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EVOLUTION OF THE CONCEPTUAL FOUNDATIONS OF DIGITAL INCLUSIVITY AND GREEN ECONOMIC GROWTH: A BIBLIOMETRIC ANALYSIS OF THE SCIENTIFIC LANDSCAPE

The article examines the evolution of the conceptual foundations of digital inclusion and green economic growth within the contemporary scientific landscape. The study focuses on the transformation of approaches to digital inclusion from a predominantly technological interpretation associated with access to digital infrastructure and overcoming the digital divide toward a multidimensional concept encompassing digital skills, accessibility, digital equity, social participation, and sustainable development outcomes. The research also explores the growing convergence between digital and green transformation agendas and the emerging role of digital inclusion as a potential factor in ensuring inclusive and environmentally oriented economic development. To identify the dynamics of conceptual and terminological changes, the study applies a combination of analytical approaches, including Google Trends analysis of search interest in the terms "digital inclusion" and "green economic growth", Google Books Ngram Viewer analysis of their long-term terminological prevalence, and bibliometric analysis of scientific publications using VOSviewer. The results demonstrate an increasing research interest in digital inclusion and a gradual expansion of its thematic boundaries, accompanied by the strengthening of links between digitalization, sustainable development, green economy, and environmental sustainability. The bibliometric analysis identifies major thematic clusters and their interconnections, highlighting the interdisciplinary nature of the research field. The findings confirm a gradual shift from the digital divide paradigm toward a broader understanding of digital inclusion as a multidimensional condition for social and economic participation and reveal the increasing integration of digital inclusion into the discourse of green transformation and sustainable economic development. The study provides a basis for further theoretical and empirical research into the role of digital inclusion as a potential catalyst for green economic growth.

Keywords: digital inclusion, digital divide, digital equity, green economic growth, green economy, sustainable development, digital transformation, environmental sustainability.

ЗЯБІНА Євгенія, ІНЬ Тінгтінг

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ЕВОЛЮЦІЯ КОНЦЕПТУАЛЬНИХ ЗАСАД ЦИФРОВОЇ ІНКЛЮЗИВНОСТІ ТА ЗЕЛЕНОГО ЕКОНОМІЧНОГО ЗРОСТАННЯ: БІБЛІОМЕТРИЧНИЙ АНАЛІЗ НАУКОВОГО ЛАНДШАФТУ

У статті досліджено еволюцію концептуальних засад цифрової інклюзивності та зеленого економічного зростання в сучасному науковому ландшафті. Основну увагу зосереджено на трансформації підходів до розуміння цифрової інклюзивності: від її переважно технологічного трактування, пов'язаного з доступом до цифрової інфраструктури та подоланням цифрового розриву, до багатовимірної концепції, що охоплює цифрові навички, доступність цифрових технологій, цифрову рівність, соціальну участь та результати сталого розвитку. Особливу увагу приділено посиленню взаємозв'язку між цифровою та зеленою трансформаціями, а також формуванню ролі цифрової інклюзивності як потенційного чинника забезпечення інклюзивного та екологічно орієнтованого економічного розвитку. Для виявлення динаміки концептуальних і термінологічних змін застосовано комплекс аналітичних підходів, зокрема аналіз пошукового інтересу до термінів «digital inclusion» та «green economic growth» за допомогою Google Trends, дослідження їхньої довгострокової термінологічної поширеності з використанням Google Books Ngram Viewer, а також бібліометричний аналіз наукових публікацій у програмному середовищі VOSviewer. Результати засвідчують зростання наукового інтересу до цифрової інклюзивності та поступове розширення її тематичних меж, що супроводжується посиленням зв'язків із цифровізацією, сталим розвитком, зеленою економікою та екологічною стійкістю. Бібліометричний аналіз виявив основні тематичні кластери та взаємозв'язки між ними, що підтверджує міждисциплінарний характер досліджуваної проблематики. Встановлено поступовий перехід від парадигми цифрового розриву до ширшого розуміння цифрової інклюзивності як багатовимірної умови соціальної та економічної участі. Водночас виявлено її дедалі активнішу інтеграцію в науковий дискурс зеленої трансформації та сталого економічного розвитку. Отримані результати формують підґрунтя для подальших теоретичних та емпіричних досліджень ролі цифрової інклюзивності як потенційного каталізатора зеленого економічного зростання.

