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BIBLIOMETRIC ANALYSIS OF SCIENTIFIC RESEARCH ON ENVIRONMENTAL AUDIT

ABSTRACT

Excessive use of the environment has raised concerns about its protection. Over time, and especially in recent years, the topic of environmental audit has become more important, being a topic of interest to companies, governments and the public. This was due to disproportionate growth in production, increasing the world economy. In this context, governments are committed to regulating the proper use and treatment of the environment. There is a special problem in this issue, contradictions between companies, governments, due to the assessment of damage and damage to the environment, analysis of the quantity and quality of preventive measures, and so on. Therefore, any activity of enterprises must be controlled, monitored, quantified, forecast and so on. An environmental audit is one of the mechanisms of such a comprehensive analysis. Based on this, we conducted a bibliometric analysis of the concept of "environmental audit" using SciVal tools from Elsevier. This allowed us to analyze the most relevant and cited works of scientists in the field of environmental audit. In addition, the areas of research that study environmental audit were identified, the main ones being: the field of ecology, energy and engineering. This state of affairs has confirmed the importance of environmental audits for conserving energy resources and finding the latest engineering solutions to reduce excessive production impact on the environment. The main subject areas of not only environmental audit but also environmental taxation and reporting were also studied, which allowed asserting the mutual influence of such concepts on the quality of environmental data. In general, we note that the results of the analysis confirm the relevance of the topic of environmental audit due to the dynamics of increasing the number of publications for the period from 2010 to 2021 compared to environmental taxation and reporting. In addition to Elsevier's SciVal toolkit, tools such as Google trends were also used. The dynamics of Internet inquiries have confirmed the fact that their number is increasing due to global climate change or changes in legislation relating to environmental regulations and changes in tax rates. The presented verified data can be used in further studies to assess the impact of environmental audit on environmental quality.

Keywords: audit, environmental audit, environmental taxation, environmental reporting, environmental activities

JEL Classification: M42

INTRODUCTION

The current state of the environment requires immediate intervention to ensure ecosystem integrity and ecological security for all countries of the world. According to the World Health Organization, there will be approximately 250,000 additional deaths by 2050 under current climate change conditions. And by 2030, the cost of reducing health damage will be between \$2 and \$4 billion per year [1]. The solution to environmental problems is becoming more and more important among experts in the field of ecology and economics. Therefore, it is necessary to investigate the indicators that can indirectly characterize the awareness of Internet users about the tools that reduce the anthropogenic impact on the environment.

These tools are environmental taxation, environmental reporting and environmental audit. Each of these tools can effectively affect the state of the environment by means of differentiated rates of environmental tax, control over actual and reported emissions of

polluting substances into the environment, analysis of the reliability of environmental information, analysis of compliance with regulatory standards, etc.

LITERATURE REVIEW

In the fundamental works of foreign scientists, for example, the authors Arlen, J., Kraakman, R. evaluated the benefits of mandatory and voluntary environmental audit and found that social well-being is maximized by a combined approach. Researchers Boehmer, T. K., Hoehner, C. M., Wyrwich, K. W., and Brownson, R. C. it was estimated that the issues of environmental audit and environmental protection are actualized in recreational areas. A Clifton, K. J., Livi Smith, A. D., & Rodriguez, D. the development of environmental audit methodology as an assessment tool for determining priority investments is presented. Consequently, scientists have sufficiently thoroughly investigated theoretical issues related to the general problems of environmental audit. Significant attention to scientific works is focused on the importance of environmental audit, but the relevance of environmental audit in the current state of environmental pollution is still unproven.

AIMS AND OBJECTIVES

Conduct a bibliometric analysis of scientific papers on environmental audit to confirm the relevance of environmental audit issues among foreign scientists. This analysis is a quantitative tool to assess the metrics of research for the relevant periods in a particular field of knowledge. The study will be based on the scientometric database SciVal from Elsevier and Google Trends.

MATERIALS AND METHODS

SciVal from Elsevier is a software tool for comprehensive analysis of research and visualization of articles indexed in Scopus. The following keywords with the logical operator AND are used to perform meta-analysis based on SciVal tools: "environmental audit", which made it possible to perform static analysis of general metrics for the selected research area (number of topics and clusters, topics in a particular research area, number of publications and citations) at the date of analysis. Google Trends is an analytical tool for comparing terms searched through Internet queries in different countries. Using Google Trends, this article provides a regional and dynamic comparative analysis of Internet queries for specific keywords in each field (environmental auditing, environmental reporting, environmental accounting).

