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Unveiling Determinants in Rice Supply Chain Studies: A Bibliometric Analysis on Food Security

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ABSTRACT

This paper seeks to provide an overview of the characteristics of the Rice Supply Chain (RSC) as studied across various research areas related to food security concerns. In agriculture, Rice Self-Sufficiency (RSS) level is an indicator of food security. However, food security encompasses broader factors such as availability, accessibility, stability, and utilisation. Given that rice holds significant importance as one of the world's staple foods, addressing the increasing demand for rice is seen as a crucial strategy to enhance national resilience against food insecurity. Inefficiencies in the rice supply chain can negatively impact production, storage, and distribution, consequently diminishing the RSS. In line with the growing attention to food security, there is a need to better understand the importance of sustaining the production of rice to cater to food security issues within broader academic research. Thus, this study has two main objectives: 1) to examine the characteristics and development of literature related to the RSC and, 2) to identify the thematic areas related to the RSC research and their connections to specific disciplines. To achieve this, a Systematic Literature Review (SLR) and bibliometric analysis of 165 journal articles listed in the Web of Science (WoS) and SCOPUS databases was conducted. This analysis revealed significant findings in research activity, highlighting the extensive and multidisciplinary nature of the studies. Study results indicate a gap in relational bibliometric studies within the field of RSC. Nevertheless, there is still potential for increased collaboration across disciplines and further investigation into how diverse RSC studies touch on food security issues for future reference.

Keywords: food security, food supply chain, rice supply chain

INTRODUCTION

Addressing food security issues has increased attention on improving the Food Supply Chain (FSC) (Rejeb *et al.* 2022). However, there's limited research on shortages in food supply, a significant challenge for poor and developing countries. Efficiency in the food supply relies on the entire food system, from cultivation to consumption (Lautala *et al.* 2015). To address challenges, a comprehensive and efficient FSC process is crucial. With the global rise in food security concerns, studies are investigating FSC issues (Durán-Sandoval *et al.* 2023).

Food security involves access to safe and nutritious food, defined by the UN as consistent access to sufficient and nutritious food (Peng & Berry 2019). Criteria for food security include availability, accessibility, utilisation, and stability (Mutungi *et al.* 2023). Achieving optimal food security requires a consistent food supply and access, emphasising the need to tackle issues like food shortages (Addai *et al.* 2022).

Food supply challenges contribute to a crisis, with high natural gas prices impacting food prices globally (Liboreiro & Vigneron 2023). Shortages affect poor nations, leading to high inflation of food prices worldwide (The World Bank 2023). A substantial portion of global food production never reaches consumption, highlighting the need for action plans to address supply shortages (Dou *et al.* 2016).

The importance of food security necessitates significant changes in agri-food systems (Yusriadi & Cahaya 2022). Rice, a global staple, faces challenges in its supply chain, identified as a critical area for improvement due to high-risk factors (Rath *et al.* 2022). To enhance

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rice production and address food security, a robust RSC system is needed.

Imbalances in global rice production, increasing rice imports, and rising consumption pose challenges to achieving self-sufficiency (Arshad *et al.* 2011). However, bibliometric analysis studies on RSC are lacking, and this research aims to fill that gap by conducting a bibliometric analysis of RSC literature, identifying clusters and relationships in the study areas (Erboz *et al.* 2023; Chopin *et al.* 2023).

This Systematic Literature Review (SLR) focused on RSC issues and utilized bibliometric analysis to confirm SLR findings. It covered publications from 2018 to 2024 in Google Scholar, SCOPUS, and Web of Science databases. The study aims to highlight RSC issues, analyse keywords, and identify common challenges using bibliometric techniques and VosViewer software (Gan *et al.* 2022). This approach provides a fair, factual, and useful way to identify networks and summarize literature findings on RSC development and characteristics. The goal is to aggregate literature findings and suggest improvements to address overall RSC issues.

Recent research on Food Supply Chains (FSC) has highlighted drawbacks, with factors such as food quality and security becoming significant concerns. Meanwhile, Rice Supply Chain (RSC) studies, particularly in Southeast Asian countries like Malaysia, Indonesia, Thailand, and Vietnam, reveal challenges due to insufficient rice production, leading to the need for imports.

