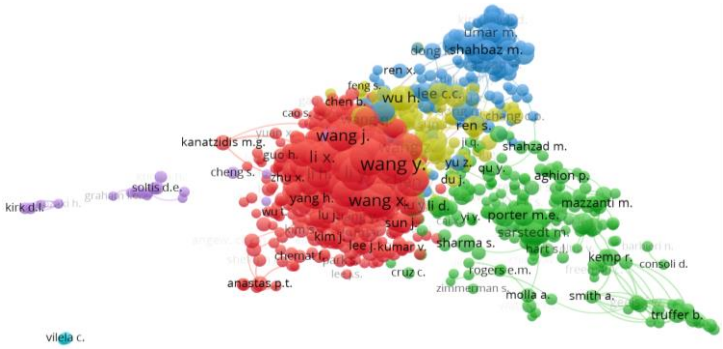
Selected	Keyword	Occurrences	Total link strength
☑	economic growth	15	30
☑	renewable energy	19	25
☑	technological innovation	18	24
☑	china	36	23
☑	co2 emissions	14	23
☑	sustainable development	17	23
☑	energy consumption	11	22
☑	sustainability	25	22
☑	financial development	15	21
☑	trade openness	9	20
☑	foreign direct investment	10	19
☑	climate change	12	18
☑	environmental regulation	21	18
☑	environmental sustainability	12	17
☑	renewable energy consumption	8	17
☑	environmental degradation	8	15
☑	green finance	17	15
☑	policy	7	15
☑	environmental pollution	9	14

Fig. 3 Bibliometric analysis of keywords associated with green innovations of companies of countries

Source: constructed by authors via VOSviewer for the keyword green innovations (Input data: 3659 documents, 2012-2022, Lens.org Database, refined).

A total of six clusters were identified based on the key words climate change, economic growth, renewable energy, technological innovation, sustainable development, environmental regulation, which are closely related to each other. It should be noted that green technological innovations belong to the core cluster of environmental regulation and are also associated with such key words as: environmental quality. The keyword green innovation is part of the sustainable development cluster and is related to the following keywords: green finance, environmental degradation, renewable energy, financial development and environmental characteristics. This makes it possible to understand the current directions of the development of green innovations and processes are involved in the innovative development of companies.

It will conduct a bibliometric analysis of the authors who researched the concept of green innovation. In the course of the conducted analysis, it was established that in modern scientific activity there are various scientific schools of the European Union, Asian countries and other countries that investigate the processes of green innovative activity of companies. This is evidenced by the citation level of the authors' scientific works devoted to green innovations (see Fig. 4).



Create Map

Verify selected authors

Selected	Author	Citations	Total link strength
☑	shahbaz m.	245	241.14
☑	razzaq a.	244	232.84
☑	ren s.	243	239.48
☑	liu s.	243	238.90
☑	sarstedt m.	243	231.10
☑	rennings k.	240	229.00
☑	yang j.	239	236.76
☑	wang d.	238	236.26
☑	wang m.	237	227.25
☑	umar m.	234	222.84
☑	xu y.	233	231.70
☑	wu y.	231	229.64
☑	ozturk i.	231	224.57
☑	yang z.	229	227.26
☑	li q.	229	225.49
☑	chen w.	228	226.45
☑	xu j.	228	224.65
☑	yang l.	223	217.90
☑	mohsin m.	222	202.35

Fig. 4 Bibliometric analysis of the authors of the study of green innovations of companies of countries

Source: constructed by authors via VOSviewer for the authors of the study of green innovations (Input data: 3435 documents of Socials Science, 2012-2023, Scopus Database, refined).

On the basis of the analyzed scientific works, it is necessary to identify the main problematic aspects, namely: the majority of scientific studies have insufficient justification of the issues of managing green innovations of companies of countries in conditions of different technological development of production. After all, the companies of the countries of the world have different technological capabilities due to different types of development of economic systems (from developing types, transitional types to developed types). Therefore, it is necessary to pay attention to the specified scientific hypothesis of this scientific research and scientifically substantiate it.

The gap in the scientific research of the analyzed literary sources consists in the insufficient development of methodological approaches to the assessment of the level of green innovations of companies around the world with different levels of technological development of production. Therefore, there is a need to propose a methodical approach to assessing the level of green innovations of companies in countries with different levels of technological development of production.