RESULTS

The quality of the natural environment and the reasonable use of natural resources are indispensable components of modern economic activity in all countries of the world. This is one of the main components of the economic and social development of society. Efficient use of natural resources, minimization of waste, and their place in the system of environmental management and environmental and economic audit are necessary conditions for the sustainable development of society. Therefore, it is necessary to confirm the relevance of the topic of an environmental audit by carrying out a bibliometric analysis.

The data in Fig. 1 show that environmental audit is the most researched in the environmental sciences, and accounts for 30.0% of the total number of publications posted in the Scopus database. The next most important industry is energy (17.9%). This is not unexpected because the issue of the energy audit is on the agenda of most developed countries. Scandinavian countries are the pioneers in the effective implementation of energy audits, which cause households and entrepreneurs to use energy-saving technologies in the construction and renovation of buildings and improve energy efficiency through insulation, installation of heat pumps and modern windows and doors. Consequently, it has had an impact on the focus of scientists in their own works to address the issue of irrational use of energy resources in order to reduce and develop measures aimed at efficient use. The industry of business, management and taxation ranks fourth in the use of the concept of "environmental audit" in the scientific papers. Indeed, this figure is at the level of 9.5%, curiously enough, it is preceded by the industry of engineering (9.8%).

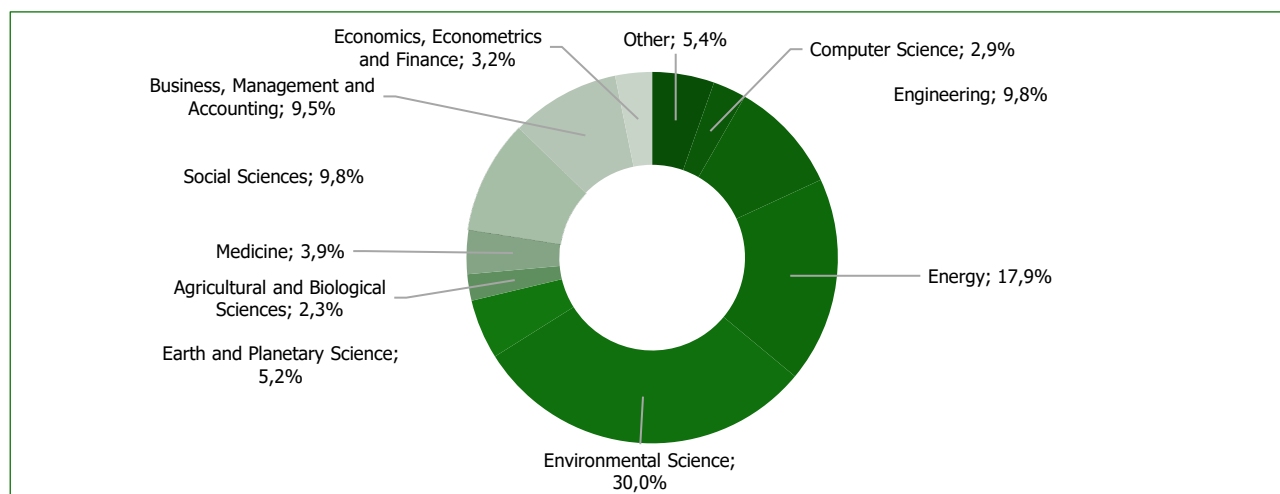


Fig. 1. Structural analysis of the subject area for the case "Environmental audit". (Compiled by the authors through SciVal from Elsevier)

As environmental audit issues are quite often presented in scientific works related to business, management and accounting, we consider it appropriate to analyze the frequency of environmental audit references with such subject branches as environmental taxation, environmental reporting and environmental business (Table 1).