John and Fielding (2014) identified the top constraints to rice production, emphasizing total rice yield losses accounting for half of the production. Rigorous searches in RSC studies have categorised factors into internal (managerial) aspects investigated by Peng *et al.* (2022) and Cheraghalipour *et al.* (2019), and external (technical) factors explored by Tao *et al.* (2023), Jifroudi *et al.* (2020), and Kakkar and Ruchi (2020). Suryani *et al.* (2022) recommended addressing both internal and external factors to enhance RSC value, emphasizing the importance of strengthening managerial and technical aspects for rice quality and safety.

As scientific information on food security increases, it becomes crucial to categorise and study current research areas. To address rice production issues, tables summarising publications in Google Scholar, WOS, and SCOPUS databases were created. Utilising SLR as the first step helps in understanding the scope of RSC studies, with papers classified based on publication numbers, providing an initial insight into the field.

METHODS

The number of publications was examined by three different types of databases which are Google Scholar, Web of Science (WoS) and SCOPUS. Based on all databases show increasing trends for the number of publications. This indicates that the prevailing trend reflects an interest in RSC studies that are associated with food security issues. At this stage, all studies that are found related and touch on RSC are included. All retrieved studies were screened to ensure no duplications.

Data collection

Considering the high quality and characteristics of impactful studies, extracting information from every publication included in this study enables this study to come out with several RSC classifications. These studies were found to have similar focus areas in their RSC research. From the SLR conducted, five classifications were identified which consist of the determinants in RSC studies. These classifications are: 1) product quality; 2) product quantity; (3) process of product flow (distribution and logistics) namely as the operational aspect known as the external factors; 4) process of information flow (organization, community, policy, person or people, and behaviour) which namely as the managerial aspect known as the internal factors; 5) technology application. Results from the findings indicate most of the studies look into product quality which has been identified in Google Scholar (15), WoS (18) and SCOPUS (21) databases for the recent years in 2023. However, publications in the year 2020 expanded more studies focusing on the process of information flows that focus on the managerial aspect of RSC. These internal factors were found to have impacts on their RSC performance. Due to current issues that touch on food security problems, recent studies were most likely to shift their focus to look into product quality rather than focusing on the other aspects of RSC.

To attain the study's objectives, inclusion and exclusion criteria are employed to screen pertinent studies. Focusing on RSC studies, an in-depth analysis was conducted. There are five main components in RSC studies which consist of: 1) raw materials; 2) supplier or producer; 3) distributor; 4) retailer; 5) consumer or customer. However, an additional component was the studies focusing on the network-related aspects of RSC between other parties were found to be of the highest interest to researchers. This emphasises that studies on RSC not only encompassed its entire supply chain but also addressed various components either by combining them or solely focusing on individual components of the RSC. Findings indicate that it is relevant to study the entire supply chain to enhance the performance of RSC. Even though the last component is highlighted in the studies of RSC network, it does not cover the entire RSC. Previous studies only touched on networks between two or three components but not all the components involved in RSC. These findings are relevant to help future studies explore further details which cover the entire supply chain that includes all five main components in RSC.

Upon reviewing the literature on the topic, it is evident that there exists a gap that needs to be addressed. Most of the studies discover only the specific related issues in terms of its key areas and Supply Chain Management (SCM) components. From this finding, there are two key areas highlighted which are the determinants of RSC and RSC components. Lists of RSC classifications which consist of the determinants found in this research findings are: 1) product quality; 2) product quantity; 3) process of product flow (distribution, logistics-external); 4) process of information flow (managerial aspect on decision making: organisation, community, policy, person or people, behavior-internal) and 5) technology application. As for the RSC listed components, there are six identified in the literature: 1) raw material; 2) supplier or producer (farmer); 3) distributor; 4) retailer; 5) consumer or customer, and vi) RSC network (between RSC parties or more than 1 party) where these components have been studied separately.

