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Factors affecting the adoption of drones in the food supply chain

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The fourth industrial revolution's digital transformation has profoundly altered how we view the food supply chain. The technological advancements associated with the fourth industrial revolution (4IR) have witnessed an upsurge in emerging technologies adoption such as drones in the food supply chain. However, research on the factors affecting the adoption of drones in the food supply chain is limited. This study therefore addresses the research gap. The study's main objective is to explore factors affecting the adoption of drones in the food supply chain. The study conducted a systematic literature review of peer-reviewed articles. This quantitative study adopted the Technology-Organizational-Environmental (TOE) framework as the theoretical lens to explore the factors influencing drone adoption. The study indicates that technological factors (cost, relative advantage, and perceived usefulness), organizational factors (strategic objectives), and environmental factors (market structure) affect the adoption of drones in the food supply chain. Despite the study's limitations, such as secondary data rather than empirical data, the study contributes to the body of knowledge on the factors influencing the adoption of drones in the food supply chain.

KEYWORDS

drones, food supply chain, food delivery service, food systems, TOE framework

1 Introduction

The Fourth Industrial Revolution produces a world in which physical and virtual production systems collaborate flexibly on a global scale (Schwab, 2017). The technological advancement associated with Industry 4.0 has disrupted several industries (Özdemir and Hekim, 2018). We now live in a new era characterized by fast change and the fast evolution of digital transformation, which affects every area of organizations. Using a variety of information, communication, computing, and networking technologies, digital transformation is a process that tries to enhance an entity by causing major changes to its characteristics (Vial, 2019). In the digital era, when products and services must be supplied both online and offline, the desire to employ new technology to gain and sustain a competitive edge is frequently linked to the concept of digital transformation (Mergel et al., 2019). Agriculture 4.0 encompasses a variety of already-in-use or in-development technologies such as robotics, artificial intelligence, machine learning, and blockchain, all of which have the potential to have far-reaching implications for future agriculture and food systems (Klerkx and Rose, 2020).

In the past decade, the attention focused on the food system (FS) discourse has increased and has moved to a more holistic view of food systems (Stefanovic et al., 2020). The 2030 Agenda of the United Nations sees food and agriculture as the pivotal players in achieving the 17 Sustainable Development Goals (FAO, 2020). The food system is the term used to refer to the interactions between and within bio-geophysical and human environments that determine a set of activities (Ericksen, 2008). Food systems go hand in hand with the term "farm to fork." The Farm to Fork concept claims that innovation and research are essential components in accelerating the transition to food systems that are sustainable, wholesome, and inclusive from primary production to consumption (Riccaboni et al., 2021).

The world has been adapting to many innovative technologies. During the COVID-19 pandemic, there was a significant increase in drone adoption in the food supply chain and logistical services to comply with social distancing (World Health Organization, 2020). Drones are unmanned aerial vehicles that fly autonomously in both natural and man-made environments (Floreano and Wood, 2015). The food supply chain and logistical services are expected to be significantly impacted by drones (Jasim et al., 2022). During COVID-19, the food supply networks needed to respond quickly to disruptions on the supply side brought on by labor shortages, panic buying, and changing food consumption patterns on the demand side of the food supply chain (Hobbs, 2020).

However, there is a lack of acceptance of drone technology in the food supply chain, particularly the usage of drones in the food system. As digital technology advances, conventional ways of transportation are gradually becoming obsolete. To examine the new revolutionary technology that will aid in the process, from farm to fork, a deeper comprehension of the adoption of drone usage for the food supply chain is required. The study conducted a systematic literature review of existing literature on factors that affect the adoption of drone usage in the food supply chain. The study's main objective was to explore factors that affect the adoption of drones in the food supply chain.

1.1 Overview of the food supply chain

We are on an unfavorable trajectory, as the world population is expected to increase by five billion people by the end of the century (UN Population Division, 2018), leading to a greater demand for food. We currently experiencing food security concerns that threaten humanity in the twenty-first century, and the public is looking for big food system opportunities. These high-quality scientific findings must be turned into policy and action as quickly as possible (Fanzo et al., 2020a). Combating global food insecurity and malnutrition requires a more holistic approach to food system thinking and planning (Fanzo et al., 2020a). With limited resources, food systems will have to feed a growing and changing population while also dealing with environmental degradation, climate change, and loss of biodiversity (Willett et al., 2019). Climate-related natural disasters, market distortions, and politics are all wreaking havoc on food systems (Barrett, 2020). As every part of the food system, contributes to climate change, the core truths about how food systems operate should adapt as a result of climate change (Hoegh-Guldberg et al., 2018). When land-use changes are taken into account, food systems account for 21–34 percent of world emissions (Fanzo et al., 2020a).

