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A Bibliometric Analysis of the Literature on Food Industry Supply Chain Resilience: Investigating Key Contributors and Global Trends

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Abstract: Purpose: In light of ongoing challenges such as climate change, pandemics, and globalization, it is critical to have resilient food industry supply chains that can operate effectively in uncertain conditions. This study aims to contribute to this effort by investigating current trends and developments in the area of food industry supply chain resilience and identifying potential areas for improvement. Design/methodology/approach: We conducted a comprehensive bibliometric analysis of 122 articles published between 2008 and 2023, utilizing multiple quantitative measures such as bibliographic coupling and keyword co-occurrence network analysis. Findings: Our study identifies five distinct clusters of research on food industry supply chain resilience. We found that food systems resilience and public health is the most extensively studied aspect, indicating the importance of ensuring that our food supply chains are capable of withstanding disruptions to maintain public health. The other four clusters–seafood supply chain resilience and risk management; digital and sustainable food systems; agri-food Industry 4.0 and sustainability; and meat production and the food industry–each represent important areas for future research and development. Originality: To our knowledge, this is the first study that uses a bibliometric approach to analyze the resilience of food supply chain systems. By doing so, we provide a unique and original contribution to the existing literature on food supply chain systems, as prior bibliometric analyses have not specifically focused on the resilience aspect. Practical implications: Our findings highlight the need for continued research and development in the area of food industry supply chain resilience. By identifying the most pressing areas for improvement and future research, our study can help inform policy decisions and guide industry efforts to create more resilient food supply chains that can adapt to changing conditions.

Keywords: resilience; food supply chain; bibliometric analysis; risk management

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1. Introduction

Food industry supply chain resilience refers to the ability of the system to withstand and recover from disruptions, such as natural disasters, pandemics, or political instability [1]. It involves not only ensuring the availability of food, but also the ability to maintain the quality, safety, and nutrition of food throughout the supply chain [2]. A resilient food industry supply chain is one that is able to adapt and respond to changing conditions, whether those conditions are related to weather, economic instability, or geopolitical risks. It is crucial for ensuring food security and maintaining social and economic stability [3]. Ensuring the resilience of food industry supply chains—the networks of activities, people, and resources involved in producing, processing, distributing, and consuming food—is critical for meeting the food needs of the growing global population and for mitigating the impacts of potential disruptions [4].

A resilient food industry supply chain is characterized by a diverse range of suppliers and distributors, efficient logistics, and robust risk management strategies [5]. One way

to improve food industry supply chain resilience is to increase the number of local and regional food producers and suppliers [6]. This can reduce the dependence on a single source of supply and help to ensure that food is available even in the event of a disruption. Another way is to use "Smart Agriculture" technology that helps to improve crop yields and make farming more efficient [7]. Another strategy is to use digital tools and technologies such as the Internet of Things (IoT), data analytics, and blockchain, to improve transparency and traceability in the food industry supply chain. This can help to identify and mitigate risks more quickly and effectively [8].

In recent years, there has been growing concern about the resilience of the global food supply chain, as a number of high-profile disruptions have highlighted vulnerabilities in the system [9]. The globalized and complex nature of food industry supply chains has made these systems increasingly vulnerable to disruptions [10]. In fact, disruptions such as natural disasters, pandemics, and other emergencies can have severe consequences for food security and economic stability [11,12].

To address these challenges, it is important to understand the key components of food industry supply chain resilience and identify strategies for improvement. These components include diversification of suppliers and sources of raw materials [13], redundancy in transportation and logistics infrastructure [14], inventory management and storage practices [15], risk assessment and contingency planning [16,17], communication and collaboration among supply chain constitute partners [18,19], and government policies and regulations related to food industry supply chain management [20].

Diversification of suppliers and sources of raw materials is a key aspect of food industry supply chain resilience. It reduces the risk of shortages and price spikes caused by disruptions to a single supplier or source [21]. Moreover, redundancy in transportation and logistics infrastructure, such as multiple modes of transportation, can provide alternative routes for goods to reach their destination in case of disruptions [22]. Additionally, inventory management and storage practices can also play a critical role in ensuring food security during disruptions by allowing for buffer stocks and timely access to food [15].

Risk assessment and contingency planning are also essential components of food industry supply chain resilience. They enable supply chain managers to identify potential risks and develop plans to mitigate or respond to them [16]. Additionally, communication and collaboration among supply chain partners are crucial in ensuring a coordinated response to disruptions. This includes sharing of information and aligning plans and protocols [18]. Finally, government policies and regulations related to food industry supply chain management play an important role in creating a supportive environment for building resilience in the food supply chain [23].

One important strategy for improving food industry supply chain resilience, especially in the fresh produce sector, is to invest in supply chain infrastructure. For example, building or upgrading cold storage facilities, distribution centers, and transportation networks can increase the capacity to store and transport fresh produce, reducing the risk of spoilage and wasted food in case of disruptions [24]. Additionally, investing in a transportation network that includes multiple modes of transportation such as rail, road and sea can provide alternative routes for goods to reach their destination in case of disruptions [25].

Another strategy is to implement traceability systems throughout the supply chain. These systems, such as RFID, Barcode, and QR-code, enable the tracking and identification of produce from farm to consumer, providing transparency and visibility into supply chain operations [26]. This can enable supply chain managers to quickly identify and address potential risks, such as food safety issues or contaminated produce.

In addition, increasing collaboration and communication among supply chain partners can improve food industry supply chain resilience [18]. This can include forming partnerships between growers, processors, distributors, retailers, and government agencies to share information, align plans and protocols, and coordinate responses to disruptions. By working together, supply chain partners can better prepare for and respond to disruptions, reducing the potential impacts on food supply and security.

Developing resilience certifications and standards can be effective in ensuring that food industry supply chains are prepared and able to respond to disruptions [27]. These standards will provide a framework and guidelines for food suppliers and other stakeholders in the food supply chain to identify risks, implement best practices and demonstrate compliance.

An increasing number of scholars have been conducting and publishing articles about food industry supply chain resilience in the past decades [27,28]. However, a bibliometric study of the food industry supply chain resilience is lacking. Unlike traditional reviews, bibliometric analysis is a valuable tool for researchers looking to understand the development and trends within a particular field of study by analyzing and summarizing a large number of publications within a specific domain [29]. Bibliometric analysis is a quantitative method of studying the academic literature within a specific field, which offers a non-predetermined and objective examination of that field. The method uses various objective metrics, such as citation counts, journal impact factors, and authorship patterns to analyze the academic literature, which helps to minimize bias and ensure that the results of the analysis are based on objective data [30]. Indeed, to better understand and address the challenges of food industry supply chain resilience, it is important to identify patterns, trends, and key players in research on food supply chain resilience.

The motivation for this study is to provide insights into the research landscape on food supply chain resilience, specifically focusing on the most productive countries, authors, and journals. Understanding the current state of research in this field is important for several reasons. First, it can help identify areas where research is lacking or where more attention is needed. Second, it can inform policymakers and practitioners in the food industry about the latest trends and developments in this area. Finally, it can help researchers and scholars identify potential collaborators or areas for future research.

