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**ECONOMIC ASPECTS OF THE USE OF INTERNET TECHNOLOGIES
IN THE AGRICULTURAL SECTOR: RESULTS OF BIBLIOMETRIC
ANALYSIS**

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ЕКОНОМІЧНІ АСПЕКТИ ЗАСТОСУВАННЯ ІНТЕРНЕТ- ТЕХНОЛОГІЙ В АГРОСЕКТОРІ: РЕЗУЛЬТАТИ БІБЛІОМЕТРИЧНОГО АНАЛІЗУ

The article presents a comprehensive bibliometric analysis of the economic aspects of the use of Internet technologies in the agricultural sector with an emphasis on determining the dynamics, geography, and affiliations of scientific research over the past decades. More than 2700 publications from 1982 to 2024 were analyzed using Web of Science as the main data source and the analytical tool Power BI. The distribution of scientific publications by years, countries, institutions, authors, research fields and citation activity was tracked. It was determined that during 2015-2024, the number of scientific publications at the intersection of agriculture and digital technologies more than tripled, reflecting the growing relevance and scientific interest in digital transformation in

agribusiness. The study revealed the dominance of countries such as the United States, England, Switzerland, the Netherlands, and Germany in terms of research volume and impact, while Ukraine's contribution remains limited at 1.8% of the total number of publications. It is determined that the scientific areas with the largest number of scientific publications on the subject of the study include 'Agriculture', 'Business and Economics' and 'Computer Science'. Key research topics include digital marketing, e-commerce, precision agriculture, Agri-IoT, and the use of economic and mathematical models to assess efficiency and return on investment. The most cited papers apply DEA, regression modeling, and system dynamics modeling, often integrating survey data with online behavioral analytics. The article emphasizes the lack of systematization of empirical research on the economic content of Internet technologies in the Ukrainian agricultural sector, and the infrastructure and skills barriers that impede the full implementation of digital tools. The findings can be used to develop national agricultural strategies, educational programs, and funding priorities in science and technology policy. In addition, the bibliometric approach used allows us to assess trends in international cooperation, identify leading research centers, and reflect thematic priorities.

У статті представлено комплексний бібліометричний аналіз економічних аспектів використання інтернет-технологій в аграрному секторі з акцентом на визначенні динаміки, географії, афіліації наукових досліджень за останні десятиліття. Проаналізовано понад 2700 публікацій з 1982 по 2024 рік з використанням як основного джерела даних Web of Science, та аналітичного інструменту Power BI. Відстежено розподіл наукових публікацій за роками, країнами, установами, авторами, галузями досліджень та активністю цитування. Визначено, що протягом 2015-2024 років кількість наукових публікацій на перетині сільського господарства та цифрових технологій зросла більш ніж утричі, що відображає зростаючу актуальність та науковий інтерес до цифрової трансформації в агробізнесі. Дослідження виявило домінування таких країн, як США, Англія, Швейцарія,

Нідерланди, Німеччина, за обсягом та впливом досліджень, тоді як внесок України залишається обмеженим - 1,8% від загальної кількості публікацій. Визначено, що до наукових напрямів з найбільшою кількістю наукових публікацій за тематикою дослідження належать «Сільське господарство», «Бізнес та економіка» та «Комп'ютерні науки». Ключові теми досліджень включають цифровий маркетинг, електронну комерцію, точне землеробство, Agri-IoT та використання економіко-математичних моделей для оцінки ефективності та повернення інвестицій. Найбільш цитовані роботи застосовують DEA, регресійне моделювання та моделювання системної динаміки, часто інтегруючи дані опитувань з онлайн-поведінковою аналітикою. У статті підкреслюється брак систематизації емпіричних досліджень щодо економічного змісту інтернет-технологій в агросекторі України, інфраструктурні бар'єри та бар'єри, пов'язані з навичками, перешкоджають повному впровадженню цифрових інструментів. Отримані результати можуть бути використані при розробці національних сільськогосподарських стратегій, освітніх програм та пріоритетів фінансування в науково-технічній політиці. Крім того, використаний бібліометричний підхід дозволяє оцінити тенденції міжнародного співробітництва, визначити провідні дослідницькі центри та відобразити тематичні пріоритети.

