Big Data in Food: A Systematic Literature Review and Future Directions

Debarun Chakraborty

Symbiosis Institute of Business Management, Nagpur

Constituent of Symbiosis international (Deemed University), Pune, India

Email: debarun84@gmail.com

Nripendra P. Rana

College of Business and Economics

Qatar University, Doha, Qatar

Email: nrananp@gmail.com

Sangeeta Khorana

Bournemouth University Business School,

Bournemouth University

Bournemouth BH8 8EB, UK

Email: skhorana@bournemouth.ac.uk

Hari Babu Singu

Symbiosis Institute of Business Management, Nagpur

Constituent of Symbiosis international (Deemed University), Pune, India

Email: haribabu.singu@sibmnagpur.edu.in

Sunil Luthra

Ch. Ranbir Singh State Institute of Engineering & Technology, Jhajjar-124103, Haryana, India

Email: sunilluthra1977@gmail.com

Big Data in Food: Systematic Literature Review and Future Directions

Abstract:

The growing importance of Big data in the food industry enables businesses to leverage information to gain a competitive advantage. This paper provides a systematic literature review (SLR) to provide an insight into the use of state-of-art of Big data applications in the food industry. The SLR relies on available literature that provides the context, theoretical construct and identifies gaps. Based on the findings, we suggest recommendations, identify limitations and suggest policy implications and future directions. Using search databases were examined and 38 relevant studies were identified for retrospective analysis. The review shows that Big Data supports the food industry in ways that enable using Artificial Intelligence to manage restaurants and mobile based applications in supporting consumers with restaurant selection. This SLR open new avenues for future research in the importance of Big data in the food industry, which will surely help researchers/practitioners in effective utilization of big data.

Keywords: *Big Data, Food, Food Safety, Food Security, Food Waste, Systematic Literature Review*

1. Introduction

The ever-changing consumer preferences and expectations have propelled the food industry (e.g. food companies and service providers, restaurants, and catering services) to adapt to consumers' changing needs and expectations [1]. Technology is more intensively being used by the food industry but more than half of the businesses engaged in the food ecosystem lack the analytical capacity to use unstructured data produced during food production operations [2,3]. Big data and analytics can improve the operational efficiency and increase profits[4] e.g. support identifying customers' behavior by analyzing buying habits, reduce average waiting times for retail payments, and predict the optimal level of inventory at different locations[5].The food industry is increasingly optimistic that big data and analytics can support analysts to analyze industry trends and deliver quality services to customers [6,7]. Many service providers lack the know-how to process the datasets to obtain information on the rapidly changing food trends to support operational, administrative, and critical decision making[5]. This necessitates the usage of Big data, which is described as the use of various data extraction techniques, databases, and numerical methodologies that enable a corporation to examine massive amounts of complex data for various purposes [8,9]. Big data and analytics are more than just a data mining technique that uses mobile development units, social media platforms, increase Internet bandwidth, and different analysis techniques[1,10]. Big data and analytics are intended to bolster the performance of companies along several dimensions[4,7,11]. The different benefits include creating openness, adapting offers and replacing decision-making with automated algorithms[12]. In addition to this, it can increase the competitive advantages of different companies in both, developed countries and emerging economies[2]. Customers are producing and leaving Big data digital footprints on social media due to personal behaviour, societal impact, privacy, technological concerns, and security[13] and this can be used effectively by the food industry. Big data has been employed effectively in other domains. For example, in the manufacturing sector, Big data analytics has improved the performance of businesses[14], in the agri-food sector, it has reduced the carbon footprint[15], to improve the food traceability[16] etc . Frameworks have been developed to identify domains where the public sector can support governments to adopt and be part of the Big data revolution[17]. Despite the phenomenal growth, many organizations are struggling to use Big data effectively with generalized models to improve the quality of Big data[18].

Various studies highlight different factors that Big data users consider vital to foster an organization's acceptance of Data Analytics[19].These variables are the value of direct and non-direct profits of data storage, assimilation and analysis[1,7]. Finally, the variables include observed values of unstructured data, different types of tools to analyse the data and services[20]. The factors that influence Big data acceptance by companies include relative competence, quality, user-friendliness, perceived benefits, safety and employee engagement[7,9].

In recent years, the food industry has spearheaded research and development on Big data in the changing digital market. Companies in the food and beverage industry are leading the way in terms of boosting their usage of digital marketing[21]. The industry has been working with global advertisers and media channels to design new technologies to examine the way shoppers interact with various social networks, smartphones, gaming apps and other digital devices[22]. The emergence of new and sophisticated data analysis allows sellers to target their consumers with custom-made advertisements based on the exhaustive information received from various online platforms regarding user behaviour[1].

Literature examining the utilization and applicability of Big data in food ecosystem has grown[23]. But, no attempt has been made in the existing literature to systematically review this emerging field of research and application in the food industry. This paper conducts a systematic literature review (SLR) to provide detailed analytical insight in this area and to identify gaps and future directions for research on the topic. The management research is interdisciplinary and interdependent24 on various disciplines such as economics, finance, psychology and sociology. Research studies on how to integrate the management concepts to achieve sustainable development goals is novelty of addressing the societal problems. Big data tools as a solution to address food crisis has been published in diverse range of journals. The purpose of SLR is to analyse existing literature and identify the challenges in adopting big data analytics in food industry and offer future research directions and framework to address the issued in the adoption of big data in food industry. Existing studies on Big data and food are in infancy and none of these provide information to understand and apply Big data to various food related issues. This study extends the previous review to examine studies on Big data and food since 2014. The SLR captures the relevant literature from various sources in published research articles on Big data and food in any industry to explore areas of growth; and proposes a conceptual model to understand the effects of Big data on food. The main research questions are:

RQ1: How has the literature on "big data" and "food" emerged and how has the literature explored the challenges of big data in food industry?

RQ2: What are the potential research questions that can be addressed by the future studies?

RQ3: How has the theoretical underpinnings supported to propose framework to address the challenges of "big data" in food industry?

SLR can deliver valuable information for scholars and professionals[25]. Academics are using systematic overviews to understand the trends and main themes cited in the literature while professionals are using the results of the SLR to recognize the essential factors based on the studies in a particular context to design the processes and strategies needed to target potential consumers. A review of studies suggests that no SLR has been published on Big data and food which identified the need to review and summarize the existing literature on Big data and food. Our research fills this gap by conducting a systematic literature review that examines the importance of Big data in food.

The following is how the rest of the paper is organized: The technique for conducting the SLR on Big Data and Food is discussed in Section 2. Section 3 presents the research context of studies reviewed. Section 4 summarizes the research methods used by the studies reviewed. Section 5 presents the research findings and presents the results, implications, limitations and future directions for research. Section 6 provides the final conclusion of the research.

Overview of Food Industry

The food industry includes agriculture, manufacturing units supporting agriculture, food processing units, promotional channels of food produce, food place markets, regulation, research, development and innovation, and financial services and support from financial institutions. According to OECD estimates, the world population doubled to 7.5 billion people since 1970s, whereas the food and nutrition insecurity still high as 820 million people still food insecurity[26]. Poverty is the major threat to the distribution of food globally and the largest contributor of food insecurity[27]. As estimated by Food and Agriculture Organization of the United Nations (FAO), the food production out should be increased by 60% by the end of 2050[27]. In order to achieve this target, right cohesion between sustainability, food security, food safety and better utilization of food produced. Also, the crisis occurred at different times has a dent on the supply chains. For instance, food stocks are at high in the early 2020 covid 19 due to Great Lock Down with a significant concentration in few countries such India and China with high commodity price variation. Covid 19 had a major impact on moving food to domestic and international markets[28]. As defined by FAO, food loss occurs along the supply chain between the producer and the market. While food waste is discarding safe and nutritious food. The food loss and food waste contribute to 28% and 8% of the world agricultural area[29]. Therefore, to achieve the UNDP Sustainable Development Goals, we need novel solutions with technological interventions for future food security and food safety without compromising on achieving other goals[29].

Overview of Big Data

The term big data has been used in many ways. Big data is often produced with high velocity and high volumes from different sources that requires new tools and methods to analyse various scenarios[30]. Big data comprise of five elements such as: volume, variety, velocity, veracity, and value[31]. Big data focuses on three main features: data, analytics of data and the presentation of the results of the analytics that allow to present scenarios of business propositions[32]. Also, big data analytics can also be seen as a combination of business processes, technology optimization and emotional connection with the data[33]. Big Data analytics amalgamates internal and external factors for multidimensional analysis[34]. For instance, using Big Data Analytics, cause-effect models are built and 'what-if' simulations were conducted to elucidate interrelationships between food distribution factors (organisational) and consumption (societal) factors. Data extracted from the social media platforms like Facebook, Twitter and YouTube are used to collect the food safety related discussion, opinions and feedback[35]. The applications of big data in addressing the issues of food security and safety, food production and consumption and innovations remains in infancy state. Recent studies on big data in food industry demonstrate potential usage of technologies which may drive better implementations in future.

2. Methodology

2.1. Structure of the Review

The purpose of the systematic literature review is to systematically synthesize the literature in a specific domain and propose future areas of research based on the gaps identified in the literature synthesis. The study synthesizes the literature on big data and food, identify research gaps and propose future research directions applying[36].

2.2. Search Strategy

The following sections present the selection of databases and inclusion and exclusion criteria of research studies.

2.2.1. Database selection and exploration of research studies

Following an extensive search of research articles on Big Data and food, this paper explores the research studies on Big data and food from sources, which include Google Scholar, Elsevier's Science Direct, Emerald Insight, Sage, Springer Link, Taylor & Francis, Elsevier, ACM, IEEE, Wiley Online Library, ProQuest, Scopus and Web of Science (WoS).

2.2.2. Key Word Selection

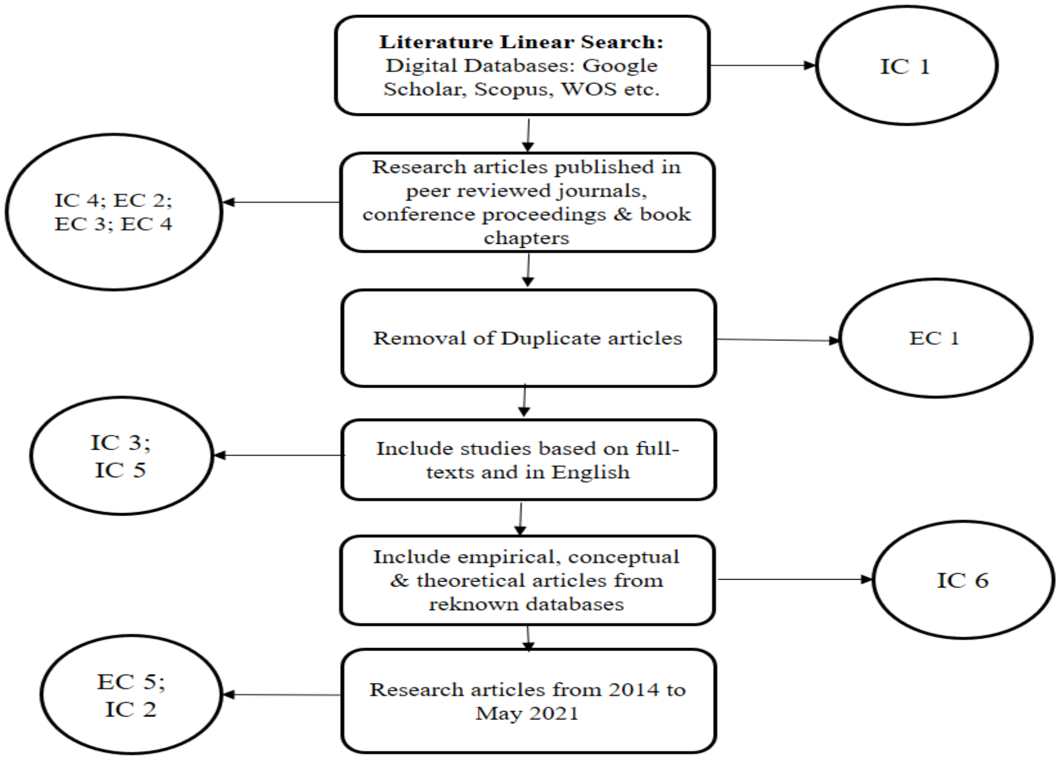
The reference database used for the selection of research articles was Google Scholar and others, the searches included the selected terms in the title, keywords and summary searched for the staircase which allowed us to eliminate non-relevant articles. To choose alternatives, keywords searched include "Big Data and food". Table 2 provides a summary of the research articles contained in each database with search syntaxes.