The determinants of RSC studies

This study recognised the importance of RSC determinants to improve rice production which helps to promote food security issues as it has become one of the world's main concerns recently. As rice is the staple food for Malaysia, it is important to examine the causes and drawbacks of RSC to overcome issues related to RSC. The determinants highlighted in this study are:

Product quality. Food quality is the most basic aspect that was being measured as a state of excellence. Gershwin (2018) defined product quality is about how well it is made, and how much it is made well. Most of the previous studies found that technology helps in maintaining product quality (Peng *et al.* 2022; Tao *et al.* 2023).

Product quantity. As defined by Gershwin (2018), quantity is about how much is produced, when it is produced, and what resources are required. Previous studies related to measuring product quantity were driven by many factors such as technology (Harun *et al.* 2021), cultivation system (Kumar *et al.* 2021), organisation initiative (Libriyanto *et al.* 2022) and many more.

Process of product flow. A supply chain needs to maintain and improve its product flow. In the supply chain, the process flow shows the activities and steps taken in delivering products. One of the process flows discovered is the external factors which look into the outside activities in transferring the product externally such as the distribution process and logistics. Zając and Swieboda (2023) explained that logistics processes are most often considered in the context of the correct flow of materials.

Process of information flow. The challenge facing the current supply chains is ensuring the continuity of supply reliability based on available information (Zając & Swieboda 2023). Zając and Swieboda (2023) stated that the unreliability of a process is not a physical or technical issue but results from insufficient reliability of the information. It has been mentioned by Ahmad and Sanjog (2023) that the information is very important for proper coordination between the stakeholders through the supply chain.

Technology application. Advancements in technology are occurring at a faster pace in various areas of human activities. New technologies such as the Internet of Things (IoT), blockchain, and Big Data Analytics (BDA) can help gather real-time information about product demand, stock levels, and location. Additional technology has been agreed by most researchers and industry professionals to help overcome the

prevailing issues related to improper product flows, disruptions, fragmentations, poor product traceability, food contamination, and food recall (Mastilović *et al.* 2023). However, implementing these technologies successfully can be challenging. In the present study, we sought to gain insight into the technology trends in the field of current technology applications in RSC.

Data analysis

This analysis aims to show whether the research area for this study is in line with the current issues in improving food security. The bibliometric analysis carried out in this research is based on the academic literature found in WOS and SCOPUS databases as it is one of the most restrictive for indexing works. From SLR analysis conducted shows publications that are available online during the exact search time. Additionally, this analysis, helps to track the papers which are "on a given subject" which gives an absolute number to show the evolution of studies on RSC.

Data retrieved from Google Scholar is used to support both databases as it covers large areas of study. For the Google Scholar database, the number of publications provides a wide range of databases which includes indexed and non-indexed databases. The results are useful as an overview of the study. However, Google Scholar is not suitable to be referred to as a scholarly article which has low in quality of the papers included. Thus, other indexed journal such as WoS and SCOPUS was included in this study. Focusing on WOS and SCOPUS, both of these databases have been established by worldwide to be useful as the most systematic and dynamic method of journal selection. Also, using Boolean (""; AND) and phrase search (rice supply chain) helps to limit the selection and the results are of sufficient scientific quality (Martínez-Falcó *et al.* 2023).

After refining the selection of the database search platform, the selection of papers has been focused on the issues related to the rice supply chain only as the main interest in this study. It was determined that the best search equation among those considered as the following:

Search = (("rice supply chain") AND PUBYEAR > 2018 AND PUBYEAR < 2024)

Analysing the algorithm, it can be seen that the search covers the related paper regarding RSC between the years 2017 and 2024. The usage of the Boolean operator "" for the phrase search of the RSC ("rice supply chain") and AND to limit the scope and searching for the related papers. These parameters were applied to the topic, which includes the title and the abstract of the papers in both databases until 2024.

Following the application of the search algorithm on 4th April 2023, a total of 111 documents were displayed. However, limitations were used in limiting the selection year which reduced the number to 86 papers. Further, PRISMA guidelines for systematic review were applied through this methodology. As mentioned by Martínez-Falcó *et al.* (2023), by following the PRISMA guidelines, the reliability and reproducibility of reviews can be enhanced due to the comprehensive methodology it employs, as well as its widespread use in conducting bibliometric analyses. In a study by (Şalvarlı & Griffiths 2021), there is a four-phase flow diagram in PRISMA guidelines that describes the identification, screening, eligibility, and inclusion criteria of the reports that fall under the scope of a review. By referring to Şalvarlı and Griffiths (2021) this study follows as in Figure 1.