While COVID-19 has exposed vulnerabilities, it hastens technological transformation toward a sustainable global economy through bold policies (Franco et al., 2020). Favorably changing the food systems ensures that the food we produce is available to everyone and that the food system continues to be a vehicle for poverty reduction and improved food security for all (Fanzo et al., 2020a). The various components of the food system include the food supply chain, food environments, individual factors, consumer behavior, and external drivers. The food system encompasses all the people and activities involved in growing, transporting, supplying, and consuming food (Fanzo et al., 2020b). This study specifically focuses on the food supply chain of the food system. Kasza et al. (2019) referred supply chain as a network of organizations connected by backward and forward integration, typically in the several stages of the production process and delivery operations that ensure a product or service reaches the consumer.

Industries are digitizing the supply chain because of the creation of new digital systems and technology within Industry 4.0 and 5.0. Using IT-enabled procedures, connection, integration of systems, and web-enabled features, the definition of a digital supply chain is the development of information systems and the use of innovative technology to improve the supply chain's agility and integration while also improving customer service and organization's long-term survival (Ageron et al., 2020). According to Havenga (2018), logistics is a crucial step in the supply chain process that prepares, executes, and successfully regulates the movement and storage of commodities. Additionally, logistics is made up of a variety of tasks and procedures, such as fleet management, inventory management, and transportation (Havenga, 2018). Organizations from all around the world are beginning to realize the importance of logistics for the agri-food sector.

1.2 Overview of drone technology

Drones are compared to automated planes and are often referred to as Unmanned Aerial Vehicles (UAVs), Remote Piloted Aircraft Systems (RPAS), Unpiloted Aircraft Systems (UAS), Quadcopters, etc. (Adepoju, 2022). Drone technology has received much interest, and like smartphones, it is anticipated that drones will become a regular part of our lives (Jasim et al., 2022). Drones have been used historically for a while. Drones, however, were mostly developed and explored in the past for military uses (Adepoju, 2022). Drone technology consists of a flying robot that may be operated remotely using flight software and Global Positioning Systems (Adepoju, 2022). The word "drone" is often used to describe autonomously controlled aircraft, those as submarines or ground-based autonomous vehicles (Yaacoub et al., 2020). A drone is a flying device that may either be piloted remotely or automatically through software to collect data. According to the type of drone, there are several categories of drones. The many drone varieties include multirotor, single-rotor, and fixed-wing aircraft (Wang et al., 2016). These technologies are designed with sophisticated stabilization mechanisms, sensors, and flying cameras that can carry out certain tasks and capture high-definition video (Adepoju, 2022).

The Internet of Drones (IoD) is a new era, where a fleet of drones is deployed and harvests the needed data under the supervision of a ground station server (GSS) over a wireless channel (Martos et al., 2021). Drones have drawn a lot of interest in improving the value of operations (Yurek and Ozmutlu, 2018). Drone technology is used in various sectors, including the medical, environmental, and service industries. Drones are easy to use and update often to reflect the newest technological advancements. Drones are utilized for various purposes, including agriculture, photography, disaster relief efforts, military surveillance activities, and industrial monitoring. The drone's technological capabilities have advanced so swiftly that they are now a viable choice not only for delivery operations but also for passenger usage and transportation (Rejeb et al., 2021).

1.3 Drone adoption in the food supply chain

Companies must use innovative technology for effective and smooth business operations to compete in the globalized business world (Ramadan et al., 2017). Drone technology has digitally transformed the food industry and gained much usage in the food supply chain. Drone technologies have become crucial in the food system process because of the digitization of the agricultural industry, often known as agriculture 5.0. Businesses can use drones as cutting-edge tools to boost the responsiveness and effectiveness of their logistics (Sah et al., 2021). Due to their ability to fly, speed, and autonomy, drones have previously been investigated for their possibilities as delivery vehicles for logistics and humanitarian aid distribution (Shavarani, 2019). Drones can improve environmental sustainability and reducing delivery times since they are fueled by electricity (Hwang et al., 2019).

