

## **Mapping the Knowledge Structure of Agricultural Economic Studies: A Co-Word Analysis**

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### **Abstract**

The study of agricultural economics has evolved significantly over the years, with various research areas and subfields emerging. This study aims to map the knowledge structure of agricultural economic studies using co-word analysis. A total of 21,730 articles published between 1985 and 2022 in agricultural economics were retrieved from the Web of Science database. The titles and abstracts of these articles were analyzed using VOSviewer software to create a map of the most frequently occurring terms. The results showed that in terms of frequency, the keyword “agriculture” had the highest frequency, and in terms of co-occurrence, the two keywords “poverty” and “panel data” had the highest frequency. The results of the co-word analysis showed that the research areas of agricultural economics studies were divided into six main clusters: (1) technology adoption, (2) demand, (3) agricultural policy, (4) trade and markets, (5) productivity and efficiency, and (6) risk. This analysis provides a comprehensive overview of the knowledge structure of agricultural economics and can guide future research and policy development in this area.

**Keywords:** Agricultural Economics, Co-Word Analysis, Knowledge Map, Knowledge Structure, Scientometrics, Co-Word Analysis.

### **Introduction**

According to the Food and Agriculture Organization of the United Nations (FAO), the global population is projected to reach 9.73 billion by 2050 and rise to 11.2 billion by 2100 (FAO, 2018). This population growth directly correlates with an increased demand for food production. Additionally, urbanization exacerbates the risk of food shortages due to higher consumption rates and reduced availability of farmland as it is replaced by infrastructure (Yuan et al., 2018). Numerous factors, such as soil salinity in arid regions, pose significant challenges to agricultural productivity, resulting in reduced crop yields (Mohamed, Abu-hashim, AbdelRahman, Schütt & Lasaponara, 2019). Furthermore, crop quality and quantity are affected by climate variability and soil conditions (Abdel-Fattah et al., 2021). Therefore, assessing land resources to support agricultural expansion in arid regions is essential (Saleh, Belal & Mohamed, 2015). As agriculture is a major contributor to national income in many

developing countries, leveraging advanced technologies to enhance agricultural practices is vital for economic development. Besides providing essential raw materials for industrial processes, agriculture ensures food production for humans and livestock. Smart Agriculture addresses these challenges by enhancing productivity, optimizing resource allocation, adapting to climate change, and minimizing food waste (Yousaf, Kayvanfar, Mazzoni & Elomri, 2023).

The field of agricultural economics is at a critical juncture in transforming agricultural economics for sustainable development (Adisa, Ilugbusi, Adewunmi, Franca & Ndubuisi, 2024) in a world facing challenges that exceed all expectations. The increasing demand for food, coupled with the inevitable concern for environmental protection, requires the shift to new agricultural practices that are fundamentally different (Pretty et al., 2018). In most cases, agricultural economics is about efficiency in production and maximizing profits at the expense of environmental and social concerns. Nevertheless, given global challenges such as climate change, resource scarcity, and social inequality, there is a growing consensus that agricultural economics needs to be redefined to bring sustainability to the forefront (Adisa et al., 2024). Agricultural economics has changed over the years due to societal changes, technological advances, and economic philosophies. Before the Industrial Revolution, the focus was on efficient resource allocation within a feudal system dominated by land ownership and peasant labor (Adisa et al. 2024). With the industrialization of agriculture through the introduction of technology and the Industrial Revolution, there was a massive change in the economy (Smith, 1776). Economic thinkers such as Adam Smith advanced the idea of a broader economic role for agriculture during this period. Agricultural economics became a distinctive field in the late 19th and early 20th centuries (Marshall, 1890). U.S. land-grant universities have been instrumental in establishing agricultural education and research, attributed to notable figures such as John Stuart Mill and Alfred Marshall, who introduced agriculture into economic theories (Adisa et al., 2024).

Agriculture is a strategic sector vital to nations' growth and development. It plays a key role in food security, the supply of raw materials, job creation, and economic stabilization. Historical evidence shows that agricultural overproduction was the leading cause of the development of many advanced societies (Motiee Langroudi, Souri & Cheraghi, 2016). The World Bank (2008) emphasizes that agriculture is an excellent development tool due to its role in the economy, food security, and environmental sustainability. Strengthening agriculture is a key to the growth of developing countries as it promotes social stability and economic development (Eftekhari, Pourtaheri, Farajzadeh, & Vakilheidari, 2009). In addition, the agricultural sector directs the flow of resources to other industries (Adisa et al., 2024) and reduces the problem of poverty (Irz, Lin, Thirtle & Wiggins, 2001). Therefore, increasing the productivity and development of the agricultural sector is the most crucial way for a country's economic growth. The role of agriculture in the process of economic growth has been viewed differently over the centuries. The first studies of economic development did not mention agriculture; instead, they described industrial development as the primary source of economic growth (Self & Grabowski, 2007; Tiffin & Irz, 2006). In the 1970s, however, this paradigm shifted towards agricultural-based economic development perspectives. The Green Revolution in Asia highlighted the agricultural sector's contribution to economic growth (Diao, Hazell & Thurlow, 2010). Over time, the potential impact of the agricultural sector on economic growth has always been of interest to development economists (Johnston & Mellor, 1961). Furthermore, agricultural innovation is a significant catalyst in combating extreme poverty and promoting collective prosperity and

development. This is supported by the sharp income increase in low-income countries, which is by far the highest observed in other sectors, exceeding two to three times (Kitole, Mkuna & Sesabo, 2024).

Digitalization is the most important thing in transforming agriculture and providing welfare to farmers in developing countries. It provides farmers with timely and relevant information and services that make it easier to build profitable and sustainable businesses (Abdulai, 2022). The connection between agriculture and economic growth is the subject of much research. Low productivity and slow growth in agriculture are often the result of low economic growth and low-income levels in developing countries (Alston & Pardey, 2014). Studies have never contradicted that increases in agricultural productivity are positively associated with economic growth (Gollin, 2010; Self & Grabowski, 2007). Development reports always highlight agriculture as an important sector for promoting economic growth and reducing poverty (World Bank, 2008). Therefore, the transformation and development of the agricultural sector is the only path to DAC, which represents a step towards economic prosperity and resilience. In addition, empirical studies show that agricultural development is one of the key factors for structural change, as it enables the shift of labor from low-productivity agriculture to higher-productivity industrial and service sectors, thereby promoting overall economic development.