Table 2: Search syntax used in the SLR for selecting research articles

Database	Search Criteria
Google Scholar	Advanced search; Search: in the title of the article
Elsevier's Science Direct	Advanced search; Find article with search term Article type: Research article, Conference papers and book chapters
Emerald Insight	Advanced search; Search term with anywhere; Content type: Articles and chapters
Sage	Enter search term with anywhere; Access type: all content
Springer Link	Advanced search with exact phrase
Taylor & Francis	Advanced search; Search for: Enter search term with anywhere
Elsevier	Basic search; Title
ACM	Advanced search with exact phrase
IEEE	Advanced search with exact phrase
Wiley online library	Advanced search: Enter search term with anywhere
ProQuest	("Big Data") AND ("Food")
Scopus	(TITLE-ABS-KEY ("Big Data*") AND(TITLE-ABS-KEY ("Food*") AND (LIMIT-TO (LANGUAGE, "English") AND (LIMIT-TO (EXACT KEYWORD, "Big Data*") OR LIMIT-TO (EXACT KEYWORD, "Food") AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "ip")
WOS	TOPIC: (Big data) AND TOPIC: (food) Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI

2.2.3. Journal Selection and Inclusion/exclusion criteria

Figure 2 explains data collection procedures which includes all the stages, and implements the inclusion and exclusion criteria. The list of items in the figure shows the different phases of capturing data in a sequential way, and illustrates the different steps taken to identify research articles for analysis from 2014-May 2021. The inclusion and exclusion criteria employed in the current investigation are indicated by the entries connected with each phase. The research data collection process has been used in a manner to ensure no discrepancy at a later stage.



Previous studies suggest that Google Scholar is the most comprehensive database that provides abundant data for bibliometric analysis[37,38], which is why this database is included in our searches. In addition, by performing a full text search query, the studies which were relevant were added to include pertinent papers by linking citations in the digital databases as presented in table 2. Both the forwards and backwards review processes were conducted.

Table 3. Study Inclusion Criteria and Exclusion Criteria

Inclusion Code	**Inclusion Criteria**
IC1	Search the database with the key words “Food” and “Big Data”. Used the search operators such as OR, AND, Allintitle.
IC2	Studies published until May 2021
IC3	Studies must be published in English Language
IC4	Studies published in peer reviewed journals, book chapters and conference proceedings from the database like Google Scholar, , Elsevier's Science Direct, Emerald Insight, Sage, Springer Link, Taylor & Francis, Elsevier, ACM, IEEE, Wiley Online Library, ProQuest, Scopus and Web of Science (WoS).
IC5	Studies with full texts
IC6	Studies which are empirical, conceptual and theoretical.
Exclusion Code	**Exclusion Criteria**
EC1	Duplicate studies or studies related to similar names
EC2	Commentary and Perspective based studies
EC3	Interview Based Studies
EC4	Dissertations and thesis
EC5	Studies before 2014

2.2.4. Selection Procedure of Research Studies for Review

The initial search of research studies pertaining to "Big Data" and "Food" from the selected data bases resulted 5160 studies (Inclusion criteria IC1). Following the inclusion criteria (IC2, IC3, IC4) and exclusion criteria (EC1 and EC5), 4724 studies were excluded. 436 studies were selected for reading the abstracts and relevance to the study. Exclusion criteria EC2, EC3 and EC4 are employed and extracted 115 relevant studies for further analysis. Studies which are not meeting the criteria of availability of full text material (IC5) and empirical, conceptual and theoretical (IC6) are excluded, leading to 43 studies. Out of 43 studies, 34 studies that focused on "big data" and "food" from the business and management dimensions are included. Forward reference and backward reference were also conducted to find 4 additional studies. Finally, the review was conducted with 38 studies. Figure shows the steps taken for article extraction and implementation of inclusion /exclusion criteria.

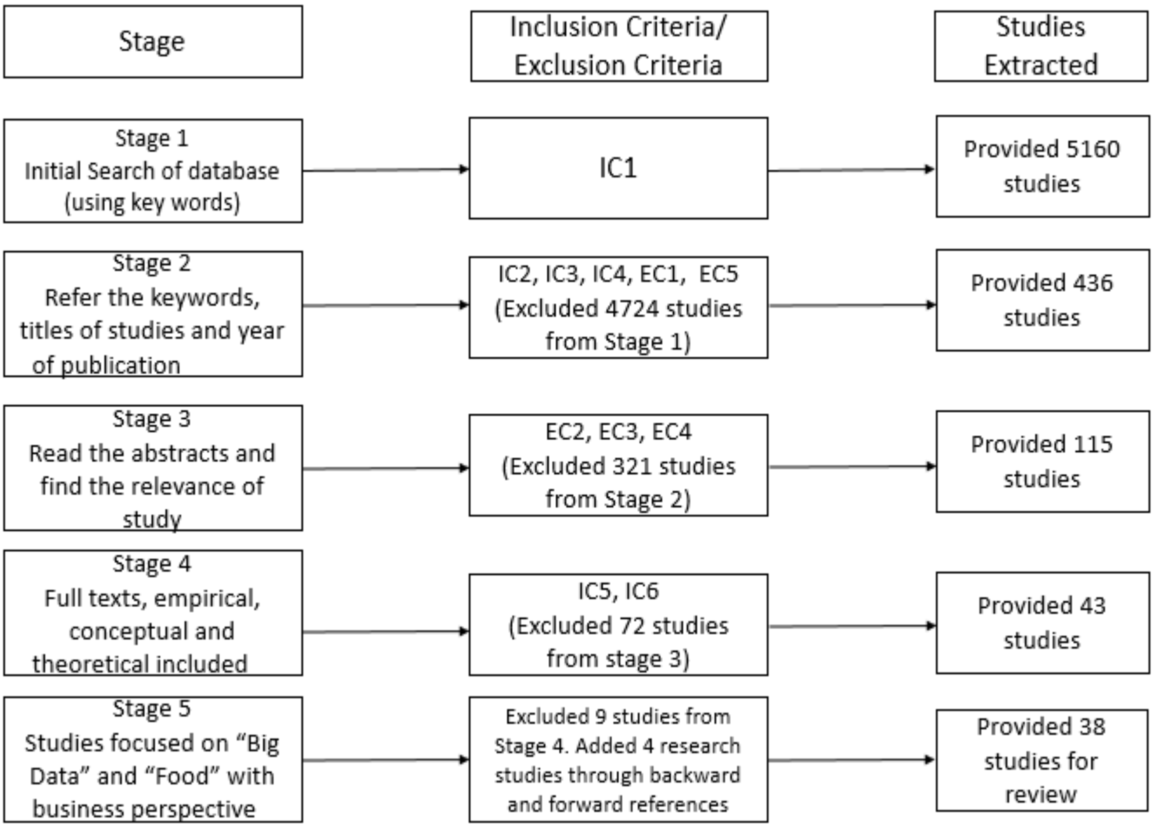


Table 3 list total articles analyzed and the number of studies by databases, and shows that Big data and food had 5160 hits out of that 38 articles selected.

Table 4: Number of studies found per database

Database	Articles Extracted	Articles Included
Google Scholar	1030	16
Elsevier's Science Direct	47	3

Emerald Insight	473	1
Sage	469	0
Springer Link	371	2
Taylor & Francis	5	3
Elsevier	17	1
ACM	9	1
IEEE	196	3
Wiley online library	1036	1
Proquest	23	1
Scopus	347	1
WOS	1137	5
TOTAL	**5160**	**38**

2.2.5. Assessment of paper quality for review

It is critical to assess the quality of the studies identified for review in order to support the submission and exclusion criteria, as well as the selection of research papers. The aim is to evaluate the quality of the articles to ensure that the survey results are impartial and accurate (39). For this reason, four quality assessment questions (QE) were developed to enhance the scope of this study. These were: QE (1) Where is the evidence that quantitative or qualitative data is being investigated? Possible answers were "Quantitative (+2)", "Qualitative (+1.5)" and "No Evidence (+0)". QE (2) whether the study clearly explores limitations and benefits? Possible answers were "yes (+2)", "partial (+1.5)" and "no (+0)". QE (3) Is the result of the study justified? Possible answers were "yes (+2)", "partial (+1.5)" and "no (+0)". The score is considered partial if the result was limited. QE (4) whether the study was published in a recognized and trusted source. The possible answers were (2) when the sum of the installments and the rate H exceeds 100, (1.5) when the amount Citation Index exceeds H or between 50 and 99, (1.0) when the amount exceeds cooled and the index H or between 1 and 49 and (+0) if the sum of the quotas and the index H is 0. QE (5) if the proposed methods are comparable with other methods then the scores will be for yes (+1) and for no (0).

Table 4: Quality Evaluation scores of Papers selected for SLR

Authors	**QE 1**	**QE 2**	**QE 3**	**QE 4**	**QE 5**	**Total**
Ahearn et al. (2016)	1.5	1.5	2	1	0	6
Alotaik et al. (2017)	1.5	1.5	2	0	0	5
Armbruster and MacDonell (2015)	1.5	2	1.5	1	0	6
Bronson (2019)	0	1.5	1.5	1	1	5
Carolan (2017)	1.5	1.5	1.5	2	0	6.5
Carolan (2018)	1.5	1.5	2	2	1	8

Chen et al. (2014)	1.5	1.5	2	1	0	6
Danezis, G. et al. (2016)	1.5	1.5	0	1.5	1	5.5
Dass and Anandappa (2017)	1.5	2	1.5	1	0	6
Dubé et al. (2014)	2	1.5	1.5	2	1	8
Dubé et al. (2018)	2	2	2	1	1	8
Evans (2016)	1.5	1.5	1.5	1	0	5.5
Freidberg (2017)	1.5	1.5	1.5	2	0	6.5
Frelat et al. (2016)	2	1.5	1.5	2	0	7
Irani et al. (2018)	2	1.5	1.5	2	1	8
Ji and Tan (2017)	2	1.5	1.5	1	0	6
Ji et al (2017)	2	2	1.5	1	0	6.5
Kim et al (2016)	2	1.5	1.5	1	0	6
Kuang et al. (2016)	1.5	1.5	0	1	1	5
Li et al (2019)	1.5	1.5	2	0	0	5
Liu et al. (2018)	1.5	2	1.5	0	0	5
Lusk (2017)	2	2	2	2	1	9
Ma et al. (2016)	2	2	1.5	1	0	6.5
Marvin et al. (2017)	1.5	1.5	1.5	2	0	6.5
Misra, et al. (2020)	1.5	1.5	1.5	1.5	1	7
Montgomery et al. (2019)	1.5	1.5	1.5	1	0	5.5
Navickas and Gružauskas (2016)	1.5	2	1.5	1	0	6
O'Connor and Kelly (2017)	1.5	1.5	2	2	0	7
Protopop and Shanoyan (2016)	1.5	1.5	1.5	1	0	5.5
Ramandita et al. (2018)	2	1.5	1.5	1	1	7
Sharma andParhi (2017)	1.5	1.5	1.5	1	0	5.5
Shuangyang et al. (2016)	0	1.5	1.5	1	1	5
Su et al. (2017)	2	2	2	1.5	1	8.5
Tao et al. (2020)	1.5	1.5	1.5	2	1	7.5
Wang et al. (2015)	1.5	2	1.5	1	0	6
Wang et al. (2016)	1.5	1.5	1.5	0	1	5.5
Xu et al. (2018)	1.5	1.5	0	1	1	5
Yang et al. (2017)	1.5	1.5	0	1	1	5

3. Findings and Discussion

The details of selected 38 research studies with the author(s), year of publication, study implications, future work, research gaps and limitations of the study are presented in Annexure1. The progress of research in "big data" and "food" over a period of time were examined and themes emanated from the thematic analysis were also discussed.