This study applies bibliometric analysis to the literature on food industry supply chain resilience, with the aim of identifying the most productive countries, journals, and authors in this field, as well as key themes and trends in the literature. Additionally, our study will shed light on the state of the art and the research gaps in this field.

Based on these factors, this study aims to answer the following questions:

Q1: Which countries, journals, and authors are driving the discourse on food industry supply chain resilience and contributing to its evolution?

Q2: What are the main major research themes, trends, and gaps in the literature on food industry supply chain resilience?

To answer these questions, we will conduct a bibliometric analysis of the literature on food industry supply chain resilience using data from the Scopus database. We will use VOSviewer software to examine over 186 academic publications and identify patterns and trends in this area. This study represents an important step toward a better understanding of food industry supply chain resilience and how to address the ongoing challenges that threaten it.

The remainder of the paper is organized as follows: The Section 2 describes the data source and the methodology used in this research in detail. Then, a range of analytical methods, such as co-occurrence, citation, and co-citation, will be employed to identify the articles, authors, countries, and organizations that have had the greatest influence in the field. Afterward, the paper will discuss the current research gaps and potential research opportunities based on the bibliometric analysis. Finally, the conclusion, limitations, and main contributions of the paper will be highlighted.

2. Data Source and Methodology

The methodology for this study was designed to provide a comprehensive analysis of the current state of research in food industry supply chain resilience. To achieve this goal, a thorough review of relevant literature was conducted through bibliometric analysis. Bibliometric analysis is classified as performance analysis and science mapping. Briefly, performance analysis shows the contributions of research constituents, whereas science mapping defines the relationships between research constituents. Various indicators for

performance analysis are available; including publication number and citations per year or per research constituent. Publication numbers are an indicator for productivity and citation numbers represent the impact and influence. Science mapping investigates the relationships between research constituents and shows the structures (i.e., conceptual, intellectual, and social) that describe the topic. Science mapping is composed of citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis [31].

The study was divided into five steps which include: literature search, data collection and pre-processing, bibliometric analysis, keyword analysis, and cluster and content analysis.

Step 1: Literature search: A comprehensive literature search was conducted using the academic database Scopus. We chose to use the Scopus database because it is the largest abstract and citation database of peer-reviewed literature, and is largely used by scholars worldwide [32]. We identified a set of keywords that we searched in keywords, titles or abstracts of the papers. We did not limit our research to specific document types.

Search String: TITLE-ABS-KEY ("food" AND "industry" AND "supply" AND "chain" AND "resilience" OR "resilient"). We did not include limits to the time span of the research. The initial search process generated 186 academic papers from 2008 (the year when the first document was published) to 2023 (the investigation period).

Step 2: Data collection and pre-processing: The collected data, including the title, authors, subject area, document type, affiliation keywords, country, and publication year, were extracted and pre-processed for further analysis. The data were cleaned to ensure consistency and accuracy of the analysis. This cleaning activity was performed by reading the abstract or keywords of the papers and allowed us to exclude 64 articles. Exclusion criteria were documents not related to food industry supply chain resilience (papers off topic) and duplicate documents.

Step 3: Bibliometric analysis: The bibliometric analysis was conducted using VOSviewer software. In the context of food industry supply chain resilience, bibliometric analysis can be used to identify key research areas and gaps in current knowledge, and track the evolution of the field over time [32]. This information can help researchers and practitioners better understand the challenges facing food industry supply chain resilience and identify opportunities for future research and innovation. Additionally, bibliometric analysis can be used to identify key researchers and institutions working in the field, facilitating collaboration and constitute knowledge sharing among professionals in the field [29]. It can also be used to identify the number of publications by country and source. This analysis provides an understanding of the distribution of research in terms of geographical location and academic journals. Furthermore, it can be used to identify the most productive authors, institutions, and journals in this field.

Step 4: Keyword analysis: co-occurrence of keyword analysis was analyzed on VOSviewer typically by including a visual representation of the relationships between keywords by network graph. Moreover, this analysis was conducted using VOSviewer mapping, where the frequency of keywords was calculated, which allows for the identification of the most frequently used keywords. These results are useful in identifying the most studied aspects of food supply chain resilience.

Step 5: Cluster and content analysis: Cluster analysis is a method of grouping similar objects together in a dataset. In this study, cluster analysis was used to group together similar keywords based on their co-occurrence patterns. The cluster analysis result on VOSviewer is a visual representation of the clusters heatmap that shows the relationships between the keywords and the grouping of similar keywords. Clustering can be useful for identifying patterns, trends, and relationships within the text data that may not be immediately apparent from reading the text alone. The cluster analysis was carried out to identify the main clusters and themes, and to propose future research directions based on these clusters. This was achieved by reading and analyzing the articles, and identifying the main concepts.

This methodology was chosen as it allows for a comprehensive and in-depth analysis of the current state of research on food industry supply chain resilience. By adopting a multifaceted approach, including bibliometric and content analysis, we were able to identify key trends, patterns, and areas for future research in this field.

3. Findings: Bibliometric Analysis Results

3.1. Publication by Year

The first publication was in 2008; since then and especially in recent years, the number of published articles on this topic has increased considerably. Between 2008 and 2018 the literature appears scarce, with fewer than four papers published per year. However, the peak of academic publications on food industry supply chain resilience occurred with the outbreak of the COVID-19 pandemic at the global level. The analysis showed that the highest percentage of published papers is in the last two years, specifically 67%, with the following distribution: 2022 (44 papers; 36%), 2021 (38 papers; 31%) (Figure 1). This result is not surprising as we expected there to be a significant increase in the publication of research on food industry supply chain management in the wake of the COVID-19 pandemic. This is due to the disruptions caused by the pandemic, which have highlighted the vulnerabilities and weaknesses of the food industry supply chain.

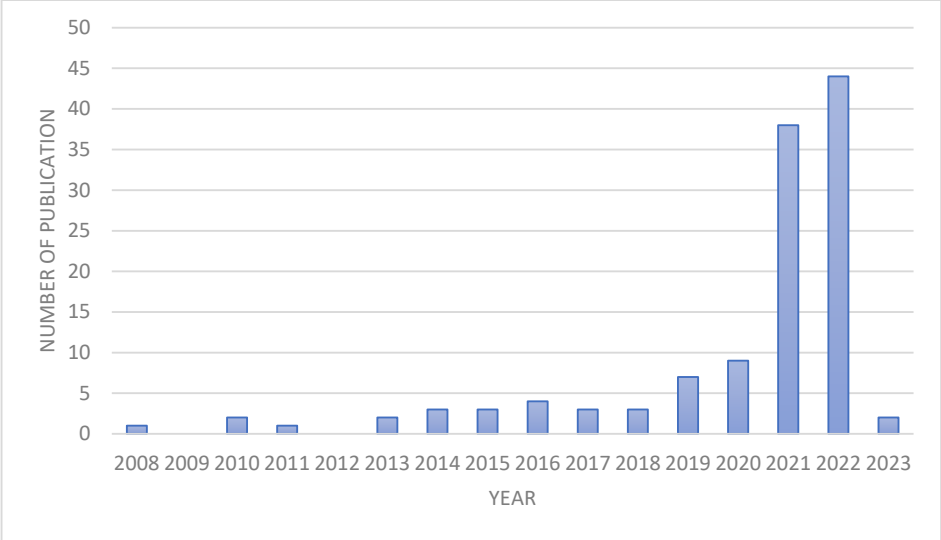


Figure 1. Time distribution of publications.