Ключові слова: цифрова інклюзія, цифровий розрив, цифрова рівність, зелене економічне зростання, зелена економіка, сталий розвиток, цифрова трансформація, екологічна стійкість.

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STATEMENT OF THE PROBLEM IN GENERAL AND ITS RELATIONSHIP WITH IMPORTANT SCIENTIFIC OR PRACTICAL TASKS

The contemporary development of the digital economy and the implementation of sustainable development principles are increasingly determined by the interaction between digital and green transformations. At the same time, the concept of digital inclusion has long been considered primarily through the lens of bridging the digital divide and ensuring access to digital infrastructure, which does not reflect the contemporary expansion of its scope to encompass digital competencies, equality of opportunities, social participation, and the effectiveness of technology use. In parallel, a new research direction is emerging in which digitalisation is linked to the green economy, environmental sustainability, and the achievement of sustainable economic growth. This gives rise to a scientific problem associated with the fragmented nature and insufficient systematisation of conceptual approaches to the interrelationship between digital inclusion and green economic growth, as well as the need to identify the stages in the transformation of the corresponding scientific discourse.

Identifying key concepts, thematic interrelationships, and directions of their evolution is important for deepening the theoretical foundations of research into digital inclusion as a potential factor in sustainable and environmentally oriented development. Thus, the relevance of the study is determined by the need for a systematic analysis of the evolution of the scientific landscape of digital inclusion and green economic growth, which will make it possible to identify current trends, established thematic clusters, and promising directions for further scientific research.

ANALYSIS OF LATEST RESEARCH AND PUBLICATIONS

The contemporary scientific discourse on digital inclusion is characterised by an expansion of its interpretation from bridging the digital divide and ensuring access to technologies towards a multidimensional concept encompassing digital skills, technology use, social participation, institutional conditions, and the effectiveness of digitalisation. At the same time, the interrelationship between digital inclusion and the goals of sustainable development, green transformation, and environmental sustainability is becoming increasingly pronounced.

The first strand encompasses studies of digital inclusion as a prerequisite for sustainable socio-economic development. Using data from 130 countries, Alhassan and Adam established a positive impact of ICT access and use on digital inclusion and its relationship with the achievement of the Sustainable Development Goals, particularly SDG 11. The authors substantiate the role of digital inclusion as a mechanism for transforming technological capabilities into social sustainable development outcomes [1]. In turn, Salisu et al., using a sample of students in Saudi Arabia, demonstrated that the impact of digital inclusion on well-being is determined not only by access, but also by digital skills, ease of use, and connectivity, confirming its multidimensional nature [11].

The second strand is associated with a rethinking of the content and measurement of digital inclusion. Jia, Du and Yan, having compared international methodologies for its assessment, identified five key dimensions: access, skills, use, adoption, and impact, emphasising the insufficient attention paid by current indices to the effectiveness of digital inclusion [9]. The institutional aspect is developed by Zayer et al., who demonstrate that digital exclusion can be shaped not only by individual limitations but also by algorithmic systems and the institutional organisation of digital environments [15]. Figueiredo et al. conceptualise digital inclusion as a collective market practice, emphasising market design, institutional responsiveness, and participatory infrastructure [5]. Smit, Swart and Broersma, examining digital citizenship among socially vulnerable groups, demonstrate that the digitalisation of public and social services can reinforce exclusion in the absence of adaptation of digital services to users' actual needs [12].

The third strand comprises studies of the relationship between digital inclusion, green transformation, and environmental sustainability. Based on panel data from 284 Chinese cities for 2011-2023, Ma et al. established a positive impact of digital inclusion on urban green transformation through the mechanisms of information dissemination, public participation, and social accountability [10]. Ji and Abbas demonstrated that inclusive finance can contribute to the expansion of digital inclusion and link it to environmental sustainability in African countries, while the effects depend on socio-demographic conditions [8]. Xu et al. consider digital financial inclusion as a factor in the adoption of climate-smart agriculture and the enhancement of supply chain resilience, emphasising the moderating role of human capital [14]. Annaufal and Muafi, in turn, demonstrate that digital inclusion does not automatically ensure improved green performance: green transformational leadership and motivation play a significant role [2].

