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Intellectual and cognitive structures of the agricultural competitiveness research under climate change and structural transformation

JEL Classification: *Q10; Q17; Q18; L11; L25*

Keywords: *agriculture; competitiveness; bibliographic coupling; co-word analysis; thematic structure; current research trends; sustainable agriculture*

Abstract

Research background: Although agricultural competitiveness is not a new topic, it is worth noting that it has recently come back to the attention of researchers due to various factors such as climate change, food security, price uncertainty, or structural transformation. Consequently, a growing number of articles have emerged on this subject, leading to shifts in overarching research trends and the structure of research within this domain.
Purpose of the article: This study aims to facilitate a comprehensive understanding of the research constituents within the field of agricultural competitiveness. Additionally, it seeks to unveil the intellectual and cognitive frameworks spanning the years 1990 to 2022. This exploration will enable the identification of thematic clusters that both shape and guide the field, shedding light on current research trends.
Methods: This research employs bibliometric analysis, specifically employing performance analysis and science mapping techniques like bibliographic coupling and co-word analyses. These tools are harnessed to scrutinize the constituents of research and the underlying intellectual and cognitive structures inherent to the agricultural competitiveness field. A dataset of 622 articles from the Web of Science database was subjected to analysis using the VOSviewer software.
Findings & value added: The findings prominently illustrate a notable surge in research activity within this domain, with a substantial proportion of articles originating from the United States. The study further identifies six distinct research topics within agricultural competitiveness: (1) energy efficiency and bioenergy, (2) price fluctuation, uncertainty, and market behavior, (3) structural transformation of agriculture, (4) rural development, (5) policy issues, and (6) climate change. Moreover, the research offers insights into potential future research avenues. The uniqueness and value of this work stem from its pioneering approach, being the first to synthesize agricultural competitiveness research through an amalgamation of bibliometric techniques. Furthermore, the study contributes substantially to the theoretical advancement of agricultural competitiveness research.

Introduction

Understanding agricultural competitiveness proves pivotal in navigating the complexities of modern farming practices (Zhang *et al*., 2024). At its core, agricultural competitiveness encapsulates the ability of a nation, re-

gion, or agricultural sector to produce goods and services that meet the demands of domestic and international markets, while simultaneously enhancing productivity, sustainability, and economic viability (Istudor *et al*., 2022; Vrabcová & Urbancová, 2021a). However, the challenge lies in the diverse perspectives stemming from different economic theories, leading to a lack of unanimity in defining and measuring agricultural competitiveness (Hoang, 2020; Nowak & Kasztelan, 2022). Varied economic paradigms view competitiveness through contrasting lenses, emphasizing factors such as comparative advantage, cost efficiency, production efficiency, access to international markets, quality and food safety, government policies, technological innovation, and environmental sustainability (Latruffe, 2010; Nowak & Różańska-Boczula, 2022; Rumankova *et al*., 2022). It can be said that the lack of unanimity in the conceptualization and measure of agricultural competitiveness underscores the necessity for ongoing research to comprehensively depict the intricate nature of this economic phenomenon from diverse standpoints (Hoang, 2020; Nowak & Kasztelan, 2022).

It is important to take into account that the competitiveness of the global agricultural sector can have social, environmental, and economic impacts at local and global levels (Castillo-Díaz *et al*., 2023; Nugroho *et al*., 2023). Therefore, it is essential to address this issue in a balanced way to ensure that agriculture globally is sustainable and benefits all stakeholders. The growing interest in the subject of study is generating debates in the academic literature and social and political circles due, among other issues, to the liberalization of trade (Rumankova *et al*., 2022), the worrying environmental impact that we are currently dealing with (Nugroho *et al*., 2023), the irruption of technological innovations and their possible consequences (Sun *et al*., 2023), the transition from conventional to synthetic and biosynthetic methods (Ribeiro & Shapira, 2019), and the growing social inequality of recent history (Nugroho *et al*., 2023).

On the societal and economic level, the relevance of agricultural competitiveness is irrefutable since it is recognized as a key factor for international trade (Anderson & Nelgen, 2012) and also as a catalyst that fosters technological advances and the development of innovative practices (Vrabcová & Urbancová, 2021a). In addition, the correct evaluation of its trajectory and evolution allows for the configuration of effective public policies by those in power, which has a relevant impact on society and the economy (Luo *et al*., 2017). As such, the review of agricultural policies allows evalu-

ating the effectiveness of existing ones, as well as helping in the development of new agricultural policies.

At the academic level, the research of agricultural competitiveness has likewise massive importance. For example, researchers are constantly trying to develop new models and techniques for measuring agricultural competitiveness (Istudor *et al*., 2022), as these tools are essential to identify areas for improvement and guide public policies. In addition, the development and implementation of the theory of competitiveness and comparative advantage in agriculture are used by researchers to suggest appropriate policies and strategies to improve a country's competitive position in the global market (Sarker & Ratnasena, 2014). Moreover, academics analyze the value chain of the agricultural sector to identify new strategies to improve agricultural competitiveness (German *et al*., 2020). Finally, scientific research in this field allows the identification of determining factors for the adoption of technologies and how they contribute to the efficiency and sustainability of the systems (Duque-Acevedo *et al*., 2022; Nugroho *et al*., 2023; Sun *et al*., 2023).

Although research on agricultural competitiveness began in the late 1930s, it is worth noting that the formal beginnings of research from an economic point of view date back to 1990 (Nowak & Kasztelan, 2022). From 1990 to the present, this research topic gained momentum mainly in 2007 and 2012; however, the years of greatest research are from 2019 to 2022 (see Figure 1). This recent explosion of research on agricultural competitiveness generated mainly by various factors such as climate change (Nugroho *et al*., 2023) food security (Campi *et al*., 2021), price uncertainty (Boyd & Bellemare, 2022), or structural transformation of the agricultural sector (Deininger *et al*., 2022) has led to the accumulation of a considerable body of literature, which is scattered, with studies dealing with different themes in diverse contexts. In addition, this new body of research brings with it a change in the general trends and structure of research in this field. However, to date, there does not appear to be any study that provides a general review or examination of the agricultural competitiveness research field that helps researchers understand the main components of this area of research, as well as the intellectual and cognitive structures of the field.

Given this research gap, the present study aims to achieve the following five objectives through an integrated bibliometric analysis: (1) detecting the main research constituents in agricultural competitiveness research in terms of journals, authors, and countries; (2) mapping co-authorship rela-

tions between authors and countries to detect collaboration status between research constituents; (3) uncovering the most influential papers in agricultural competitiveness research; (4) exploring the intellectual structure of research in agricultural competitiveness; and (5) mapping the evolution of agricultural competitiveness research and identifying future research avenues.