3.2. Contribution by Journals

Table 1 presents the scores and rankings of the top 10 most cited journals in the field of food industry supply chain resilience. The data analyzed includes the number of documents, citations, SCImago Journal Rank (SJR), CiteScore, and source normalized impact (SNIP) (except for those that are not available: NA). It is worth noting that SJR measures the weighted citations received by the journal, taking into account the prestige of the citing journal and the subject field. CiteScore, on the other hand, measures the average citations per document, and SNIP measures the actual citations received relative to the expected citations for the journal's subject field. The ranking indicates that journals in this field have varying ranks and quality, highlighting the prominence and interest in the topic among editors and publishers. The analysis includes 98 journals and proceedings, with the top 10 journals and proceedings publishing approximately 22.13% of the publications in this field. Additionally, the journal *Supply Chain Management* had the highest combined number of publications and citations.

Table 1. Scores and ranking of the top 10 most cited journals (source: Scopus and VOSviewer).

Source	Publisher	TP	TC	SJR	SNIP	Cite Score
Supply Chain Management	Emerald Publishing	4	653	0.27	0.22	0.33
Sustainability (Switzerland)	Multidisciplinary Digital Publishing Institute (MDPI)	4	25	0.267	1.066	1.65
Agricultural Systems	Elsevier	3	48	0.91	0.72	1.12
Frontiers in Sustainable Food Systems	Frontiers Media SA	3	32	NA	NA	NA
British Food Journal	Emerald Publishing	3	31	0.47	0.31	0.54
Resources, Conservation and Recycling	Elsevier	2	564	1.87	1.09	2.05
Journal of Business Research	Elsevier	2	81	3.129	2.69	3.48
Applied Economic Perspectives and Policy	Oxford University Press	2	64	NA	NA	NA
Trends in Food Science and Technology	Elsevier	2	52	3.57	3.07	4.24
PLoS ONE	Public Library of Science (PLoS)	2	32	2.77	1.44	NA
Journal of cleaner production	Elsevier	2	28	6.05	4.39	6.96

TP: Total publications by source. **TC:** Total citations of source. **SJR:** SCImago Journal Rank, a measure of the prestige of a journal based on the number and quality of the citations it receives. **SNIP:** source normalized impact per paper, a measure of the citation impact of a journal relative to its subject field and geographic region. **Cite score**: a metric developed by Scopus that measures the average number of citations received by papers published in a particular journal over a three-year period.

3.3. Research Areas on Food Industry Supply Chain Resilience

Figure 2 illustrates the number of research studies conducted in various domains related to the food industry supply chain. The data suggests that there is a significant amount of ongoing research in this field and that many research groups globally are actively working in these areas. However, it also shows that 42% of the total number of publications in this field are concentrated in three specific areas: agricultural and biological sciences (16%), business, management, and accounting (13%), and environmental science (13%). This highlights the fact that the food industry supply chain is a multidisciplinary subject, with contributions from various fields of study.

3.4. Country Analysis

In order to gain a deeper understanding of the global trend in the resilience of food industry supply chain phenomena, an analysis of the interest levels in different countries was conducted. It is challenging to accurately assign each paper to a specific country or continent as many papers are the result of international collaborations with authors from various countries [32]. Nevertheless, by examining the distribution of papers based on the nationality of the corresponding author, it is evident that globally, the majority of papers are authored by individuals from developed countries.

The data presented in Figure 3 illustrates the geographical distribution of publications on food industry supply chain resilience. The color on the map is proportional to the number of documents. The most active countries on the topic, which are highlighted on the map, are labeled with the number of documents they contributed. It is evident that the research activity in this field is a global effort, with 57 countries contributing to growth. However, a closer examination of the data reveals that a significant proportion of the publications are concentrated among a few countries. Specifically, the United Kingdom (20%), the United States (17%), Austria (12%), and Canada (8%) are key players in advancing research on this topic, as they together account for approximately 58% of the world's publications in this field. This highlights the importance of these countries in shaping the current state of knowledge and future direction of research in food industry supply chain resilience.