Thus, contemporary studies demonstrate the conceptual transformation of digital inclusion – from a tool for bridging the digital divide to a systemic prerequisite for social, economic, and environmental sustainability. At the same time, the scientific field remains fragmented: individual studies focus on the measurement of digital inclusion [9], social outcomes [1; 11], institutional mechanisms [5; 12; 15], or its impact on green transformation [2; 8; 10; 14]. This necessitates a comprehensive study of the evolution of scientific approaches, thematic structure, and interrelationships between digital inclusion and green economic growth, which determines the subsequent logic of conducting the bibliometric analysis.

FORMULATION OF THE OBJECTIVES OF THE ARTICLE

To investigate the evolution of the conceptual foundations of digital inclusion and green economic growth based on an analysis of the dynamics of scientific and public interest in the respective concepts, their terminological transformation, and the thematic structure of the contemporary scientific landscape, using Google Trends [7], Google Books Ngram Viewer [6], and the VOSviewer bibliometric tool [13].

PRESENTATION OF THE MAIN MATERIAL

The first stage of the study is to identify the socio-scientific salience of the concepts “digital inclusion” and “green economic growth” in the digital information environment. For this purpose, the Google Trends tool [7] was used, which makes it possible to trace the dynamics of search interest in the specified terms over time. This approach complements the traditional analysis of scientific publications, as it makes it possible to capture not only the quantitative growth in research but also changes in attention to the respective concepts in the global information space. This is particularly relevant in the context of the acceleration of digital transformation, the COVID-19 pandemic, the spread of artificial intelligence, intensifying climate challenges, and the transition towards green economy models. The contemporary European approach is also indicative, as it regards the digital and green transitions as interconnected directions of economic and societal transformation [3].

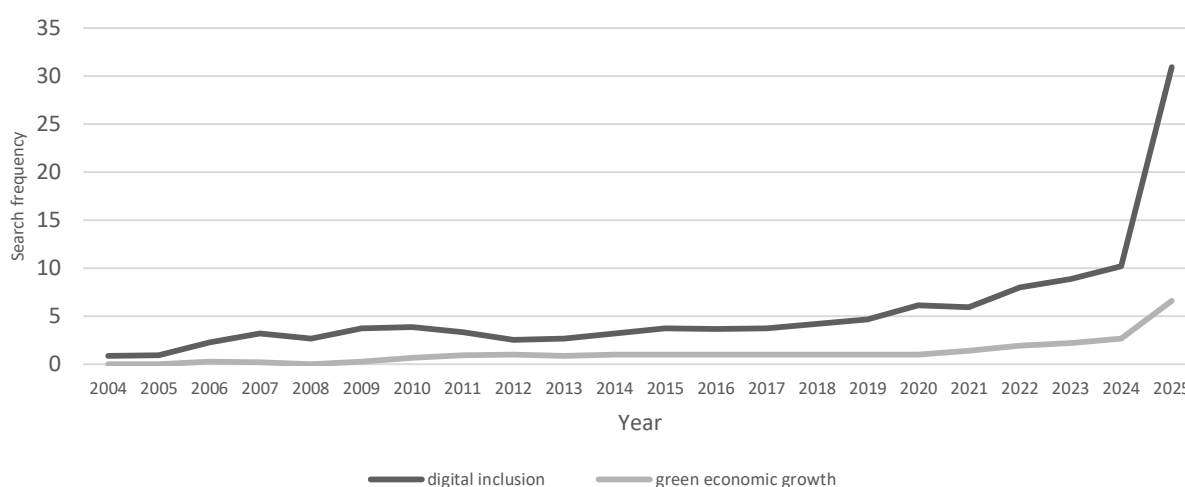


Fig 1. Dynamics of search queries “digital inclusion” and “green economic growth” on Google, 2004–2025

Source: constructed by the authors based on data [7]

The dynamics presented in Fig. 1 demonstrate a gradual but uneven increase in attention to both concepts under study. During 2004–2018, search interest in “digital inclusion” remained relatively low, with occasional fluctuations, corresponding to a period of gradual transition from the digital divide agenda towards a broader understanding of digital inclusion. After 2019, more sustained growth can be observed, which became particularly pronounced in 2020. This turning point can be associated with the COVID-19 pandemic, which sharply increased the dependence of education, employment, public and social services on digital infrastructure while simultaneously exacerbating the problem of unequal access to it. The United Nations also emphasised that the pandemic demonstrated the critical importance of digital technologies for remote work, education, healthcare, and access to services [4].