Through these five objectives, this investigation achieves the five elements that a bibliometric analysis must comply with to lead to the theory advancement (Mukherjee *et al*., 2022) and thus, it has relevant implications for the advancement of agricultural competitiveness theory. First, we objectively identify the knowledge clusters. Second, we describe the nomological networks existing in the research field. Third, the study maps the social patterns helping with the development of the field. Fourth, we track the evolutionary nuances to address where the field is going. Fifth, we detect crucial knowledge gaps to propose future research lines.

The next section of the article addresses a background of relevant aspects to understanding agricultural competitiveness research. Following it, the next section describes the research methods chosen in this study. Then, the results and discussion of major research constituents and social networks are presented, followed by a discussion of the findings related to the intellectual and cognitive structures analysis. Finally, conclusions, implications, and limitations are presented.

Background to agricultural competitiveness research

Agricultural competitiveness is a highly relevant issue in the socioeconomic development of all economies, being the engine of development in many countries where it represents their largest economic activity. In the first place, the relevance of production factors must be taken into account when evaluating the competitiveness between economies. The evolution of international trade and the legislation of each country also encourage competition between them. All this, in addition to the inclusion of sustainable agricultural innovation and new technologies, has become the key factor for agricultural competitiveness.

The importance of productive factors in agricultural production

In the comparison of the competitiveness of an agricultural system against others, the measurement of the factors stands out as a means to reach conclusions. Factors such as the available infrastructure, the natural resources of each area, the technology used, the importance of education in the field of study, the training of agricultural workers, and political restrictions are decisive when evaluating the differences between them. These findings make each agricultural production system particular and different, and therefore difficult to compare.

The report on international development at the agricultural level prepared by The World Bank (2007) points out that solid, sustainable, and inclusive food systems are fundamental to achieving development objectives worldwide. The development of the agricultural sector worldwide constitutes one of the most important pillars when it comes to ending extreme poverty, boosting global prosperity, and feeding a mass population that is expected to reach 9.7 billion inhabitants in the year 2050 (The World Bank, 2023).

Figure 1 collects data on world agricultural production together with the population explosion of the last 50 years. It represents the percentage of the evolution of the world GDP that the agricultural sector supposes (including divisions 1–5 of the International Standard Industrial Classification of economic activities with forestry, hunting, and fishing, in addition to the cultivation of crops and animal husbandry) (United Nations, 2008) compared to the volume of world population from 1972 to 2022. The graph shows the evolution since the end of the last century when the primary sector had a large presence in the GDP of the majority of the economies. Agriculture represented the livelihood of the majority of the population, but a change in trend can be seen starting in 1974, due to the exodus of the rural population to the big cities, and with it the rise of the secondary and tertiary sectors (Timmer, 1992). However, in the years closest to the present, it can be seen how economic growth driven by agriculture, poverty reduction, and food security are increasingly at risk.

Economic integration of international markets

The globalization and liberalization of global trade policies are fostering the integration of commodity markets with developing and underdevel-

oped economies. This entails a growing interconnectedness and interdependence between these markets and economies (Vijayakumar & Bozward, 2021). The integration of all international markets directly affects agricultural competitiveness, by reducing production costs. Indeed, it can influence some or all phases of the value chain, due to international expansion of markets (Ma, 2022).

Moreover, the establishment of integration coalitions emerges as a logical reaction to crisis situations and the adverse implications of globalization, particularly amplifying amid the instability of the global economic landscape and escalating imbalances in the development of the world economy and its regional components (Adamchuk, 2023). In recent times, there have been multiple shocks that are affecting agri-food systems. These shocks include disruptions related to pandemics such as COVID-19, extreme weather events, and wars (Miranda *et al*., 2023). As a result, agri-food systems are suffering a direct impact that is causing an increase in food prices.

Standardization in the agricultural sector

Given the growing integration of the economy worldwide, changes in macroeconomic policies are playing an increasingly important role in trying to alleviate a situation that affects not only the agricultural sector, but all economic and social sectors. In 2015, the United Nations (UN) approved the 2030 Agenda to achieve full sustainable development through 17 Sustainable Development Goals (European Commission, 2023) that include issues such as climate change, equality, the importance of protecting the environment or the end of poverty in the world. This international agreement represents an opportunity for the countries involved in the agreement to embark on a new path toward an improvement in the lives of all (United Nations, 2023).

In the European context, in December 2019, the European Commission introduced the European Green Deal as a pivotal initiative for the European Union (Bongardt & Torres, 2022). This comprehensive plan encompasses various policy measures for the agricultural sector, such as clean energy, sustainable industry, building and renovation, creating a sustainable food system (farm to fork), pollution elimination, promoting sustainable mobility, and safeguarding biodiversity (Boix-Fayos & de Vente, 2023). The European Green Deal is not only a domestic agenda, but is also aligned with the

global commitment to the United Nations 2030 Agenda and its SDGs. Essentially, it outlines a holistic approach to address environmental challenges and promote sustainability across diverse aspects of society and the economy within the European Union (Nowak & Różańska-Boczula, 2023).

Sustainable agricultural innovation and new technologies

The adoption of new technologies is a key factor in the agri-food sector which, together with the inclusion of more efficient and sustainable agricultural practices, represents a huge improvement in the competitiveness of farms (Cavazza *et al*., 2023). The sector faces a series of challenges that translate into increases in profitability. It is important to emphasize the supervision and management of crops, optimize natural resources, and pay attention to production performance in terms of quality and food safety (Bhagat et al., 2022). The Food and Agriculture Organization (FAO, 2009) points out that the agriculture of the future faces multiple challenges; by 2050, it will be necessary to produce 70% more food, due to the growing world population.

The introduction of AI technology into agriculture has elevated the industry to a whole new standard by enhancing crop production and refining various facets of crop monitoring (Bhagat *et al*., 2022). This technological integration has led to notable improvements in the efficiency and precision of monitoring and managing crops (Sharma *et al*., 2022). Moreover, recent advancements in the Internet of Things and unmanned aerial vehicles have brought about a transformative impact on conventional agriculture, introducing intelligence and automation (Cavazza *et al*., 2023). In a standard intelligent agriculture setup, there is a continuous generation of extensive and real-time data. Essentially, this marks a shift towards a more technologically sophisticated agricultural ecosystem, where the integration of IoT and UAVs facilitates efficient data processing and management to enhance decision-making in farming practices (Kumar *et al*., 2022).