The most valid tools for measuring scientific production today are bibliometric indicators. This so-called science measurement became popular in the late 1960s and has been accepted in scientific communities ever since (Bookestein, 1994). Co-word analysis is one of the most common methods for analyzing the structure of knowledge in various fields and creating conceptual maps. The keyword analysis method visually represents the content of topics in a research area by examining key terms in articles. By determining the frequency and co-occurrence of keywords, researchers can gain insights into the most critical issues and relationships within a field. This method allows for a deeper understanding of the knowledge structure and can help researchers identify gaps in the literature or areas for further research (Kohandel Jahromi, 2022). To meet the increasing need for sustainable and efficient agricultural practices, in-depth knowledge of agricultural economics is required. One way to get there is to learn the map of agricultural economics. Mapping knowledge structures in agricultural economics provides a critical understanding of the trends and growth of research and development in this area (Fuglie & Rada, 2013). Researchers, policymakers, and other stakeholders can accordingly identify knowledge gaps, classify research areas, and facilitate collaboration between institutions by systematically analyzing words, key concepts, key phrases, and relationships between these concepts. In addition, agricultural innovations are also crucial for achieving economic, social, and environmental goals. To achieve these goals, it is vital to understand the main factors on which agricultural production and economic organization are based. Knowledge mapping in agricultural economics can serve the purpose of such understanding by identifying fundamental research areas and shedding light on current or upcoming research trends and directions (Alston & Pardey, 2014). To illustrate that agricultural research is an essential catalyst for economic and social growth, reports from around the world were used (Adisa et al., 2024).

### **Research Questions**

The research questions of this study aim to answer the following questions:

1. How are the trends in agricultural economics from 1985 to 2022 represented in the WOS

database?

2. What does the coexistence map of agricultural economic terms in the VOSviewer software look like in the WOS database?

3. Which clusters were formed in the WOS database from 1985 to 2022, and which topics in agricultural economics do they relate to?

### Literature Review

Agricultural economics has experienced significant growth in recent decades, with an increasing focus on sustainability and efficiency in food production. Therefore, it is essential to understand this area's current state of research and identify trends and gaps for future development. Several studies have been conducted on the structure of scientific research, and this study will address the most important ones.

RA, Zalizar, Triwanto, Ervayenri, Mel, Iswahyudi, and Ekalaturrahmah (2024) studied the bibliometric analysis on agricultural ecotourism (2012 to 2022) via VOSviewer, and the results showed that the number of research documents published by 269 authors increased steadily annually. China is the leading country regarding the number of publications and research collaborations. Additionally, monitoring the viability of ecotourism sites and providing vocational training to the local untrained population would increase the overall efficiency of the ecotourism industry (Xu, Li, Zhang, & Zhang, 2024). This article concludes that bibliometric analysis provides a comprehensive understanding of sustainable agriculture in the digital era, highlighting influential publications, collaboration patterns, historical hotspots, and emerging trends. It emphasizes the integration of digital technologies for sustainable agricultural practices and biodiversity conservation while addressing management challenges. Practical implications include guiding policymakers, researchers, and industry stakeholders in adopting digital innovations. However, limitations like citation delays, data source biases, and subjective cluster interpretations call for future research using diverse methods and databases for deeper insights.

Iswahyudi, Widodo, Warkoyo, Hendroko, Sutanto, Vincēviča-Gaile, and Mustaqim (2023) studied the bibliometric analysis of contaminating microplastics in compost (2018 to 2022) via VOSviewer, and the results showed that the number of research documents published by 111 authors increased steadily annually. China is the leading country in publications and research collaborations (Yousaf et al., 2023). This article concludes that the application of Operations Research (OR) methods, combined with Artificial Intelligence (AI) and Machine Learning (ML) technologies, is rapidly expanding in smart agriculture, with a focus on prediction and resource management. Given climate change and food security challenges, future research should leverage advanced optimization and simulation techniques to reduce resource waste, enhance productivity, and achieve Agriculture 4.0 goals. Additionally, greater emphasis is suggested on applying these theories to innovative farming systems like vertical farms and plant factories.

Academic mapping study of business publications in D8 member countries showed a positive economic performance trend, with Turkey and Malaysia leading in production (Kohandel Jahromi, 2022). The study identified seven major topic clusters in the academic structure of economics in D8 member countries, including economic growth prospects, financial policy, economic education and globalization, financial disintegration, organizational structure of investment companies, entrepreneurship, engagement, and organizational culture.

Hoepner, Kant, Scholtens, and Yu (2012) conducted a citation analysis to identify the most influential articles, authors, journals, and environmental and ecological economics institutions. The study found that Ecological Economics, Energy Economics, and the Journal of Environmental Economics and Management had the most influential articles and published highly influential authors. The University of Maryland, Resources for the Future, the University of East Anglia, and the World Bank were the most influential institutions in this field. Pashootanzadeh and Osareh (2009) conducted a citation analysis and historiographical overview of agricultural scientific production from 2000 to 2008 using the Science Citation Index. The study found an average annual publication growth of seven percent, with over 51,000 authors citing over 658,000 sources. The historiographic overview based on LCS and GCS formed five clusters, and agricultural articles were submitted from 173 countries and 14,852 institutes and published in 3,252 journals in 15 different formats and 25 languages. Zhang (2007) conducted a citation study to examine the use of information in agricultural economics research. The study found that agricultural economists rely heavily on journal articles as their primary source of information, with electronic resources increasingly contributing to information consumption.