The most pronounced feature of the figure is the sharp increase in search interest in “digital inclusion” in 2025, whereas “green economic growth” was characterised by substantially lower search frequency for most of the period and only gradual growth. This dynamic reflects increasing attention to the inclusiveness of digital transformation against the backdrop of the active spread of generative AI, digital public services, and the digital economy. Notably, in 2025, the European Commission placed particular emphasis on the need to simultaneously ensure digital transformation, the development of digital skills, and the inclusion of the population in the digital society, while also using digitalisation to support the green transition [3]. At the same time, the lower search activity for the term “green economic growth” does not indicate the lower significance of the green agenda, but may result from the use of a broader range of alternative concepts, such as green growth, green economy, sustainable development, green transition, and others.

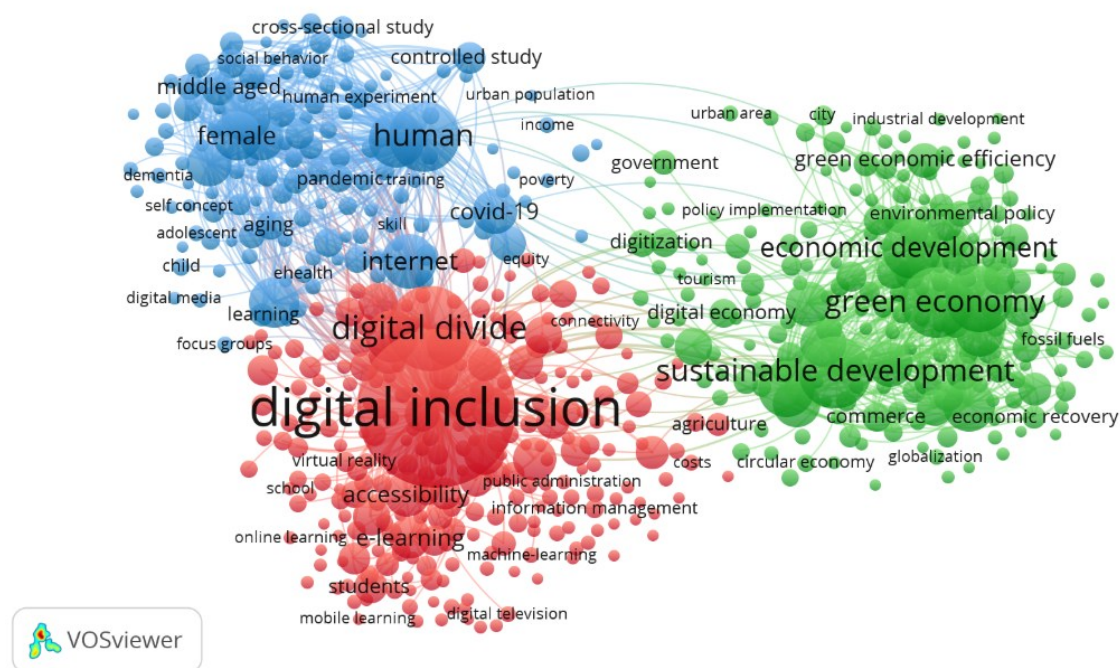
The dynamics identified using Google Trends [7] characterise contemporary attention to the concepts but do not make it possible to trace their formation over the long term or changes in the ways in which they have been conceptualised. Therefore, the next stage of the study involves the use of Google Books Ngram Viewer [6], which makes it possible to analyse the frequency of use of the respective terms in a corpus of digitised books over time. This makes it possible to complement the analysis of current search activity with a retrospective examination of

The chart displays two data series over time from 1990 to 2022. The blue line, labeled 'digital inclusion', starts near zero in 1990 and shows a consistent upward trend with some fluctuations, reaching approximately 0.00000700% by 2022. The red line, labeled 'green economic growth', also starts near zero and shows a very gradual, steady increase, reaching approximately 0.00000005% by 2022. The y-axis represents the contribution to GDP growth in percentage, ranging from 0.00000000% to 0.00000800%. The x-axis represents years from 1990 to 2022, with major ticks every five years.