Keywords: *internet technologies, agricultural sector, digitalization, e-commerce bibliometric analysis, ICT, Internet marketing, economic efficiency.*

Ключові слова: *інтернет-технології, аграрний сектор, цифровізація, електронна комерція, бібліометричний аналіз, ІКТ, інтернет-маркетинг, економічна ефективність.*

The problem statement in general terms and its connection with important scientific or practical tasks. The digitalization of the agricultural sector is gaining strategic importance for government policy, businesses and

households in different regions of the world. In the United States, according to Business Insider, the digitalization of the agricultural sector is focused on the introduction of the Internet of Things (IoT) and precision agriculture. Farmers use sensors to monitor soil moisture, temperature, and nutrients to optimize resource use and increase yields [5]. However, the adoption of these technologies is slowing down due to technical problems in rural areas, high costs, and the need for better data analytics. In the EU, according to Smartagrihubs, the digitalization of the agricultural sector is integrated into the Digital Decade and Green Deal policies. In particular, the Common Agricultural Policy supports the introduction of digital information systems for management, monitoring and evaluation, as well as promotes the development of “smart villages” and the provision of digital advisory services. However, as noted in the Smartagrihubs research, the level of use of digital technologies in EU agriculture remains low due to the lack of systematization of analytical information and digital skills [15].

Amid the war and integration processes into the European market, Ukraine is actively implementing digital technologies in the agricultural sector. The Strategy for the Development of Agriculture and Rural Areas until 2030 envisages digital transformation as a key element of the sector's modernization, in particular through the introduction of precision farming, digital services, and support for small farmers. However, as noted in the study M. Bezpartochnyi and I. Britchenko, only large agricultural enterprises have sufficient resources to implement digital technologies, which creates a risk of digital inequality between different categories of producers [2]. Successful implementation requires concerted efforts by the state, business, and households, as well as overcoming existing barriers such as digital inequality, lack of infrastructure, and the need to develop digital skills among farmers.

Internet technologies are one of the tools of digitalization and are increasingly influencing the transformation of the agricultural sector by providing new channels for marketing, communication, analytics, and decision-making. According to OECD and FAO studies, the share of e-commerce in agricultural

production is growing annually, especially among small and medium-sized farms that access new markets through online platforms [12]. For example, the Statista report shows that in 2023, online sales of certain types of agricultural products in Europe exceeded \$15 billion, and in the United States - more than \$25 billion, demonstrating an annual growth of certain types of products by 12-15% [17]. Similarly, in Ukraine, more than 30% of farmers are actively using online sales channels, especially as part of digitalization initiatives after 2022 [24].

At the same time, despite the rapid growth of publications on the digitalization of the agricultural sector, there is a lack of systematization of scientific results. A bibliometric analysis based on the Web of Science databases shows that the number of articles on the intersection of "agriculture" and "digital technologies" has tripled over the past five years [21]. However, most publications are fragmentary, which makes it difficult to draw generalized conclusions for the practical implementation of Internet technologies, and necessitates an integrated approach to literature analysis using modern bibliometric methods, scientific knowledge maps, and the identification of leading schools and research areas in the field of agricultural digital transformation [1].

Analysis of recent research and publications. In the scientific works of both domestic and foreign experts, more and more attention is paid to the role of information and communication technologies (ICT) and Internet technologies in the transformation of the agricultural sector. Particular attention should be paid to works that include studies of institutional aspects and policies of digitalization of the agricultural sector K. Nemashkalo, L. Zemliana, & S. Vashechko [11], M. Do Thi, T. Le Huyen, L. Le Thi [3]. W.Geng, L. Liu, J. Zhao, X. Kang, W. Wang [6] analyze the main trends of agricultural digitalization in the context of digital transformation. Internet communication is increasingly used as a tool for shaping agricultural policy. E. D. Cvik and R. M. Pelikanova in their study emphasize the influence of the digital environment on the formation of legislative norms [13].