In the study of the literature, it should also be noted the main Sustainable Development Goals, which characterize the implementation of green innovations in the activities of companies in countries, which should include: SDG9 – Industry, innovation and infrastructure, SDG12 – Responsible consumption and production, SDG17 – Partnerships for the goals [34].

METODOLOGY OF RESEARCH

The research methodology includes the following stages of scientific research.

The first stage of the research includes the establishment of indicators for assessing the level of green innovation potential of companies in countries based on the input data of the Global Innovation Index Report (GII) [2]. These indicators were clustered according to the criteria for the implementation of the Sustainable Development Goals by companies of countries that produce environmentally friendly products and services (9. Industry, innovation and infrastructure; 12. Responsible consumption and production; 17. Partnerships for the goals). When choosing these Sustainable Development Goals, the production, eco-innovation, and marketing components of companies in countries that fulfill these Sustainable Development Goals and meet the criteria of environmental orientation and responsible consumption were taken into account.

The second stage of the research includes the matrix of determining the places (ranks) of indicators of green innovations of companies of the countries, where the place (rank) of each indicator (R_{ij}) is identified. It should be noted that the weight of each indicator ($Vaga_i$) was determined using the Analysis of Hierarchies method by T. Saati [35].

The third stage of the study forms a weighted assessment [36] of clusters of indicators of green innovation of companies in countries depending on the Sustainable Development Goals.

$$Rang_{ij} = \sum(R_{ij} \cdot Vaga_{ij}), \quad (1)$$

where:

$Rang_{ij}$ – weighted estimate of the i-th indicator of green innovations of the companies of the j-th country;

R_{ij} – the rank of the i-th indicators of green innovations of the companies of j-th country; $Vaga_i$ – the weight of the i-th indicator of green innovation of the companies of the j-th country.

The fourth stage of the research determines the companies of the leading countries (L) and the companies of the outsider countries (A) of green innovation based on the formed weighted assessment of the green innovations of the companies of the countries of the world.

The fifth stage of the research is determined by the distance range of the companies of the leader country from the companies of the outsider country of green innovations according to the formula [36]:

$$D_v = Rang_A - Rang_L, \quad (2)$$

where:

D_v – the distance range of the companies of the leader country from the companies of the outsider country of green innovations;

$Rang_A$ – a weighted assessment of the companies of the outsider country of the green innovation;

$Rang_L$ – a weighted assessment of the companies of the country-leader of green innovations.

The sixth stage of the study contains the determination of the competitiveness of the country's companies that implement green innovations according to the formula [36]:

$$KSOP_i = \frac{(Rang_A - Rang_I)}{D_v}, \quad (3)$$

where:

$KSOP_i$ – competitiveness of companies of the i-th country that implement green innovations; $Rang_i$ – weighted assessment of companies of the i-th country implementing green innovations.

The seventh stage of the study establishes the level of environmental sustainability, which affects the implementation of green innovations by the companies of the countries, according to the formula:

$$LE_i = \frac{RC_i}{RC_{max}}, \quad (4)$$

where:

LE_i – the level of environmental sustainability of companies of the i-th country that implement green innovations;

RC_i – the current value of environmental sustainability of companies of i-th countries that implement green innovations;

RC_{max} – the maximum value of the indicator of environmental sustainability of the companies of the leading countries in the world that implement green innovations (according to the Global Innovation Index Report [2]).

The eighth stage of the study includes an assessment of the level of green innovation potential of the countries' companies according to the formula:

$$PGI_i = KSOP_i \cdot LE_i, \quad (5)$$

where:

PGI_i – the level of green innovation potential of companies of the i-th country.

The ninth stage of the research includes the definition of a multi-rank criterion range of levels of the green innovation potential of the countries' companies, using the Sturges formula:

$$k_{PGI_i} = \frac{PGI_{i_{max}} - PGI_{i_{min}}}{1+3.322lgN}, \quad (1)$$

where:

k_{PGI_i} – the Sturges coefficient, which characterizes the range of criterion values for the level of green innovation potential of companies in the i-th country;

$PGI_{i_{max}}$ – the maximum value of the green innovation potential of companies in the i-th country;

$PGI_{i_{min}}$ – the minimum value of the green innovation potential of companies in the i-th country;

N – the number of countries (according to the respective companies), assessment objects.