Year	Digital Inclusion Contribution (%)	Green Economic Growth Contribution (%)
1990	0.00000000	0.00000000
1995	0.00000000	0.00000000
2000	0.00000005	0.00000000
2005	0.00000015	0.00000000
2010	0.00000025	0.00000001
2015	0.00000035	0.00000002
2020	0.00000060	0.00000004
2022	0.00000700	0.00000005

The data presented in Fig. 2 demonstrate a fundamentally different temporal pattern. The term “digital inclusion” was virtually absent from book discourse for a long period; however, beginning in the late twentieth and early twenty-first centuries, its frequency gradually increased, and after 2000 it acquired a distinct upward trend. This is consistent with the spread of digital technologies, the formation of the information society, and the gradual shift in research focus from digital access towards issues of digital inequality and inclusion. By contrast, “green economic growth” is characterised by a considerably lower frequency and slower dynamics, which may be explained by the fact that the conceptual issues of the green economy developed for a long time under different terminological designations.

Thus, a comparison of the two information environments provides grounds for distinguishing between the short-term dynamics of public and academic interest (Google Trends) and the long-term evolution of terminological discourse (Google Books Ngram Viewer). The identified trend confirms the appropriateness of proceeding to the next stage of the study – a bibliometric analysis of scientific publications and keywords using VOSviewer [13]. While Google Trends [7] and Ngram [6] make it possible to establish the temporal dynamics and dissemination of concepts, VOSviewer [13] will make it possible to determine the structure of the established scientific field, the interrelationships between key terms, thematic clusters, and directions of their transformation. It is precisely the combination of these levels of analysis that will make it possible to comprehensively reveal the evolution of the conceptual foundations of digital inclusion and green economic growth.



Вісник Хмельницького національного університету. Серія: Економічні науки 2026, № 5 173

The results of the bibliometric analysis of keywords, presented in Fig. 3, make it possible to move from the quantitative recording of the dynamics of research interest to determining the structure and internal organisation of the contemporary scientific landscape of digital inclusion. In contrast to the analysis of search queries conducted at the previous stage, the visualisation of relationships between keywords makes it possible to establish which concepts form stable thematic cores, how they are interconnected, and in which directions the subject field of research is expanding. As the results indicate, the established scientific discourse has a pronounced interdisciplinary character and develops at the intersection of digital, socio-economic, and environmental issues.

The central position is occupied by digital inclusion, which is directly associated with digital divide, accessibility, internet, connectivity, learning, online learning, public administration, information management, and other concepts. This structure confirms that digital inclusion remains a fundamental category of the research field, although its content is gradually extending beyond the problem of physical access to digital infrastructure. The presence of the categories accessibility, connectivity, learning, skills, and equity within this cluster indicates a transition towards a multidimensional understanding of the digital divide, whereby the issue is not only the ability to connect to the digital environment but also the capacity of the population to use digital resources effectively for education, employment, access to services, and social interaction.

At the same time, the structure of the network demonstrates a substantial expansion of the social dimension of digital inclusion. A distinct thematic core is formed by the concepts human, female, aging, middle aged, adolescent, child, health, and social behavior, indicating growing attention to the differentiated impact of digitalisation on various social and demographic groups. Issues concerning the digital participation of older people, the accessibility of digital services, education, and healthcare are becoming particularly relevant. The presence in the network of concepts associated with the pandemic additionally reflects the role of COVID-19 as a catalyst for rethinking digital access: digital technologies became a necessary condition for maintaining educational, professional, and social activity, while simultaneously exacerbating the problem of digital inequality.

An equally important result is the convergence of the digital and green thematic clusters. The green cluster concentrates concepts such as green economy, sustainable development, economic development, green economic efficiency, environmental policy, economic recovery, circular economy, agriculture, and others, while the connection with digital issues is established through digitisation, digital economy, connectivity, government, income, poverty, and economic development. This indicates the gradual formation of an interdisciplinary field in which digitalisation is considered not only as a source of economic modernisation but also as a potential informational, institutional, and technological catalyst for green transformation. Thus, the identified structure of the scientific field confirms a gradual shift from studying digital inclusion as a mechanism for bridging the digital divide towards considering it as a component of a mechanism for ensuring socially inclusive and environmentally oriented economic development.