There are a number of studies on the role of Internet resources in the development of new management practices in the agricultural sector. A. Sipica

proposes methods for analyzing managerial efficiency through digital indicators that have applied significance for the agricultural production system [14]. These approaches are especially relevant for countries with economies in transition, where digitalization provides access to modern management tools.

The use of Internet technologies is seen as a factor in strengthening competitiveness, increasing innovation and effective management. For example, A. Zia and M. Alzahrani [23] analyze the impact of e-marketing on achieving competitive advantages in agribusiness, M. Khanna emphasizes the importance of implementing digital strategies in the transformation processes of the agricultural sector [7].

In the global dimension, W. Geng, L. Liu, J. Zhao, X. Kang, W. Wang [6] consider the main trends in the digital transformation of agriculture, emphasizing the economic effect of the introduction of big data, ERP systems, satellite monitoring. Particular attention should be paid to the study of the role of information and communication technologies as tools for improving economic efficiency. D. Spielman, E. Lecoutere, S. Makhija and B. Van Campenhout [16] investigate the impact of ICTs on farmers' productivity in developing countries through access to information, digital services and online commerce. S. Wolfert, L. Ge and C. Verdouw [22] analyze the impact of the Agricultural Internet of Things (Agri-IoT) in the context of Smart Farming, where ICTs provide automation, analytics, and decision-making. X. Liu, J. Walsh interpret online marketing as a means of increasing revenues and strengthening market positions, which is especially important for small producers in transition economies [8]. These approaches confirm the economic feasibility of the digital transformation of the agricultural sector as a whole and Internet technologies, the importance of digital promotion, reducing transaction costs and strengthening the market presence of key agricultural market participants.

In the Ukrainian scientific space, the study of the economic content of the introduction of Internet technologies in the agricultural sector is also actively developing. In particular, M. Nehrey studies the digital transformation of the

agricultural sector of Ukraine through the prism of the economic feasibility of introducing digital technologies and the need to support small producers in the process of adapting to digital business conditions [10, 26]. The researcher emphasizes the importance of developing digital infrastructure, digital competencies and relevant public policy in the context of post-crisis recovery.

I. Voronenko and her team of co-authors study the peculiarities of managing advertising strategies in Internet marketing on the example of the Google ecosystem. Data Envelopment Analysis was used to evaluate the effectiveness of advertising in 35 European countries, which allowed them to rank countries by the level of “advertising productivity” and outline the potential for budget optimization. The study emphasizes the importance of a comprehensive, data-driven approach to the formation of digital strategies in a highly competitive online environment [20, 25].

Regarding theoretical aspects, studies by domestic scientists contain a comparative analysis of scientific activity in the field of agricultural digitalization in Ukraine and abroad in general, identifying the dominant trends in modern scientific research [19].

The analyzed literature allows us to conclude that the importance of Internet technologies in the agrarian economy is growing both at the micro and macro levels, acting as a factor of modernization, as well as a tool for economic development and cooperation between agribusiness, consumers and the state. The review of the scientific literature outlines the strategic benefits of digitalization for agricultural enterprises, ranging from enhancing communication with the market to optimizing management processes. At the same time, the economic content of the introduction of Internet technologies, taking into account the national and regional characteristics of the agricultural sector of Ukraine, requires a deeper study and systematization of existing research on this topic.

Formulation of the main objectives of the article (task statement). The purpose of the study is to carry out a bibliometric analysis of scientific research on the economic content of the introduction of Internet technologies in the agricultural

sector. For the purpose of the study, the hypothesis of a stable positive dynamics of scientific activity on Internet technologies in the agricultural sector, which has been tending to increase since 2015, was determined. The bibliometric analysis includes a quantitative analysis of the bibliographic characteristics of scientific publications, which allows to identify trends and patterns, and as a result, to conduct a qualitative assessment of the bibliography. The analysis included several key research stages (fig.1).