After filtering and refining the data according to the scope of this study, the number of documents was reduced from a total of 165 overall to 132 items. All of these data fall under the categories of Agricultural and Biological Sciences, Computer Science, Environmental Science, Business, Management and Accounting, Engineering, Social Sciences, Economics, Econometrics and Finance, Decision Sciences, Earth and Planetary Sciences, and Energy. It shows that this study had gone through an extensive view of the scope of rice supply chain studies which covers the overall categories and areas.

Furthermore, to enhance the analysis, a network map was created using version 1.6.18 of the VOSviewer tool. This tool is a software application for constructing and visualising bibliometric network (Martínez-Falcó *et al.* 2023). More specifically, a network map was generated to visualize the co-occurrence of keywords. The keywords that appeared at least ten times in the analysed records were included, and clusters were identified based on predetermined parameters. The networks included in this study to create a term co-occurrence map are based on text data and individual publications counting known as authorship. It was agreed by Martínez-Falcó *et al.* (2023) that authorship was one of

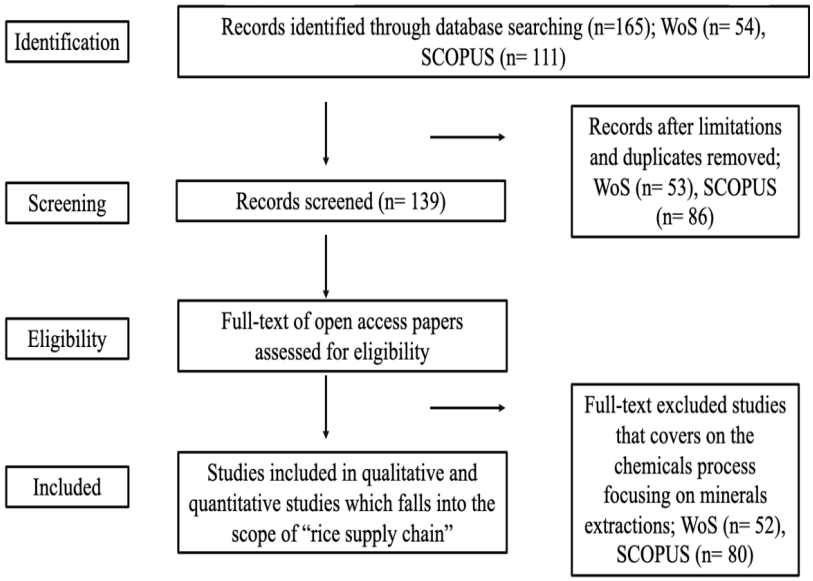


Figure 1. PRISMA flow diagram of the paper selection process used in the present study

the most important variables to be considered in bibliometric analysis. This analysis helps to identify the clusters involved and thus distinguish the leading research areas in this study field. Also, this map displays the connections between each keyword and co-authorship that have connectivity between them.

RESULTS AND DISCUSSION

Referring to the study by Guo *et al.* (2019) bibliometric analysis was applied to analyse and visualise the relationships among the authors, countries, journals, co-citations, and terms. Every pattern that is displayed has its meaning. The size of the circles represents the occurrence of keywords with the larger circle reflecting that more a keyword has been co-selected in the rice supply chain publications. Additionally, the distance between each keyword demonstrated relative strength and topic similarity. From the visual of bibliometric, different colours reflects different cluster which discussed a similar topic among these publications with the connection of link. Each link has its strength where the higher the value, the stronger the link. The total link strength under the item displayed indicates the number of publications in which two keywords occur together.

Bibliometric analysis on keyword terms of the rice supply chain in Web of Science (WOS) database

In reference to the data sorted and analysed in the WoS database, a table of verified selected terms is displayed in Table 1. From this table, the number of occurrences for each keyword was displayed.