The agriculture of the future will be developed mainly with highly sophisticated technologies such as robots, temperature, and humidity sensors, as well as aerial images and GPS tracking technology (Cavazza *et al*., 2023; Shaikh *et al*., 2022). This type of innovative technology, advanced devices, robotic systems, and precision agriculture will allow farms to be more profitable, efficient, safe, and respectful of the environment and its resources. In short, the benefits of smart agriculture are the optimization of

productivity, the maximization of benefits, help in decision-making, sustainability, cost reduction, and food safety.

Research methods

Data collection

The Web of Science (WoS) database was chosen for this study because it is considered by researchers as the leading and comprehensive database of academic papers and the one with the longest history (Mongeon & Paul-Hus, 2016; Ogutu *et al*., 2023). We selected the two main WoS indexes, i.e., the Social Science Citation Index (SSCI) and the Science Citation Index (SCI). A search was carried out with the parameters [TOPIC ("agricult*") AND TOPIC ("competitive*")]. The initial search uncovers 5.781 documents. To guarantee the quality of the papers analyzed, the search was limited to articles, leaving aside books, book chapters, conference proceedings, and papers to congresses, editorials, and research notes, since they contain less validated knowledge (Munteanu *et al*., 2022; Podsakoff *et al*., 2005). This exclusion criterion led us to 5.198 articles. As we are primarily interested in analyzing the state-of-the-art of scientific research on agricultural competitiveness in the discipline of economics, we filtered by WoS category "Economics". By applying this filter, we refine our search to 688 articles. For the study period, we selected articles published between 1990 and 2022. The rationale for taking the year 1990 as the start-point of the period under study was that the WoS database yielded virtually zero publications on this topic within the "Economics" field before that year. We identified only 8 articles between 1939 and 1989, which are insignificant for bibliometric purposes. Finally, we refined our search to include articles written in English only. Thus, we met a final sample of 622 articles. It should be highlighted that the sample exceeds the minimum of 200 documents suggested by Rogers *et al*. (2020) and even the more restrictive threshold of 500 items proposed by Donthu *et al*. (2021).

Analysis techniques and tools

For this study, we focus on two complementary bibliometric techniques; namely performance analysis and science mapping (Donthu *et al*., 2021).

Performance analysis includes three different types of metrics to examine the contributions of research constituents to a given field (Cobo *et al*., 2011). These are (1) publication-related metrics, (2) citation-related metrics, and (3) citation-and-publication-related metrics. It should be noted that each of these covers a large number of metrics. In this study, we focus on analyzing various metrics of each of them; specifically, we examine the most productive journals, the most prolific authors, the most productive countries, and the most cited articles. The analysis of these metrics allows for presenting the performance of different research constituents (e.g., journals, authors, and countries) and is considered the hallmark of bibliometric studies (Donthu *et al*., 2021). Therefore, we have carried out first a performance analysis with the bibliographic data of the 622 publications extracted from WoS and the help of Microsoft Excel 2010. Additionally, VOSviewer software (Van Eck & Waltman, 2010) was used to visually represent the existing relationships between some of the research constituents (e.g., co-authorship network among authors or the international cooperation based on co-authorship between countries).

Second, to study the intellectual and cognitive structures of the agricultural competitiveness research field, we carry out bibliographic coupling and co-word analyses. On the one hand, the bibliographic coupling is based on the premise that two publications sharing common references are also similar in their content (Donthu *et al*., 2021). The analysis is carried out based on the division of scientific contributions into thematic groups on the basis of shared references (Zupic & Cater, 2015). Thematic clusters are created based on cited publications, and thus, recent publications can gain visibility (Donthu *et al*., 2021), which makes it possible to determine the recent/emerging intellectual structure of a scientific field and its latest developments (Zupic & Cater, 2015).

Co-word analysis, on the other hand, allows for establishing relationships through the keywords used by authors to characterize their studies and build a conceptual structure of the main topics within a research field (Callon *et al*., 1983). The assumption is that when keywords appear frequently in several publications, it means that the concepts behind those words are closely related (Zupic & Cater, 2015). The result of this science mapping technique is a semantic map that allows an understanding of the cognitive structure of a scientific field and graphically visualizes the past, current, and future research trends (Börner *et al*., 2005). For both analyses, we relied again on the VOSviewer software (Van Eck & Waltman, 2010).

Results and discussion

Major research constituents: Trends and social networks

Journals

Table 1 shows a list of all journals that have published ten or more articles on agricultural competitiveness. As can be seen, a total of fourteen journals appear on the list. As Table 1 shows, the journal of *Agricultural Economics Zemedelska Ekonomika* is the one with the most publications with 64 contributions, followed by the *American Journal of Agricultural Economics* with 52 publications. Other prominent sources include the *Food Policy* journal, *Agricultural Economics*, and *European Review of Agricultural Economic*s. Table 1 also includes some journal quality metrics like the Australian Business Deans Council (ABDC) ranking, the Web of Science Impact Factor, and the Scopus CiteScore. Among the highest publishers, considering the highest quality journal, they encourage analysis of problems relevant to research and extension, as well as interdisciplinary research with a significant economic component. In addition to the titles focused purely on agriculture, it can also be seen that there are some journals with different topics such as applied economics, food policy, ecological economics, world development, or energy policies. Therefore, it can be said that there is an interesting balance in several high-quality journals. If we take into account the CiteScore metric, two journals with the highest data on the list stand out to a great extent, with the highest ratio of citations per published scientific article.

Authors and countries

When analyzing the most outstanding scientists in the field of study, Table 2 offers information about the authors who publish the most on competitiveness in the agriculture sector. The most prolific author is *Richard J. Sexton*, from the University of California Davis, who has published 12 articles and they have been the most cited (249 times). This author is closely followed by *Lubos Smutka* with 8 publications, and *Matthew Gorton* and *Tina Saitone*, with 5 publications each. All of them have a citation average of approximately 15 citations per article.

Figure 3 presents the co-authorship network among authors of the field of study. In the Figure, we can see that various groups of authors collabo-

rate. The author *Smutka, L.* stands out mainly, who has connections with various authors from various affiliations, but highlights a strong close collaboration with *Svatos, M.*

Table 3 lists the countries that have contributed the most to research on competitiveness in agriculture, with the *United States of America* standing out to a great extent over the other predominant countries in the field of study, with 216 articles in the period studied and a total of 4,508 citations. Next is *England* with 47 publications and an average of 19.85 citations per publication. In terms of influence, the information in the table highlights that some of the major world powers contribute the most to scientific knowledge in the field of study of this document. In terms of influence, Table 3 shows there are two countries, such as *Canada* and *Italy*, which stand out with 18.13 and 21.85 citations per publication respectively, surpassing the European country even the data per publication of the *United States of America*, as the largest country that publishes articles in the subject of study.