Table 1. Main subjects and corresponding subject areas of environmental audit and taxation, accounting and business for 2016-2021, as of 20.12.2021. (Compiled by the authors through SciVal from Elsevier)

№	Environmental audit and environmental taxation		Environmental audit and environmental reporting		Environmental audit and environmental activities	
	Industry	%	Industry	%	Industry	%
1	Ecology	26.7	Ecology	15.4	Ecology	19.2
2	Social sciences	13.8	Others	14.3	Others	15.1
3	Energy	13.5	Engineering	11.9	Engineering	12.3
4	Economics, Econometrics and Finance	13.1	Medicine	10.9	Medicine	11.9
5	Engineering	8.1	Social sciences	9.6	Social sciences	10.2
6	Others	8.2	Business, Management and Accounting	8.0	Business, Management and Accounting	8.5
7	Business, Management and Accounting	7.3	Energy	7.7	Energy	7.9

We consider that the issue of environmental audit acquires unremarkable relevance in the field of taxation and accountability of business entities through the introduction of environmentally responsible activities, which can attract additional investment by the management of enterprises.

Taking into consideration the fact that environmentally responsible business is aimed at preserving the natural environment and reducing the anthropogenic impact on the environment by implementing the latest methods and procedures for controlling the actual amount of emissions into the air, water bodies, soil, so it is necessary to analyze the place of environmental audit in terms of environmental sciences (Fig.2).

The figure shows that the issue of environmental audit is most of all considered in the normative-legal aspect, in the context of management, monitoring and policy. In particular, 191 publications were written in such an area, which is 23.2% of the total number of publications posted in the environmental sciences concerning issues related to the environmental audit. It is also worth noting the largest field, which is 24.3% (200 scientific publications) and characterizes the general environmental science. Consequently, this confirms the fact that the environmental audit has a direct impact on the environmental condition because it is the basis for decisions to implement the latest treatment facilities or restructure the production process.

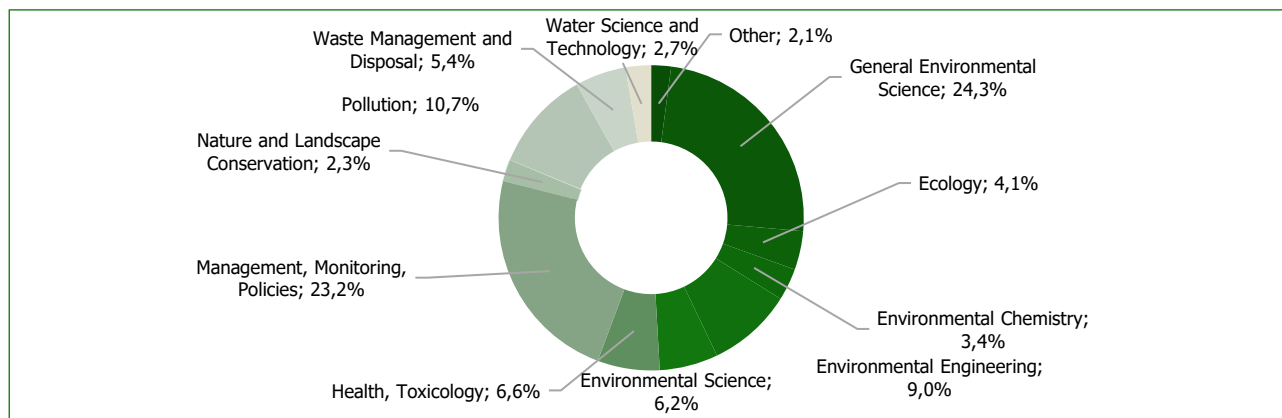


Fig. 2. Structural analysis of environmental science industries for the "Environmental audit" case study. (Compiled by the authors through SciVal from Elsevier)

The next equally important stage of the study is the analysis of publications related to environmental audits in terms of their quality, citation, revision, and so on (Fig. 3).