Previous research has shown that scholars worldwide are interested in studying the internal structures of various disciplines using bibliometric methods, particularly co-word analysis. Understanding the dynamics within scientific disciplines is crucial because it helps map scientific landscapes and elucidate the underlying structures of different fields. Given the need to adapt to global changes to improve quality of life and advance science and technology, monitoring and evaluating scientific results in countries is crucial. This study aims to examine the development of agricultural economics by analyzing data from the Web of Science. Key aspects include the volume of articles and citations, leading countries, and frequently cited authors. Research will address the nature of scholarly resources, prominent authors and publication types, geographic distribution, affiliated institutions, language preferences, core journals, and disciplinary intersections within agricultural economics.

### **Materials and Methods**

The present study is a descriptive survey using bibliometric indicators. The population examined in this study consists of 21,730 scientific documents indexed in the Web of Science database in agricultural economics from 1985 to 2022. The data collection method was as follows: First, the term "TS= ("Agricultural Economics " or "agroeconomics") was used. To determine the topic and specify the desired period with "PY=1985- 2022", all agricultural economics articles indexed in the Web of Science database over the last 38 years were retrieved. The data was stored in groups of 500 in plain text format and transferred to a personal computer. Different software tools were used to answer the individual questions. The HistCite software was used to answer the first question, and the VOSviewer software was used to answer the second and third questions. Finally, a knowledge map of scientific production in agricultural economics and the connections between scientific documents was created using the VOSviewer software. The relationships between documents in the formed clusters were then subjected to statistical analysis.

## Result

### How are agricultural economics trends from 1985 to 2022 represented in the WOS database?

The findings and results from the search for articles published between 1985 and 2022 with the title “Agricultural Economics” on the academic platform Web of Science show that the total number of articles is 21,730. Scientific papers related to agricultural economics were published in 20 document types on the Web of Science platform. Articles account for most scientific productions, accounting for 59% of the total documents. Conference summaries and book reviews follow this in second and third place with 21% and 11.0% respectively (Figure 1). These three types of documents account for 92.0% of all scientific productions. Other documents, such as procedural papers and editorial materials, only account for 7.0% of all documents produced. However, the least represented are discussions, notes, book chapters, review articles, letters, biographical items, early access, items about an individual, corrections, correction additions, books, news reports, software reviews, data papers, and retracted publications.

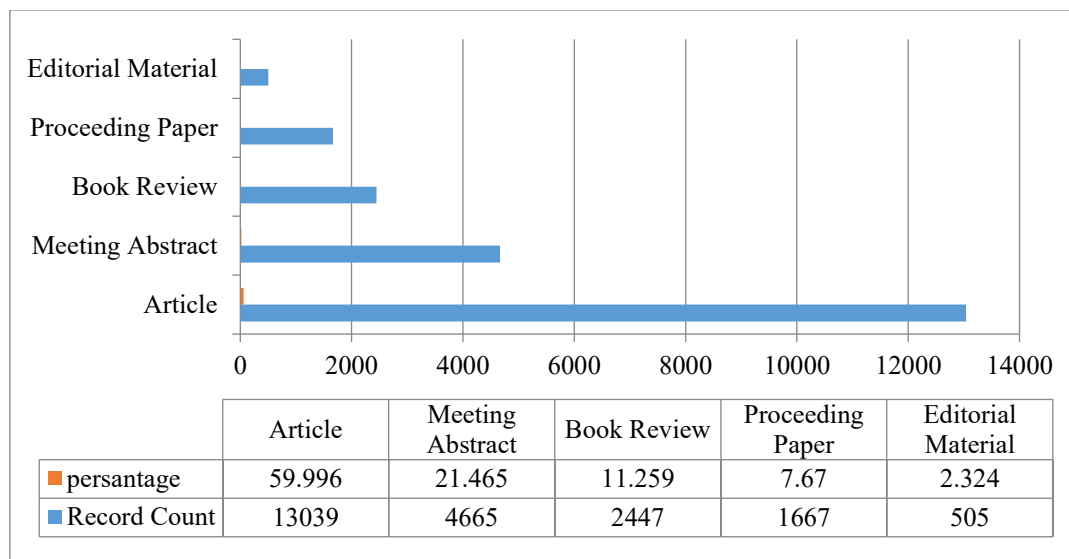


Figure 1: Scientific documents published on the WOS platform

The majority of scientific publications in agricultural economics published on the Web of Science platform are in English, with over 98% of all scientific productions being published in this language. The proportion of other languages is very low, amounting to less than 0.3% of all documents (Figure 2).

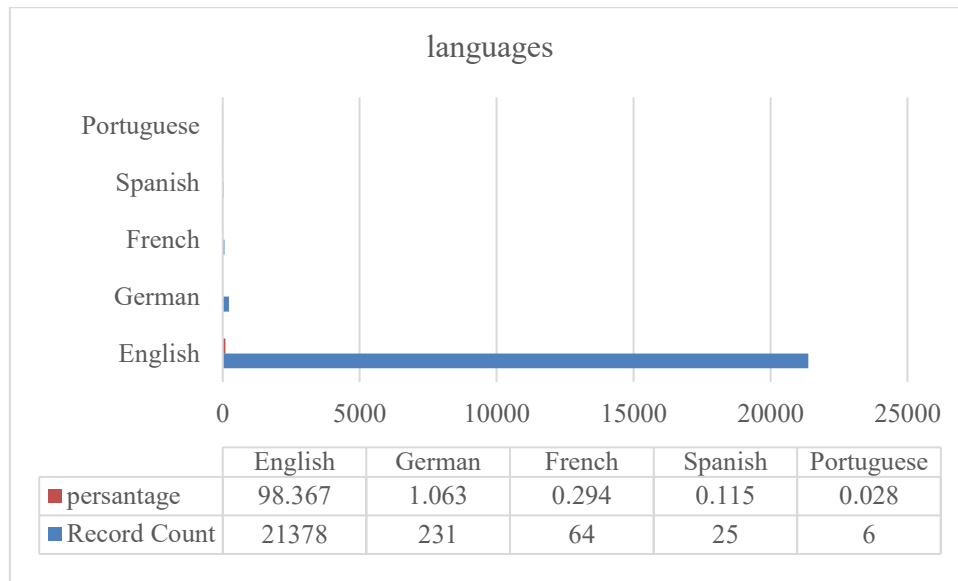


Figure 2: Language documents published on the WOS

The United States is the most active country in producing scientific documents in the field of agricultural economics on the Web of Science platform, accounting for more than 58% of all scientific productions in this subject area. After the United States, two other English-speaking countries, Canada and the United Kingdom, ranked second and third, with 8% and 5% of global productions, respectively (Figure 3). Iran ranks 51st with 37 articles.