Figure 3 presents the co-authorship network between countries that study competitiveness in the agriculture sector. The authors from the *United States of America* are the most prominent in this area of research and are closely related in collaborative authorship with the authors from the *People's Republic of China*, *Canada*, *Australia*, *England*, and *the Czech Republic*. The Figure shows different collaborative groups, (co-authorship relationships) between countries, mostly from Europe.

As a reflection of these findings, we could say that it would be interesting to see a better balance in terms of publications on this subject, especially in countries such as Spain that are heavily dependent on agriculture.

Most cited articles

Table 4 lists the most influential scientific research papers related to competitiveness in agriculture in terms of citations. The article by (Howitt, 1995), titled "Positive Mathematical-programming" and published by the *American Journal of Agricultural Economics* is the most cited article with 523 citations. The article focuses on the development of a method to calibrate agricultural production models, analyzing resources with non-linear performance functions.

This article is followed by (Benjamin, 1992), titled, "Household composition, labor-markets, and labor demand-testing for separation in agricultural

household models" with 260 citations, and (Hennessy, 1998), titled, "The production effects of agricultural income support policies under uncertainty" with 218 citations. Lauri *et al.* (2014) present an article on the scarcity of resources to cover world energy consumption. Other influential scientific studies in the field of agricultural competitiveness include Binswanger-Mkhize (2012); Kirwan (2009); Zhang *et al*. (2017); Moschini *et al*. (2008); Pope and Just, (1991); Bai *et al*. (2012); Paul *et al*. (2004); Latacz-Lohmann and Van Der Hamsvoort (1998); Copeland and Taylor (2009); Serra *et al*. (2006); and Murphy *et al*. (2011).

Intellectual and cognitive structures

Bibliographic coupling analysis

As manifested earlier, bibliographic coupling analysis allows us to analyze the intellectual structure of a scientific discipline (Zupic & Cater, 2015), and thus identify the thematic groups that shape and guide the field. Using VOSviewer, the bibliographic coupling analysis segregated the 622 documents into six major clusters (see Figure 4). A close analysis of the papers included in each cluster has allowed us to characterize them.

Cluster 1 (red cluster): *Energy efficiency and bioenergy*. This cluster mainly consists of studies dealing with the development of energy systems that are concurrently energy efficient and enhance agricultural competitiveness. The key articles of this cluster are published in journals such as *Energy Economics*, *Energy Policy*, and *Food Policy*. Papers of this conglomerate emphasize that the importance of agricultural competitiveness lies not only in its food function, but also in the production of bioenergy (e.g., biomass and biofuels) (Bai *et al*., 2012; Lauri *et al*., 2014), and point to the growing current and future economic competitiveness of electricity and heat from energy crops (Styles & Jones, 2007; Bojnec & Papler, 2011). Studies of this cluster also indicate that bioenergy production based on agricultural commodity crops will continue to be important for food security and agricultural competitiveness (Murphy et al., 2011; Winchester & Reilly, 2015).

Cluster 2 (green color): *Price fluctuation, uncertainty, and market behavior*. This cluster mainly groups studies that analyze how price fluctuation, uncertainty, and market behavior affect agricultural competitiveness, both for companies and the sector in general. Specifically, topics such as the effects on the production of farm income support policies under uncertain conditions

(Hennessy, 1998) and the uncertainty generated by new product introduction, new processing technology adoption, and asymmetric information of farmers and how these factors affect agricultural competitiveness (Du *et al*., 2016) are covered in this thematic cluster. Other studies appearing in this group debate issues like price jumps in agricultural products and how these jumps can highlight the chaotic state of economic analysis of agricultural markets (Wright, 2014) and how the effectiveness of resource management can predict changes in prices (Copeland & Taylor, 2009). Moreover, topics related to market conditions, market systems, and market structure are also analyzed. The journals that have published mainly on these topics are the *American Economic Review*, *American Journal of Agricultural Economics*, *Ecological Economics*, and *Journal of Economic Perspectives*.

Cluster 3 (light blue cluster): *Structural transformation of agriculture and its implications*. The cluster primarily deals with how to improve technical efficiency and competitiveness in the agricultural sector through structural transformation. The manuscripts of this cluster are mainly found in journals such as *Agricultural Economics*, *Annual Review of Resource Economics*, *European Review of Agricultural Economics*, and *Journal of Productivity Analysis*. In its origins, this cluster began to study the relationship between farm restructuring and its implications for competitiveness, highlighting that farm production structures are important for agricultural competitiveness and that it was therefore appropriate for some farms to restructure the way they operate (Sarris *et al*., 1999). Articles in this cluster further discuss the relationship between scale economies and efficiency and whether this relationship could mean the end of traditional farms. Empirical evidence in this cluster suggests that increasing competitiveness in the agricultural sector will require small farms to move towards more diversified production on a larger scale, as well as an improvement in efficiency towards the levels of large farms (Paul *et al*., 2004). Another study on this cluster suggests that outsourcing may be a good managerial strategy for smaller farms to achieve higher levels of efficiency, which is probably best resorted to improving competitiveness rather than pursuing an increase in their average farm size (Picazo-Tadeo & Reig-Martínez, 2006). The recent articles appearing in this cluster focus on the structural transformation of the agricultural sector towards export orientation and productivity in the low-and middle-income economies (Khan, 2020; Deininger *et al*., 2022).

Cluster 4 (purple color): *Rural development.* This cluster encompasses mainly articles dealing with the relationship between rural development and

agricultural competitiveness. It consists majorly of themes such as rural poverty reduction through increased farm competitiveness, labor demand and labor supply of the farm household in the rural labor market and rural employment (Benjamin, 1992), lack of purchasing weather insurance by farmers (Binswanger-Mkhize, 2012), development of effective rural development programs and access to credits to increase competitiveness (Coomes, 1996), and the loss of competitiveness due to farm labor outflows despite farm output growth (Zhang *et al*., 2017). The journals that have published mainly on these topics are *China Economic Review*, *Econometrica*, *Journal of Development Studies*, and *World Development*.