The industry needs to think more widely about food logistics and take the idea of the food supply chain into consideration. The supply chain is unquestionably responsive to the supply chain's complexity and comprises a sizable number of producers, suppliers, and customers. Stakeholders can now obtain and analyze data previously inaccessible at any stage of the food supply chain through drone technology usage. The outcome serves as the basis for new process development and improvement in the food supply chain. In the supply chain, logistics is the planning, execution, and management of the safe, effective movement and storage of goods, services, and information to satisfy customer demands (Croom et al., 2018). Drones' high mobility may considerably optimize various logistical activities while lowering supply chain costs. Flexible logistics systems are required because modern logistics and supply chains have become more dynamic, complicated, and technology-driven. These systems must be able to adapt to customer requirements more quickly and effectively. In a world that is getting more complex, the added complexity of introducing drones is less frightening than it would have been 10, or even five, years ago.

There is a significant, unexplored global market for on-demand food delivery services as technology improves people's quality of life (Liu, 2019). Congested or isolated places will benefit from drone logistics in the supply chain since they offer a greater level of service and accessibility in less time than conventional delivery methods (Kim et al., 2021). The period of food delivery is the key benefit of using drones in the food supply chain and logistics as a food delivery system; due to the perishable nature of the items and the need for on-time delivery, drones are ideal for this application (Doole et al., 2018). The regulations and permissions for drones are one of the barriers to drone logistics (Kuschke and Cassim, 2019). Drones are a brand-new, cutting-edge technology that is ever-evolving and responding to users' demands. Using drones has been shown to lower carbon emissions, increase efficiency, decrease labor costs, save lives, and expedite delivery (Ayamga et al., 2021).

1.4 Related studies

Several studies have explored drone usage in the supply chain using various approaches. For instance, an exploratory case study by Sermuksnyte-Alesiuniene et al. (2021) analyzed how digital technology can enhance food supply chain operations. Singh et al. (2021) used a simulation model to highlight the importance of a robust supply chain during pandemics and the potential disruptions to the food supply chain. Waris et al. (2022) applied an extended technology acceptance model (TAM) to investigate customer use of drone technology for food delivery services. Rejeb et al. (2021) conducted a systematic literature review to examine the potential benefits and challenges of drones in supply chain management and logistics but did not specifically address drone adoption in the food supply chain. A review of existing studies reveals that none have utilized the TOE framework to explore drone adoption in the food supply chain and logistics. Therefore, this study addresses this gap by applying the TOE framework to explore factors affecting drone adoption in the supply chain.

1.5 Theoretical framework

The study adopted the Technological-organizational-environmental (TOE) framework developed by Tornatzky and Fleisher (1990). The TOE framework is the most suitable theoretical framework to explore different factors affecting the adoption in various contexts (Baker, 2012). The TOE framework offers an effective analytical tool for examining both possibilities and challenges linked to the adoption, adaptation, and incorporation of technical breakthroughs into a business strategy of an organization (Oliveira and Martins, 2011). From an organization perspective, the TOE framework outlines three areas of consideration in organizations that impact the adoption of the decision-making process at the application level (Tornatzky and Fleischer, 1990). The three elements that offer a complete view of drone adoption in the food supply chain are technological, organizational, and environmental.

1.5.1 Technological

Firstly, the technological element consists of all the firms' relevant technologies, internal and external, these technologies are those that have already been used at the firm and those available to the firm via the marketplace (Baker, 2012). Through 4th industrial revolution principles, firms' internal operations, communication channels, components of the product, and any other crucial supply chain component and logistics activities are experiencing faster digitization. The TOE framework's technology category has several subcategories, including compatibility, complexity, relative advantage, security concerns, costs, technological competency, and technological resources which play a pivot role in the adoption process (Oliveira and Martins, 2011).

1.5.2 Organizational

Secondly, the organizational element describes the resources and characteristics of the organization such as the links between workers, internal communication channels, the number of slack resources, and the business size (Baker, 2012). The organizational factor considers all enterprise characteristics and consists of subcategories such as infrastructure, top management support, organizational readiness, firm size, financial commitment, and employee information systems knowledge, which are all significant influences on a technology adoption culture that may influence the adoption of technological innovations (Baker, 2012).