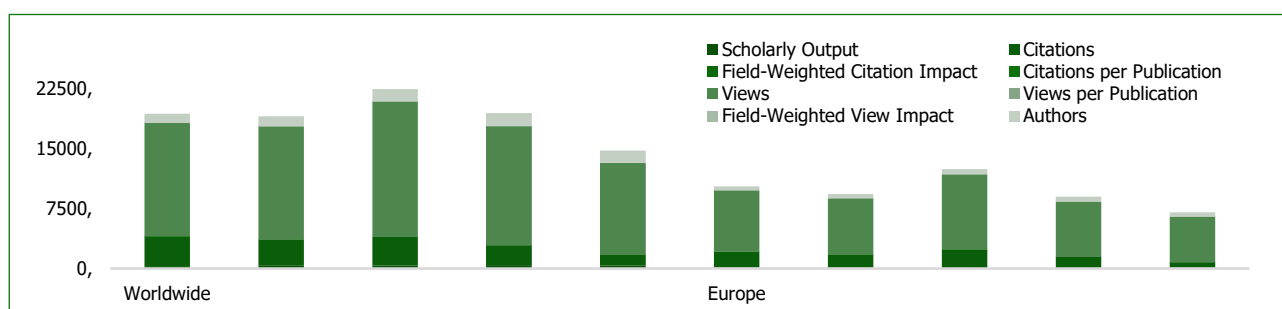


Fig. 3. Analysis of world, European and Ukrainian publications of the Ecological audit due to its use in the scientometric database Scopus for 2016-2021, as of 20.12.2021 (Compiled by the authors through SciVal from Elsevier)

Fig. 3 shows that the largest number of publications related to environmental auditing is generated by the world community. Thus, the scientific results on such topics were most viewed in 2018 with 16901 views, while the European community reached its maximum also in 2018 with 9394 views. As for the domestic works, there were 643 views for 2018.

Next, we suggest investigating the most popular research topics related to environmental audit (Fig.4).

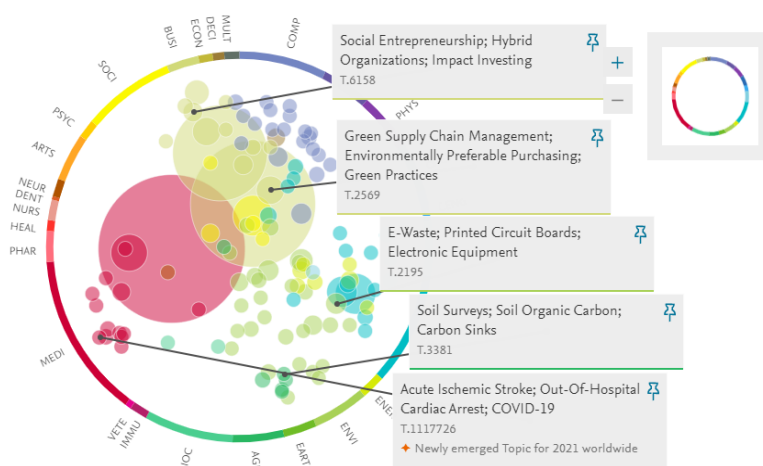


Fig. 4. Top 1% of topics for environmental audit in 2021. Note COMP Computer Science; MATH Mathematics; PHYS Physics and Astronomy; CLMI Chemistry; CENG Chemical Engineering; MATE Materials Science; ENER Energy; ENVI Environmental Science; EART Earth and Planet Sciences; AGRI Agricultural and Biological Sciences; BIOC Biochemistry, Genetics and Molecular Biology; IMMU Immunology and Microbiology; VETE Veterinary Science; MEDI Lines; PHAR Pharmacology, Toxicology and Pharmacy; HEAL Health Professions; NURS Nursing; DENT Dentistry; NEUR Neuroscience; ARTS Art and Humanities; PSYC Psychology; SOCI Social Sciences; BUSI Business, Management, and Accounting ECON Economics, Econometrics, and Finance; DECI Decision Sciences; MULT Major. (Compiled by the authors through SciVal from Elsevier)

The results of the research confirm the fact that the topic of environmental audit is relevant but not widespread among scientists, therefore we suggest analyzing the most quoted scientific works that contain the keyword "environmental audit" (Table 2).

Analysis has shown that in the economic activities of European enterprises is a widely distributed practice of environmental audit in order to justify the integration of activities in the field of environmental protection with other areas of activity, to determine an objective assessment of compliance with the requirements of regulations and requirements of environmental management of the audited object.

Also, the works of British scientists were analyzed, who in the course of their own empirical studies identified eight hypotheses that may affect the disclosure of environmental information. The hypotheses about the quality of voluntary disclosure by industrial enterprises experiencing visible environmental problems between, e.g. service industries, were confirmed. Also, enterprises in the extractive, chemical and petrochemical industries have a greater tendency to report results on the direct impact on the state of the natural environment, as such have a greater impact on the pollution of the ecosystem as a whole. Taken together, the results suggest that the quality of environmental disclosure abroad depends largely on the size of the firm and the nature of the business activity.