Cluster 5 (blue color): *Policy issues*. This cluster addresses diverse issues related to the formulation, implementation, and evaluation of policies for the agricultural sector within an economic framework and its impact on competitiveness. As such, papers on this thematic group aim to inform the decision-making and policy-making community about contemporary and emerging policy issues. The studies of this cluster are mainly found in journals such as *American Journal of Agricultural Economics*, *Applied Economic Perspectives and Policy*, and *Food Policy*. Articles on this conglomerate focus on topics such as the intellectual property rights in agriculture and institutional features of agricultural R&D (Moschini & Lapan, 1997), the impact of public agricultural research and extension on total factor productivity in agriculture (Huffman & Evenson, 2006), and the evaluation of policies to regulate vertical coordination in agricultural markets (Crespi *et al*., 2012). Another study on this topic highlights that for the design of effective policies, it is relevant to examine which forms of collective action are the most effective in terms of their outcomes for market participation and biodiversity conservation (Kruijssen *et al*., 2009).

Cluster 6 (yellow color): *Climate change*. The articles of the climate change cluster focus on the bidirectional relationship between climate change and competitiveness in the agricultural sector. Of the six clusters, this is the one with the latest research start; therefore, it can be said that it is the newest cluster in the intellectual structure of research in agricultural competitiveness. It involves topics like environmental challenges for the agricultural sector (Ionescu *et al*., 2020), transformative policies toward a green economy (Pegels & Altenburg, 2020), the green revolution in the agricultural sector (Ariga *et al*., 2019), and the emergence of community supported agriculture (Connolly & Klaiber, 2014). Other articles appearing in this cluster discuss issues like what are the motivations for implementing environmental man-

agement practices in agricultural firms (Singh *et al*., 2015) or how the companies of this sector promote their corporate social responsibility practices (Vrabcová & Urbancová, 2021b) and how this impact in their competitiveness. It is worth noting that the articles in this cluster are mainly found in journals such as *Agricultural Economics*, *Ecological Economics*, *Economic Research-Ekonomska Istraživanja*, and *World Development*.

The presented analysis illuminates six distinct thematic clusters within agricultural competitiveness research. This organization provides a succinct overview of the core research foci, ratifying the multifaceted nature of the field (Nowak & Kasztelan, 2022; Rumankova *et al*., 2022). These clusters serve as intellectual anchors, guiding researchers through the complex tapestry of agricultural competitiveness considerations since the clusters elucidate significant dimensions within agricultural competitiveness. For instance, Cluster 1 emphasizes the symbiotic relationship between energy efficiency, bioenergy, and agricultural competitiveness, highlighting the evolving role of agriculture in sustainable energy production (Lauri *et al*., 2014). Cluster 2 directs attention to the pivotal role of price fluctuations and market behavior in shaping the sector's competitiveness (Wright, 2014). Similarly, Cluster 3 delves into the structural transformation of agriculture, raising questions about scale efficiency and diversification (Paul *et al*., 2004). Finally, the clusters showcase that agricultural competitiveness extends beyond production and encompasses aspects like policy formulation (Cluster 5) (Crespi *et al*., 2012) and climate change adaptation (Cluster 6) (Ariga *et al*., 2019; Pegels & Altenburg, 2020). Thus, these findings provide significant advances to the current literature on agricultural competitiveness over previously published studies and allow a better understanding of the recent changes in general trends and intellectual structure in this field.

Co-word analysis

As mentioned before, co-word analysis with the help of VOSviewer software allows one to graphically analyze the cognitive structure of an academic discipline (Zupic & Cater, 2015). Specifically, in this study, co-word analysis allows us to detect past researched topics and forecast future research in the field (cf. Donthu *et al*., 2021). Thus, from a temporal point of view (see Figure 4), one can argue that scholars focused on topics such as oligopoly and oligopsony power (Russo *et al*., 2011; Sexton *et al*., 2007), imperfect competition (Osborne, 2005; Soregaroli *et al*., 2011), asymmetric

information (Bogetoft *et al*., 2005), and risk aversion (Havlík *et al*., 2005; Isik, 2002) at the first decade of the 21st century. As time went on, researchers turned their attention to themes such as (common) agricultural policy (Kožar et al., 2012), WTO and international trade (Han & He., 2012), comparative advantage (Matkovski *et al*., 2017; Sarker & Ratnasena, 2014), market power (Lloyd, 2017), and sustainability (Ariga *et al*., 2019).

Finally, topics with a more recent emergence and which, therefore, require more attention in future research include technical efficiency (Čechura *et al*., 2022; Cillero & Reaños, 2023), agribusiness (Hernández-Espallardo *et al*., 2022), food security (Campi *et al*., 2021; Khalid *et al*., 2020), price uncertainty (Bellemare *et al*., 2020; Boyd & Bellemare, 2022), and structural transformation (Deininger *et al*., 2022; Khan, 2020). Current fields of study such as technical efficiency, food safety, or structural transformation have gained great relevance due to the social transformations and the economic and environmental changes suffered in recent years, which have caused greater concern in society. The search for productive efficiency could identify new areas for improvement while maximizing production. Scientific research on food scarcity contributes to guaranteeing equitable access to safe and nutritious food while trying to improve its distribution. Moreover, we assume that agribusiness and price uncertainty have gained recent relevance in agricultural competitiveness research because they directly impact the economic viability and sustainability of agricultural enterprises. Agribusiness encompasses the entire value chain, from production to distribution, and its efficiency influences a nation's capacity to compete globally. Price uncertainty, on the other hand, caused by a series of negative effects (COVID-19, extreme weather events, and wars), affects farmers' income stability and decision-making, influencing their ability to remain competitive in fluctuating markets. Both factors are integral to understanding and enhancing agricultural competitiveness in a dynamic global landscape.

These recent topics of scientific study are crucial to addressing future challenges in the agri-food field. For this reason, research in these areas can have a significant impact when it comes to improving resource management and promoting sustainable economic growth, as well as may lead to an improvement in the quality of life of the world population, guaranteeing food safety.

Conclusions

Using bibliometric performance analysis and science mapping techniques, this paper rigorously explores the field of agricultural competitiveness. The trends in major research constituents suggest that there has been a consistent increase in the number of publications. The field is mostly published by journals like *Agricultural Economics-Zemedelska Ekonomika*, *American Journal of Agricultural Economics*, *Food Policy*, *Agricultural Economics*, *European Review of Agricultural Economics*, and *Ecological Economics* which are high-quality research outlets in the economics discipline. It highlights the prominence, popularity, and issue of concern of the topic in both academia and practice. Most research in the field has come from scholars in the *United States*. The bibliographic coupling analysis unveils that present research in the field is led by six major thematic groups. These six clusters shed light on the diverse facets of agricultural competitiveness, ranging from energy efficiency and bioenergy to policy issues and climate change considerations. The co-word analysis of the discipline suggests that the major emergent topics explored by authors are technical efficiency, agribusiness, food security, price uncertainty, and structural transformation. Our study suggests that these themes need more attention and development by scholars of agricultural competitiveness research.