Table 1. Number of occurrences by keywords in WoS database from 2018–2023

Term	Occurrence	Total link strength
Chain	172	675
Data	38	234
Farmer	37	145
Efficiency	25	171
Blockchain	24	157
CSC	12	228
Green investment level	12	228
SCRA	12	228
Cooperative	10	46

CSC: Construction Supply Chain
SCRA: Supply Chain Risk Assessment

Scientific studies show a large number of research areas, which highlight the top five highest keywords listed as a chain (172), data (38), farmer (37), efficiency (25), and blockchain (24). These keywords reflect the number of studies conducted in the rice supply chain, mostly related, and highlight this area of study. Unfortunately, it is seen that limited studies touch on cooperative aspects, which have the least number of 10 shown.

As a result, from the WoS database, details on related rice supply chain studies a network visualisation shows the trends and patterns of its relationships between each item in scientific literature. In addition, this analysis also helps to understand aspects of knowledge that fall in the scope of the rice supply chain. The analysis serves two purposes: first, to investigate the development of knowledge in the academic discipline, and second, to analyze the linkages between each item. To visually demonstrate the connections and linkages between these items, a keyword occurrence analysis was conducted. Figure 2 enabled the identification of the relationships between the keywords.

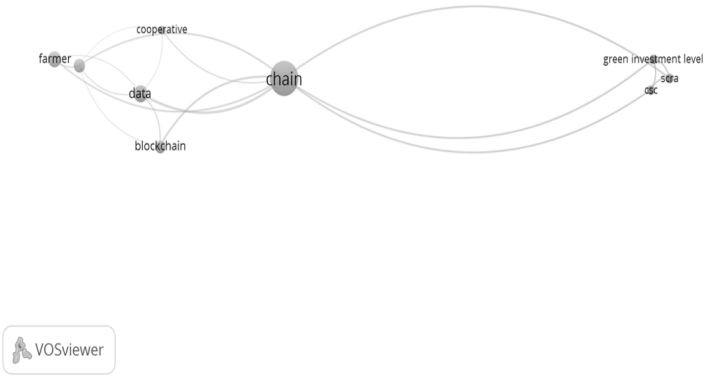
As can be seen from Figure 2, there is a strong connection between each keyword with other items: total link strength for chain (675), data (234), efficiency (171), blockchain (157), farmer (145), supply chain risk assessment (scra) (84), and cooperative (46). Furthermore, these keywords are linked with each other. Among others, the cooperative keyword reflects the lowest occurrence value which reflects that few studies focus on this aspect. It can be concluded that not many studies have explored the cooperative aspects of rice supply chain studies.

Bibliometric analysis on keyword terms of the rice supply chain in the SCOPUS database

On the other hand, in reference to the data sorted and analysed in the SCOPUS database, a table of verified selected terms is displayed in Table 2. From this table, the number of occurrences for each keyword was displayed.

Scientific studies have revealed numerous research areas in the field of the rice supply chain in the SCOPUS database, with the top five highest keywords being model (118), farmer (76), cost (49), price (45), and performance (39). These keywords reflect the extensive research conducted in the rice supply chain, predominantly related to these areas, highlighting the importance of this field of study. However, a lack of study was found focusing on trust aspects which shows the lowest value in the area of the rice supply chain. From this, it can be concluded that there has been limited exploration of the trust aspects of rice supply chain studies.

In order to gain a deeper understanding of the knowledge boundaries within the rice supply chain field, a network visualisation was generated using data obtained from the SCOPUS database. This visualization allowed for an examination of the trends and patterns of relationships between each item in the scientific literature. Additionally,



Note: For practical reasons, we have included those keywords that appear at least 10 times in the records considered (unit of analysis: all keywords) but excluded keywords which have not related to the study area. The size of the nodes is proportional to the number of times keywords appear