The objects of the research are companies from the countries of Central and Eastern Europe with different levels of technological development of production, which implement green innovations. Thus, among the research objects are companies from Switzerland, which is a leader in terms of technological development of production in the EU countries according to data [2, 37] (score 64.4; 1st rank of GII), companies from Lithuania and Poland – have an average level of technological development of production (Lithuania – score 37.4; 38th rank of GII and Poland – score 37.5; 39th rank of GII), Ukrainian companies have a sufficient level of technological development of production (31.0 score; 57th rank of GII), Albanian companies have a low level of technological development production (score 24.4; 84th rank of GII).

After conducting the scientific research procedure, research conclusions will be formed.

RESULTS OF RESEARCH

Let's move on to highlighting the results of the scientific research, taking into account the specified methodology of its implementation, namely to form the economic support of this administration, by developing an evaluation of green innovations of the companies of the world.

We will determine the indicators for assessing the level of the green innovation potential of the companies of the countries based on the input data of the Global Innovation Index Report [2] and Sustainable Development Goals [34] are listed (see Table 1).

Let's move on to the implementation of the second stage of evaluation, namely the matrix for determining the place (rank) of indicators of green innovations, where the place (rank) of each indicator (R_{ij}) and the weight of each indicator ($Vaga_i$) are identified, which is determined using the method Analysis of hierarchies T. Saati (see Table 2).

Table 1

Indicators for assessing the level of green innovation potential of companies in countries

Sustainable Development Goals [34]	Item (GII) [2]	Components of the global innovation index [2]	Symbol	Unit (score, conventional unit – C.U.)
12. Responsible consumption and production	*3.3*	*Ecological sustainability*	X_1	C.U.
	3.3.1	GDP (unit of energy use)	X_2	C.U.
	3.3.2	Environmental performance	X_3	C.U.
	3.3.3	ISO 14001 environmental certificates (bn. PPP$ GDP)	X_4	score
9. Industy, innovation and infrastructure	*5.2*	*Innovation linkages*	X_5	C.U.
	5.2.1	University-industry R&D collaboration	X_6	C.U.
	5.2.2	State of cluster development and depth	X_7	C.U.
	5.2.3	GERD financed by abroad (% GDP)	X_8	score
	5.2.4	Joint venture/strategic alliance deals (bn PPP$ GDP)	X_9	score
	5.2.5	Patent families (bn. PPP$ GDP)	X_{10}	score
17. Partnerships for the goals	6.2.1	Labor productivity growth (%)	X_{11}	score
	6.2.2	New businesses (th. pop. 15-64)	X_{12}	score
	6.2.3	Software spending (% GDP)	X_{13}	score
	6.2.4	ISO 9001 quality certificates (bn. PPP$ GDP)	X_{14}	score
	6.2.5	High-tech manufacturing (%)	X_{15}	score

Source: compiled by authors from the [2, 34].

When determining the expo-pair hierarchies of indicators X_1-X_{15} and their vector (weight), using the method Analysis of hierarchies by T. Saati and the MS Office Excel software complex, it was established that the range of the square root of the product of the expo-pair hierarchies of indicators X_1-X_{15} is [0.01 -92.95], and, accordingly, the weight range of indicators X_1-X_{15} [0.06-0.07] (Table 2). It should be noted that the received indicator values have a fairly large sample of indicators X_1-X_{15}, which affects the obtaining of their geometric mean value in the range [0.99-1.00]. Such a geometric mean value of X_1-X_{15} reduces the range of the obtained values of the weights of indicators X_1-X_{15}, without going beyond the framework of model adequacy.

Table 2

Matrix for determining the location (rank) of green innovation indicators of companies in countries with different levels of technological development of production and their weights (value of the indicator, rank; weight)