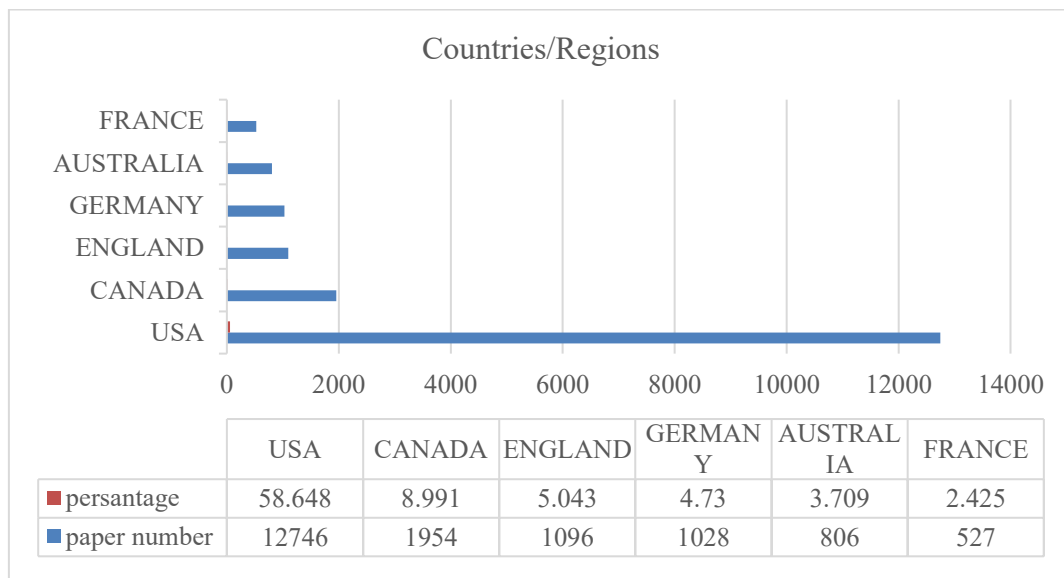


Figure 3: Active country in Scientific documents published on the WOS

Most documents in the field of agricultural economics come from authors from the US Department of Agriculture (USDA), with 1221 articles in first place, followed by the University of California System with 1212 articles in second place, and RLUK Research Libraries UK in third place with 1007 articles. The most prolific author in agricultural economics on the Web of Science platform over the past 38 years is Zilberman D, who has contributed to scientific research with 108 articles and takes first place. After Zilberman, Alston JM is in second place with 93 articles, and Chavas JP is in third place with 90 articles (Figure 4).

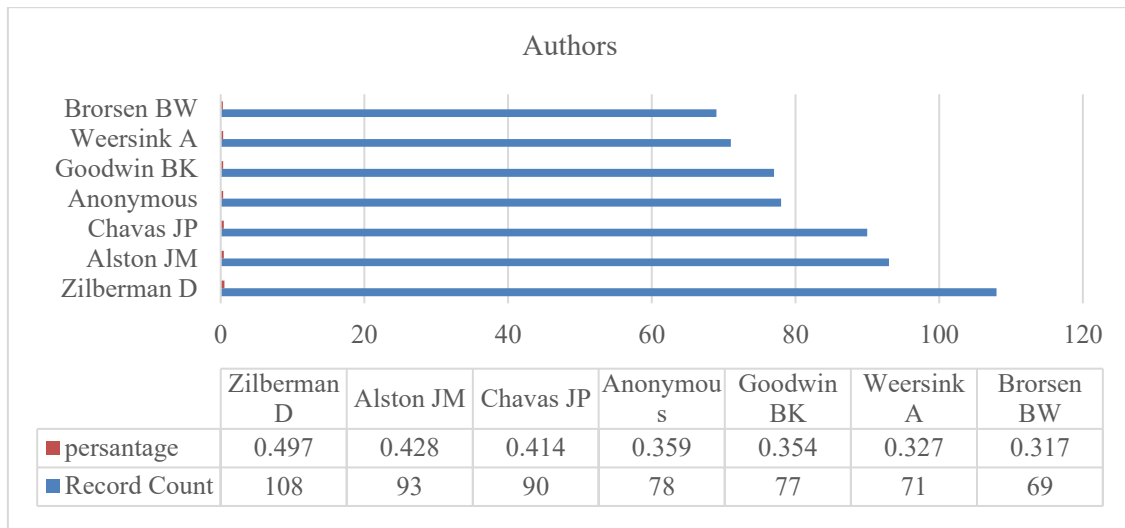


Figure 4: The highest number of documents produced in WOS

Over 38 years, 766 scientific publications related to agricultural economics have been produced. The journals “American Journal of Agricultural Economics”, “Journal of Agricultural Economics”, and “Agricultural Economics” are in first to third place with 47.0%, 13.0%, and 9.0% of all scientific documents, respectively. These three journals have published almost 70% of all scientific documents produced in the field. Figure 5 shows that the number of documents published in 1991 and 1999 was higher than the number of publications from 1999 to 2022 (Figure 5).