3.1. Progress in Research studies

Figure 4 depicts the annual number of research articles on Big Data and Food that are published. The annual publications of the research articles show a significant increase over 2014-May 2021.The continued growth in the trajectory of Big Data studies and adoption behavior evidences the importance of this topic. The analysis shows an increase, with 11 in 2016 and 2017, respectively but a fall in 2018 (7).

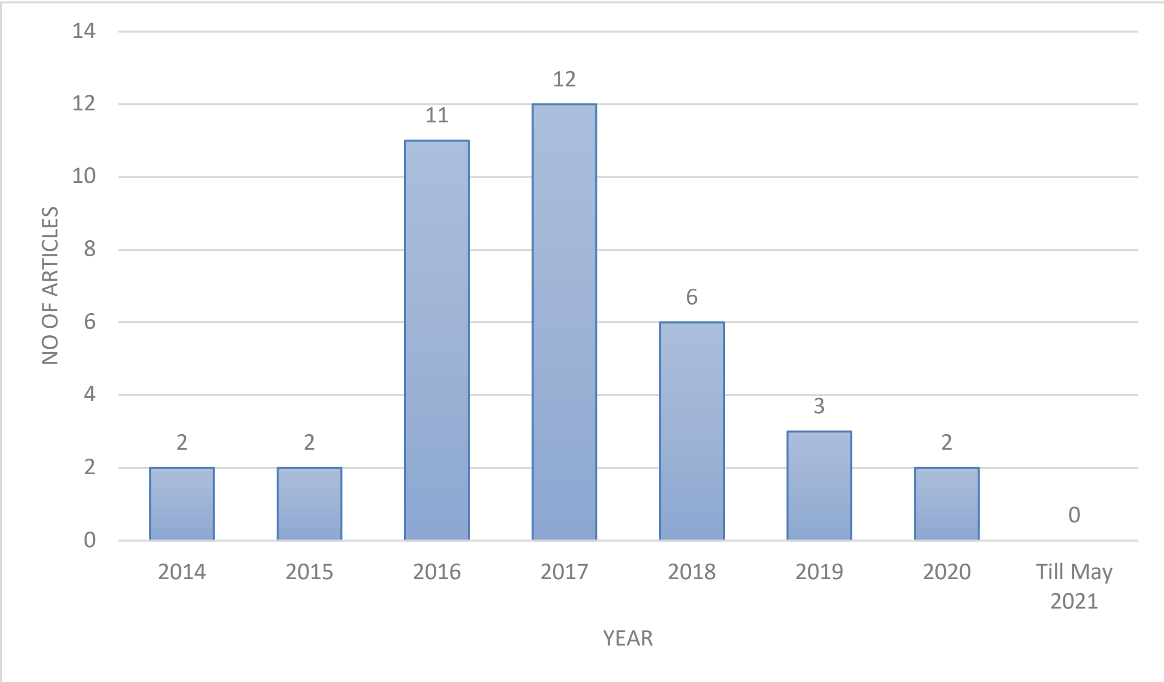


Fig. 4: Annual scientific production of research studies

3.2. Publications by major countries

The highest number of studies published on Big data & Food are in China and USA (Figure 5). Countries like Canada & UK also figure prominently, followed by Africa, Ireland, Netherlands, Lithuania, India, Indonesia, Korea and Greece. This suggests that country specific studies on Big Data and food are absent, which justifies the need for this research.

Fig. 5: Studies classified on the basis of country of study

3.3. Journals contribution

The fig. 5 shows that Annals of New York Academy of Science has the highest H index of 225, more than any of the journals examined.

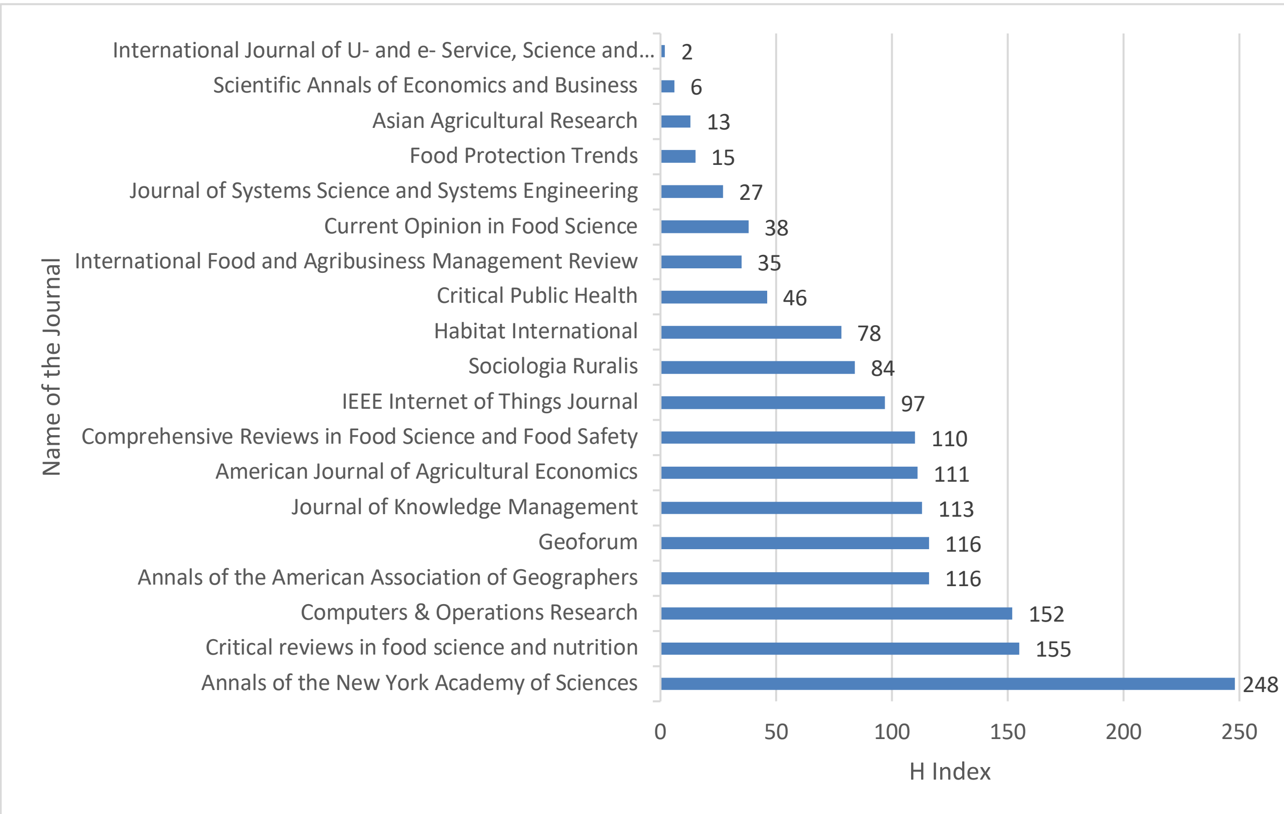


Fig. 3: H Index of the selected journals

3.5. Citation Analysis

Next, the most cited contemporary studies pertaining to "Big Data" and "Food" was examined. Table 5 presents the most cited studies among the selected 38 studies for review. Considering both the number of google scholar citations (as on September 17, 2022) and average citations per year for the study, a study conducted by (40,41) can be considered as the most influential studies in contemporary big data studies in food industry.

Table 5. Most Cited Studies

Rank	Study	Journal	No of Google Scholar Citations	Average Citations per year
1	Misra et al., 2020	IEEE Internet of Things Journal	133	66.5
2	Frelat et al., 2016	Proceedings of the National Academy of Sciences of the United States of America	316	52.7
3	Carolan, 2017	Sociologia Ruralis	221	44.2
4	Tao et al., 2020	Comprehensive reviews in food science and food safety	85	42.5
5	Irani et al., 2018	Computers and Operations Research	115	28.8
6	Danezis et al., 2016	Current Opinion in Food Science.	130	26.0
7	Marvin et al., 2017	Critical Reviews in Food Science and Nutrition	102	25.5
8	Liu, P. et al., 2020	Journal of Cleaner Production	51	25.5
9	O'Connor, C., & Kelly, S. 2017	Journal of Knowledge Management.	114	22.8
10	Lusk, J. L. 2017	American Journal of Agricultural Economics	76	15.2

3.6. Top contributing authors

Figure 6 describes that Carolan, Dube, Ji, Li, Ma, Tan & Wang has written the two articles from 2014 to 2019 on Big data and Food, which implies that these authors are most productive in the field of Big data and Food.

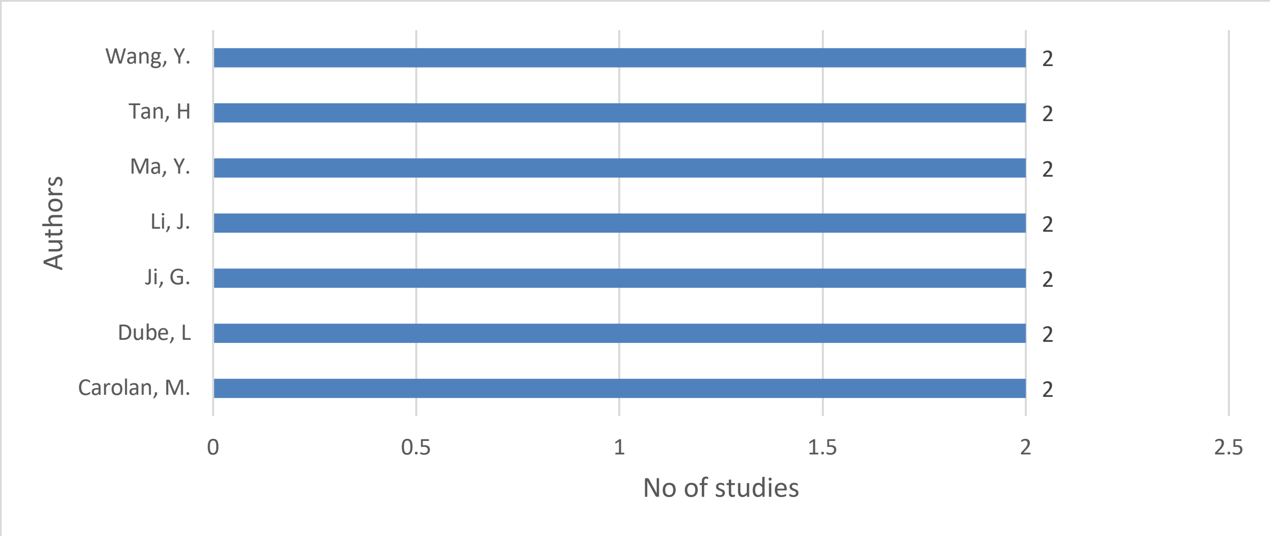


Fig. 6: Top contributing authors (≥ two papers)

3.7. Cross -country collaborations among authors

Figure 7 shows the level of collaboration between authors across countries. Among the 38 research papers reviewed, only four present evidence of cross-country collaboration, with the highest number of collaborations between Australia, UK, USA and other countries.