Components of the global innovation index	Index	Switzerland	Lithuania	Poland	Ukraine	Albania
X_1	value	54.0	46.9	32.2	21.5	39.6
	value (max)	57.3 (Malta)				
	rank	1	2	4	5	3
	weight	0.06	0.06	0.07	0.06	0.07
X_2	value	24.8	12.9	12.1	5.40	16.5
	rank	1	3	4	5	2
	weight	0.07	0.07	0.07	0.07	0.07
X_3	value	65.9	55.9	50.6	49.6	47.1
	rank	1	2	3	4	5
	weight	0.07	0.07	0.07	0.07	0.06
X_4	value	3.60	8.00	2.20	0.60	4.00
	rank	3	1	4	5	2
	weight	0.07	0.07	0.07	0.06	0.06
X_5	value	64.3	33.8	23.0	21.3	21.4
	rank	1	2	3	5	4
	weight	0.07	0.07	0.07	0.07	0.07
X_6	value	77.6	53.7	37.1	41.5	50.5
	rank	1	2	5	4	3
	weight	0.07	0.07	0.07	0.07	0.07
X_7	value	71.9	44.0	45.9	39.9	28.9
	rank	1	3	2	4	5
	weight	0.07	0.07	0.07	0.07	0.07
X_8	value	0.20	0.30	0.10	0.10	n/a
	rank	2	1	3	4	5
	weight	0.07	0.07	0.07	0.07	0.07
X_9	value	0.20	0.00	0.00	0.00	0.00
	rank	1	2	3	5	4
	weight	0.06	0.06	0.06	0.07	0.07
X_{10}	value	7.90	0.30	0.30	0.20	0.00
	rank	1	2	3	5	4
	weight	0.06	0.06	0.06	0.07	0.07
X_{11}	value	0.90	3.40	2.90	2.70	1.30
	rank	1	2	3	4	5
	weight	0.07	0.06	0.06	0.07	0.07
X_{12}	value	4.60	3.00	1.60	1.70	1.50
	rank	1	2	4	3	5
	weight	0.07	0.07	0.07	0.07	0.07
X_{13}	value	0.70	0.10	0.30	0.60	0.10
	rank	1	4	3	2	5
	weight	0.06	0.06	0.07	0.07	0.07
X_{14}	value	12.0	13.0	8.30	3.00	9.40
	rank	2	1	4	5	3
	weight	0.07	0.07	0.07	0.07	0.07
X_{15}	value	67.3	17.0	34.1	21.0	4.0
	rank	1	4	2	3	5
	weight	0.07	0.07	0.07	0.07	0.07

Source: constructed by authors, using [2] – for values, values max; experts' evaluation – for ranks/weights of the indicators.

Note that in order to reduce the subjectivity of the model, the ratio of agreement (RA) of this assessment was calculated between expert groups (university scientists, company employees, independent experts), which for the evaluated companies of the countries has a range of values [0.148-0.153] (14.8-15.3%), which corresponds to its satisfactory value of VU ≤ [10-20%] [38]. So we have a hierarchical model that is adequate.

It should be noted that with the same value of the green innovation indicators of the companies of the countries, the ranks were different, in order not to violate the adequacy of the assessment, based on the generalized indicator of the group (X_1, X_5), in the group of indicators of the Sustainable Development Goals (17. Partnerships for the goals) at the same value of the indicators, the benchmark for determining the ranks of the indicators was the assessment of the level of technological development of countries (Score) according to the source [37].

The following stages (3-8) are related to the assessment of the level of green innovation potential of companies in countries of the world with different levels of technological development of production. The results of this assessment are shown in Table 3.

Table 3

Results of evaluation of green innovations of companies of countries of the world with different levels of technological development of production.

Parameters	Switzerland	Lithuania	Poland	Ukraine	Albania
A weighted estimate of the indicator of green innovations of the companies of the country (Rang)	1.29	2.19	3.41	4.31	4.13
The distance range of the companies of the leader country from the companies of the outsider country of green innovations (D_v)	3.02				
Competitiveness of companies of the country that implement green innovations (KSOP)	1.00	0.70	0.30	0.00	0.06
The level of environmental sustainability of companies of the country that implement green innovations (LE)	0.94	0.82	0.56	0.38	0.69
The level of green innovation potential of companies of the country (PGI)	0.94	0.58	0.17	0.00	0.04
Cross-country ranking ($Rang_{PGI}$)	1	2	3	5	4

Let's move on to the graph-analytical presentation of the results of evaluating the level of green innovation potential of companies in countries where the leader has an approximation of 1.0 by vector (the maximum value of the vectors is 1.0 c.u) (see Fig. 5).