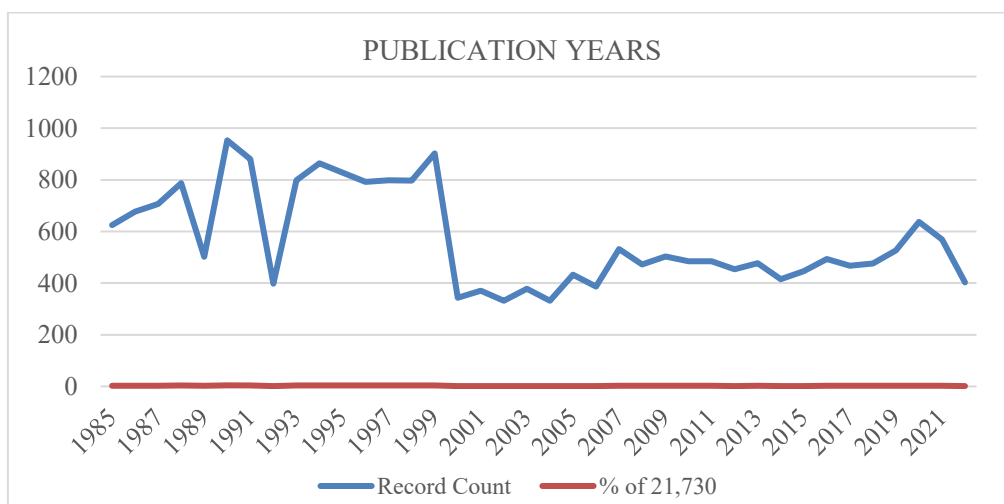


Figure 5: Publication years of scientific documents published on the WOS

**What does the co-occurrence map of agricultural economic terms in the VOSviewer software look like in the WOS database?**

A total of 56,465 repetitions for 23,626 unique keywords were counted in the scientific production of the research area. After standardizing the keywords in terms of singular and plural forms and removing non-informative keywords such as gender, country names, monetary units, and abbreviations, 190 keywords with a minimum frequency of 37 repeated 7,206 times were selected as the basis for collocation analysis and Matrix construction using VOSviewer software. The top most frequent keywords are listed in Figure 6 and Table 1.

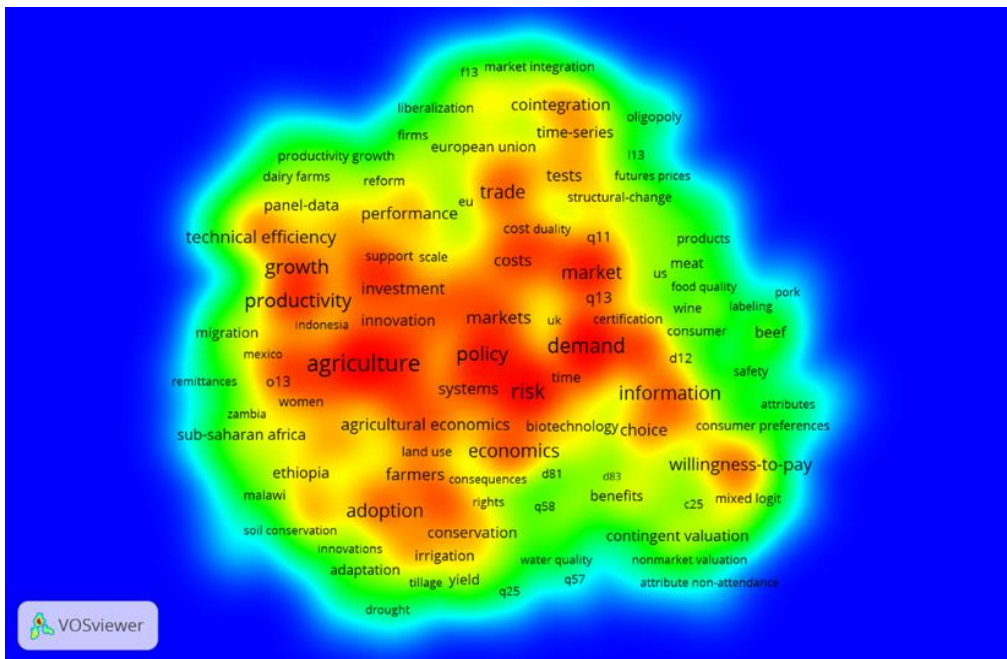


Figure 6: Frequent keywords

The keyword “agriculture” had the highest frequency, with 353 repetitions. It was also found that the keywords “agricultural economics” and “technical efficiency” are identified with frequencies of 221 and 147, respectively, ranking second and third.

Table 1  
Frequent keywords

Row	Keywords	Frequent
1	agriculture	353
2	agricultural economics	221
3	technical efficiency	147
4	agricultural policy	145
5	Climate change	141
6	food security	128
7	risk	114
8	poverty	112
9	panel data	112
10	technology adoption	110
11	Willingness to pay	109
12	choice experiment	98
13	productivity	96
14	efficiency	95
15	crop insurance	90
16	food safety	87
17	Common Agricultural Policy	73
18	trade	73
19	international trade	67
20	Data Envelopment Analysis	67

The co-occurrence of a keyword pair is an essential factor that receives special attention in

scientometrics research. This is because concurrent and other keywords can draw researchers' attention to a subset of that field. Table 2 shows the top 20 pairs of co-occurring keywords with the highest frequency in this field. The keywords “poverty” and “panel data” have the highest concurrent frequency in research studies in this area, with 112 concurrent occurrences.

Table 2  
Co-occurring keywords

Row	Co-occurrence	Frequent
1	Poverty-panel data	112
2	Common agricultural policy-trade	73
3	Risk Management-Rural Development	66
4	Risk Management-Agricultural Trade	66
5	Rural development-agricultural trade	66
6	Market power-price transmission	56
7	Land use-innovation	55
8	Rice-transaction costs	54
9	Economic growth-choice experiments	49
10	Economic growth-structural change	49
11	Choice experiments-structural change	49

### Which clusters were formed in the WOS database from 1985 to 2022, and which topics in agricultural economics do they relate to?

The analysis identified six main keyword clusters representing the key themes and topics studied in agricultural economics (Figure 7). The analysis identified six main keyword clusters representing this area's key themes and topics. These clusters include: (1) technology adoption, (2) demand, (3) agricultural policy, (4) agricultural market and trade, (5) agricultural productivity and efficiency, (6) risk.