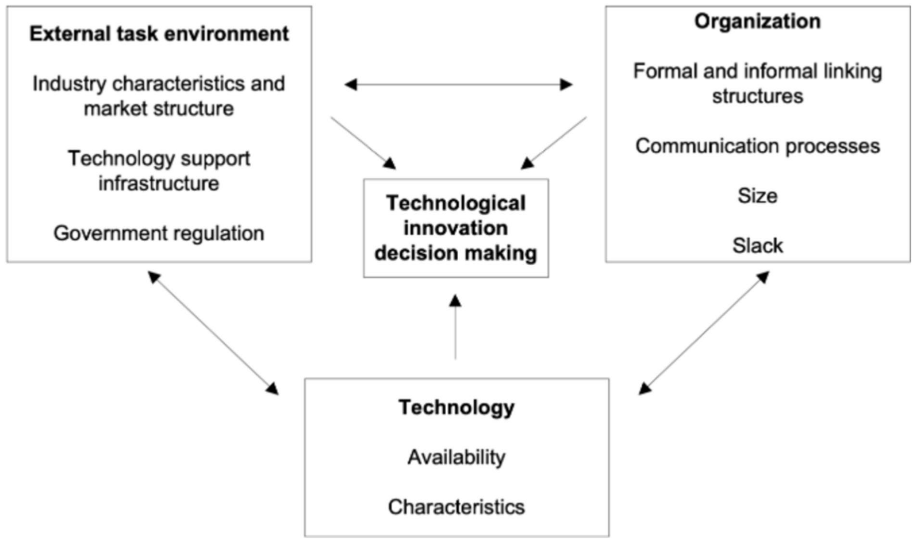

FIGURE 1
Technology-Organizational-Environmental (TOE) framework (source: Tornatzky and Fleischer, 1990).

1.5.3 Environmental

Lastly, the industrial structure, the existence or lack of technical service providers, and the regulatory environment make up the environmental component (Baker, 2012). The environmental context focuses on all external elements that might affect innovation inside a company, such as governmental regulations, competition, external stakeholders, and the availability of external resources (Baker, 2012) (Figure 1).

2 Methodology

The research design process involves deciding which aspects will be observed, by whom, and for what purpose (Babbie, 2016a). The study adopted a systematic literature review (SLR) combined with quantitative content analysis to address the research question and objectives. Fink (2014, p. 3) defines a systematic literature review as an explicit, rigorous, and repeatable process for identifying, analyzing, and summarizing the body of completed and recorded work done by researchers, academics, and practitioners. Systematic literature reviews are a preferred review approach for summarizing the current body of knowledge in an area (Kraus et al., 2020). The following phases are involved in the completion of an SLR: formulating review questions; identifying relevant work; assessing the quality of research; summarizing the evidence; and interpreting the findings (Khan et al., 2003). According to Mouton (2001, p. 179), a systematic literature review has a non-empirical design categorization that uses secondary data, and the key research question consists of descriptive, theoretical, and conceptual questions. The study's research question is descriptive, which aligns with the research objective.

The purpose of content analysis, a family of research methodologies, is to extract systematic, reliable, accurate, and repeatable conclusions from texts and other forms of communication (Drisko and Maschi, 2015). Content analysis is a fairly transparent research tool; the coding scheme and sample procedures may be explicitly laid forth (Bryman, 2012). The research design was chosen because a systematic approach is essential for thorough content analysis, as it ensures clarity for readers and allows for replication by other researchers (Drisko and Maschi, 2015). In addition to providing the researcher with theoretical insight, the content analysis provides an objective, text-driven appraisal of the literature (Cheng et al., 2018). It is a very adaptable approach that may be used for a wide range of unstructured textual data types (Bryman, 2012). Designing a research topic, establishing hypotheses, developing a coding system, collecting data, statistical analysis, presenting findings, and concluding are all processes in quantitative content analysis.

2.1 Unit/s of analysis

The what or the who being researched is the unit of analysis (Babbie, 2016b). For this research study, organization was the unit of analysis. The organizations' features include their size, composition, place, and collective descriptions of their members (Babbie and Mouton, 2001). The UOA comprises organizations that utilize drones in the food supply chain. The study explores drone adoption in the food supply chain. Its main objective was to explore factors that affect drone adoption in the food supply chain.

2.2 Instrument development

The study used a literature matrix as our research instrument. Content analysis is a technique for mapping symbolic data into a data matrix suitable for statistical analysis (Roberts, 2015). The literature matrix will be used to find and analyze useful literature and group it under its subcategories. Using search terms like "Drones," "food supply chain," "logistics," "food delivery services," "food systems," and "TOE framework," the literature was searched to find all publications pertinent to the research issue. To prepare the content for categorization, which was adopted from the technology, environmental, and organizational (TOE) framework factors as shown in Table 1, all articles published from 2019 to 2022 were selected resulting in 50 articles. These articles were then manually coded in an Excel spreadsheet using word frequency analysis to find patterns in the qualitative data. This establishes the basis for converting qualitative data into quantitative data, which may then be subjected to additional data and statistical analysis using an SPSS statistics software tool to generate frequencies, analysis of variance (ANOVA), and correlations of TOE factors as provided in Table 1.