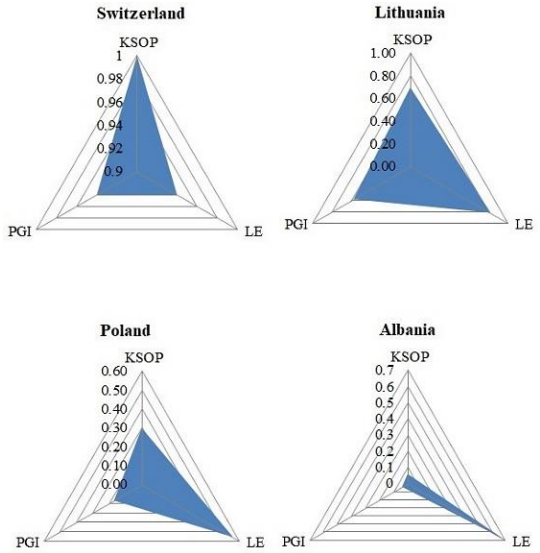


Fig. 5 Histogram of the results of the assessment of the level of green innovation potential of the companies of the countries

Let's move on to stage 9 of the scientific research methodology, namely the determination of the multi-rank criterion range of levels of green innovation potential of countries' companies, which is necessary for the formation of effective management decisions by various stakeholders of green innovations of countries' companies (company owners, executive management of companies, government bodies, investors, public associations, suppliers, consumers of green innovations). In the course of the calculation, the criterion range of the level of green innovation potential of the companies of the countries with the step was established:

$$k_{PGI_i} = \frac{0.94-0}{1+3,322lg5} = \frac{0.94}{6.35} = 0.15 \quad (7)$$

The resulting data of the multi-rank criterion range of levels of green innovation potential of the countries' companies is shown in Table 4.

DISCUSSION

Regarding the substantiation of the obtained results of the level of green innovation potential of the countries' companies, it should be noted that there is a significant impact on this potential of the level of competitiveness of the country's companies implementing green innovations. According to the obtained results of the evaluation of green innovations of the companies of the countries of the world with different levels of technological development of production, it can be concluded that Switzerland is the leader of the companies among the studied companies of the countries that implement green innovations, while the outsiders are the companies of Ukraine. In turn, at the level of technological development, Ukraine occupies a higher place than Albania, but it should be noted that the influence of negative factors, such as the military actions currently taking place on the territory of Ukraine, the decrease in the level of the population's solvency, the deterioration of the ecological environment due to the pollution of land and water resources and air negatively affect the overall rating of this country in the system of implementing green innovations by companies.

Table 4

Multi-rank criterion range of green innovation potential levels of companies of countries

PGI_i (C.U.)	**Characteristics of the range of criterion values PGI_i**	**Group**
$PGI_i \geq 0,75$	The green innovation potential of the country's companies is of high importance, which characterizes the ability of the country's companies to be in the zone of green innovation leaders and to shape the main trends of green innovation in the market	Leaders: Switzerland
$0,75 \leq PGI_i < 0,60$	The green innovation potential of the country's companies has an above-average value, which characterizes the ability of the country's companies to be generators of green innovations, forming an effective innovation ecosystem of startups, innovative projects and green innovation programs.	Green Innovation Engines: there is no correspondence among the analyzed countries
$0,60 \leq PGI_i < 0,45$	The green innovation potential of the country's companies has an average value, which characterizes the ability of the country's companies to be from the zone of competitiveness of green innovations and to effectively promote them in the domestic and foreign markets	Competitive entities: Lithuania
$0,45 \leq PGI_i < 0,31$	The green innovation potential of the country's companies is of sufficient importance, which characterizes the ability of the country's companies to be innovators of green innovations and to try to enter the zone of competitive companies implementing green innovations	Innovators: there is no correspondence among the analyzed countries
$0,30 \leq PGI_i < 0,15$	The green innovation potential of the country's companies has a satisfactory value, which characterizes the country's companies as green innovation conservatives and implementing time-tested green innovation programs using benchmarking technologies	Conservatives: Poland
$0,15 \leq PGI_i < 0$	The green innovation potential of the country's companies has a low value, which characterizes the country's companies as honest implementers of green innovation programs, while using only simple practices of implementing green innovations	Fair performers: Albania
$PGI_i = 0$	The green innovation potential of the country's companies has an unsatisfactory value, which characterizes the country's companies as an outsider in the implementation of green innovations with a significant reduction or closure of green innovation projects	Outsiders: Ukraine

It should also be noted that the obtained level of green innovation potential of the country's companies is based on the product of the competitiveness index of the country's companies implementing green innovations and the level of environmental sustainability, which affects the implementation of green innovations by the countries' companies. This indicator is set as the ratio between the current indicators of environmental sustainability of the analyzed companies of the countries and the maximum value of the indicators of environmental sustainability, which affects the implementation of environmental innovations by the companies of the countries, such companies of the country are Malta with an indicator of environmental sustainability – 57.3 C.U.