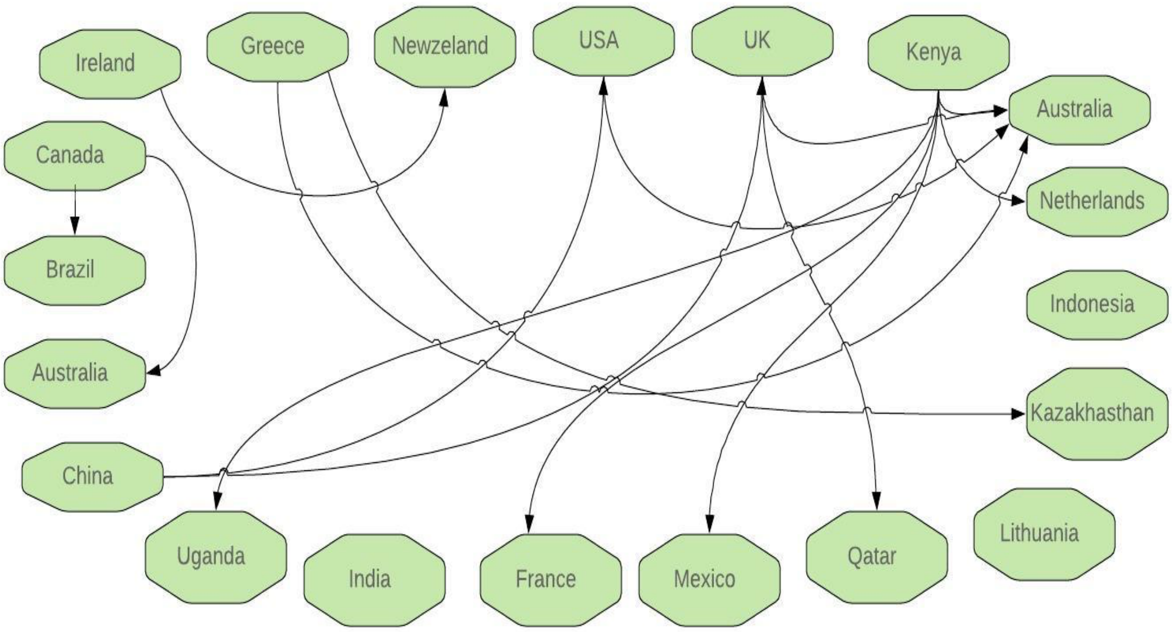


Fig. 7: Showing the collaboration of research between countries

3.8. Sector -wise distribution of studies

Retail industries are the main industry with highest number of articles selected - 19 out of 38 studies selected. Other studies have been selected from other industries, such as supply chain, agriculture, agri-food, beverage, digital, education and social media. Other than retail, supply chain and agriculture, the remaining are less in number.

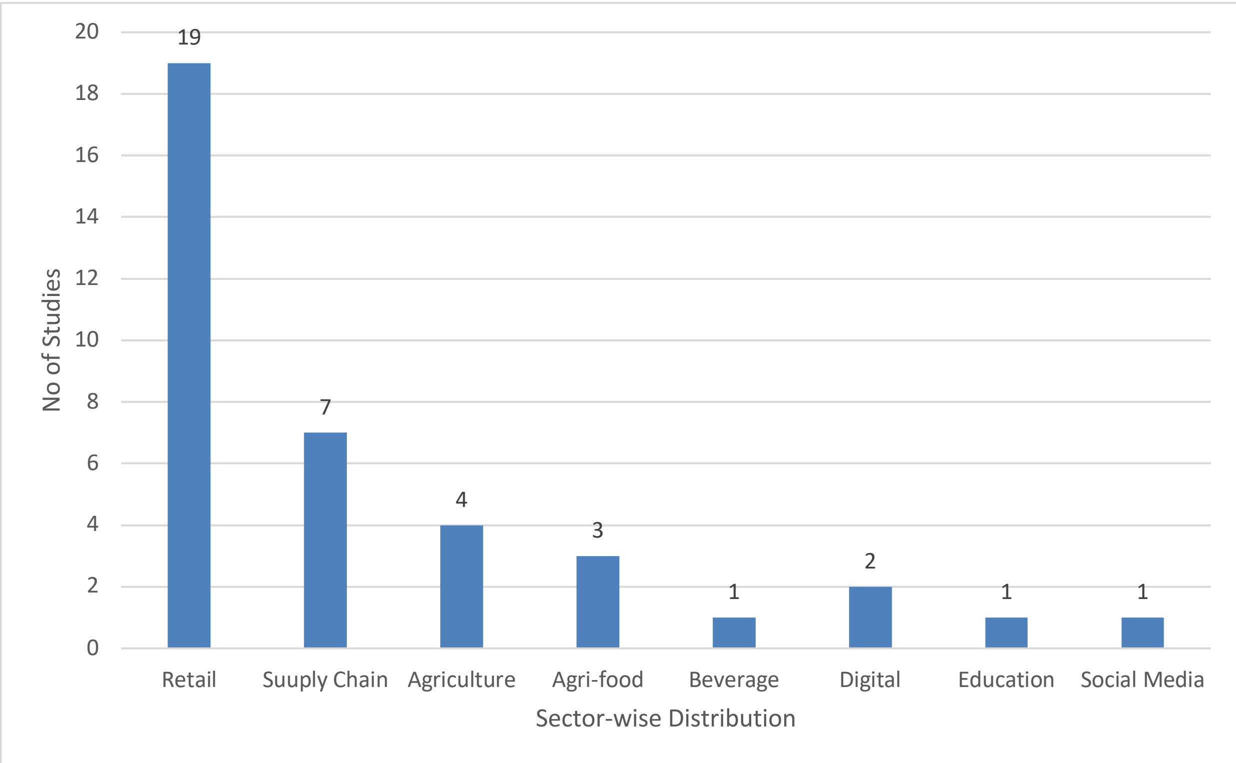


Fig. 8: Sector-wise distribution of studies

3.9. Word cloud view of studies

Figure 9a describes that the world cloud on selected article titles shows that the term Big Data and Food have made bigger clouds compare to other words.

Fig. 9a: Word cloud on selected studies article title

Figure 9b describes that the world cloud on selected studies keywords showing that the words Big Data and food is Bigger in size as most of the articles are related to these particular keywords. Hence it has been found from both the word clouds that Big Data and Food are most repeated words in paper titles and as keywords.

Fig. 9b: Word cloud on selected studies keywords

3.10. Thematic Analysis of the literature

Thematic analysis was conducted to explore the emerging themes in the area of "big data" and "food". All these articles are read and open coded to arrive at a conclusion for final set of themes. The final set of themes from the selected 38 studies emanated are as climate change, food safety, education, spirituality, food image, food waste, sustainability, food security and social media. The themes explored from the selected studies and key findings relevant to the themes are presented in table 6.

Table 6. Summary of Thematic Analysis

S.No	Themes	No of Studies	Author(s), year	Key findings
1	Climate Change	6	Dubé et al. (2018), Ma et al. (2016), Alotaik et al. (2017), Ji and Tan (2017), Zakaria, M. M. K. N. H., & Rashid, A. (2017), Armbruster and MacDonell (2015)	Climate change is proving costly creating exorbitant loss to the companies. There is a strong need for harmonization of multisectors for addressing food safety, security and equity distribution of foods.
2	Food Safety	7	Lusk (2017), Protopop and Shanoyan (2016), Su et al. (2017), Irani et al. (2018), Ma et al. (2016), Montgomery et al. (2019), Ji et al (2017)	Early warning of food safety reduces the risk of food safety problems, tracking, quantitative analysis and information about forecast. Big data has been applied to trace logistics information, encourage regional and industry information sharing platform, realize the connectivity and fundamentally solve the problem of food safety.
3	Education	1	Navickas, V., & Gružauskas, V. (2016)	Big Data and Education have considerable space in addressing the issues such as green ecological crisis. In the era of artificial intelligence and big data, through the large collaborations of teachers and students, a series of uncertainties in green food segment can be addressed.
4	Spiritual	1	Navickas, V., & Gružauskas, V. (2016)	Big data can also be applied to analyze the equilibrium point of material food and spiritual food (mental hunger).
5	Food Image	1	Zakaria, M. M. K. N. H., & Rashid, A. (2017).	Using big data analytics, analyzing contextual information one can estimate food volume and generate food estimate images. Also, data collated from unmanned aerial vehicles or drones, one can indicate the plant health to estimate the food volume production.
6	Food Waste	1	Lusk, J. L. (2017)	Big data analytics support the reduce of food waste. Cause-effect models, 'what-if' simulation models, fuzzy cognitive map approaches elucidate emerging food loss occurring scenarios. Integration of producers, market makers, logistics

				and consumption address the concerns in food processing and food waste.
7	Sustainability	4	Frelat et al. (2016), Irani et al. (2018), Ma et al. (2016), Zakaria, M. M. K. N. H., & Rashid, A. (2017).	Big data improves the efficiencies in agri food supply chain such as lag in the knowledge generated about supply chain responses to the customer demand to the adoption in the supply 8chain. As governments poised towards climate change outcomes such as reducing carbon emissions, supply chains are under immense pressure. Big data and machine intelligence are both applied to food production and supply chain to address the wicked problem of twinned food security and sustainability challenges.
8	Food Security	10	Dubé et al. (2018), Lusk, J. L. (2017), Irani et al. (2018), Navickas, V., & Gružauskas, V. (2016), Ji, G., & Tan, K. (2017), Ji, G., Hu, L., & Tan, K. H. (2017), Nita, S. (2015), Zakaria, M. M. K. N. H., & Rashid, A. (2017), Ji, G., & Tan, K. (2017), Evans, B. (2016).	Big data offers real time feedback on the how well the food security policies are implemented and how poor are getting out of vicious circle of poverty. Leveraging on big data, food security issues raised due to revolution, wars, droughts and other disruptive shocks are tackled.
9	Social Media	7	Freidberg, S. (2017), Chen, K.,et al, (2014), Alotaik et al. (2017), Ramandita et al. (2018), Ji, G., & Tan, K. (2017), Kim, S. J., et al., (2016), Evans, B. (2016)	Twitter, Facebook, WhatsApp potentially discover and disseminate real-world flood scenarios which are potential threats for food safety and security. Big data has implications not only for farmers, but also for other stakeholders throughout the agri supply chain system. It also helps to predict customer sentiments across different cultures.

Theme 1: Climate Change

The development of alternative policies for impact assessment and climate change solutions, and the need to fund data collection complemented with the need to develop partnerships to address the challenges involved are key to improving the food chain and ensuring food security in future. Biological research is used to facilitate the adaptation and mitigation which must be accompanied by hydrological, economic and other related activities to create a sound policy environment which can actual affect the quality of the food. More sophisticated models containing better data is also needed to develop local solutions and policies that facilitate the necessary actions. The global nature of the problem will require creating partnerships between universities and the private sector, including deeper international cooperation[42].

Theme 2: Food Safety

Big Data technology extracts the information from a large volume of data on food safety and thus provides an effective warning of food safety risks. Information on food safety hazards covers both statutory and non-statutory data. Standard information, administrative licensing information, law enforcement administrative information, inspection and discovery information, complaint reports, and business information are all examples of regulatory information[43]. Data security for food security can undermine the value of Big data and generate a timely and accurate risk warning for food security. Managing food safety data, on the other hand, allows for actual performance monitoring and intelligent control, as well as improved food safety monitoring[44].

Theme 3: Higher Education

This is a crucial theme since it encourages teachers and students to continue investigating a wide range of topics related to green foods and business, as well as define Big Data and technology aspects. It also laid emphasis for innovations and collaborations among the higher education institutions, industry and regulatory bodies to address the concerns such as food safety and security, food waste, and leveraging on technologies in the context of climate change. However, few studies have been conducted on this context, and among others a series of results of Intelligent Systems Survey can be used directly to study organic foods and industrial orientation[45].

Theme 4: Spiritual Nourishment

There are several studies available that deal with material food and its manner of production, which need thorough analysis and inquiry, but spiritual sustenance and its mode of creation also deserve thorough examination. Researchers discovered that material food and its forms of production are strongly tied to spiritual food and its modes of production through research and examination of the positioning of green food and its business, but that no systematic study has been able to connect the two[46].

Theme 5: Food Image

Results show that food images attract the interest of researchers. Topic examined consider both portion size and food estimates images. A single image may be a difficult research problem and future research may want to include contextual information for the estimation of food volume. In-depth learning has generalized the attention and the constitutional neural network proved success in many computer visualization tasks. Food, in comparison to common objects such as persons, faces, and buildings, suffers from a lack of structure. An effective restoration network and location classification improves the accuracy of food identification[47].