Based on this detailed analysis of the research constituents and the intellectual and cognitive structure of this field, this study fulfills the five proposed objectives and meets the five elements that a bibliometric analysis must comply with to lead to the theory advancement. Thus, it has relevant implications for the advancement of agricultural competitiveness research and practice. For academics, this study serves as a guiding framework, illuminating the path for expanded investigations. This research not only identifies the fundamental theoretical underpinnings of this field but also highlights topics necessitating more profound research. Our findings open the debate to analyze the dynamic interplay between the six thematic groups and their potential overlap to offer new insights into the cross-disciplinary nature of agricultural competitiveness. Furthermore, our analysis unveils the evolutionary trajectory of thematic clusters and research subjects, exposing the dynamic changes in research emphasis over time. This exploration brings to the fore transformative shifts in research priorities, mirroring responses to global phenomena such as technological strides, policy recalibrations, and ecological exigencies.

The findings not only enrich the academic discourse, but also have direct practical implications. Policymakers and practitioners can leverage these findings to inform decision-making and strategic planning, directing resources toward areas that are not only academically significant but also practically relevant. They can draw from Cluster 5's policy-oriented findings to inform decision-making processes related to policy reforms and supportive frameworks (e.g., introducing policies that incentivize the adoption of modern agricultural technologies, such as tax credits or subsidies for farmers investing in precision farming equipment would be justified) or investment and funding strategies (e.g., establishing funds or grants specifically aimed at supporting research and development in agriculture, focusing on innovative practices and sustainable activities).

Cluster 4's exploration of rural development offers insights into strategies for poverty reduction and increased competitiveness. Activities such as the implementation of community-driven agricultural cooperatives, which empower small farmers to collectively market their products, improving their bargaining power and market access, or the implementation of training programs focused on modern agricultural practices, financial literacy and business management techniques tailored to rural farmers to increase productivity and income could be interesting areas where resources could be directed. The emergence of Cluster 6, which delves into climate change, highlights the growing recognition of environmental factors within the competitiveness equation, underpinning the urgency of sustainability in agriculture. In this case, activities such as encouraging the adoption of climate-smart agricultural techniques like agroforestry or conservation agriculture to enhance resilience against climate change impacts or implementing policies that promote the use of renewable energy sources in farming operations or regulations aimed at reducing agricultural emissions would be interesting measures that could be promoted by policymakers and practitioners.

While this study adheres to a rigorous methodological approach, it is not exempt from limitations. The primary constraint arises from the vast volume of literature encompassing the subject of study. This abundance of material impedes a more nuanced examination of individual papers, occasionally necessitating generalization in certain areas. Additionally, the process of curating a representative sample of papers demands a series of decisions that inevitably influence the outcome. Factors such as the chosen database, search parameters, and paper inclusion and exclusion criteria all

contribute to shaping the final selection. Despite these acknowledged limitations, the findings, implications, and conclusions derived from this study remain both robust and valid.

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Annex

Table 1. Major publishing journals in agricultural competitiveness

Journal	TP	ABDC	Impact Factor	CiteScore
Agricultural Economics Zemedelska Ekonomika	64		2.2	4.5
American Journal of Agricultural Economics	52	A*	4.2	7.8
Food Policy	36	B	6.5	9.9
Agricultural Economics	32	A	4.1	5.7
European Review of Agricultural Economics	31	A	3.4	7.8
Ecological Economics	24	A	7	11.0
Canadian Journal of Agricultural Economics	20	A	9	15.4
Custos e agronegocio on line	19		0.3	1.0
Energy Policy	19	A	9	15.2
World Development	17	A	6.9	10.9
China Agricultural Economic Review	14	C	5.1	7.9
Journal of Agricultural Economics	14	A	3.4	7.0
Journal of Agricultural and Resource Economics	13	A	1.4	3.1
Applied Economics	10	A	2.2	3.4

Source: Own elaboration based on Web of Science database (2023).

Table 2. Most prolific scholars publishing on agricultural competitiveness

Authors	Affiliation	Total publications	Total citations	Citations per publication
Sexton RJ	University of California Davis	12	249	20.75
Smutka L	Czech University of Life Sciences	8	120	15
Gorton M	University of Newcastle upon Tyne	5	74	14.8
Saitone TL	University of California Davis	5	78	15.6
Chavas JP	University of Wisconsin Madison	4	31	7.75
Ciaian P	European Commission	4	65	16.25

Table 2. Continued

Authors	Affiliation	Total publications	Total citations	Citations per publication
Davidova S	University of Kent	4	61	15.25
Svatos M	Czech University of Life Sciences	4	70	17.5
Urbancova H	Univ Econ & Management	4	20	5
Zilberman D	University of California Berkeley	4	133	33.25

Source: Own elaboration based on Web of Science database (2023).

Table 3. Most prolific countries publishing on agricultural competitiveness

Countries/Regions	Total publications	Total citations	Cites per Publication
USA	216	4508	20.87
England	47	933	19.85
Czech Republic	44	450	10.23
Peoples R China	44	587	13.34
Canada	39	707	18.13
Germany	34	392	11.53
Australia	26	336	12.92
Italy	26	568	21.85
France	24	470	19.58
Spain	23	545	23.7

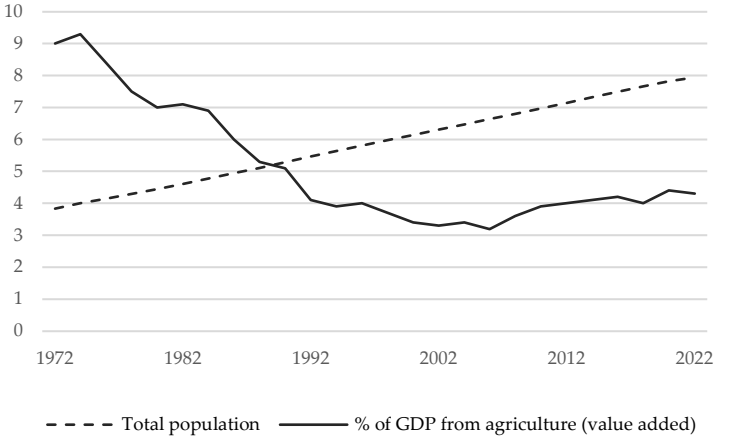
Source: Own elaboration based on Web of Science database (2023).