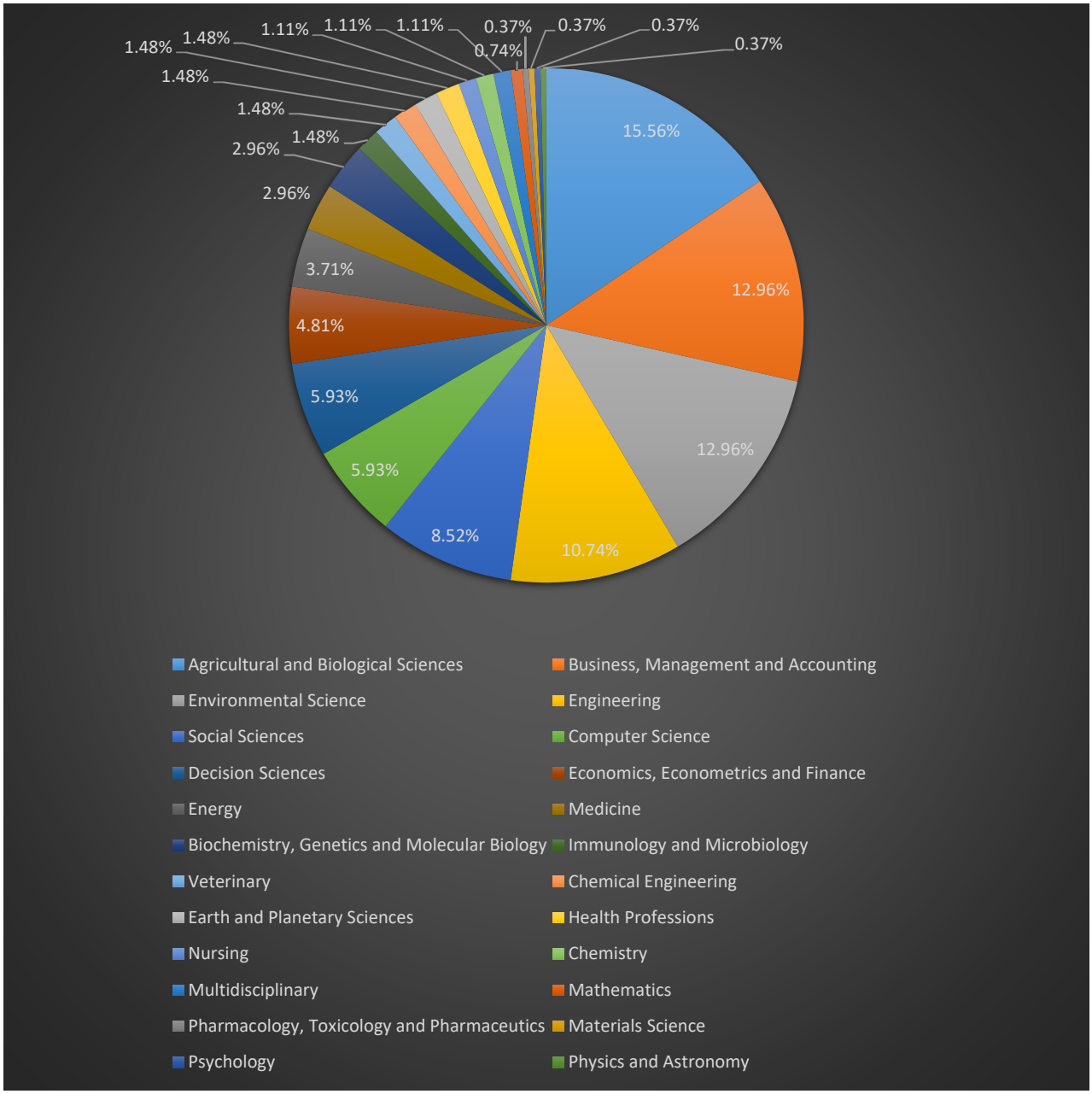
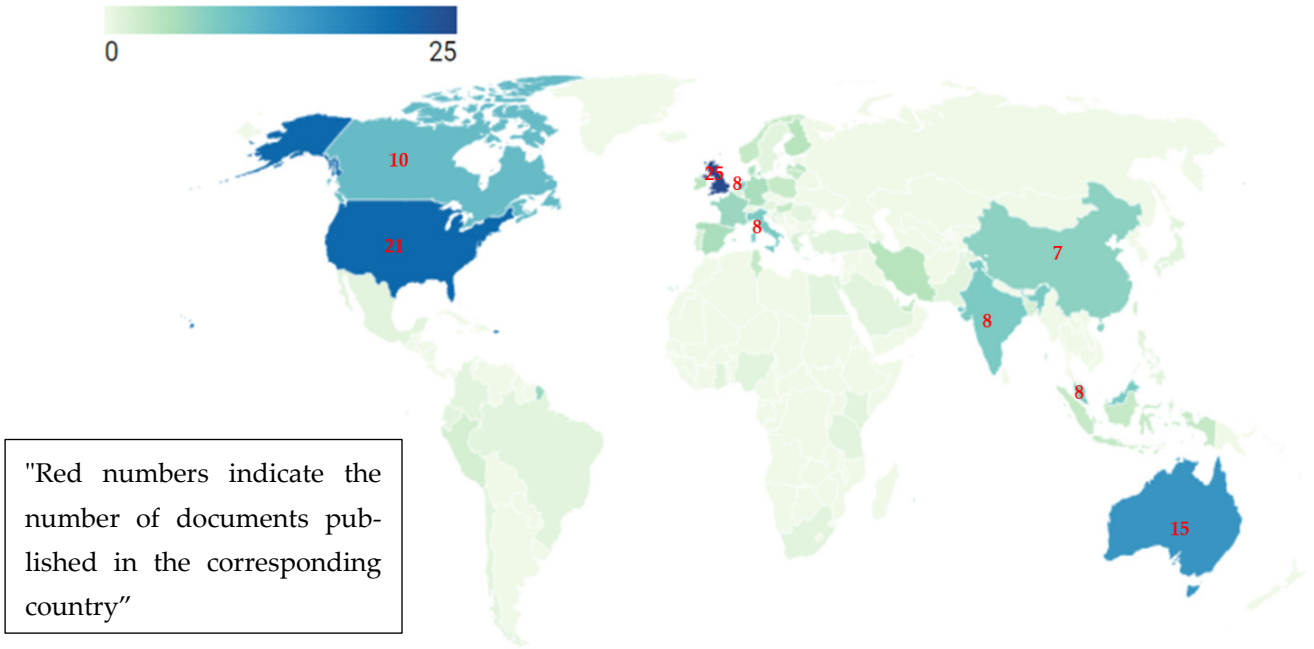


Figure 2. Documents by subject area (created by authors on Microsoft Excel).

3.5. Influence of Authors

The analysis of the authorship of a recent paper in the field of food industry supply chain resilience reveals that while there is a large number of authors, only a small subset have a significant number of publications in the domain. Out of the 143 authors, only 13 have published more than two papers, and the highest number of publications among this group is four (Rahimifard, S.). This suggests that there is a lack of specialized experts in this field, as the majority of authors have only a limited number of publications.

However, when considering the number of citations as a measure of an author's expertise and impact in the field, a different picture emerges. A comparison of the authors' citation counts reveals a significant difference among the 143 authors. For example, Scholten, K. has a high number of citations, with 366 citations, while Schilder, S. has 358 citations. On the other hand, Arabsheybani, A. and Arshadi Khasmeh, A. have comparatively low citation counts, with only 20 citations each.



"Red numbers indicate the number of documents published in the corresponding country"

Figure 3. Paper distribution per country (created by authors on https://app.datawrapper.de/ (accessed on 14 January 2023)).

It is important to consider various metrics, not just the number of publications, when evaluating an author's expertise and impact in a field. The number of citations is also a valuable metric to take into account. This is why other parameters such as co-citation of authors are also considered.

Figure 4 depicts a network of authors who have been cited more than 10 times in the field of food industry supply chain resilience. The co-citation analysis does not distinguish between primary and secondary authors. Ivanov D., the most cited author, is prominently located in the center of the network. Based on the degree of collaboration between the writers, the network can be separated into groups, each represented by a different color. The lines between the circles denote collaborative links, while the size of the circles represents the frequency of occurrence of each author. It should be noted that core authors within one category could not work well with authors within other groups. For instance, Stevenson, M. primarily works with authors in the yellow group, though they also occasionally collaborate on projects together. Folke, C., who is in the green group, is another example.

3.6. Most Relevant Contributions

Table 2 presents the results of an analysis that aimed to identify the most important contributions in food industry supply chain management. The analysis was conducted by reviewing the most highly cited articles in food logistics and distribution, and data was collected on the number of citations each article received from other researchers in the field. A total of 122 articles were analyzed. The results of the analysis revealed that the most relevant contributions focused on the study of the food industry supply chain, risks, and themes such as COVID-19. Furthermore, it was found that the top-cited articles were primarily focused on sustainability and environmental impact in food industry supply chain management, with a particular emphasis on reducing food waste and implementing sustainable packaging solutions.