Theme 6: Food Waste

Knowledge transfer, market access, and a broader organizational commitment should all be part of management efforts to manage and mitigate the effects of food security and waste[48]. This means that a change in food safety management is more than a risk issue, emphasizing the importance of considering and including human and organisational issues when building a food security or waste reduction solution[49].

Theme 7: Sustainability

Monocultures limit biodiversity, ecosystems, and migration corridors, reducing the resilience of farming systems increasingly challenged with climatic volatility, including reducing genetic material available when environmental constraints shift[50]. Future research should include a variety of food production strategies in peasant or agro-ecological ways based on ecological principles like renewal, as well as technology-intensive digital agriculture, according to the researchers [51].

Theme 8: Food Security

The digital data revolution can assist existing early warning systems maintained by NGOs and UN agencies that focus on climate shocks in rural areas. Large-scale data derived from mobile phone use, when supplemented with traditional climate warnings, will improve understanding of regional food security. Increasing traffic on mobile network networks, depletion of mobile banking funds, and increased tweets about food shortages and prices are likely to aid organizations in better understanding their business. a crisis that lasts for a reasonable amount of time[52]. Simultaneously, sensors are increasingly being employed in farm early reporting of crop health issues, enabling for early public health and safety monitoring[53].

Theme 9: Social Media

Social networks provide data, including information on food choices of people visiting a location. But the available data are not structured in human language. The challenge is two-fold: understanding the meaning, and extracting information relevant to dietary trends. Therefore, social networks inform about commercial opportunities in gastronomy. Further, social networks are also used as a marketing tool to gain access to a large consumer base. Twitter is used for culinary marketing, and the account users comment on culinary products. This is employed to select foods based on recommendations by people that have tasted the culinary products[54,55]. However, poor data quality and privacy concerns limit the widespread use of social media applications. Other minor sources of text data have been used to create useful information systems that aid consumers in their purchasing, cooking, and eating decisions[56].

3.11. Theoretical Perspectives

This review explored the theories and models used in the “big data” and “food” research. A brief articulation of theories used in the studies are as follows:

a) Actor Network Theory

Actor network theory[57,58], relies on the concept of heterogenous network. Action network theory highlights the integration of social and technical factors with the creation and maintenance of human and non-human elements that include people, organizations, software, computer and communications hardware and infrastructure standards[58]. Researchers employed actor-network theory to investigate the steep learning curve of managers to manage supply chain sustainability. Also, how best the real risks, both environmental and reputational risks are managed by food companies that relate buyers, suppliers and competitors[59].

b) Resource- based theory

Resource- based theory[60,61] argued the resources are valuable and those resources which are rare brings competitive advantage. The advantage can be sustained for a longer period of time to the extent that the firm can is able to protect the limited resources, and limited substitutability. Drawing on resources -based theory, big data and knowledge are mutually exclusive[62]. Knowledge acquisition and application are limited resources that SMEs can gain competitive advantage that stems from strategic orientation and asymmetrical power relationships within a network.

4. Research Gaps Identified in the Systematic Literature Review

This section describes three different types of research limitations used in the research articles reviewed in this SLR on Big data and food.

4.1. Region and country specific study

Big data and food related studies are mostly region-specific study[40,63]. Limited number of scenarios on food waste and food security presented in the study which is country specific perspective also[64]. There are country specific presentations of the framework which explain accuracy and predictability of the proposed model to test larger datasets[65]. The country specific presentation on Big data and food has been observed and a few studies were developed which have been extrapolated for developing countries[41,66-71]. The main shortcoming is that the study was conducted in Africa and not tested in any developing economies[92].

4.2. Theoretical perspectives and limited datasets used

Theoretical perspectives presented by studies on Big data and food related papers[72-74] presented a theoretical framework related to resourced based perspective and actor network[75]. Limited dataset has been used in a few studies where the accuracy can be checked after using larger datasets[64,65,76-78].

4.3. Other limitations

Data sparseness is an underlying issue[79]. One study showed a tiny group of instances of how a new large-scale dataset can be used to gain insights into food demand[80]. Big data consumer analytics is accounted for knowledge management in small and medium enterprises in agri-and-food sector[62]. As a result, Big data is only available in limited quantities for conventional food systems around the world[81], and Big data is neither scaled nor spatially neutral[82]. The unpredictability of human behaviour, social and ancestral backgrounds, as well as the possibility of designing erroneous data, are all deceptive[83]. The pillars of the method used by food microbiologists to measure quality and safety parameters are isolation, enumeration, and culture[84]. Though the development of large data by the food industry is available[85] assessing nutrition or energy intake from a single photograph remains a difficult research topic[43].

5. Discussion and Future Research Directions

It is a well-known fact that big data is a value driver throughout the business value chain in different business settings. However, there are few challenges derived from the systematic literature review on big data and food industry should be addressed before leveraging the benefits of big data.

5.1. Challenges of Big Data in Food Industry

5.1.1. Lack of food safety risk assessment analysis

Differing patterns of climate, climate change and food security in agricultural supply chains lead to a lack of research in food safety risk assessment analysis. The policy issues discussed relate to the use of Big data in agriculture[66] but studies on behavioral issues related to the adoption of food-based technologies are missing[41]. Rather than focusing on agricultural productivity and minimizing yield gaps, studies generally focus on enhancing market access and non-farm options for farmers as an approach for increasing food security[40]. There is also a lack of food safety risk assessment systems to gather real-time evidence[86]. The established surveillance networks and management platforms solely identify early warnings related to food safety and security[70,72].

5.1.2. Lack of tools and organisational factors in Big Data

The tools on big data for food safety assessment are limited[63] and there is a lack of holistic understanding of the organisational factors on food safety management[64]. Research, policy, and other intervention efforts, primarily in the health sector, have been identified to challenge existing, potentially harmful data-driven marketing tactics and to leverage the potential of big data to achieve beneficial results. Because there is a scarcity of data and analytical methodologies to deal with the breadth and depth of the rapidly evolving digital food and beverage sector, the impact on community food and health behavior's is largely studied[74].

5.1.3. Creation of a Big Data knowledge management framework

There is a relationship between small-scale agricultural and industrial value chains, but demand is largely disregarded[81]. This link can be used throughout the society to induce behavioral changes in creating a framework to manage Big Data knowledge which links demand to supply. Small farmers in developing nations have limited access to resources and markets, which is the principal impediment to the adoption of new technologies and the development of new capacities. Other studies explain the need for a shared model for managing data security based on Big Data[65]. There is evidence on an increase of generation of food development using data and sentiment analysis[71] despite growing adoption of Big Data technologies to manage food chains[82].

5.1.4. Lack of sustainability measures

There is a lack of sustainability measures in place for large organizations in the food chain[73], which highlights the need for data reporting on food safety[77]. Businesses require not just the capabilities, but also insights into how Big data is assisting in the resolution of food chain issues as a result of the information explosion[87]. Researchers have introduced Big data technologies to explore the level of salt, sour, taste (bitter and sweet) across the perception maps[78]. The ability to compare data from similar trials is lacking, which is a significant flaw in the field of food authenticity[88].

5.1.5. Emergence of miscellaneous gaps

Current studies lack the insight to find or create a pathway between perceptions of eating systems, motivations and goals that lead to healthy and sustainable eating behaviors'[79]. There is a dearth of research on consumer behavior and food consumption patterns using Big Data[69]. Big Data has been utilised in the food chain to find production decisions and use technology to transform product demand into processes and divide operations into tasks and assets[87]. Previous researchers explained how to utilise Big data in small and medium-sized businesses as well as find new information on consumer behavior[62,80]. Further, the lack of studies on large data applications in small food chain markets[75] highlight the gaps in the agricultural supply chain[68].

4.4. Future Research Directions

Despite there are few challenges of big data in food industry, there is wealth of opportunities to answer non-trivial research questions. Therefore, the given below section presents the future research directions.

4.4.1. Advanced traceability system and policy developments

Rather relying on agricultural development, multi-sectoral policies, incentives, and diversification of job sources are needed. Mobile phones and modern traceability systems for food security monitoring, as well as the usage of social media, necessitate tools and infrastructure that are supplemented by substantial data capabilities[63]. A real-time logistics data management system needs to be developed for real-time information exchange to ensure traceability and food safety[72]. Storing added value and creating an information system on food security and food security based on big data is a new area[68]. Food-related data has shown to be an effective tool for the government, regulators, food companies, the media, and consumers in ensuring food quality and reducing the risk of foodborne illness[85].

Potential Research Questions:

a) How does the food companies can take leverage of mobile technologies with big data solutions for improving food safety?

b) How does big data platforms can be integrated with the social media platforms to address potential risks in food safety?

5.2.2. Innovation in food and understanding diversity

The geographic analysis of user-generated content in geo-referenced information can provide information on the influence of choice of foods[79]. This may suggest opportunities to differentiate consumer information for better convergent innovation. Several categories of geo-data have been included in the development of models to measure the availability of healthy foods[76]. Collaborative work between departments and several colleges and universities can make discoveries or innovations[89]. A wide range of food production systems have been incorporated, ranging from ecologically based agro-ecological methods to technology-intensive digital agriculture[90]. Food safety has improved as a result of the humanitarian use of Big Data, but history teaches that change and innovation are gradual[83]. In the future, researchers would be interested in analyzing common food category hierarchies and the use of agglomeration and user feedback can form an efficient system[43].

Potential Research Questions:

a) What are the potential enablers and inhibitors in establishing technovation research cells in Universities and Colleges to offer technology based (big data) solutions for efficient food production systems?

b) How does effective collaborations can be made between Government, regulatory bodies, industry and higher education institutes for an efficient technology intensive digital agriculture?

c) What potential costs and benefits the innovators accrue with the integration of big data with a humanitarian perspective?

d) How does big data act as enabler of sustained business innovation in food industry?

5.2.3. Dynamic framework for an integrated digital architecture

Consumer social networks affect food consumption[80].The extrapolation of theories of behavioural science explain the phenomenon of Big data in SMEs and provide guidance to authorities and facilitators for effective data management[62]. An integrated model related to food technology can be introduced[41]. In the food supply chain, big data is being used to make better manufacturing decisions[87]. People would see the representation of the data in a real environment and make a complete calculation of the diet[91].

Potential research questions

a) What is the impact of big data on SMEs supply chain for better manufacturing decisions?

b) What factors influence the big data and social networks adoption to estimate food consumptions?

c) How can big data can be effectively used to facilitate effective data management and reduce risks and costs among SMEs of food industry?

5.2.4. Testing and optimization of models

Researchers need to obtain information on the determinants and barriers to be able to suggest innovative solutions based on large data to assess the problems of small farmers[92]. Quantitative analysis and models have been developed to use larger data sets for forecasting accuracy[73,77]. Several food waste and food safety scenarios have been tested with Big data analysis in different geographical areas[64]. Testing and optimizing models increase market competitiveness[75]. A mathematical model has been established which optimizes the distribution of the food bank for census in a fair manner[67]. Food production facilities can use "smart sampling" technique as a research tool for food processing and general monitoring activities[84].

Potential research questions

a) How big data analytics solve the problems and concerns of small farmers in improving productivity?

b) Using big data analytics derive optimization models to improve the productivity and supply chain logistics under different food safety scenarios?

5.2.5. Miscellaneous future research directions

Larger datasets have been included to test the accuracy and predict the framework for areas of the food chain[87]. The frameworks have been extrapolated for other countries using larger datasets[65]. Local food systems have been used to collect sociological data for agriculture and nutrition. Linking Big Data with other statistics and surveys, as well as a comprehensive portfolio of advanced analytic models to drive practices, policies, system design, and sectoral innovations, is a step toward an integrated knowledge platform[81]. Robust food safety mechanisms are required in developing economies[66]. The adoption of precision agriculture and climate-smart agriculture techniques is the future. Public Private Partnerships (PPP) framework allowing organizations to work with the farmers and authorities[66].