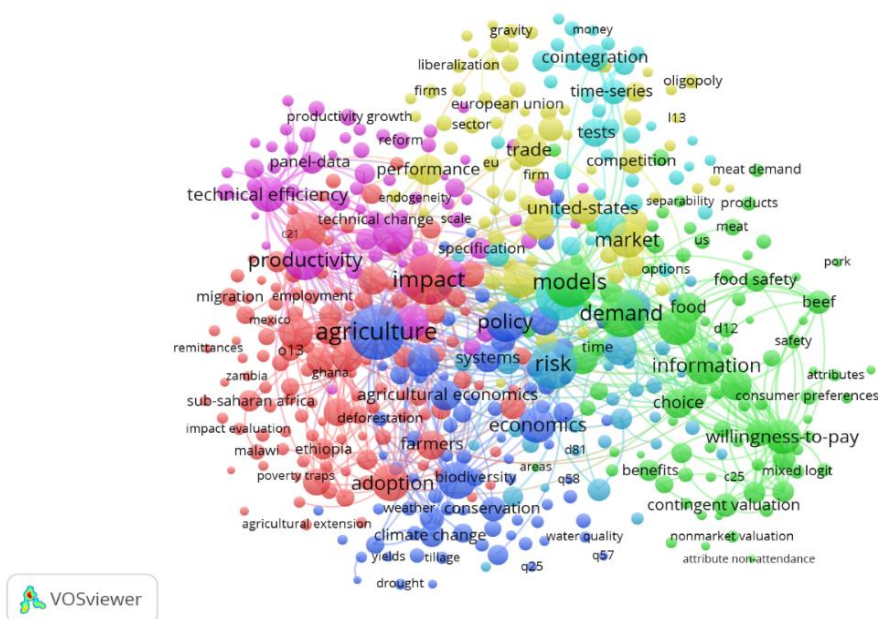


Figure 7: Visualization of six main clusters of keywords in agricultural economics

The first cluster identified through co-word analysis in agricultural economics is technology adoption. This cluster includes 85 elements with 348 occurrences and a total link strength 1615. Within this cluster, “poverty reduction” emerges as the most significant term regarding frequency of co-occurrence and has strong links and connections with other keywords. The “technology adoption” cluster in agricultural economics includes terms such as “food security,” “technology transfer,” “poverty alleviation,” “agricultural innovation,” “agricultural expansion,” and “income.”

The second key area of research in agricultural economics identified through co-word analysis is the demand cluster. This cluster includes 78 items with 523 occurrences and a total link strength of 1940. Within this cluster, “willingness to pay” emerges as the most significant term regarding frequency of co-occurrence and has strong links and connections with other keywords. Demand clustering in agricultural economics focuses on understanding the various factors influencing the demand for farm products and consumer behavior in the agricultural market. It includes terms such as “consumer behavior,” “food choice,” “nutritional value,” “food safety,” “food quality,” and “purchasing power.” The importance of this cluster suggests that extensive research in agricultural economics is dedicated to studying the demand for agricultural products and the factors that influence it.

The third key research area in agricultural economics identified through the co-word analysis is the agricultural policy cluster. This cluster includes 69 items with 737 occurrences and a total link strength 2922. Within this cluster, “management” emerges as the most significant term regarding co-occurrence frequency and has strong links and connections with other keywords. The Agricultural Policy Cluster in Agricultural Economics focuses on the various policies and regulations that govern the agricultural sector. It includes terms such as “agricultural policy,” “trade policy,” “market regulation,” “price support,” “subsidies,” and “management.”

The trade and market cluster are the fourth research focus in agricultural economics identified through the co-word analysis. This cluster includes 69 items with 319 occurrences and a total link strength 1213. Within this cluster, “cost” emerges as the most significant term regarding co-occurrence frequency and has strong links and connections with other keywords. The trade and market cluster in agricultural economics emphasizes the importance of understanding the dynamics of agricultural markets and trade. It includes terms such as “transaction costs,” “international trade,” “market access,” “trade liberalization,” and “supply chain management.”

The fifth key area of research in agricultural economics identified through co-word analysis is the agricultural productivity and efficiency cluster. This cluster includes 61 items with 416 occurrences and a total link strength 1985. Within this cluster, “technical efficiency” emerges as the most significant term regarding frequency of co-occurrence and has strong links and connections with other keywords. The Agricultural Productivity and Efficiency Cluster is an outstanding research area in agricultural economics. The focus is on using new technologies and techniques to increase efficiency and productivity in agriculture. Within this cluster, two important terms often appear simultaneously: “technical efficiency” and “total factor productivity”.

The sixth key area of research in agricultural economics identified through co-word analysis is the risk cluster. This cluster includes 41 items with 549 occurrences and a total link strength 2628. Within this cluster, “crop insurance” emerges as the most significant term

regarding frequency of co-occurrence and has strong links and connections with other keywords. This cluster includes terms such as “pesticide use,” “crop insurance,” “risk management,” “yield variability,” “price volatility,” and “disaster risk reduction.” The most important keywords for each cluster are listed in Table 3.