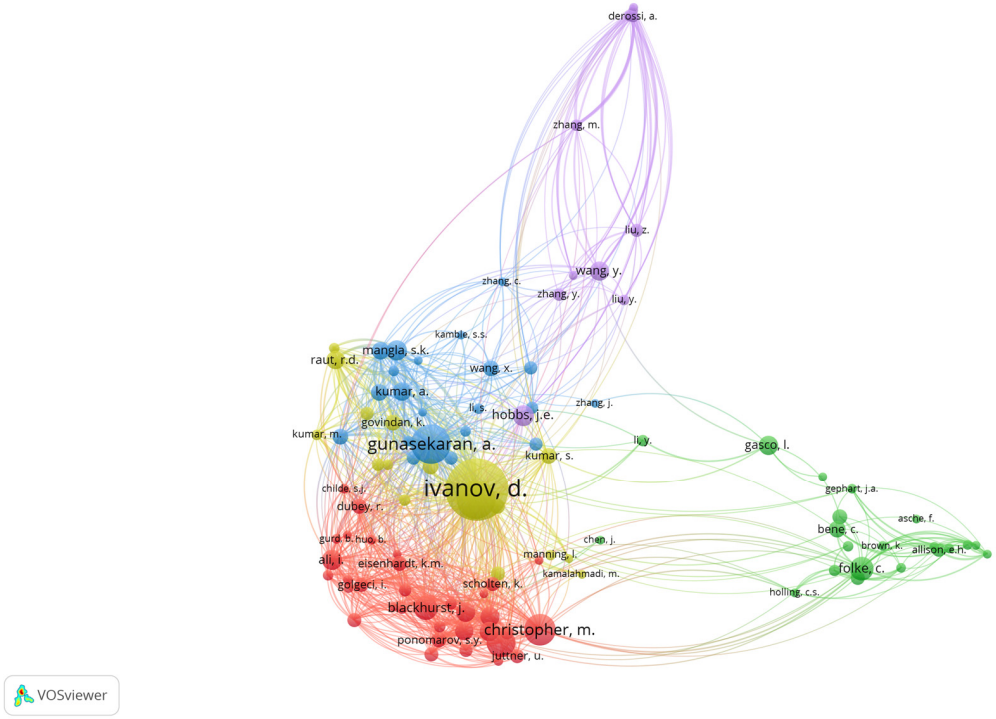


Figure 4. Co-citation author's network (created by VOSviewer).

Table 2. Top 10 of most relevant contributions.

Document	Citations	Title	Journal
Scholten, K. (2015)	358	The role of collaboration in supply chain resilience	*Supply Chain Management*
Sharma, H.B. (2020)	283	Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic	*Resources, Conservation and Recycling*
Ibn-Mohammed, T. (2021)	281	A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies	*Resources, Conservation and Recycling*
Leat, P. (2013)	153	Risk and resilience in agri-food supply chains: the case of the ASDA PorkLink supply chain in Scotland	*Supply Chain Management*
Stone, J. (2018)	133	Resilience in agri-food supply chains: a critical analysis of the literature and synthesis of a novel framework	*Supply Chain Management*
Khatun, R. (2017)	117	Sustainable oil palm industry: the possibilities	*Renewable and Sustainable Energy Reviews*
Xu, Z. (2020)	107	Impacts of COVID-19 on global supply chains: facts and perspectives	*IEEE Engineering Management Review*
Tsolakis, N. (2021)	58	Supply network design to address United Nations Sustainable Development Goals: A case study of blockchain implementation in Thai fish industry	*Journal of Business Research*
Chenarides, L. (2021)	51	COVID-19 and food supply chains	*Applied Economic Perspectives and Policy*
Ali, M.H. (2021)	50	Supply chain resilience reactive strategies for food SMEs in coping to COVID-19 crisis	*Trends in Food Science and Technology*

4. Analysis of Research Trends

In this section, the process of analyzing keyword co-occurrences is employed to map the research on food industry supply chain resilience. The aim is to identify the main research areas by creating keyword networks and clustering the keywords.

4.1. Keyword Analysis of Research Hotspots on Food Supply Chain Study

Keyword co-occurrence is a widely used method in bibliometrics and scientometrics research to identify research hotspots and trends in various disciplines [29,32]. As a secondary support for scientific research, it allows to reveal the most frequent and relevant terms used in a specific field of study [30]. In this study, all types of keywords were considered (i.e., author keywords and index keywords). Furthermore, we used the "temporal display" feature in VOSviewer and three as a minimum number of keywords' co-occurrence, to analyze the literature related to food industry supply chain resilience. This display shows three distinct features of the literature: the size of the nodes on the co-word map highlights the relative frequency of various topics; the proximity and links in the co-citation map provide insight into the relationships between topics; and colorful nodes on the co-word map reveal the relative recency of various topics as they appear in the reviewed articles. This temporal analysis is useful for identifying emerging topics or what is known in the literature as the "research front" [33]. As can be seen in Figure 5, the co-occurrence of keywords in the reviewed articles allows to identify the research areas that have gained more attention in recent years and the relationships between them.

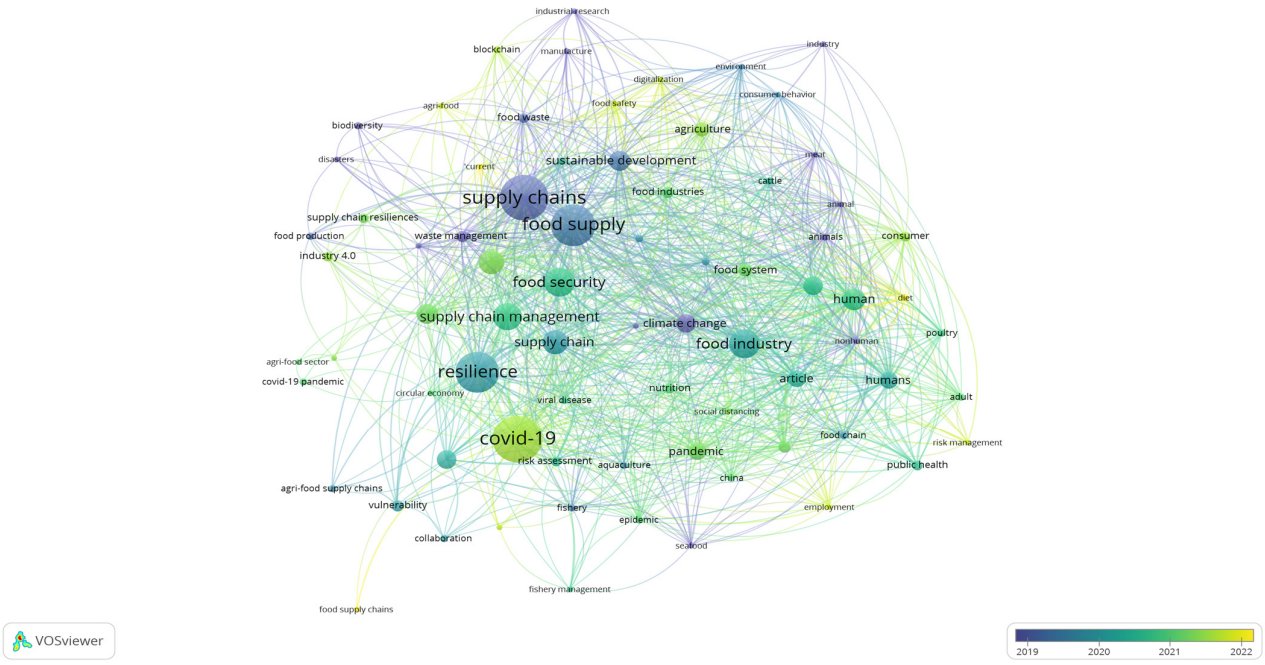


Figure 5. Keyword co-occurrence network.