Table 2. The most relevant papers on environmental audit based on Scopus and SciVal. (Compiled by the authors through SciVal from Elsevier)

Nº	Author (year)	Bibliometrics	Quotation
1	Arlen, J., & Kraakman, R. (1997) [2]	Controlling corporate misconduct: An analysis of corporate liability regimes. <i>New York University Law Review</i> , 72(4), 687-779.	163
2	Boehmer, T. K., Hoehner, C. M., Wyrwich, K. W., Brennan Ramirez, L. K., & Brownson, R. C. (2006) [3]	Correspondence between perceived and observed measures of neighborhood environmental supports for physical activity. <i>Journal of Physical Activity and Health</i> , 3(1), 22-36.	71
3	Clifton, K. J., Livi Smith, A. D., & Rodriguez, D. (2007) [4]	The development and testing of an audit for the pedestrian environment. <i>Landscape and Urban Planning</i> , 80(1-2), 95-110.	262
4	Darnall, N., Seol, I., & Sarkis, J. (2009) [5]	Perceived stakeholder influences and organizations' use of environmental audits. <i>Accounting, Organizations and Society</i> , 34(2), 170-187.	128
5	Emmanuel, O., Uwuigbe, U., Teddy, O., Tolulope, I., & Eytomi, G. A. (2018) [6]	Corporate diversity and corporate social environmental disclosure of listed manufacturing companies in Nigeria. <i>Problems and Perspectives in Management</i> , 16(3), 229-244.	9
6	Moudon, A. V., & Lee, C. (2003) [7]	Walking and bicycling: An evaluation of environmental audit instruments. <i>American Journal of Health Promotion</i> , 18(1), 21-37.	221
7	Savino, M. M., & Mazza, A. (2014) [8]	Toward environmental and quality sustainability: An integrated approach for continuous improvement. <i>IEEE Transactions on Engineering Management</i> , 61(1), 171-181.	43
8	Taylor, D. W., Sulaiman, M., & Sheahan, M. (2001) [9]	Auditing of environmental management systems: A legitimacy theory perspective. <i>Managerial Auditing Journal</i> , 16(7), 411-422.	18

Additional attention is required to analyze the time range for search queries on issues related to environmental auditing, reporting, and taxation. The publicly available Google trends web application was used for this analysis (Figure 5).

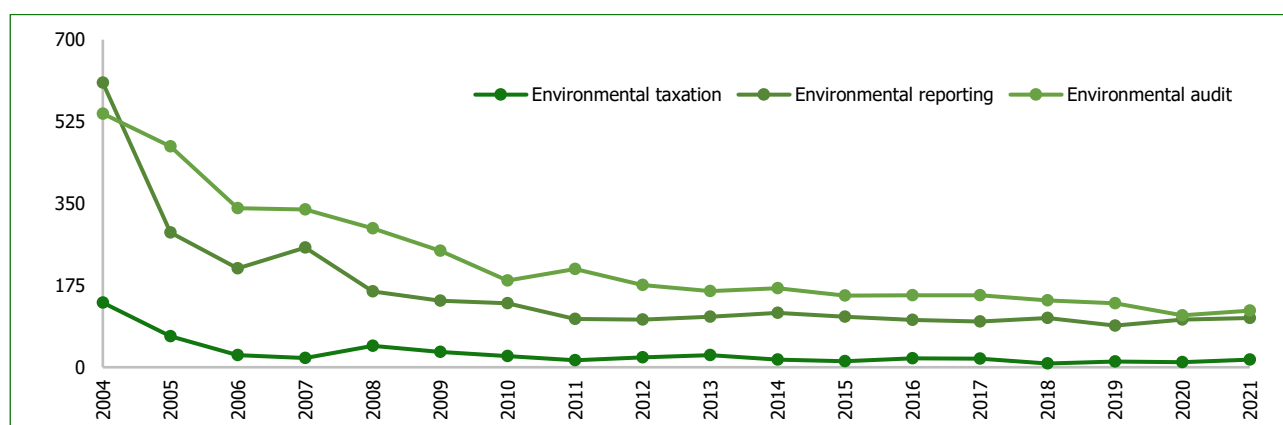


Fig. 5. Internet queries on environmental taxation, audit and reporting in 2004-2021, as of 11.10.2021.
(Compiled by the authors through Google trends)