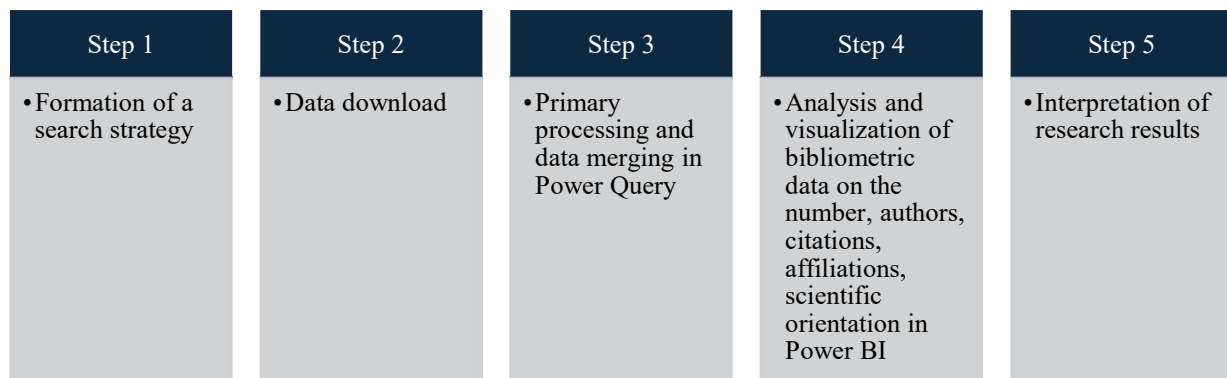


Fig. 1 Stages of the study according to the research topic.

Source: authors' own development.

At the initial stage, 3 groups of keywords were formed according to the research topic, which were later combined using logical operators:

- terms describing technologies: Internet technologies/tools/ platforms, Online technologies/tools/ platforms, Web technologies/tools/ platforms, Digital tools/ platforms technologies/tools, Digitalization, Information and communication technologies/ tools/ platforms, E-commerce, Agri-tech, FinTech, Internet/Digital marketing, Online/Internet advertising, Websites, Marketplaces;

- terms describing the scope of application - agriculture and the agricultural sector: Agriculture/ Agricultural, Agricultural sector, Agribusiness, Farmer;

- terms describing the economic aspects of technology application: Efficiency, Economic/ Economic impact, Cost, Profitability, Return on investment (ROI), Revenue, Expenses, Savings, Prices, Sales, Development, Impact, Trading/Trade.

Web of Science databases were used to collect data, the choice being based on the functionality of the database for generating search queries.

Power BI was used for primary processing, analysis, and creation of basic visualizations. Some analytical elements were created using Web of Science Insights.

Presentation of the main research material. For the bibliometric analysis, several search queries were formed that included combinations of keywords, taking into account the specifics of the databases and the intended methodology for researching scientific publications. Basic query (generalized) - 2579 results by the beginning of 2025. The sample of bibliometric data contains information about the title, abstract, keywords, authors, affiliation, scientific field, year of publication, citation, and type of publication.

To analyze the overall publication activity in Power BI, the results of query (generalized) were taken - generalized data that as of April 2025 contain 2713 results, Fig. 2 shows the overall dynamics of publication activity for a generalized search query indicating a growing interest in the topic, for example, in 2024, 432 scientific publications were published, the peak of publication activity in 2020-2024 (fig. 2).