The results of our study show that the keyword "COVID-19" was the most frequently encountered, with 32 occurrences and 162 links to other keywords. Additionally, the keyword "supply chain" appeared 31 times and had 158 links. Our findings also showed that the keywords "food supply" had 28 occurrences and 193 links, and "resilience" had 27 occurrences and 109 links. These findings indicate that the impact of COVID-19 on the food supply chain and its resilience is a prominent topic in the literature reviewed in our study.

4.2. Cluster Analysis

The same analysis of the co-occurrence of keywords could be applied for identifying the research front with regard to topical trends in food industry supply chain resilience

research. We used cluster visualization (Figure 6) to obtain a holistic intellectual landscape of food industry supply chain resilience. To understand the underlying patterns in the corpus of investigated documents, co-occurrences were used as a tool. We were able to recognize five different clusters using cluster visualization, each of which consists of a collection of keywords with similar co-occurrence patterns. Clusters in VOSviewer are commonly identified by numbers and colors. The density of the elements at each place on the density visualization is represented by a color. In addition to the VOS-assigned default hue, we have given each cluster a label to further define it. These labels, which are based on each cluster's main study theme, were chosen in order to describe the components found inside each cluster as shown in Table 3: Food Systems Resilience and Public Health (Cluster 1 'Red') contains 20 items. Similarly, the other clusters were labeled Seafood Supply Chain Resilience and Risk Management (Cluster 2 'Green'), Digital and Sustainable Food Systems (Cluster 3 'Blue'), Agri-food Industry 4.0 and Sustainability (Cluster 4 'Yellow'), Meat Production and the Food Industry (Cluster 5 'Purple').The salient results and issues of inquiry in each cluster are summarized in the following sections.

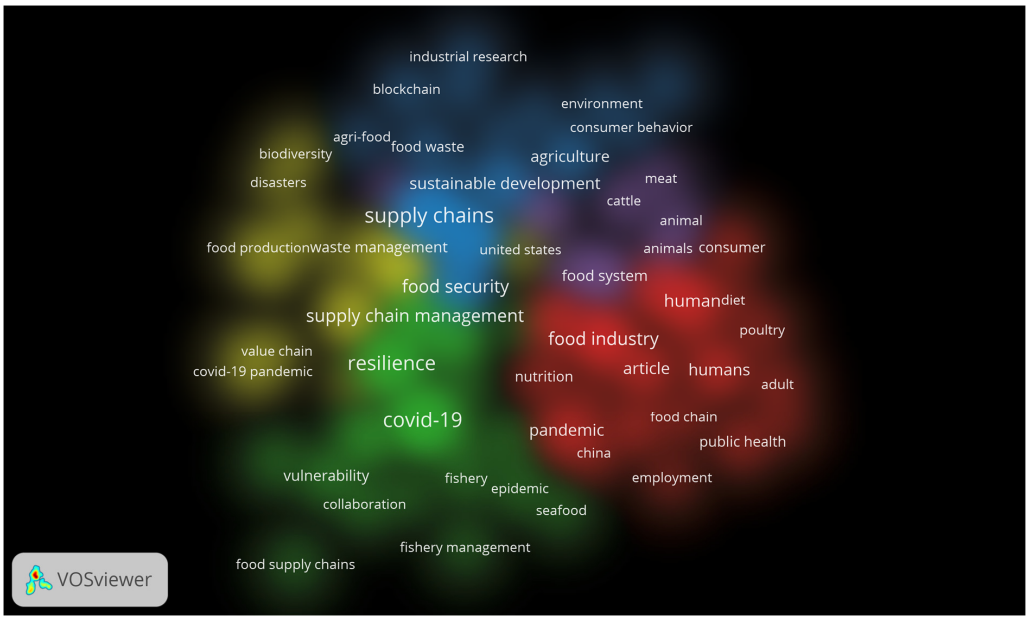


Figure 6. Cluster density visualization.

Table 3. Authors keywords' co-occurrence network.

Cluster	Color	76 Items	Main Items	Cluster Label
Cluster 1	red	20 items	Human, food industry, public health, diet, food chain, nutrition, pandemic, risk management	Food Systems Resilience and Public Health
Cluster 2	green	18 items	Supply chain resilience, fishery, seafood, food supply chain, COVID-19, risk assessment	Seafood Supply Chain Resilience and Risk Management
Cluster 3	blue	16 items	Sustainable development, food security, food safety, food waste, environment, blockchain, digitalization	Digital and Sustainable Food Systems
Cluster 4	yellow	14 items	Agri-food sector, food production, Industry 4.0, sustainability, disasters	Agri-food Industry 4.0 and Sustainability
Cluster 5	purple	8 items	Meat, animal, food system, cattle, food industries	Meat Production and the Food Industry

Cluster 1:

One possible name for this cluster could be "Food Systems Resilience and Public Health" This name captures the interconnected nature of the various items and emphasizes the importance of building resilience within the food system in the face of pandemics and other crises.

Food systems resilience refers to the ability of the food system to withstand and recover from disruptions, such as natural disasters or economic crises. Public health refers to the overall health and well-being of a population. Food systems resilience is critical for public health, as disruptions to the food system can lead to shortages of food and essential nutrients, as well as an increase in the price of food [12]. This can have negative impacts on the health of the population, particularly for vulnerable groups such as children and the elderly [34].

There are several strategies that can be used to improve the resilience of the food system and protect public health. These include the diversification of food sources and production systems, the development of robust traceability systems, and the promotion of food security policies and programs [12]. In addition, the development of local and regional food systems, which are more resistant to supply chain disruptions, can improve the resilience of the food system and protect public health [35].

However, there are also challenges to improving the resilience of the food system and protecting public health. These include the increasing global demand for food, which can put pressure on resources and lead to environmental degradation, and the impact of climate change, which can lead to more frequent and severe natural disasters and changes in the availability and distribution of food [36].

Overall, the literature suggests that food systems resilience is critical for public health. Strategies to improve the resilience of the food system, such as the diversification of food sources and the development of local and regional food systems, can help to protect public health and mitigate the negative impacts of disruptions.

Cluster 2:

"Seafood Supply Chain Resilience and Risk Management" is a cluster that focuses on the specific topic of seafood supply chains and how these systems can be made more resilient and risks managed, particularly in the context of the COVID-19 pandemic.

Seafood supply chain resilience refers to the ability of the seafood industry to withstand and recover from disruptions, such as natural disasters or economic crises. Risk management is the process of identifying, assessing, and mitigating risks to the supply chain. The seafood industry is characterized by complex and globalized supply chains, which can make it vulnerable to a variety of risks, including natural disasters, economic crises, and political instability [28]. In addition, the seafood industry is facing increasing pressures due to climate change, which can lead to more frequent and severe natural disasters, as well as changes in the availability and distribution of seafood species [37].