Potential Research Questions

a) Application of qualitative and quantitative big data to derive robust analytical models for an efficient food value chain model.

b) How does public private partnerships benefit and challenges pertaining to it assist the farmers to increase food production?

c) Derive deterministic and stochastic models to develop frameworks for accurate prediction of food production in various geographical contexts.

d) How has the big data analytics can be used to investigate the impact of gastronomy, gastronomy tourism, food culture, food choices, food consumption pattern & preferences on the agribusinesses value chain?

5. Implications of the Study

6.1 Practical Implications of Study

The results of the study indicate that the findings emanated from the study have short term and long- term practical implications. The potential research questions for future research have several implications for the industry and regulators.

6.1. 1. Accessibility

Information on the availability of food ends the concerns for the certain food distribution in concordance with the food consumption patterns. The variability in consumer preferences in traditional demand systems and preference choices can be understood with the algorithms of big data and machine learning. Big data assisted patterns assists the practitioners to efficiently monitor risks and implement effective food tracking and classification. In addition, integrating key drivers such as mobile, data, sensor and social media creates a profound impact on society[93]. Harnessing on the big data, availability of food to reduce obesity and chronic diseases can be a game changer in the field of public health[74].

6.1.2. Food security and Safety

Big Data and its relevant applications are used to improve food security[81]. Big Data can also be used to overcome the challenges of scaling up solutions to combat hunger in society and improving the convergence of traditional and modern food systems in developed and developing countries. The risk alert system for food safety is based on the management of large data[70]. The current state of supply chain logistics, Big Data and other advanced information technologies such as mobile internet has created a food safety management platform This is done through the logistics information chain to develop a fully traceable information exchange platform to ensure food security[72]. The challenges of food security and sustainability addressed by the Big data[90]. Information such as house hold information, price trends, crop production trends and biophysical data for predicting food insecurity are expensive to acquire[94]. Collaborations with Universities and colleges act as an enabler for technological innovations in to solve the food crisis problems in humanitarian perspective.

6.1.3. Digitalization in Agriculture

A geo-Big data approach is used to measure the availability of healthy foods and identify an increase in the demand of food[76]. Genomic sequencing technology has revolutionized information availability by providing a deeper understanding of the microbiological world, and agri-food manufacturers are eager to exploit this information to make better use of test expenditures[84]. The emergence of agriculture knowledge information systems offers a wide variety of data that support the management in agriculture and food production[95]. Big data analytics can be applied by small and medium enterprises to leverage on analytical capabilities with a positive impact on the competitiveness[62].

6.1.4 Other implications

The applications of Big data have been used in reducing food waste with the help of management perspective developed from organisational factors[64]. These seek to explore causal relationship between consumption and distribution factors. Existing and future technologies are attempting to improve Big data application efficacy in agriculture value chains, particularly in poor nations[92]. A variety of intelligent system research findings can be immediately applied to a number of challenges with organic foods and their industrial orientation[89]. The innovations such as iPlate's design technology is supporting restaurant's future decision-making[91]. The application of Big data for food is to assure food quality traceability, data identification, and information technology that can assist food authorities in effective food quality monitoring[85]. Big data analytics can be applied to analyse the shopping habits of millions of people, to assist the suppliers to develop effective marketing strategies based on purchasing patterns and demographics[96].

6.2. Theoretical Contribution

Since big data has the potential to replicate long-standing interactions between food system stakeholders – such as between farmers and companies or organic and conventional farmers – it requires scholarly evaluation from experts in critical data and food studies. The era of big data analytics has widened across various fields of health, food and agriculture, supply chain and logistics and decision sciences and many more. Big data has become an essential topic of research. Critically investigating big data in food and agriculture opens up a new topic of inquiry for critical data theorists, allowing them to examine the connections between big data and the material aspects of data use[97].

Studies included in the literature review adopted data – driven approach and lacks strong theoretical foundation, providing the ample opportunities for future studies. We propose theoretical base for future investigations in big data analytics approach in food and agriculture industry. Research in big data analytics allows the social science researchers to combine theory and data driven approach to offer innovative solutions for societal problems.

7. Proposed Framework as a recommendation for future research

The integrated framework on big data and food consist of three main components: challenges in Big data and food, how to overcome the challenges and outcomes based on addressing research questions. The study suggests how to overcome challenges whilst integrating innovations in food to implement a dynamic framework.

The proposed framework can be interpreted or explained under different theoretical underpinnings. Supported by environmental psychological theory, Stimulus-Organism-Response (SOR)[98], examines the environmental factors (as stimulus) which leads to individual or company's internal evaluation (as organism) and that generate an expected outcome (as response). From the angle of Stimulus- Organism- Response framework, lack of awareness, lack of knowledge, fear of adoption, less utility in developing nations and less usage in food sectors act as stimulus factors are the major impediments in the adoption of big data in food industry. Organizations need to overcome all the barriers to realize value from data by transforming it into valuable insights that can add value to their businesses. Also, rooted in organisational learning theory[99], organisations tend to understand the internal and external situational factors to make decisions to improve operational efficiencies.

Innovations in food industry, implementing dynamic resources capabilities framework and developing policies are considered as the organism factors as per SOR framework. These are the enablers required for effective outcomes in the implementation of big data analytics in food industry. Nonetheless, for an innovation driven by institutional capabilities, considerations in understanding how resources are developed and how they are integrated within the firm is the need of the hour. In consonance with the dynamic capabilities' perspective[100], dynamic resources and strategies adopted by the company guide them for sustainability and gain competitive advantage. Food industry pulled by the obstacles such as resources constraint, climate change, food safety and security, food waste and piled up stock of food materials, adopting the big data analytics assist the companies in using its capabilities to the maximum extent.

The responses or expected outcomes from the implementation of big data analytics are presented as an outcome of the organism factors. The expected outcomes of implementing big data analytics in food industry, to name a few, are food availability at affordable rates, consumers and producers connected with mobile apps, trend analysis of consumer buying behaviours, applying deep learning to understand the diet pattern, and conduct sentiment analysis to monitor customer's behaviour through social networks. Supported by Resources based view of the firms, these outcomes derived from the implementation of innovations such as big data analytics, can be sustained for a longer period of time to the extent the firms can protect themselves from imitation, transfer or substitution[61,101].

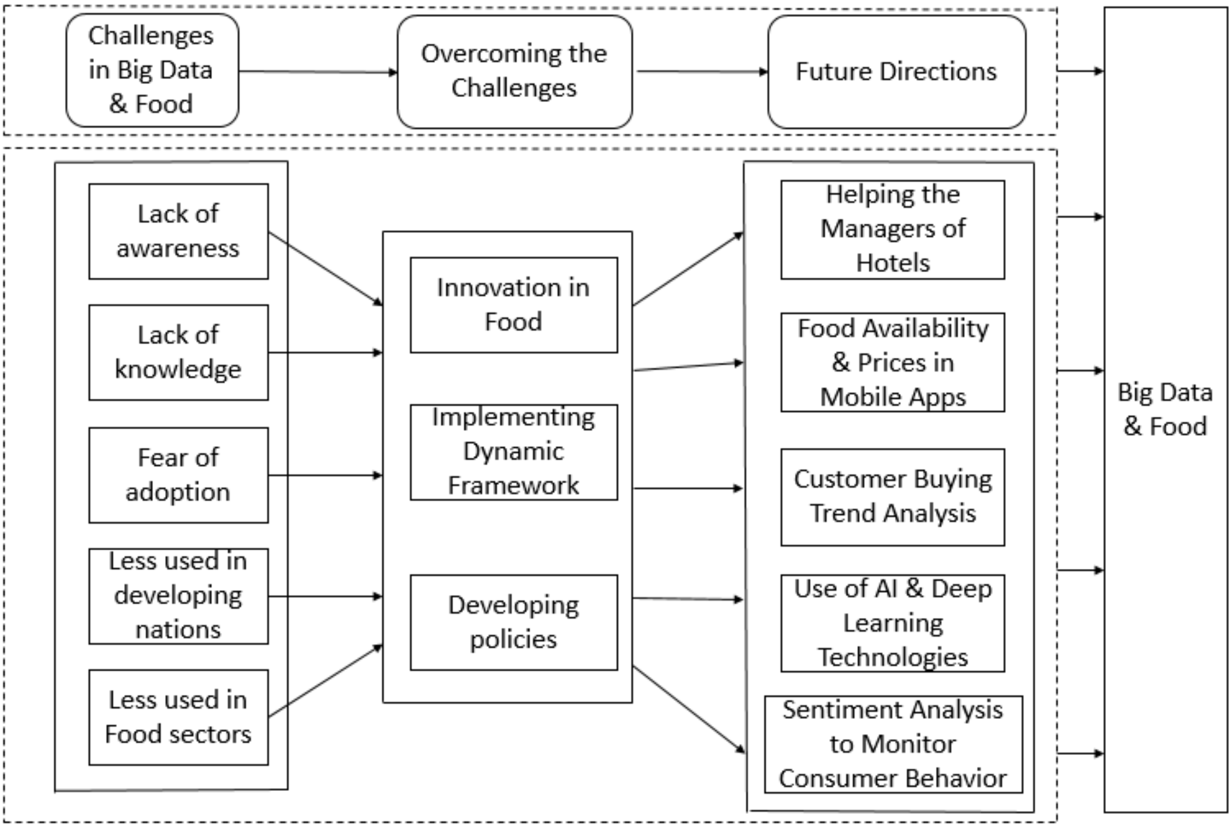


Fig. 11: Integrated Framework

Conclusion

This paper analyses how food industry uses data and analysis to capture and analyse the potential volatility of new plants and product lines in relation to the final result. It predicts the probability of potential losses, explores a series of possible loss results, and identifies potential risks. Using large data-based tools to quantify risks food and beverages companies assign values to the unknown, predict the extent of potential financial damage, and evaluate potential mitigation options for managing exposures. In short, Big data analysis drives smart business decisions and changes. The study has few limitations also. Firstly, there are dearth of research in this particular field. Secondly, the Big Data in food studies are complicated in nature. Thirdly, most of the studies are related developed countries and very few studies are available from developing or under developed countries. Fourthly, most of the studies are country specific or region specific. Finally, limited datasets have been used in most of the studies.

The study also discussed about the future directions. Precision agriculture, supply-chain efficiency, and agricultural-focused payment systems are just a few examples of how rising economies may take advantage of digital's potential in the food chain. Precision agriculture is a technology-driven farming management method that tracks, measures, and analyses the needs of specific areas and crops. It allows farmers to apply specialized care and manage water more effectively, increasing output, increasing economic efficiency, and reducing waste and environmental impact. To improve fleet management and prevent spoilage, automated solutions that indicate the status, performance, and possible bottlenecks of critical equipment in real time can be used. Transportation times can be cut in half by using smart meters to improve routing. Payment systems and financial services tailored to agriculture can help farmers establish more resilient economic models. To limit weather risk, some producers, for example, use insurance contracts. Premiums are calculated based on the likelihood of a specific meteorological occurrence, such as frost, and the consequences for a crop at a specific time of its growth cycle.

Using Big data in the food sector is recent, and several aspects will have to be documented using different methods. Based on the review of literature, researchers conclude that it is possible 1) to use generalized methods to evaluate the use of Big Data, 2) comment on the effectiveness of Big data, and 3) undertake well-grounded research on existing theoretical frameworks and seminar work. Researchers anticipate that the next phase of food industry will experience a revolution in Big Data.

References

1. Gandomi A, Haider M. Beyond the hype: Big data concepts, methods, and analytics. Int J Inf Manage. 2015 Apr;35(2):137–44. https://doi.org/10.1016/j.ijinfomgt.2014.10.007
2. Kamioka T, Luo X, Tapanainen T. An empirical investigation of data governance: The role of accountabilities. In: Pacific Asia Conference on Information Systems, PACIS

2016 - Proceedings. 2016.