Table 3  
Clusters of agricultural economics

Cluster	Item	The most important members of the cluster		Total link strength	Item	Occurrence
1	Technology Adoption	Technology transfer	Food security	1615	85	348
		Agricultural innovations	Poverty reduction			
		Agricultural extension	Nutrition			
		Technology adoption	Migration			
		Rural development	Social Networks			
		smallholders	smallholder farmers			
		Unemployment	Social exclusion			
2	demand	Food safety	Competition	1940	78	523
		Consumer preferences	Food quality			
		Demographics	Consumer demand			
		Market trends	Income levels			
		Product availability	Price elasticity			
		Seasonal demand	Purchasing power			
		Willingness to pay	Supply and demand			
3	Agricultural policy	Agricultural economics	Agricultural credit	2922	69	737
		Biodiversity conservation	Yield			
		Common Agricultural Policy	Climate change			
		Conservation Environmental	Trade policy			
		Ecosystem services policy	Domestic support			
		Sustainable development	Land tenure			
		Management	Market regulation			
		Import/export regulations	Market intervention			
			Price support			
4	Agricultural Market and trade	Agricultural trade	Transaction costs	1213	69	316
		International trade	Market access			
		Agricultural markets	Competition			
		Market Power	Market integration			
		Supply chain management	Market			

Cluster	Item	The most important members of the cluster		Total link strength	Item	Occurrence
			transparency			
		Trade agreements	WTO			
		Technical barriers to trade	Trade liberalization			
		Export & Import markets				
5	Productivity and efficiency	Technical efficiency	Efficiency analysis	1985	61	416
		Investment subsidies	Input-output Panel date			
		Technological change	Growth			
		Total factor productivity				
6	risk	Damage control	Crop insurance	2628	41	549
		Price uncertainty	Pesticide use			
		Price volatility	empirical-analysis			
		Disaster risk reduction	Risk aversion			
		Risk management	Environmental risks			
		Yield variability	Financial risks			
		Risk preferences	Market risks			
		Adverse selection	Moral hazard			
		Asymmetric information				

### Discussion

The findings and results from the search for articles published between 1985 and 2022 with the title “Agricultural Economics” on the academic platform Web of Science show that the total number of articles is 21,730. Scientific papers related to agricultural economics were published in 20 document types on the Web of Science platform. Articles account for most scientific productions, accounting for 59% of the total documents. This is followed by conference summaries and book reviews in second and third place with 21% and 11.0% respectively. These three types of documents account for 92.0% of all scientific productions. Most scientific publications in agricultural economics published on the Web of Science platform are in English, with over 98% of all scientific publications being published in this language. The most prolific author in agricultural economics on the Web of Science platform over the past 38 years is Zilberman D, who has contributed to scientific research with 108 articles and takes first place. After Zilberman, Alston JM is in second place with 93 articles, Chavas JP is in third place with 90 articles, and Anonymous is in fourth place with 78 articles. And the keyword “Agriculture” had the highest frequency among all keywords with 353 repetitions, and it was found that the keywords “Agricultural Economics” and “Technical Efficiency” had frequencies of 221 and 147, respectively, ranking second and third. And two keywords, “poverty” and “panel data,” have the highest standard frequency in research studies in this area, with 112 concurrent occurrences.

Co-word analysis provides a helpful tool for understanding the knowledge structure of agricultural economics studies. Identifying these six major keyword clusters provides a framework for understanding the key research areas in the field and identifying areas for future research. The results of the co-word analysis suggest that agricultural economics is a diverse

field with a wide range of topics. The study identified six key research areas: technology adoption, demand, agricultural policy, agricultural markets and trade, agricultural productivity and efficiency, and risk. These research areas are crucial to addressing the challenges facing agriculture and rural development in the 21st century.

The Technology Adoption Cluster is the most crucial agricultural economics cluster focusing on using new technologies in agriculture. This cluster includes 85 items with 348 occurrences and a total connection strength 1615. Within this cluster, the term “poverty reduction” emerges as the most significant in terms of frequency of co-occurrence as well as strong links and connections to other keywords. These insights are essential for policymakers and agricultural producers because they can help them make informed decisions about adopting new technologies that can improve agricultural productivity and increase farmers' income while addressing problems such as poverty and food insecurity. The results are consistent with the research of Mendola (2007) and Mulugeta, Habtewold, and Heshmati (2023).

Demand clustering is the second key research area in agricultural economics identified by co-word analysis. This cluster includes 78 elements with 523 occurrences and a total connection strength of 1940. “Willingness to pay” is the most significant term in this cluster. The demand cluster focuses on factors that influence demand for agricultural products and consumer behavior, including terms such as “consumer behavior,” “food choice,” “nutrition,” “food safety,” “food quality,” and “purchasing power.” Understanding consumer behavior can help producers align their production with market demand and produce what consumers want. Insights into willingness to pay and purchasing power enable the development of targeted marketing campaigns that appeal to different consumer segments. The results align with the research of Henson and Reardon (2005).

The third key research area in agricultural economics identified through the co-word analysis is the agricultural policy cluster. This cluster includes 69 elements with 737 occurrences and a total connection strength 2922. “Management” is the most prominent term within this cluster. The Agricultural Policy cluster focuses on policies and regulations for the agricultural sector and includes terms such as “agricultural policy,” “trade policy,” “market regulation,” “price support,” “subsidies,” and “management.” This result is crucial for policymakers and provides valuable insights for designing and implementing effective policies. The findings from the Agricultural Policy Cluster are vital for policymakers for several reasons. The close connection between “management” and various policy-related terms underlines the importance of effective policy design and implementation. Proper management of agricultural policy ensures that regulations are effectively enforced, leading to better outcomes in the agricultural sector, as Mahé (2010) explained.

The trade and market cluster is the fourth research focus in agricultural economics identified through the co-word analysis. This cluster includes 69 items with 319 occurrences and a total connection strength 1213. Within this cluster, the term “cost” is the most significant in frequency of co-occurrence and has strong links and connections with other keywords. The trade and market cluster in agricultural economics emphasizes the importance of understanding the dynamics of agricultural markets and trade. It includes terms such as “transaction costs,” “international trade,” “market access,” “trade liberalization,” and “supply chain management.” These terms refer to the complex interactions between producers, buyers, and intermediaries in the agricultural sector and the impact of global trade policies and market conditions on the agricultural industry. The insights from the trading and market cluster are crucial for several

reasons. The importance of “transaction costs” highlights their influence on market efficiency and profitability. Reducing transaction costs can improve the efficiency of agricultural markets by reducing the costs associated with buying and selling products. This is supported by recent studies such as those by Shah et al (2021). Insights into “international trade” highlight the need to understand global trade policies and their impact on agricultural products. This knowledge, consistent with the findings of Anderson and Martin (2021), is critical for developing strategies to improve market access and competitiveness on a global scale. The concept of “market access” is crucial to expanding the reach of agricultural products. Understanding market entry barriers can help develop strategies to overcome these barriers and explore new market opportunities, as Jaffee, Henson, Unnevehr, Grace, and Cassou (2018) discussed. “Trade liberalization” is about reducing trade barriers such as tariffs and quotas. This can lead to more competition, lower prices and greater market opportunities for agricultural producers, in line with research by Josling (2018). Effective “supply chain management” is crucial to ensure agricultural products are distributed efficiently from farm to consumer. Improved supply chain management can reduce costs, minimize losses, and increase the overall efficiency of the distribution process, as Easwaran et al (2024) note.