It should be noted the establishment of these values of the level of green innovation potential of the companies of the analyzed countries of Central and Eastern Europe. It should be noted that projects and programs of green innovations are currently trending in the countries of the European Union, as the main element of the implementation of the Sustainable Development Goals. When assessing the level of green innovation potential of five companies of the European Union countries, it was established that Switzerland is in the *Leaders* group ($PGI_i = 0.94$) – but it lacks the improvement of the level of environmental sustainability of the country's companies to achieve absolute leadership. Lithuanian companies at the level of environmental innovation potential ($PGI_i = 0.58$) are located in the *Competitive entities* group, which include the competitive promotion of green innovations on the domestic and foreign markets. Polish companies at the level of environmental innovation potential ($PGI_i = 0.17$) are in the Conservatives group, which characterizes the implementation of sustainable and effective green innovation programs using benchmarking approaches (implementation of successful EU practices in the field of green innovations) and vector to innovative programs. Albanian companies with levels of green innovation potential ($PGI_i = 0.04$) are in the *Fair performers* group, implementing only simple green innovation practices (energy-efficient construction and energy saving). Ukrainian companies are included in the *Outsiders* group with a level of green innovation potential ($PGI_i = 0.00$), characterized by a significant reduction and closure of green innovation programs due to external factors (military actions on the territory of the country, deterioration of the economic situation).

CONCLUSIONS

In the period of modern technological development of production, the main task is to increase the level of implementation of ecologically oriented innovations of the companies of the countries. In this research, the theory of management was developed by using the bibliometric analysis of the definition of green innovation. In the course of this analysis, it was established that recently more and more popularization of the introduction of green innovations in scientific research is given by representatives of scientific schools in China. An evaluation of the potential of green innovations of companies of countries of the world with different levels of technological development of production has been formed. Thus, in the course of calculations of the level of the potential of green innovations, it was established that the companies of the countries insufficiently emphasize environmental sustainability, giving preference to technological innovations in production, so Switzerland is the leader in the Global Innovation Index [2]. In the country's companies, in order to approach the zone of absolute leadership, there is a need to focus more on environmental sustainability in their work (environmental start-ups, eco-oriented production and services, cantonal programs for careful consumption, green campuses, green transport, etc.). Companies of Switzerland is of high importance of green innovation [0.94], which characterizes the ability of the country's companies to be in the zone of green innovation leaders and to shape the main trends of green innovation in the market

Companies of Lithuania have an average value of green innovation [0.58], which characterizes the ability of the country's companies to be from the zone of competitiveness of green innovations and to effectively promote them in the domestic and foreign markets.

Companies of Poland have a satisfactory value of green innovation [0.17], which characterizes the companies as green innovation conservatives and implementing time-tested green innovation programs using benchmarking technologies.

In turn, other analyzed companies of the countries, such as Ukraine, Albania, have a lower level of green innovation potential [0- 0.04], which is due to developing and transitional processes in the technological development of production in these countries, where the first place can it is precisely the economic component of business activity (economic factors of companies' activity) that should come out, and not the environmental component.

This conclusion confirms the sufficient level of innovation linkages of the economic activity of companies (for example, for Albania it is 21.4 c.u., for Ukraine it is 21.3 c.u., according to the report [2].

Companies of Albania have a low value [0.04], which characterizes the country's companies as honest implementers of green innovation programs, while using only simple practices of implementing green innovations.

Companies of Ukraine have an unsatisfactory value of green innovation potential [0], which characterizes the country's companies as an outsider in the implementation of green innovations with a significant reduction or closure of green innovation projects.

Criterion provision of the results of the evaluation of the green innovation potential of the companies of the countries has been formed, which contains a multi-criteria range of the levels of the green innovation potential of the companies of the countries (step 0.15 between clusters), which makes it possible to cluster the companies of the countries according to the level of the green innovation potential in order to make effective management decisions by all interested stakeholders (owners of companies, executive management of companies, state

administration bodies, investors, public associations, suppliers, consumers of green innovations).

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