Table 4. Most influential articles on the topic agricultural competitiveness

Title	Authors	Year	Journal	TC	C/Y
Positive Mathematical- Programming	Howitt, R	1995	American Journal of Agricultural Economics	523	18.03
Household composition, labor-markets, and labor demand - testing for separation in agricultural household models	Benjamin D.	1992	Econometrica	260	8.13
The production effects of agricultural income support policies under uncertainty	Hennessy DA.	1998	American Journal of Agricultural Economics	218	8.38
Woody biomass energy potential in 2050	Lauri P., Havlik P., Kindermann G., Forsell N., Bottcher H., Obersteiner M.	2014	Energy Policy	184	18.4
Is There Too Much Hype about Index-based Agricultural Insurance?	Binswanger-Mkhize HP.	2012	Journal of Development studies	137	11.42
The Incidence of US Agricultural Subsidies on Farmland Rental Rates	Kirwan BE.	2009	Journal of Political Economy	126	8.4
Mechanization outsourcing clusters and division of labor in Chinese agriculture	Zhang XB., Yang J., Thomas R.	2017	China Economic Review	115	16.43
Geographical indication protection in the united states	Moschini G., Menapace L., Pick D.	2008	American Journal of Agricultural Economics	115	7.19
On testing the structure of risk preferences in agricultural supply analysis	Pope RD., Just RE.	1991	American Journal of Agricultural Economics	107	3.24
Biofuel supply chain design under competitive agricultural land use and feedstock market equilibrium	Bai Y., Ouyang YF., Pang JS.	2012	Energy Economics	90	7.5
Scale economies and efficiency in U.S. agriculture: Are traditional farms history?	Paul CM., Nehring R., Banker D., Somwaru A.	2004	Journal of Productivity Analysis	80	4
Auctions as a means of creating a market for public goods from agriculture	Latacz-Lohmann U., Van der Hamsvoort CPCM.	1998	Journal of Agricultural Economics	80	3.08
Trade, Tragedy, and the Commons	Copeland BR., Taylor MS.	2009	American Economic Review	79	5.27
Effects of decoupling on the mean and variability of output	Serra T., Zilberman D., Goodwin BK., Featherstone A.	2006	European Review of Agricultural Economics	79	4.39
Global developments in the competition for land from biofuels	Murphy R., Woods J., Black M., McManus M.	2011	Food Policy	77	5.92

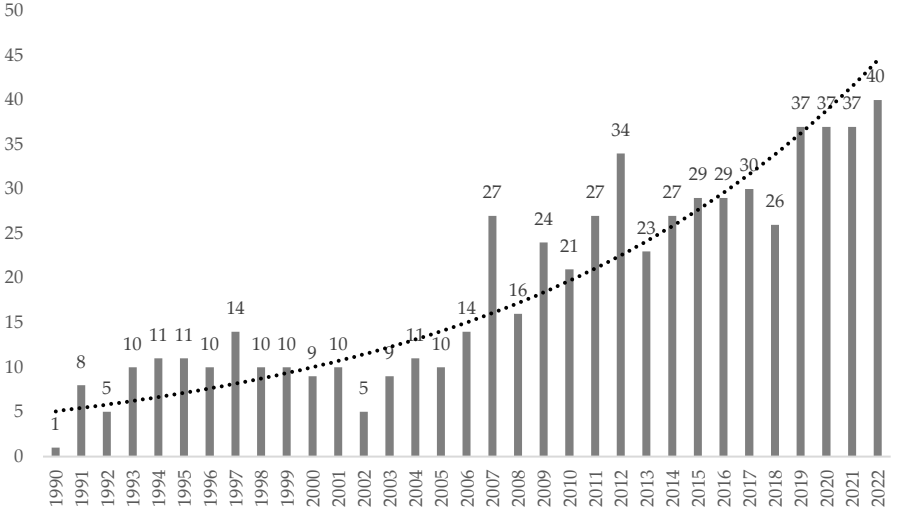
Source: Own elaboration based on Web of Science database (2023).

Figure 1. Comparison between the percentage of GDP from agriculture and the volume of world population in the last 50 years based on data from the World Bank



Source: Own elaboration based on data from the World Bank.

Figure 2. Year wise publication. This figure represents the publication trend on the topic between 1990 and 2022



Source: Own elaboration based on Web of Science database (2023).

Figure 3. Co-authorship network among publishing on the topic agricultural competitiveness