3. Liu P, Long Y, Song HC, He YD. Investment decision and coordination of green agri-food supply chain considering information service based on blockchain and big data. J Clean Prod. 2020 Dec;277:123646. https://doi.org/10.1016/j.jclepro.2020.123646
4. Sun S, Cegielski CG, Jia L, Hall DJ. Understanding the Factors Affecting the Organizational Adoption of Big Data. J Comput Inf Syst. 2018 Jul 3;58(3):193–203. https://doi.org/10.1080/08874417.2016.1222891
5. Choudhury A. Big Data Analytics Services Are Helping Food Industry Companies to Achieve Millions in Operational Cost Savings – A Study by Quantzig. https://www.businesswire.com/news/home/20190109005531/en/Big-Data-Analytics-Services-Are-Helping-Food-Industry-Companies-to-Achieve-Millions-in-Operational-Cost-Savings-%E2%80%93-A-Study-by-Quantzig. 2019.
6. Edu AS. Positioning big data analytics capabilities towards financial service agility. Aslib J Inf Manag. 2022 Jun 10;74(4):569–88. https://doi.org/10.1108/AJIM-08-2021-0240
7. Kwon O, Lee N, Shin B. Data quality management, data usage experience and acquisition intention of big data analytics. Int J Inf Manage. 2014 Jun;34(3):387–94. https://doi.org/10.1016/j.ijinfomgt.2014.02.002
8. Huang L, Zhou J, Lin J, Deng S. View analysis of personal information leakage and privacy protection in big data era—based on Q method. Aslib J Inf Manag. 2021 Sep 5;74(5):901–27. https://doi.org/10.1108/AJIM-05-2021-0144
9. Shin DH. Demystifying big data: Anatomy of big data developmental process. Telecomm Policy. 2016 Sep;40(9):837–54. https://doi.org/10.1016/j.telpol.2015.03.007
10. Borra E, Rieder B. Programmed method: developing a toolset for capturing and analyzing tweets. Aslib J Inf Manag. 2014 May 19;66(3):262–78. https://doi.org/10.1108/AJIM-09-2013-0094
11. Park JH, Kim YB. Factors Activating Big Data Adoption by Korean Firms. J Comput Inf Syst. 2021 May 4;61(3):285–93. https://doi.org/10.1080/08874417.2019.1631133
12. Brown B, Bughin J, Chui M, Dobbs R, Hung Byers A, Manyika J, et al. Big data: The next frontier for innovation, competition, and productivity [Internet]. McKinsey Global Institute. 2011 Jun. Available from: http://scholar.google.com/scholar.bib?q=info:kkCtazs1Q6wJ:scholar.google.com/&output=citation&hl=en&as_sdt=0,47&ct=citation&cd=0
13. Muhammad SS, Dey BL, Weerakkody V. Analysis of Factors that Influence Customers’

Willingness to Leave Big Data Digital Footprints on Social Media: A Systematic Review of Literature. Inf Syst Front. 2018 Jun 15;20(3):559–76. https://doi.org/10.1007/s10796-017-9802-y

14. Mangla SK, Raut R, Narwane VS, Zhang Z, priyadarshinee P. Mediating effect of big data analytics on project performance of small and medium enterprises. J Enterp Inf Manag. 2020 Jan 28;34(1):168–98. https://doi.org/10.1108/JEIM-12-2019-0394
15. Singh A, Kumari S, Malekpoor H, Mishra N. Big data cloud computing framework for low carbon supplier selection in the beef supply chain. J Clean Prod. 2018 Nov;202:139–49. https://doi.org/10.1016/j.jclepro.2018.07.236
16. Feng H, Wang X, Duan Y, Zhang J, Zhang X. Applying blockchain technology to improve agri-food traceability: A review of development methods, benefits and challenges. J Clean Prod. 2020 Jul;260:121031. https://doi.org/10.1016/j.jclepro.2020.121031
17. Klievink B, Romijn BJ, Cunningham S, de Bruijn H. Big data in the public sector: Uncertainties and readiness. Inf Syst Front. 2017 Apr 15;19(2):267–83. https://doi.org/10.1007/s10796-016-9686-2
18. Wahyudi A, Kuk G, Janssen M. A Process Pattern Model for Tackling and Improving Big Data Quality. Inf Syst Front. 2018 Jun 25;20(3):457–69. https://doi.org/10.1007/s10796-017-9822-7
19. Low C, Chen Y, Wu M. Understanding the determinants of cloud computing adoption. Ind Manag Data Syst. 2011 Aug 23;111(7):1006–23. https://doi.org/10.1108/02635571111161262
20. Mahrt M, Scharkow M. The Value of Big Data in Digital Media Research. J Broadcast Electron Media. 2013 Jan;57(1):20–33. https://doi.org/10.1080/08838151.2012.761700
21. Orciari M. Food company computer games increase junk food consumption. https://news.yale.edu/2012/01/09/food-company-computer-games-increase-junk-food-consumption. 2012.
22. Montgomery KC, Chester J, Grier SA, Dorfman L. The New Threat of Digital Marketing. Pediatr Clin North Am. 2012 Jun;59(3):659–75. https://doi.org/10.1016/j.pcl.2012.03.022
23. Lokers R, Knapen R, Janssen S, van Randen Y, Jansen J. Analysis of Big Data technologies for use in agro-environmental science. Environ Model Softw. 2016 Oct;84:494–504. https://doi.org/10.1016/j.envsoft.2016.07.017

24. Parris DL, Peachey JW. A Systematic Literature Review of Servant Leadership Theory in Organizational Contexts. J Bus Ethics. 2013 Mar 22;113(3):377–93.
25. Piper RJ. How to write a systematic literature review: a guide for medical students. Natl AMR [Internet]. 2013;1(2):1–8. Available from: http://cures.cardiff.ac.uk/files/2014/10/NSAMR-Systematic-Review.pdf%0Acures.cardiff.ac.uk/files/2014/.../NSAMR-Systematic-Review.pdf
26. OECD/FAO. Food Security and Nutrition. OECD; 2018. https://doi.org/10.1787/9789264183780-en
27. Gladek E, Roemers G, Muños OS, Kennedy E, Fraser M, Hirsh P. The Global Food Systems: An Analysis. https://www.metabolic.nl/publication/global-food-system-an-analysis/. 2017.
28. FAO. Food Outlook – Biannual Report on Global Food Markets. FAO; 2020. https://doi.org/10.4060/ca9509en
29. Vågsholm I, Arzoomand NS, Boqvist S. Food Security, Safety, and Sustainability—Getting the Trade-Offs Right. Front Sustain Food Syst. 2020 Feb 21;4. https://doi.org/10.3389/fsufs.2020.00016
30. Jin C, Bouzembrak Y, Zhou J, Liang Q, van den Bulk LM, Gavai A, et al. Big Data in food safety- A review. Curr Opin Food Sci. 2020 Dec;36:24–32. https://doi.org/10.1016/j.cofs.2020.11.006
31. White M. Digital workplaces: Vision and reality. Bus Inf Rev [Internet]. 2012;29(4):205–14. Available from: https://doi.org/10.1177/0266382112470412
32. Gantz J, Reinsel D. THE DIGITAL UNIVERSE IN 2020: Big Data, Bigger Digi tal Shadows, and Biggest Growth in the Far East. Vol. 2007, Idc. 2012.
33. Agarwal R, Weill P. The benefits of combining data with empathy. MIT Sloan Manag Rev. 2012;54(1):35–41.
34. Akter S, Wamba SF. Big data analytics in E-commerce: a systematic review and agenda for future research. Electron Mark. 2016 May 16;26(2):173–94. https://doi.org/10.1007/s12525-016-0219-0
35. Soon JM. Consumers' awareness and trust toward food safety news on social media in Malaysia. J Food Prot. 2020 Mar 1;83(3):452–9. https://doi.org/10.4315/0362-028X.JFP-19-415
36. Tranfield D, Denyer D, Smart P. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. Br J Manag. 2003 Sep;14(3):207–22. https://doi.org/10.1111/1467-8551.00375

37. Chadegani AA, Salehi H, Yunus MM, Farhadi H, Fooladi M, Farhadi M, et al. A Comparison between Two Main Academic Literature Collections: Web of Science and Scopus Databases. Asian Soc Sci. 2013 Apr 27;9(5). https://doi.org/10.5539/ass.v9n5p18
38. Mongeon P, Paul-Hus A. The journal coverage of Web of Science and Scopus: a comparative analysis. Scientometrics. 2016;106(1):213–28. https://doi.org/10.1007/s11192-015-1765-5
39. Ouhbi S, Idri A, Fernández-Alemán JL, Toval A. Predicting software product quality: A systematic mapping study. Comput y Sist. 2015 Oct 4;19(3):547–62. https://doi.org/10.13053/CyS-19-3-1960
40. Frelat R, Lopez-Ridaura S, Giller KE, Herrero M, Douxchamps S, Djurfeldt AA, et al. Drivers of household food availability in sub-Saharan Africa based on big data from small farms. Proc Natl Acad Sci. 2016 Jan 12;113(2):458–63. https://doi.org/10.1073/pnas.1518384112
41. Carolan M. Publicising Food: Big Data, Precision Agriculture, and Co-Experimental Techniques of Addition. Sociol Ruralis. 2017 Apr;57(2):135–54. https://doi.org/10.1111/soru.12120
42. Nelson G. Supporting Profitability with Climate-Smart Agriculture. 2015 Feb;(1459-2016–120532):28. Available from: http://ageconsearch.umn.edu/record/205019. https://doi.org/10.22004/ag.econ.205019
43. Wang J, Yue H. Food safety pre-warning system based on data mining for a sustainable food supply chain. Food Control. 2017 Mar;73:223–9. https://doi.org/10.1016/j.foodcont.2016.09.048
44. Zhao S, Yang X. Food safety risk assessment in whole food supply chain based on catastrophe model. Adv J Food Sci Technol. 2013 Dec 5;5(12):1557–60. https://doi.org/10.19026/ajfst.5.3384
45. Nelson RJ, Gubernick DJ, Blom JMC. Influence of photoperiod, green food, and water availability on reproduction in male California mice (Peromyscus californicus). Physiol Behav. 1995 Jun;57(6):1175–80. https://doi.org/10.1016/0031-9384(94)00380-N
46. Hong Y, Zhang M, Meeker WQ. Big data and reliability applications: The complexity dimension. J Qual Technol. 2018 Apr 3;50(2):135–49. https://doi.org/10.1080/00224065.2018.1438007
47. Kong F, He H, Raynor HA, Tan J. DietCam: Multi-view regular shape food recognition

with a camera phone. Pervasive Mob Comput. 2015 May;19:108–21. https://doi.org/10.1016/j.pmcj.2014.05.012

48. Halloran A, Clement J, Kornum N, Bucatariu C, Magid J. Addressing food waste reduction in Denmark. Food Policy. 2014 Dec;49(P1):294–301. https://doi.org/10.1016/j.foodpol.2014.09.005
49. Abul Basher S, Raboy D, Kaitibie S, Hossain I. Understanding Challenges to Food Security in Dry Arab Micro-States: Evidence from Qatari Micro-Data. J Agric Food Ind Organ. 2013 Jan 22;11(1). https://doi.org/10.1515/jafio-2012-0012
50. Dawson TP, Jackson ST, House JI, Prentice IC, Mace GM. Beyond Predictions: Biodiversity Conservation in a Changing Climate. Science (80-). 2011 Apr;332(6025):53–8. https://doi.org/10.1126/science.1200303
51. Eastwood C, Klerkx L, Nettle R. Dynamics and distribution of public and private research and extension roles for technological innovation and diffusion: Case studies of the implementation and adaptation of precision farming technologies. J Rural Stud. 2017 Jan;49:1–12. https://doi.org/10.1016/j.jrurstud.2016.11.008
52. Mayer-Schönberger V, Kenneth Cukier. Big Data for Development: Challenges & Opportunities. 2013.
53. Misra NN, Dixit Y, Al-Mallahi A, Bhullar MS, Upadhyay R, Martynenko A. IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry. IEEE Internet Things J. 2022 May 1;9(9):6305–24. https://doi.org/10.1109/JIOT.2020.2998584
54. Deni W, Deni W, Sasmita A. Analysis and Implementation Fuzzy Multi-Attribute Decision Making SAW Method for Selection of High Achieving Students in Faculty Level. Int J Comput Sci Issues. 2013 Jan;10(1):674–80.
55. Melia Y. Multi Attribute Decision Making Using Simple Additive Weighting and Weighted Product in Investment Introduction : Int Acad J Bus Manag. 2016;3(7):4–5.
56. Tao D, Yang P, Feng H. Utilization of text mining as a big data analysis tool for food science and nutrition. Compr Rev Food Sci Food Saf. 2020 Mar 16;19(2):875–94. https://doi.org/10.1111/1541-4337.12540
57. Iyamu T, Mgudlwa S. Transformation of healthcare big data through the lens of actor network theory. Int J Healthc Manag. 2018 Jul 3;11(3):182–92. https://doi.org/10.1080/20479700.2017.1397340
58. Callon M. Actor-Network Theory—The Market Test. Sociol Rev. 1999 May 9;47(1_suppl):181–95. https://doi.org/10.1111/j.1467-954x.1999.tb03488.x
59. de Camargo Fiorini P, Roman Pais Seles BM, Chiappetta Jabbour CJ, Barberio