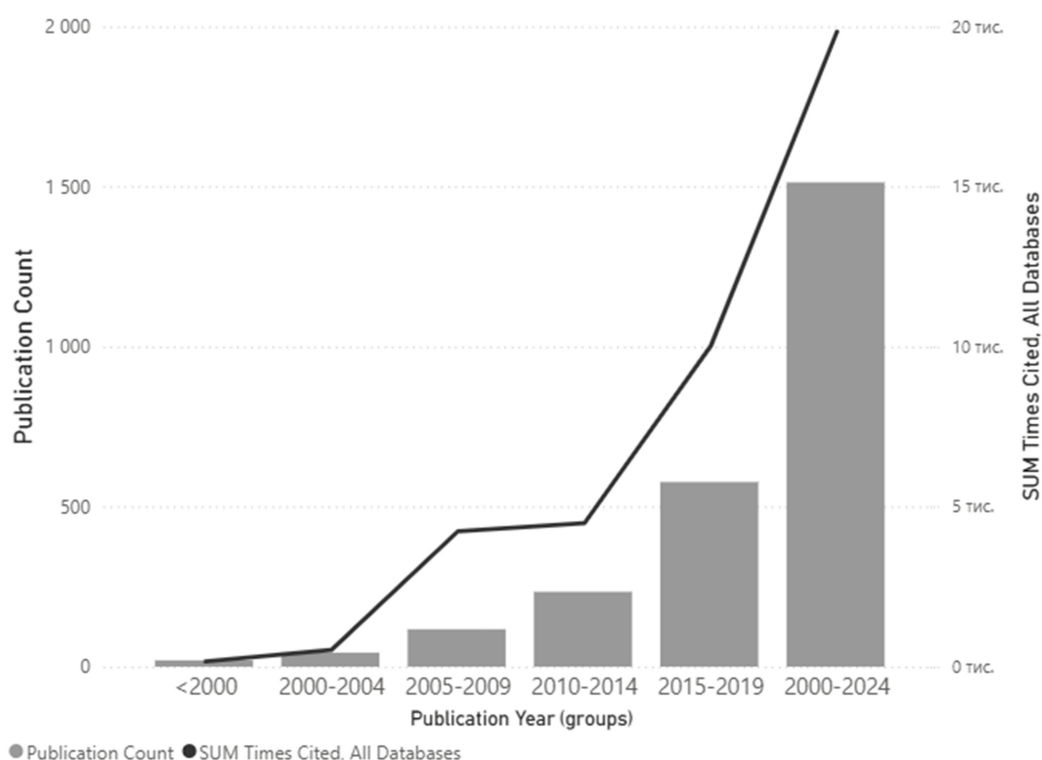


Fig. 2 Dynamics of publication activity by generalized search query 1 in 1982-2024.

Source: authors' own development based on [21].

The distribution of scientific publications by document type indicates the largest share in the total volume of articles (68%) and conference proceedings (23%).

Among the leading countries in terms of the number of publications: USA, UK, France, Netherlands, Switzerland. The United Kingdom, the United States, and the Netherlands are the highest in terms of citations, and the United States, the United Kingdom, and Switzerland are the highest in terms of the number of publications. Ukraine is in the top 20 countries in terms of the number of publications (19 publications), but its share in terms of citations is rather small – 51 (fig. 3).