Figure 2. Network map of the occurrence of keywords in WoS database

Table 2. Number of occurrences by keywords in SCOPUS database from 2018–2023

Term	Occurrence	Total link strength
Model	118	865
Farmer	76	642
Cost	49	454
Price	45	437
Performance	39	296
Problem	37	267
Information	36	410
Market	36	374
Production	32	258
Actor	31	272
Blockchain	30	263
Risk	30	172
Activity	28	263
Demand	28	362
Framework	28	253
Policy	25	337
Stakeholder	24	158
Smart Contract	22	325
Effect	19	174
Use	19	141
Loss	18	151
Rice Production	18	152
Safety	18	190
Grain	16	145
Government	15	179
Supply chain performance	15	118
Profitability	14	156
Rice Mill	14	122
Covid	13	139
Cooperative	11	110
Rice Industry	11	109
Trust	10	53

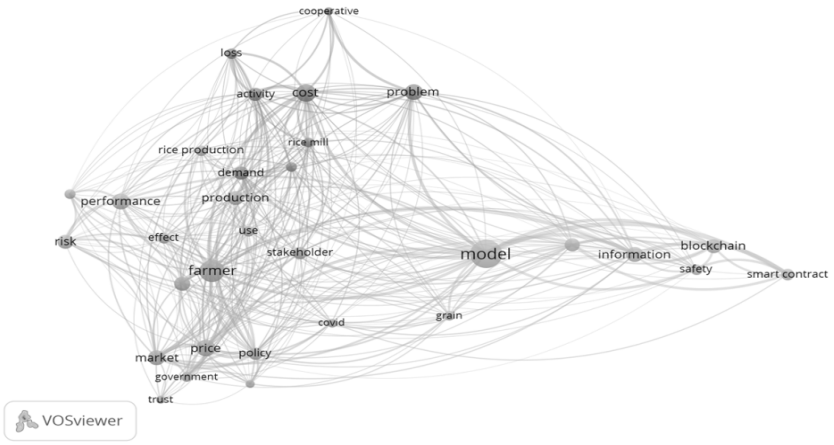
a keyword occurrence analysis was conducted to illustrate the connections and linkages between these items in a graphical format. The resulting Figure 2 facilitated the identification of relationships between the various keywords.

Figure 3 displays a significant correlation between each keyword and other items, with the farmer (455) having the highest value of total link strength followed by cost (345), price (329), market (293), information (251), and performance (210). Even though the item has a high occurrence, it does not mean that it also has a high value of link strength. These keywords exhibit connections with each other where high link strength indicates the number of publications in which two keywords occur together. From this analysis, most studies looked into the perspective of a supplier which specifically relates to the farmer who is the main provider in the rice supply chain. There are a lot of improvements that need to be made in moving towards reliable access to a sufficient food supply by looking into the overall component in a holistic view of the rice supply chain. In achieving a high level of food security in the rice supply chain, it must be considered the entire supply chain which was being measured by the four pillars of food security; availability, access, utilisation, and stability.

CONCLUSION

This study has explored the overall studies related to the rice supply chain, covering indexed databases such as WoS and SCOPUS, which contain high-quality research studies from around the world. Analyzing the current and recent studies in this area provides insightful views and information for future improvements. The astounding number of keywords identified in the indexed databases highlights potential research areas and their occurrence and total link strength, which identifies the most common study area. Additionally, authorship emphasizes the same interests as this study's objectives.

Thus far, this paper concludes that despite the current trends that look into food security issues, improvements in the RSC can be made toward more sustainable practices that consider social and economic aspects. New strategies and improvements in practices among stakeholders can lead to more sustainable practices that align with the SDGs agenda.



Note: For practical reasons, we have included those keywords that appear at least 10 times in the records considered (unit of analysis: all keywords) but excluded keywords which have not related to the study area. The size of the nodes is proportional to the number of times keywords appear.

Figure 3. Network map of the occurrence of keywords in the SCOPUS database

The analysis concludes that the majority of researchers who have the same interest in rice supply chain studies still need more improvement related to their contribution to the overall RSC performance. Both internal factors, which cover the managerial side, and external factors on the technical side such as material distribution activities, must be viewed holistically. Both the internal and external factors must be considered without dismissing any.

As food security issues continue to increase all over the world, improvements in RSC studies must not be overlooked. As rice is known as the staple food for most countries in the Asia region, it may help reduce the shortages of food supply that have recently been highlighted. Further study is required for future review, which can help improve RSC performance, thus reducing food security issues.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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