Effective risk management is critical to the resilience of the seafood supply chain. According to [38], risk management strategies in the seafood industry often focus on the identification and assessment of risks, as well as the implementation of risk mitigation measures, such as insurance, diversification of sources, and the use of contracts to transfer risk. In addition, the development of robust traceability systems can improve the transparency and traceability of the supply chain, which can help to reduce the impact of disruptions.

However, the seafood industry is often characterized by a lack of transparency and weak governance, which can make it difficult to effectively manage risks [28]. In addition, the complexity of the seafood supply chain, with multiple actors and stages, can make it difficult to identify and assess risks [39].

In general, according to the literature, the implementation of effective risk management practices is essential for the maintenance of resilience within the seafood supply chain. Despite this, the complexity and lack of transparency of the seafood industry can make it challenging to effectively identify and mitigate risks.

Cluster 3:

"Digital and Sustainable Food Systems" is a cluster that encompasses the ways in which digitalization and sustainable development intersect and impact the food industry. Digital technologies, including sensors, drones, and GPS systems, can be used to improve the efficiency and sustainability of food production. For example, precision agriculture techniques, which use sensors and GPS to collect data on soil conditions, weather, and crop growth, can assist farmers in optimizing irrigation, fertilization, and pest management, leading to reduced water and chemical inputs and increased crop yields [40]. Additionally, drones can be used to collect data on crop health and monitor field conditions, enabling farmers to respond to problems more quickly [41].

Digital technologies are also being used to improve supply chain efficiency and reduce food waste. For example, logistics and transportation management systems can be used to optimize routes and reduce distance [42]. In addition, food waste tracking systems can be employed to monitor food waste throughout the supply chain, allowing companies to identify opportunities to reduce waste and enhance efficiency [43].

Digital technologies are also being used to improve food safety and traceability. For example, blockchain technology, which allows for the secure and transparent tracking of transactions, is being used to trace the origin of food products and ensure that they meet safety standards [44]. Furthermore, food safety monitoring systems, such as those using sensor technologies, can be utilized to detect foodborne pathogens and prevent outbreaks [40].

Overall, the literature suggests that digital technologies have the potential to significantly improve the sustainability of food systems by increasing efficiency, reducing waste, and improving food safety. Nevertheless, the adoption of these technologies is often limited by a lack of infrastructure and the high costs of implementation [45].

Cluster 4:

The name of this cluster is "Agri-food Industry 4.0 and Sustainability". It captures the focus on the agri-food sector and the adoption of Industry 4.0 technologies, and emphasizes the importance of considering sustainability in these endeavors. The agri-food industry is undergoing a digital transformation, often referred to as agri-food Industry 4.0, which involves the use of advanced technologies such as IoT, artificial intelligence (AI), and robotics to improve the efficiency, traceability, and sustainability of food production and distribution [46]. The adoption of Industry 4.0 technologies has the potential to bring about significant benefits for the agri-food sector, including increased productivity, reduced waste, and improved food safety [47].

The adoption of Industry 4.0 technologies in the agri-food industry has the potential to improve the sustainability of the industry through increased efficiency and resource conservation. However, there are also potential challenges to the adoption of Industry 4.0 technologies in the agri-food industry. One major challenge is the cost of implementation, which can be a barrier for small- and medium-sized enterprises (SMEs) [47]. In addition, there are concerns about the potential negative impacts of digital technologies on employment, as well as the potential for data privacy breaches [48].

In summary, the literature indicates that Industry 4.0 technologies have the capacity to enhance the sustainability of the agri-food industry through increased efficiency and resource conservation. However, there are also challenges to the adoption of these technologies, including the cost of implementation and concerns about the potential negative impacts on employment and data privacy.

Cluster 5:

The cluster "Meat Production and the Food Industry" include topics related to the various processes involved in producing and processing meat, as well as the economic and environmental impacts of the meat industry. Meat production is a significant contributor to the global food industry, with the demand for meat increasing in many parts of the world. Nonetheless, the production of meat has detrimental impacts on the environment and public health, and there are growing calls for more sustainable and plant-based alternatives.

The environmental impacts of meat production include greenhouse gas emissions, water pollution, and land degradation [49]. The production of meat, particularly from ruminant animals such as cattle and sheep, generates significant greenhouse gas emissions through enteric fermentation (the release of methane from the digestive process of these animals) and manure management. In addition, animal agriculture is a major consumer of water, with the production of a single pound of beef requiring approximately 1800 gallons of water [50]. The production of feed crops such as corn and soybeans, which are often used to feed livestock, can also lead to land degradation and deforestation [51].

The consumption of meat has also been linked to negative health outcomes, including an increased risk of chronic diseases such as cardiovascular disease, cancer, and type 2 diabetes [52]. This is likely due, in part, to the high levels of saturated fat, cholesterol, and sodium found in many types of meat, as well as the absence of certain nutrients found in plant-based foods [52].

In response to these negative impacts, there has been a growing movement toward more sustainable and plant-based alternatives to meat. Plant-based protein sources, such as beans, lentils, and tofu, have lower environmental impacts and can provide similar levels of protein as meat [53]. In addition, alternative protein sources such as insects and lab-grown meat are being explored as potential ways to meet the growing demand for protein while reducing the negative impacts of traditional meat production [54].

Overall, the literature suggests that the production and consumption of meat have negative impacts on the environment and public health. While the demand for meat is likely to continue to grow, there is a need for more sustainable and plant-based alternatives to traditional meat production.

5. Research Gaps and Future Research Opportunities

The food industry is facing increasing challenges in terms of supply chain resilience. In recent years, natural disasters, pandemics, and other disruptions have highlighted the vulnerability of food supply chains and the need for greater resilience. One way to better understand these challenges is through keyword co-occurrence analysis of news articles discussing food supply chain disruptions.

Our analysis revealed that the most commonly co-occurring keywords were “COVID-19”, “supply chains”, “food supply”, “resilience”, “food industry”, “food security” and “sustainability”. This suggests that these are the key themes and challenges facing the food industry in terms of supply chain resilience. For example, “pandemic” and “supply chain” frequently appear together, indicating that the COVID-19 pandemic has had a significant impact on food supply chains [25]. Additionally, “food industry” and “sustainability” frequently co-occur, indicating that the industry is also grappling with the effects of a changing climate on food production [55].

However, based on a bibliometric analysis, a potential research gap in the field of food industry supply chain resilience could be the lack of focus on specific regions or countries. While there is a significant body of literature on food supply chain resilience in general, there is a lack of studies that specifically examine the challenges and opportunities facing food supply chains in certain regions or countries. Another potential research gap is in the area of SMEs in the food industry. While larger companies may have more resources to invest in supply chain resilience, SMEs may face different challenges and have different needs in terms of risk management and sustainability.

Research opportunities in this field include conducting case studies in specific regions or countries to understand the unique challenges and opportunities facing food industry supply chains in those areas. This could include studying the impact of government policies and regulations on food industry supply chain resilience in different countries. Additionally, research on the application of technology and innovation in improving food supply chain resilience could be a valuable area of study. Understanding how consumer behavior and demand influence food industry supply chain resilience could also provide valuable insights.