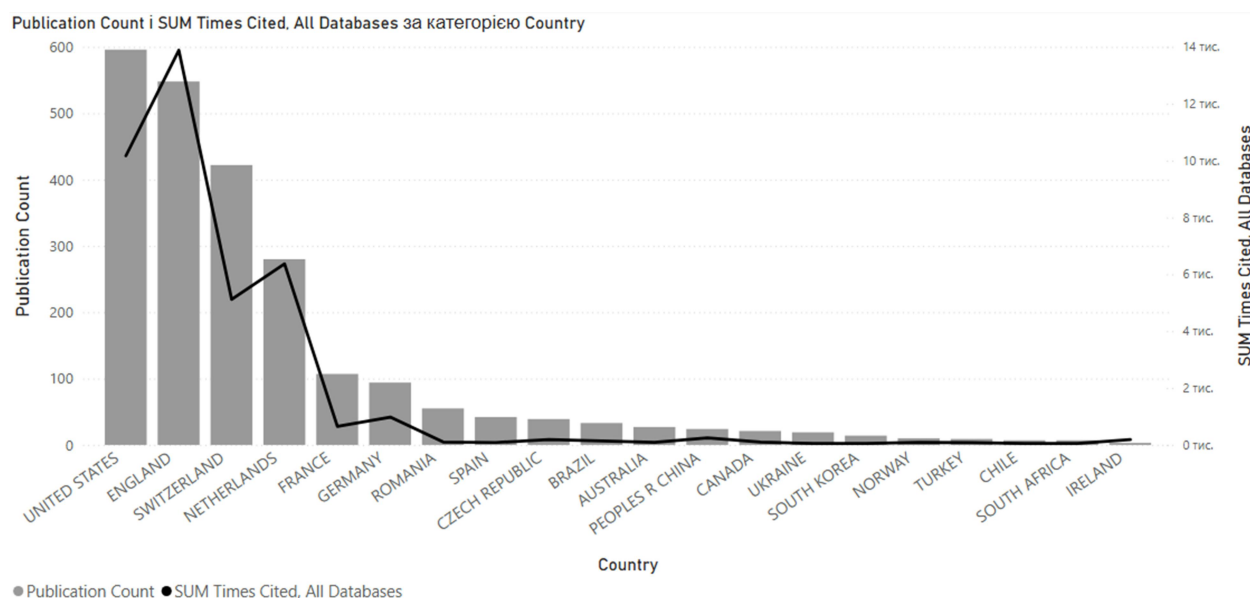


Fig. 3 Distribution of countries by the number of publications and citations by generalized search query (TOP-20)

Source: authors' own development based on [21].

It is worth noting the publication activity of affiliated organizations, among which the Ministry of Education and Science of Ukraine, Wageningen University (Netherlands), and the Consultative Group on International Agricultural Research (CGIAR) have the best positions, with 49 publications with their own affiliations in Web of Science.

The distribution of organizations by the largest number of publications, taking into account scientific areas, was studied separately. Among the 5 most active publishing organizations, the Ministry of Education and Science of Ukraine has the largest number of publications in business and economics, as well as science, technology and other areas, Wageningen University (Netherlands) conducts research in agriculture, environmental management and ecology, the Consultative Group on International Agricultural Research (CGIAR), the University of California System, and the University of Hohenheim - similarly - in agriculture, food sciences and technology (fig. 4).