The figure shows that the least number of Internet users generate queries with the concept of "ecological taxation". Although there was a lot of demand among search queries in 2008. We think this could be due to the fact that in 2008 the British Columbia government launched the first carbon tax reform in North America [1]. Thus, the amount paid per ton of CO₂ rose to \$10 Canadian and increased by \$5 annually. At the time, such environmental reform was not well received by the public, and the consequences of such rapid changes were monitored by experts, scientists and governments around the world. Over the next five years, scientific studies confirmed that the carbon tax reduced greenhouse gas emissions.

The next most relevant Google search query is environmental reporting. It peaked among search queries in 2004 but declined by 320 queries in 2005. Today, the number of queries for environmental reporting reaches 121 queries. Environmental reporting is an important tool of environmental communication and provides companies with reports on their environmental impact. We believe that environmental reporting remains relevant in search queries because of its variability in different contexts (corporate, national). Environmental reporting is also a mechanism of social responsibility.

The term "environmental audit" is the most relevant among Google search queries. Environmental audit plays a key role in economic and environmental control. The implementation of auditing activities allows to really assess the compliance of business entities with the requirements in the field of environmental protection, nature management and environmental safety. In addition, the environmental audit helps to identify vulnerabilities in the assessed area and develop constructive measures and prevent damage to the environment. In 2004, requests for the concept of "eco-audit" were at 542. Analyzing the domestic situation of ecological audit, 2004 was the beginning of the development of the normative sphere of an ecological audit. During the ten years, the number of inquiries fluctuated between 110 and 210, which is the highest number compared to environmental reporting and environmental taxation.

Thus, among the tools that reduce environmental pollution are environmental taxation, environmental reporting and environmental audit. Among them, environmental audit plays a significant role, occupying the leading position among Google search queries. This situation is due to the fact that every year there is a growing demand for independent audit reports on the effectiveness of the company's environmental performance, which increases the confidence of stakeholders and expands the economic opportunities of the company.

Analyzing the domestic experience of an environmental audit between domestic enterprises, it should be emphasized that it should become mandatory, and therefore be normatively defined. Article 11 of the Ukrainian Act "On environmental audit" should be supplemented and mandatory audit should be defined for such industries as energy, metallurgical, coal, chemical and petrochemical [10]. Environmental activities of the enterprises of particular industries should be audited annually by an independent auditor, and their reports should be public because their activities affect the health of citizens living in the surrounding areas and the overall level of environmental pollution.

Particular attention should be paid to the results of the environmental activities of enterprises, which, according to the Ministry of Ecology and Natural Resources of Ukraine, are the largest polluters of the natural environment (Table 3). As of 2019, the total amount of pollution is according to [11]:

- discharges of polluted wastewater into water bodies - 628.92 million m³;
- waste generation - 411,443,312.0 tons;
- emissions to atmospheric air - 1,946,799 thousand tons.

Table 3. Top 5 largest environmental polluters by type of pollution as of 2019. (Compiled by the authors based on [11])

№	Discharges to water bodies		Waste generation		Emissions to atmospheric air	
	Company name	mln m ³	Company name	mln tons	Company name	thousand tons
1	PJSC "AK Kyivvodokanal"	287,4	PJSC "Northern GZK"	85,0	PJSC "Ilyich Iron And Works Of Mariupol"	247,3
2	PJSC "Dneprovsky Integrated Iron&Steel Works"	55,7	PJSC "Ingulets GZK"	69,9	PJSC "ArcelorMittal Kryvyi Rih"	230,8
3	Utility company "Dnirovodokanal"	51,9	PJSC "Central GZK"	64,8	Burshtyn TES PJSC DTEK "Zahidenergo"	169,9
4	LLC MCF «NICE»	33,8	PJSC "Poltava GZK"	62,9	Kurakhivska TES LLC DTEK "Skhidenergo"	131,4
5	LMUC "Lvivvodokanal"	33,0	LLC "Yeristovo GZK"	28,8	PJSC "Pavlogradvuhilla"	120,6

Data from the Ministry of Ecology and Natural Resources of Ukraine also confirms the fact that every year emissions of pollutants into the water and air and also waste are increasing. And the number of the biggest polluters is growing. That confirms the necessity of functioning of the obligatory ecological audit. After all, an environmental audit is one of the effective tools of control over the actual performance of environmental activities of enterprises. Analysis of foreign experience confirmed the fact that the greater the environmental impact of the enterprise, the more it discloses its own environmental information, on the implemented environmental measures, installed treatment facilities, the choice of alternatives among eco-materials, etc.