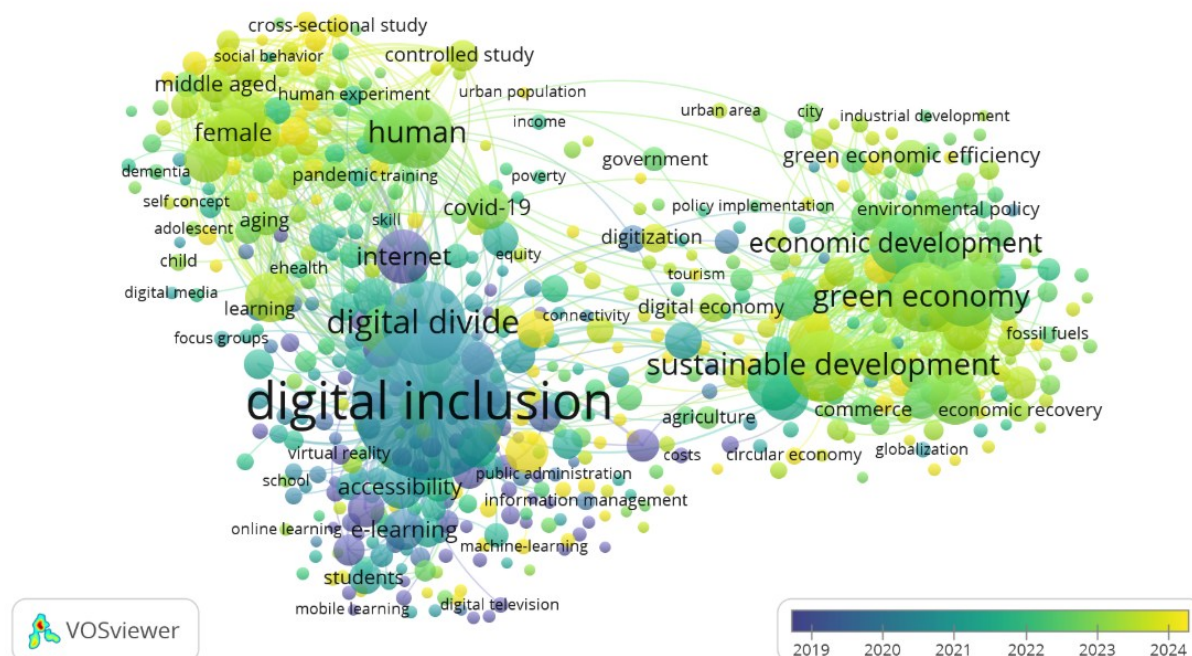


Fig 4. Evolution of thematic emphases in research on digital inclusion and green economic development
Source: constructed by the authors using [13]

The dynamic evolution of the scientific discourse on digital inclusion and green economic growth is presented in Fig. 4, which makes it possible to complement the static visualisation of thematic interrelationships with an analysis of their transformation over time. Whereas the previous map reflects the structure of the established scientific field

and the relationships between its thematic components, the evolutionary map makes it possible to trace changes in research priorities and the gradual expansion of the subject area of digital inclusion. The identified dynamics indicate a gradual transition from a narrow focus on access to information and communication technologies and the digital divide towards a comprehensive consideration of digital participation, social equality, sustainable development, and green transformation.

At the initial stages of the period under study, concepts primarily related to digital divide, information technology, internet, access, and digital inclusion dominate, reflecting the infrastructure and technological paradigm underlying the formation of the concept. The main attention of researchers was focused on the problems of unequal access to digital resources and the need to ensure the basic prerequisites for population participation in the information society. Subsequent evolution is characterised by a shift in emphasis towards digital skills, digital literacy, accessibility, social inclusion, and digital equity. Thus, digital inclusion gradually acquires a multidimensional character, in which the effectiveness of digital inclusion is determined not only by the availability of access but also by the ability of different population groups to use digital technologies effectively and derive economic and social benefits from them.

At subsequent stages, the scientific landscape shows an increasing presence of concepts related to sustainable development, green economy, environmental sustainability, economic development, digital economy, and green transformation. This indicates a gradual conceptual convergence of the digital and environmental agendas. Digitalisation is increasingly viewed as a factor in the structural modernisation of the economy, improving resource-use efficiency, fostering innovation, and shaping new models of sustainable production and consumption. At the same time, digital inclusion itself is gaining importance as a mechanism for ensuring that the benefits of digital and green transformation are accessible to broader sections of the population rather than being concentrated exclusively among the most technologically and economically capable groups.