While our analysis provides valuable insights into the challenges and opportunities facing food industry supply chain resilience, further discussion and analysis can be improved by incorporating existing literature on bibliometric analysis. By examining previous studies that have utilized bibliometric analysis to examine supply chain management and related topics, we can gain a more comprehensive understanding of the broader literature on supply chain resilience.

For example, the study by Agnusdei and Coluccia (2022) used bibliometric analysis to identify the main research streams and hotspots in the literature on sustainable food supply chain management. They found that research on this topic has grown significantly in recent years and identified several key research themes, such as environmental sustainability, social sustainability, and economic sustainability. By examining the intersections between these themes, they were able to identify potential research gaps and future directions for research [56].

Another relevant study is that by Li et al. (2022), which used bibliometric analysis to examine the evolution of research on food supply chain management in the context of the COVID-19 pandemic. They found that the pandemic has had a significant impact on the research landscape, with a surge in publications related to food supply chain disruptions and resilience. They also identified several emerging research topics, such as the use of blockchain technology and the role of social media in food supply chain management. By incorporating insights from these previous studies, we can further enhance our understanding of the literature on food supply chain resilience and identify potential areas for future research. For example, one area of interest could be the use of blockchain technology as a tool for enhancing the resilience of food supply chains, which has been identified as an emerging research topic [57].

6. Conclusions

The concept of resilience, despite being relatively new, has garnered significant attention from researchers and experts across various fields, particularly the food industry. This paper outlines the evolution of the field of food industry resilience through the use of bibliometric analysis to identify significant research trends and potential avenues for future study. The literature data was collected from Scopus, and 122 related publications were obtained after cleaning the data. To analyze this data, multiple quantitative measures were conducted, including publication types, top journals, and co-occurrence networks using VOSviewer to gain a visual understanding of the trends.

The results of this quantitative bibliometric analysis can be presented as follows: (1) the yearly research output regarding this field shows that it steadily increased from 2008 to 2023, but changed to a sharp increase from 2020 to 2022 with the outbreak of the COVID-19 pandemic at the global level; (2) the analysis includes 98 journals and proceedings, with the top 10 journals and proceedings publishing approximately 22.13% of the publications in this field, and the journal "Supply Chain Management" was ranked first according to their outputted number of articles; (3) the food industry supply chain is a multidisciplinary subject, with contributions from various field such as agricultural and biological sciences business, management and accounting or environmental science; (4) research in this field is particularly advanced in the United Kingdom, United States, Austria, and Canada, which together account for nearly 58% of global publications on the topic; (5) the field of study lacks a significant number of specialized experts as the majority of authors have only a limited number of publications; (6) the most relevant contributions focused on the study of food industry supply chain, risks, and themes such as COVID-19; (7) The keyword "COVID-19" was the most commonly used, appearing 32 times and linking to 162 other keywords, highlighting that the impact of COVID-19 on the food supply chain and its resilience is a central theme in the literature examined in our study; (8) an analysis of co-citations among references revealed five distinct clusters, each comprising a specific set of literature. These clusters offer potential avenues for future research on resilience in the food industry supply chain.

Overall, our study contributes to the literature on food supply chain resilience by providing a comprehensive bibliometric analysis of the research in this field. Our results can inform future research and policy decisions aimed at improving the resilience of food supply chains, particularly in light of the disruptions caused by the COVID-19 pandemic.

The results of our study provide several important lessons for researchers, policymakers, and practitioners in the food industry. First, our analysis shows that research on food supply chain resilience is a global issue, with contributions from researchers and institutions around the world. Second, our results highlight the importance of interdisciplinary research in this field, with contributions from a wide range of disciplines including engineering, agriculture, and economics. Finally, our analysis reveals that research on food supply chain resilience is closely tied to other important topics such as sustainability, risk management, and innovation. Understanding these interconnections is important for developing effective strategies to enhance the resilience of food supply chains.

The primary contributions of this paper may be succinctly summarized as follows: by utilizing quantitative bibliometric methods, such as algorithms and software tools, we were able to examine the flow of information over time and gain a comprehensive understanding of the subject matter to help researchers and industry professionals capture new research opportunities and build new perspectives. To the best of our knowledge, no prior research in this field has presented such a holistic literature review, encompassing bibliometric analysis, thematic content analysis and information on food supply chain resilience. We have also provided a clear structure by examining different sections, and have established a roadmap and future agenda based on the findings obtained.

However, it is important to note that certain limitations should be considered for future research. The study relied solely on the Scopus database for data collection, which may have resulted in certain articles not being included in the analysis. We could extend the data source to include more publications (dissertations, theses, etc.) from other sources (Google Scholar, Web of Science, Science Direct, etc.). Bibliometric analysis can provide valuable insights into the field of food industry supply chain resilience, but it cannot fully explain the underlying reasons behind the results. To better understand these underlying factors, future research could incorporate social science methods, such as expert interviews. Furthermore, while conducting co-occurrence analysis, for example, the VOSviewer results are based on selecting a certain number of nodes as sample data, which can lead to certain publications being excluded. Future research could consider using alternative bibliometric software to address these limitations.

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Glossary

Blockchain technology	A digital ledger system that allows for secure and transparent tracking of transactions.
Carbon footprint	The total amount of greenhouse gases that are emitted through the production and consumption of goods and services.
Circular economy	An economic system that aims to minimize waste and make the most of resources by reusing and recycling materials.
Digital technologies	Technologies that use digital information and communication to improve efficiency and productivity.
Food security	The state of having reliable access to sufficient, safe, and nutritious food.
Food supply chain systems	The network of interconnected entities involved in the production, processing, packaging, storage, transportation, and distribution of food products from the farm to the table. This includes farmers, suppliers, manufacturers, wholesalers, retailers, and consumers, as well as the infrastructure and technologies that facilitate the movement of food products through the supply chain.

Food systems resilience	The ability of the food system to withstand and recover from disruptions.
Food waste	The disposal of food products that are still safe and nutritious for consumption.
Industry 4.0	The integration of advanced technologies, such as automation, data analytics, and artificial intelligence, into the manufacturing process.
Precision agriculture	The use of sensors and GPS to collect data on soil conditions, weather, and crop growth to optimize farming practices.
Precision farming	A type of farming that uses data analytics and technology to optimize crop yields and reduce waste.
Public health	The overall health and well-being of a population.
Risk management	The process of identifying, assessing, and mitigating risks to the supply chain.
Seafood supply chain	The process of moving seafood products from producers to consumers.
Smart agriculture	The use of technology, such as drones and sensors, to monitor crop health and improve efficiency.
Supply chain disruptions	Interruptions or delays in the process of moving products from producers to consumers.
Sustainability	The ability to meet the needs of the present without compromising the ability of future generations to meet their own needs.
Traceability	The ability to track the movement of products or ingredients throughout the supply chain.
Transparency	The degree to which information is readily available and accessible.

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