CONCLUSIONS

The research presented directions correlating with the study of environmental audit, where special attention should be paid to the relationship of an environmental audit with the protection of life and health of the population. Also, an environmental audit acts as a mechanism for assessing the quality of environmental activities of enterprises, which proportionally affects the sphere of health care. Particular attention was paid to the essence of the environmental audit, which is a process of the compliance audit, and it was also determined that it cannot be identified with the audit of financial statements. So, the bibliometric analysis showed that the issue of environmental audit is actualized every year and depends proportionally on environmental pollution.

It is also worth paying attention that the domestic legislation in the field of an environmental audit requires changes, especially attention should be paid not only to the regulatory support but also to the process of environmental auditing. Because every year the environmental situation is deteriorating, and the existing mechanisms of control over the level of pollution in the natural environment have lost their effectiveness. While the environmental audit will serve not only through the control of environmental activities of the business entity but also will encourage businesses to conduct environmentally responsible business in order to expand markets and increase investment through increased stakeholder confidence in a particular organization.

Further, the authors will present hypotheses that probably affect the quality of the environmental audit. Such research will be carried out with the help of the mathematical modelling tool Stata.

ADDITIONAL INFORMATION

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БІБЛІОМЕТРИЧНИЙ АНАЛІЗ НАУКОВИХ ДОСЛІДЖЕНЬ ІЗ ПИТАНЬ ЕКОЛОГІЧНОГО АУДИТУ

Надмірне використання навколишнього середовища викликало занепокоєння щодо його охорони. Із часом, особливо за останні роки, тематика екологічного аудиту стала більш важливою, будучи темою, яка цікавить компанії, уряди та громадськість. Це стало наслідком непропорційного зростання виробничих показників, примноживши світову економіку. У цьому контексті уряди зобов'язуються регулювати належне використання навколишнього середовища та поводження з ним. У цьому питанні виникають особливі проблеми, суперечності між компаніями, урядами через оцінку збитків і шкоди навколишньому середовищу, аналіз кількості та якості профілактичних заходів тощо. Тому будь-яку діяльність підприємств необхідно контролювати, наглядати, кількісно оцінювати, прогнозувати тощо. Екологічний аудит є одним із механізмів такого всебічного аналізу. Саме на основі цього ми провели бібліометричний аналіз поняття «екологічний аудит» за допомогою інструментів SciVal від Elsevier. Це дозволило проаналізувати найбільш релевантні та цитовані роботи вчених на тему екологічного аудиту. Окрім цього були визначені напрями досліджень, які вивчають екологічний аудит, серед них основними є сфера екології, енергетики та інженерії. Таке становище підтвердило важливість екологічного аудиту для збереження кількості енергетичних ресурсів та пошуку новітніх інженерних рішень для скорочення надмірного виробничого впливу на довкілля. Також у роботі було досліджено основні предметні галузі не лише екологічного аудиту, але й екологічного оподаткування та звітності, що дало змогу говорити про взаємний вплив таких понять на якість екологічних даних. Загалом зауважимо, що результати аналізу підтверджують актуальність теми екологічного аудиту через динаміку зростання кількості публікацій за період з 2010 по 2021 роки, порівнюючи з екологічним оподаткуванням та звітністю. Окрім інструментарію SciVal від Elsevier, у роботі також був використаний Google trends. Динаміка інтернет-запитів підтвердила факт підвищення кількості їх унаслідок глобальних кліматичних змін чи змін законодавства, яке стосується екологічних норм та змін ставок податків. Представлені перевірені дані можуть бути використані в подальших дослідженнях для оцінки впливу екологічного аудиту на якість навколишнього середовища.

Ключові слова: аудит, екологічний аудит, екологічне оподаткування, екологічна звітність, екологічна діяльність

JEL Класифікація: M42