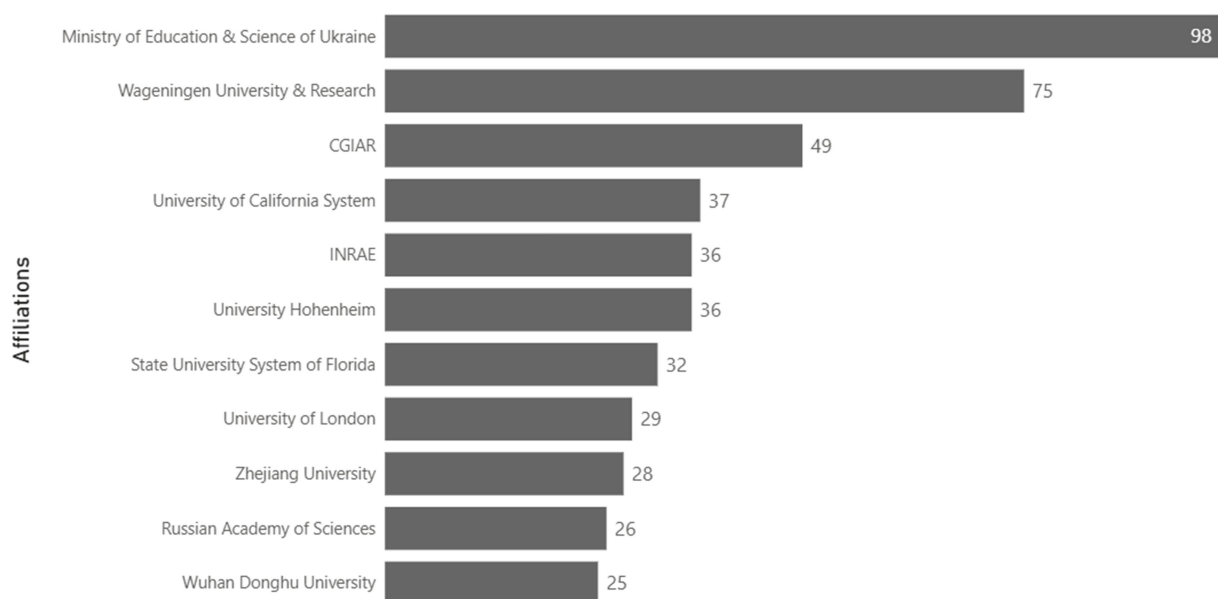


Fig. 4 Organizations by the largest number of publications in 1982-2024.

Source: authors' own development based on [21].

In general, the scientific areas with the largest number of scientific publications include Agricultural, Business and Economics, and Computer Science, which corresponds to the priority areas of development of the agricultural sector in the countries where the publications are presented, for example, the active implementation of IoT in the United States (fig. 5).

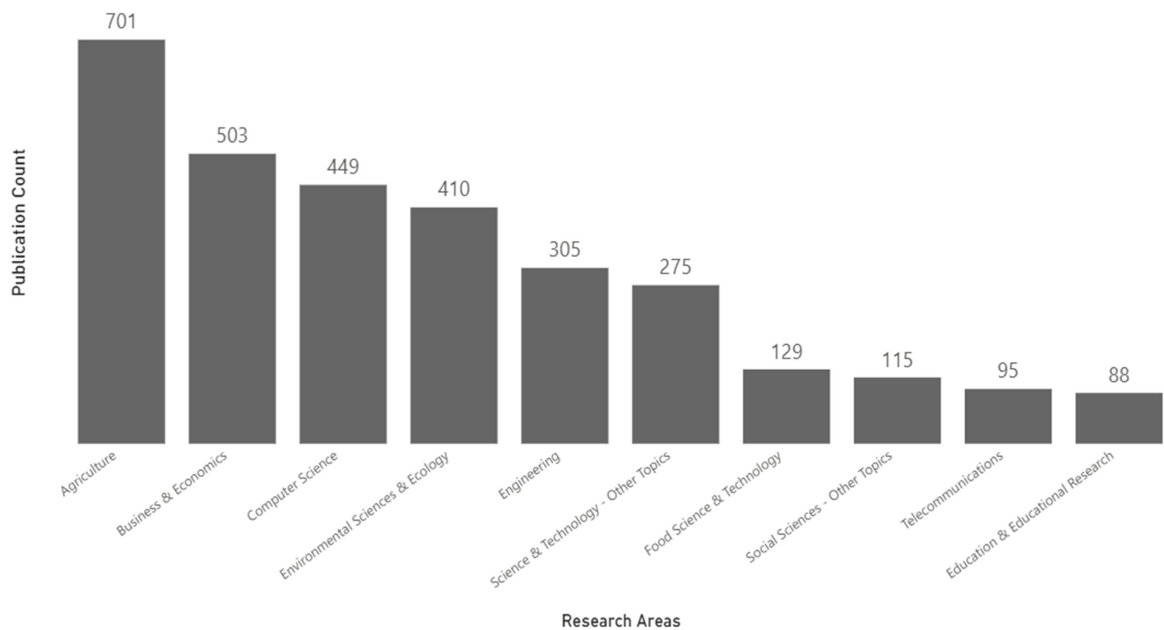


Fig. 5 Distribution of publications by their scientific fields (TOP-10)

Source: authors' own development based on [21].

The total H-Index for the search query is 76, which takes into account the total number of citations - 20,702, of which 20,108 are without self-citation. Among the most cited authors: Klerkx, Laurens, Sejna, Miroslav, Simunek, Jiri, van Genuchten, Martinus Th., who have a citation level both average for publications and total over 1 thousand (tabl. 1).