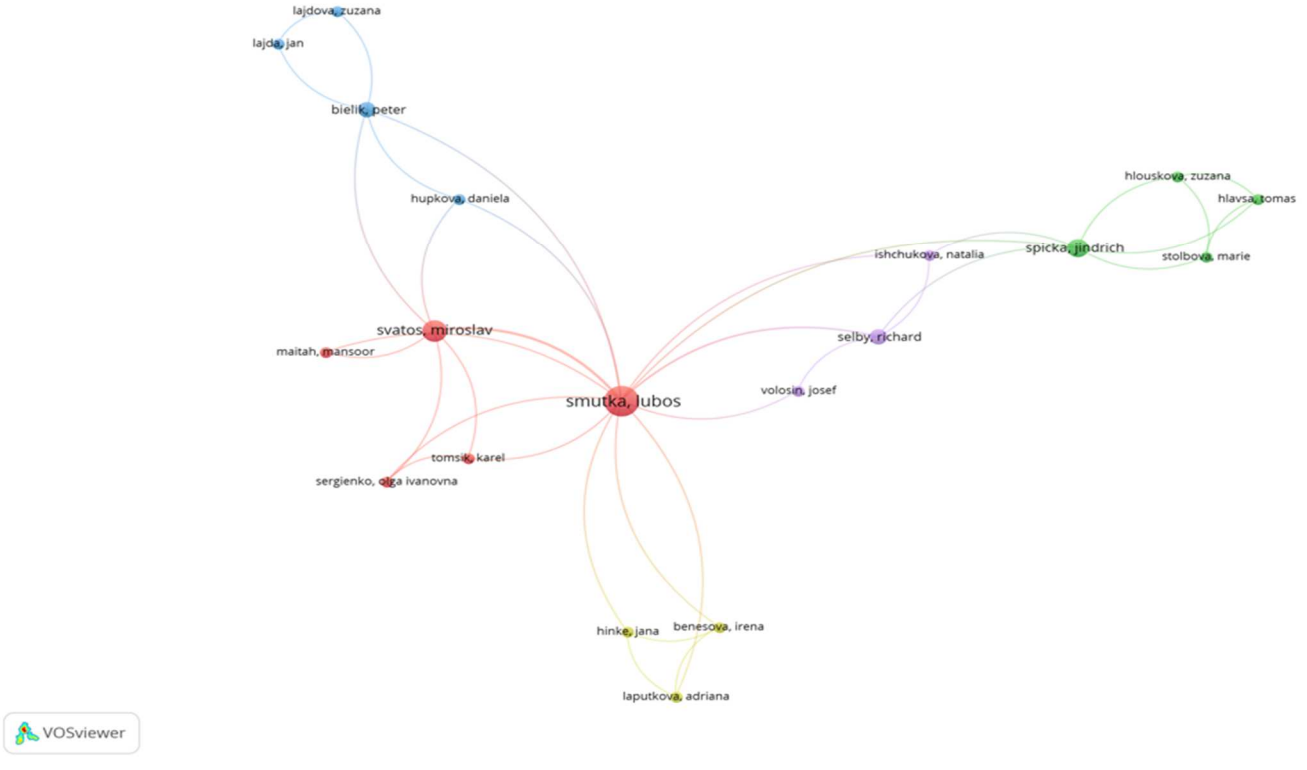


Figure 4. Co-authorship network among countries publishing on the topic agricultural competitiveness

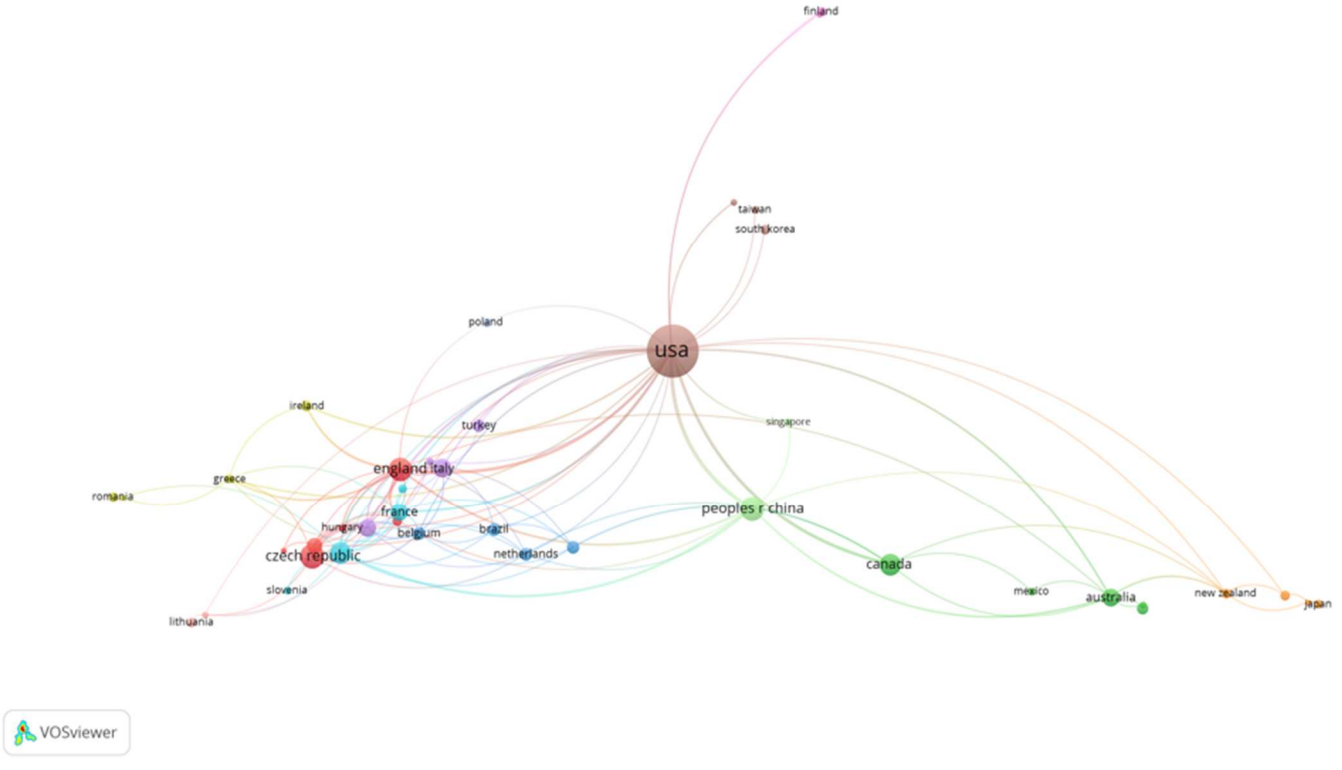


Figure 5. Bibliographic coupling analysis on the topic agricultural competitiveness

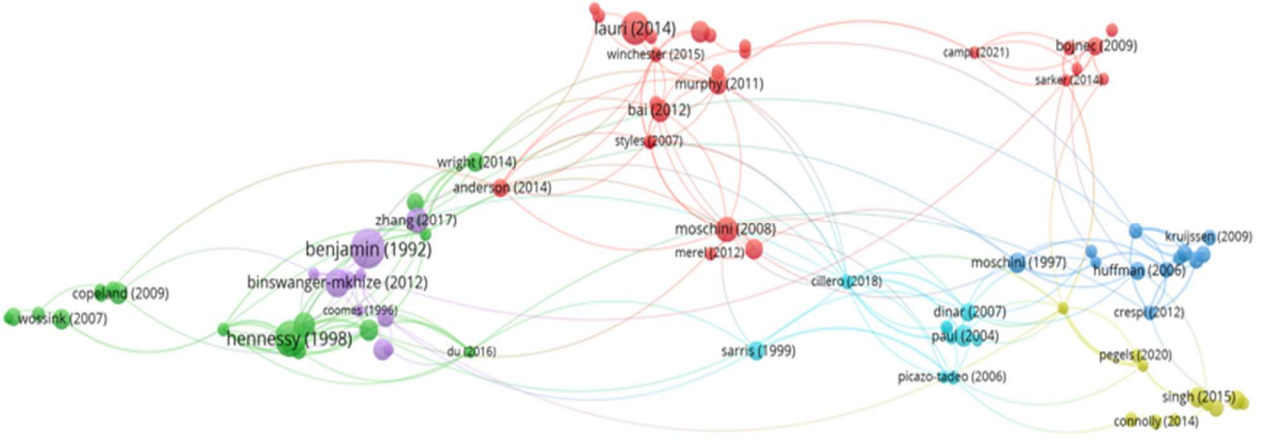


Figure 6. Co-word analysis (overlay visualization) on the topic agricultural competitiveness