Thus, Fig. 4 reflects the gradual formation of a contemporary integrated research paradigm in which digital inclusion, social inclusion, and green economic growth are regarded as interconnected components of the transformation of the economy and society. The evolution of keywords demonstrates a transition from the issue of the digital divide to the broader category of digital inclusion and subsequently to its combination with sustainability, green economy, environmental sustainability, and digital transformation. At the same time, this dynamic confirms that contemporary scientific discourse is shifting from the study of individual digital barriers towards the search for systemic mechanisms for using digital opportunities to ensure inclusive and environmentally oriented economic development. This result provides the theoretical basis for further generalisation of the identified trends and the formation of the conceptual foundations of digital inclusion as a catalyst for green economic growth.

Thus, the analysis conducted demonstrated a consistent transformation of the scientific landscape of digital inclusion and green economic growth – from a predominantly technology-oriented focus on access to digital infrastructure and bridging the digital divide towards a comprehensive understanding of digital inclusion as a multidimensional factor in social, economic, and environmental transformation. The combination of the analysis of search dynamics using Google Trends [11], terminological evolution based on data from Google Books Ngram Viewer [14], and bibliometric analysis of keywords in VOSviewer [15] made it possible to identify not only temporal changes in research attention but also the gradual convergence of the digital and green agendas. At the same time, the results confirm the fragmented nature of existing scientific approaches and the need for their conceptual generalisation, thereby providing a basis for developing a holistic understanding of the role of digital inclusion in ensuring inclusive, sustainable, and environmentally oriented economic development.

CONCLUSIONS FROM THIS RESEARCH AND PROSPECTS FOR FURTHER RESEARCH IN THIS DIRECTION

The study established that the contemporary conceptualisation of digital inclusion is undergoing substantial transformation: from its initial interpretation as a mechanism for ensuring access to digital infrastructure and bridging the digital divide to a multidimensional category encompassing accessibility, digital skills, technology use, equality of opportunities, social participation, and the outcomes of digitalisation. The analysis of contemporary scientific publications demonstrated the increasing interdisciplinary nature of this field and its gradual integration with issues of sustainable development, social well-being, digital citizenship, the institutional environment, and environmental sustainability. At the same time, it was found that digital inclusion is increasingly regarded not as an end result of digitalisation but as a mechanism for ensuring the equitable distribution of the economic and social effects of digital transformation. The analysis of search dynamics in Google Trends [7] confirmed growing public and academic attention to digital inclusion, particularly during periods of increasing digital dependence of economic and social processes, while the analysis of Google Books Ngram Viewer [6] made it possible to trace the long-term establishment of the respective terminology within the broader socio-economic discourse.

Bibliometric analysis and the visualisation of keywords in VOSviewer [13] made it possible to systematise the established scientific landscape and identify its main thematic interrelationships. The results demonstrated the coexistence of several interconnected research areas: digital access and bridging the digital divide; social and digital inequality; digital skills and accessibility; digital governance and public participation; as well as sustainable development, the green economy, and environmental sustainability. The evolutionary analysis of keywords confirmed

a gradual shift in scientific emphasis from the categories of digital divide and access towards digital inclusion, digital equity, digital transformation, sustainable development, and green economy. Thus, the research findings demonstrate the formation of a new interdisciplinary research field in which digital inclusion acquires potential significance as one of the factors of green economic transformation, although the nature and strength of this relationship remain insufficiently systematised at the conceptual and empirical levels.

The study confirms the relevance of further developing an integrated approach to understanding digital inclusion in the context of green economic growth, which should simultaneously take into account technological, social, institutional, and environmental dimensions. The identified evolution of the scientific discourse provides a theoretical basis for moving from the analysis of individual manifestations of digital inequality towards the study of mechanisms through which ensuring equal access to digital resources, developing digital competencies, and engaging different social groups in the digital economy can contribute to achieving the objectives of green transformation. A promising direction for further research is the development of methodological tools for assessing digital inclusion as a potential catalyst for green economic development, particularly taking into account the specific characteristics of national economies, regional differentiation, and contemporary socio-economic challenges.

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