Table 1. The most cited authors by generalized search query

Authors	Sum of Times Cited Publications, All Databases	Avg Value of Times Cited, WoS Core	Publication Count
Klerkx, Laurens	1303	156,88	8
Sejna, Miroslav	1109	947	1
Simunek, Jiri	1109	947	1
van Genuchten, Martinus Th	1109	947	1
Pretty, Jules	794	684	1
Toulmin, Camilla	794	684	1
Williams, Stella	794	684	1
Jakku, Emma	792	153,2	5
Butala, Richa	698	676	1
Choi, TsanMing	698	676	1
Dutta, Pankaj	698	676	1
Somani, Surabhi	698	676	1
Labarthe, Pierre	679	328	2
Hawkes, Corinna	591	506	1
Klich, Maren A.	578	472	1

Source: authors' own development based on [21].

The qualitative analysis of scientific publications makes it possible to determine the content of scientific trends among the most cited and relevant publications on the economic aspects of the use of Internet technologies in the agricultural sector. Most of the articles focus on the impact of information and communication solutions (Big Data, Agri-IoT, smart-farming platforms) and Internet marketing tools (e-commerce, SEO/PPC, SMM) on the productivity and profitability of agricultural producers. The methodological aspect is dominated by: economic and mathematical models (DEA, regression and panel analysis, system dynamics) for quantitative assessment of efficiency; mixed methods that combine farmer surveys with big data analysis of online transactions; case studies and comparative studies to compare countries and types of farms. At the same time, the lack of comprehensive analytics on the use of Internet solutions in the agricultural sector was revealed, which requires more detailed research.

Conclusions and prospects for further research in this area. The conducted bibliometric analysis allowed us to systematically outline the scientific dynamics and spatial representation of research on the economic aspects of the introduction of Internet technologies in the agricultural sector. According to the Web of Science database, over the past five years, the number of scientific publications on the intersection of “agriculture” and “internet/digital technologies” has increased more than threefold, which confirms the relevance of research on the digital transformation of agricultural production. At the same time, applied research dominates, highlighting the positive economic effect of the use of Internet technologies, in particular through improved management efficiency, e-commerce development, process automation, and expansion of sales markets.

The scientific literature demonstrates a gradual transition from fragmented research to a systemic vision of the digital transformation of agricultural production. A generalized query in the Web of Science database revealed more than 2.7 thousand publications, 432 of which were published in 2024. The total h-index is 76, and the number of citations exceeds 20 thousand, which indicates the high relevance of the topic in the academic environment.

The main research focuses on the introduction of digital technologies and supply chain optimization. ICT, Smart Farming, Big Data, IoT, as well as Internet marketing and e-commerce are the most actively researched topics. About 1400 publications are devoted to e-commerce and marketing tools (SEO, SMM, PPC), with a focus on increasing productivity and profitability. The empirical aspects of the introduction of Internet technologies in Ukraine remain insufficiently researched. The share of publications by Ukrainian authors is only 1.8%, indicating the need to develop systematic long-term research and broader participation in global scientific exchange.

Comparison of global and Ukrainian experience in terms of the content of publications showed different levels of digital readiness of agricultural sectors: in the US and EU countries, digitalization takes place in the context of the introduction of precision agriculture, Agri-IoT, and ERP systems, but encounters infrastructure and educational barriers, while in Ukraine, there is an intensification of state policy on digitalization of the agricultural sector after 2022, but there is still uneven access to digital solutions between large and small producers. The problems of digital inequality, lack of analytical information, and digital competencies are common to Ukraine and many transition economies.

The work reflects a comprehensive approach to identifying scientific trends in the research topics both in general in terms of their dynamics and for individual countries, organizations, and authors. Ukraine is relatively less represented in this area, as there is a lack of large-scale panel data and funded longitudinal studies, and the available publications are mostly limited to individual case studies and analysis of local initiatives that do not provide a representative empirical base.

There is a need for further research on the effectiveness of various online platforms for selling agricultural products. It is advisable to pay attention to small farms, digital inequality, and infrastructure. It is important to create models for assessing the effectiveness of digital platforms, taking into account regional conditions and the level of digital skills of agricultural producers.

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