The fifth key area of research in agricultural economics identified through co-word analysis is the farm productivity and efficiency cluster. This cluster includes 61 elements with 416 occurrences and a total link strength 1985. “Technical efficiency” is the most prominent term within this cluster, often appearing together with “total factor productivity.” This research area focuses on increasing efficiency and productivity in agriculture through new technologies and techniques. Key terms include “technical efficiency,” “total factor productivity,” input-output, and efficiency analysis. The importance of the agricultural productivity and efficiency cluster in agricultural economics underlines its crucial significance for the field. This area of research is critical because it addresses the fundamental need to improve agricultural practices in a world where demand for food and finite resources is increasing (Owuor et al., 2024). By focusing on terms such as “technical efficiency” and “total factor productivity,” this cluster highlights the need to maximize output while minimizing input, promoting sustainable agricultural practices. The insights gained from this cluster are invaluable to farmers, policymakers, and agribusinesses, providing strategies to increase yields, optimize resource use, and enhance overall productivity. This, in turn, contributes to food security, economic stability, and environmental sustainability, making it a cornerstone of agricultural economics research. The results align with the research of Huang et al. (2024).

The sixth key area of research in agricultural economics identified through co-word analysis is the risk cluster. This cluster includes 41 elements with 549 occurrences and a total connection strength 2628. “Crop insurance” is the most prominent term within this cluster. The risk cluster addresses various risks in agricultural production and management strategies to mitigate them. It includes terms such as “pesticide use,” “crop insurance,” “risk management,” “yield variability,” “price volatility,” and “disaster risk reduction”. The importance of this cluster points to extensive research focused on understanding and managing agricultural risks. This finding is critical for policymakers and agricultural producers, providing insights for informed decisions about risk management strategies and agricultural investments. Research on crop insurance and risk management highlights how these tools can mitigate the impact of yield variability and price volatility. The emphasis on disaster risk reduction also underscores the need for comprehensive strategies to handle natural calamities affecting agriculture. The results

align with the research of Chatellier (2011) and Anagonou, Ewemoje, Toyi & Olubode (2023).

Overall, the co-word analysis highlights the importance of interdisciplinary research in agricultural economics, encompassing various areas such as technology, policy, trade, and risk management. The insights gained from this research can help policymakers and farming producers make informed decisions about producing, marketing, and distributing agricultural products to promote sustainable development and improve farmers' livelihoods. This aligns with recent studies emphasizing the role of integrated risk management approaches in enhancing agricultural resilience (Choirun, Santoso & Astuti, 2020).

The results of this study have important implications for policymakers, researchers, and practitioners in agricultural economics. Policymakers can use the identified research areas to make policy decisions and determine investment priorities. Researchers can use the identified keyword clusters to guide their research and identify potential collaborators in other areas. Practitioners can use the findings to inform their practice and develop new solutions to agriculture and rural development challenges. In summary, co-word analysis represents a valuable tool for understanding the knowledge structure of agricultural economics studies. Identifying meaningful keyword clusters highlights the field's interdisciplinary nature and provides a framework for future research. The results of this study have important implications for addressing the challenges facing agriculture and rural development in the 21st century.

### Conclusions

The results of this study highlight the broad and dynamic nature of agricultural economics and its connection to various social, economic, and environmental challenges. The bibliometric analysis reveals that agricultural economics is a highly productive research field and addresses critical global issues such as food security, rural development, ecological sustainability, and income inequality. This significance is further underscored by projections showing a growing global population directly correlating with increasing food production demands. At the same time, urbanization exacerbates food shortages by driving higher consumption rates and reducing farmland availability due to infrastructure expansion.

The study provides valuable insights into the scope and distribution of research findings across various countries, journals, and keywords while emphasizing the urgent need to explore emerging trends in the field. Future research should investigate the interplay between technology adoption and agricultural productivity, particularly how innovations like precision agriculture, artificial intelligence, and digital platforms can address productivity and environmental challenges. This aligns with the critical need to overcome obstacles such as soil salinity in arid regions, which significantly impacts crop yields, and the broader effects of climate variability and soil conditions on crop quality and quantity. Consequently, assessing and optimizing land resources in arid areas is indispensable for agricultural growth. Furthermore, additional research is needed to understand the broader social impacts of emerging technologies, particularly their roles in poverty reduction and food access in developing regions. Given that agriculture is a major contributor to national income in many developing economies, leveraging advanced technologies is critical for economic development and ensuring sustainable food production systems. Innovations in smart agriculture, which enhance productivity, optimize resource use, adapt to climate change, and reduce food waste, are particularly crucial in this context.

Building on these findings, future research needs to examine the intricate relationships

between different research clusters identified in this study, such as the connections between agricultural policy, trade, risk management, and technological innovation. Policymakers should leverage these research trends to design integrated and forward-looking policies that promote sustainable farming practices while addressing the challenges of climate change and food security. In particular, initiatives are urgently needed to facilitate small-scale farmers' access to advanced technologies and foster interdisciplinary collaboration among agricultural economists, technologists, and environmental experts. As agricultural economics evolves to address global crises, strategies must focus on improving productivity while ensuring the sector's resilience and sustainability. This study provides a roadmap for these efforts, highlighting the importance of continued investment in research to enable agriculture to thrive in an increasingly interconnected and complex world.

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