Mariano E, de Sousa Jabbour ABL. Management theory and big data literature: From a review to a research agenda. Int J Inf Manage [Internet]. 2018;43:112–29. Available from: https://www.sciencedirect.com/science/article/pii/S026840121830553X

60. Barney JB. The Emergence of Resource-Based Theory: A Personal Journey. J Manage. 2021 Sep 24;47(7):1663–76. https://doi.org/10.1177/01492063211015272

61. Wernerfelt B. A resource-based view of the firm. Strateg Manag J. 1984 Apr;5(2):171–80. https://doi.org/10.1002/smj.4250050207

62. O'Connor C, Kelly S. Facilitating knowledge management through filtered big data: SME competitiveness in an agri-food sector. J Knowl Manag. 2017 Feb 13;21(1):156–79. https://doi.org/10.1108/JKM-08-2016-0357

63. Marvin HJP, Janssen EM, Bouzembrak Y, Hendriksen PJM, Staats M. Big data in food safety: An overview. Crit Rev Food Sci Nutr. 2017 Jul 24;57(11):2286–95. https://doi.org/10.1080/10408398.2016.1257481

64. Irani Z, Sharif AM, Lee H, Aktas E, Topaloğlu Z, van't Wout T, et al. Managing food security through food waste and loss: Small data to big data. Comput Oper Res. 2018 Oct;98:367–83. https://doi.org/10.1016/j.cor.2017.10.007

65. Chen K, Tan H, Gao J, Lu Y. Big Data Based Design of Food Safety Cloud Platform. Appl Mech Mater. 2014 Apr;536–537:583–7. https://doi.org/10.4028/www.scientific.net/AMM.536-537.583

66. Armbruster W, MacDonell M. Big Data for Big Problems-Climate Change, Water Availability, and Food Safety. In 2015. https://doi.org/10.2991/ict4s-env-15.2015.22

67. Alotaik O, Chellappa VS, Steadman S, Kumara S. Little Data, Big Data, and Food Insecurity: An Integrated Approach. In: IIE Annual Conference Proceedings. Institute of Industrial and Systems Engineers (IISE); 2017. p. 1490–5.

68. Sharma R, Parhi S. A review on use of big data in warehousing to enhance accessibility of food. In: Proceedings of the 2nd International Conference on Communication and Electronics Systems, ICCES 2017. IEEE; 2018. p. 663–7. https://doi.org/10.1109/CESYS.2017.8321162

69. Carolan M. Big data and food retail: Nudging out citizens by creating dependent consumers. Geoforum. 2018 Mar;90:142–50. https://doi.org/10.1016/j.geoforum.2018.02.006

70. Liu G, Li G, Yang R, Guo L. Improving Food safety in Supply Chain based on Big Data. E3S Web Conf. 2018 Sep 14;53:03084. https://doi.org/10.1051/e3sconf/20185303084

71. Mihuandayani, Ramandita HD, Setyanto A, Sumafta IB. Food trend based on social media for big data analysis using K-mean clustering and SAW: A case study on yogyakarta culinary industry. In: 2018 International Conference on Information and Communications Technology, ICOIACT 2018. IEEE; 2018. p. 549–54. https://doi.org/10.1109/ICOIACT.2018.8350805
72. YANG J-L, HOU H-P, ZHANG J, XU N, QIN B-W. Cold-Chain Logistics Big Data Problems Based on Food Safety Research. DEStech Trans Soc Sci Educ Hum Sci. 2018 Mar 2;(icssd). https://doi.org/10.12783/dtssehs/icssd2017/19225
73. Freidberg S. Big Food and Little Data: The Slow Harvest of Corporate Food Supply Chain Sustainability Initiatives. Ann Am Assoc Geogr. 2017 Nov 2;107(6):1389–406. https://doi.org/10.1080/24694452.2017.1309967
74. Montgomery K, Chester J, Nixon L, Levy L, Dorfman L. Big Data and the transformation of food and beverage marketing: undermining efforts to reduce obesity? Crit Public Health. 2019 Jan 26;29(1):110–7. https://doi.org/10.1080/09581596.2017.1392483
75. Navickas V, Gružauskas V. Big Data Concept in the Food Supply Chain: Small Markets Case. Sci Ann Econ Bus. 2016;63(1):15–28. https://doi.org/10.1515/saeb-2016-0102
76. Su S, Li Z, Xu M, Cai Z, Weng M. A geo-big data approach to intra-urban food deserts: Transit-varying accessibility, social inequalities, and implications for urban planning. Habitat Int. 2017 Jun;64:22–40. https://doi.org/10.1016/j.habitatint.2017.04.007
77. Wang Y, Yang B, Luo Y, He J, Tan H. The Application of Big data Mining in Risk Warning for Food Safety. Asian Agric Res [Internet]. 2015;7(8):83–6. Available from: http://ageconsearch.umn.edu/record/210801
78. Kim S-J, Eun H-J, Kim Y-S. Food Recommendation System Using Big Data Based on Scoring Taste Adjectives. Int J u- e- Serv Sci Technol. 2016 Jan 31;9(1):39–52. https://doi.org/10.14257/ijunesst.2016.9.1.05
79. Dubé L, Du P, McRae C, Sharma N, Jayaraman S, Nie J-Y. Convergent Innovation in Food through Big Data and Artificial Intelligence for Societal-Scale Inclusive Growth. Technol Innov Manag Rev [Internet]. 2018 Sep;8:49–65. Available from: http://timreview.ca/article/1139
80. Lusk JL. Consumer research with big data: Applications from the food demand survey (foods). Am J Agric Econ. 2017 Mar 2;99(2):303–20. https://doi.org/10.1093/ajae/aaw110
81. Dubé L, Labban A, Moubarac J-C, Heslop G, Ma Y, Paquet C. A nutrition/health

mindset on commercial Big Data and drivers of food demand in modern and traditional systems. Ann N Y Acad Sci. 2014 Dec;1331(1):278–95. https://doi.org/10.1111/nyas.12595

82. Mary Clare A, Young R. Big Data's Potential to Improve Food Supply Chain Environmental Sustainability and Food Safety. Int Food Agribus Manag Rev. 2016;19(A):155–71.

83. Evans B. Using Big Data to Achieve Food Security. In: Big Data Challenges. London: Palgrave Macmillan UK; 2016. p. 127–35. https://doi.org/10.1057/978-1-349-94885-7_11

84. Chitlapilly Dass S, Anandappa A. Food Factory Genomics: Where Big Data Drives Quality and Food Safety. Food Prot Trends. 2017 Sep;37(5):368–74.

85. Li S, Tan F, Liu J, Cheng S, Liu H, Keith W, et al. An Outline of Big Data Emerging from Food Supply Chain and Potential Value in Food Management. In: Proceedings of the 2016 International Conference on Computer Science and Electronic Technology. Paris, France: Atlantis Press; 2016. https://doi.org/10.2991/cset-16.2016.53

86. Ma Y, Hou Y, Liu Y, Xue Y. Research of food safety risk assessment methods based on big data. In: Proceedings of 2016 IEEE International Conference on Big Data Analysis, ICBDA 2016. IEEE; 2016. p. 1–5. https://doi.org/10.1109/ICBDA.2016.7509812

87. Ji G, Tan K. A big data decision-making mechanism for food supply chain. MATEC Web Conf. 2017 Mar 8;100:02048. https://doi.org/10.1051/matecconf/201710002048

88. Danezis GP, Tsagkaris AS, Brusic V, Georgiou CA. Food authentication: state of the art and prospects. Curr Opin Food Sci. 2016 Aug;10:22–31. https://doi.org/10.1016/j.cofs.2016.07.003

89. Li J, Yang Q, Zou X. Big data and higher vocational and technical education: Green food and its industry orientation. In: ACM International Conference Proceeding Series. New York, New York, USA: ACM Press; 2019. p. 118–23. https://doi.org/10.1145/3322134.3322150

90. Bronson K. Digitization and Big Data in Food Security and Sustainability. In: Encyclopedia of Food Security and Sustainability. Elsevier; 2019. p. 582–7. https://doi.org/10.1016/B978-0-08-100596-5.22462-1

91. Xu X, Hou L, Guo Z, Wang J, Li J. Developing a Chinese food nutrient data analysis system for precise dietary intake management. In: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 2018. p. 360–6. https://doi.org/10.1007/978-3-319-94301-5_30

92. Protopop I, Shanoyan A. Big Data and Smallholder Farmers: Big Data Applications in the Agri-Food Supply Chain in Developing Countries. Int Food Agribus Manag Rev [Internet]. 2016 Jun;19(1030-2016–83148):173–90. Available from: http://ageconsearch.umn.edu/record/240705. https://doi.org/10.22004/ag.econ.240705
93. Gastaldi M. Integration of mobile, big data, sensors, and social media: Impact on daily life and business. In: 2014 IST-Africa Conference and Exhibition, IST-Africa 2014. IEEE; 2014. p. 1–10. https://doi.org/10.1109/ISTAFRICA.2014.6880670
94. Lukyamuzi A, Ngubiri J, Okori W. Towards Harnessing Phone Messages and Telephone Conversations for Prediction of Food Crisis. Int J Syst Dyn Appl. 2015 Oct 1;4(4):1–16. https://doi.org/10.4018/ijsda.2015100101
95. Ingram J, Maye D. What Are the Implications of Digitalisation for Agricultural Knowledge? Front Sustain Food Syst. 2020 May 21;4. https://doi.org/10.3389/fsufs.2020.00066
96. Serazetdinova L, Garratt J, Baylis A, Stergiadis S, Collison M, Davis S. How should we turn data into decisions in AgriFood? J Sci Food Agric. 2019 May 7;99(7):3213–9. https://doi.org/10.1002/jsfa.9545
97. Hentzen JK, Hoffmann A, Dolan R, Pala E. Artificial intelligence in customer-facing financial services: a systematic literature review and agenda for future research. Int J Bank Mark. 2021 Sep 1;40(6):1299–336. https://doi.org/10.1108/IJBM-09-2021-0417
98. Mehrabian A, Russell JA. The Basic Emotional Impact of Environments. Percept Mot Skills. 1974 Feb;38(1):283–301. https://doi.org/10.2466/pms.1974.38.1.283
99. Larson PD, Foropon C. Process improvement in humanitarian operations: An organisational theory perspective. Int J Prod Res. 2018 Nov 2;56(21):6828–41. https://doi.org/10.1080/00207543.2018.1424374
100. Wade M, Hulland J. Review: The resource-based view and information systems research: Review, extension, and suggestions for future research. MIS Q Manag Inf Syst. 2004;28(1):107–42. https://doi.org/10.2307/25148626
101. Barney JB. Strategic Factor Markets: Expectations, Luck, and Business Strategy. Manage Sci. 1986 Oct;32(10):1231–41. https://doi.org/10.1287/mnsc.32.10.1231