2.3 Data sources, sampling strategies, and techniques

The study used secondary data which is data that has previously been collected for another purpose (Sharma, 2018). The data was collected electronically from electronic databases such as Ebscohost, Google Scholar, Mendeley, Scopus, and ScienceDirect Journals. These databases which contain published articles relevant to the study were accessible through the university account. A portion of the target population is known as the research population, from which the sample is drawn (Hu, 2014). The research population included published articles on drone adoption in the food supply chain. The research sample was 50 peer-reviewed articles published from 2019 to 2022. The journal articles were selected based on the keywords. A convenience (opportunity) sampling approach was used as a non-probability strategy to collect the relevant information. Convenience sampling is used in research to identify target research objects that satisfy certain practical requirements, such as ease of access, geographic closeness, availability at a specific time, or a willingness to contribute (Dörnyei, 2007). The convenience sampling approach was selected for the study because it involved sourcing and choosing articles published from 2019 to 2022, focusing on the factors affecting the adoption of drones in the food supply chain. The study targeted organizations that used drones in the food supply chain.

2.4 Research methods

The systematic literature review (SLR) approach of content analysis was used to answer the research question and achieve the study's objective. The systematic literature review (SLR) approach is versatile to adopt quantitative and qualitative research methods. The data collection method was qualitative, using convenience sampling to acquire and analyze data by inputting keywords related to the research topic into the search engines of specific scientific databases. Content analysis was employed to identify the presence of keywords within a set of qualitative data. This method allows researchers to quantify and assess the presence, meanings, and relationships within the data. According to Siddaway et al. (2019), a systematic review involves using structured and explicit procedures to identify, select, and evaluate relevant research on a specific issue, as well as to collect and analyze data from the included studies. As per Siddaway et al. (2019), the SLR process consists of five steps: scoping, planning, identification, screening, and eligibility. The SLR content analysis approach was suited for the study since the study was a non-empirical study that utilizes secondary data to answer the research question using published articles. Statistical methods were used to analyze and summarize the results of the included studies.

TABLE 1 TOE factors that influence drone adoption.

Technology factors	Organizational factors	Environmental factors
Complexity	Organizational readiness	Government pressure
Compatibility	Resource capacity	Competition
Cost	Firm size	Policy/Regulation
Perceived usefulness	Technical skills	Market structure
Relative advantage	Management support	Vendors capabilities
Security	Strategic objectives	Maintenance and support

2.5 Data analysis

Data analysis is the process of obtaining solutions to problems by analysis of data. The main analytic processes are to find problems, assess the availability of acceptable data, decide on appropriate methodologies for addressing the topics of interest, implement the techniques, and finally analyze, summarize, and present the results (Sharma, 2018). The data from selected 50 published articles were manually coded and then analyzed using quantitative content analysis. According to Mouton (2001, pp. 165–166), content analysis is a study that analyses the content of a text or document. The study needs to be qualitative and make use of secondary data, and the key research question needs to be exploratory or descriptive (Mouton, 2001).

The study used the literature matrix method to categorize data collected from published articles. The qualitative data was organized based on the technological, organizational, and environmental framework constructs variables that affect drone adoption in the food supply chain. Reliability refers to the extent to which a measure of a concept is stable and consistent (Bell et al., 2022). Inter-coder reliability a numerical measure of agreement among multiple coders on coding the same data was used for the manual coded data (O'Connor and Joffe, 2020). Cronbach's alpha was employed to assess the reliability of the TOE factors. Therefore, the qualitative data used in the study was transformed into codes for the quantitative data analysis. The quantitative data was analyzed using statistical analysis software, SPSS, to obtain statistical results.

3 Results and discussion

This section presents the study results on factors that affect the adoption of drones in the food supply chain analyzed data from the 50 articles published between 2019 and 2022. This section is subdivided into the following sub-sections: Section 3.1 presents the demographic frequencies; Section 3.2 presents the frequency of Technological, Organizational, and Environmental factors that influence drone adoption in the food supply chain from the selected 50 articles. Lastly, section 3.3, presents the analysis of variance (ANOVA) and correlation results.

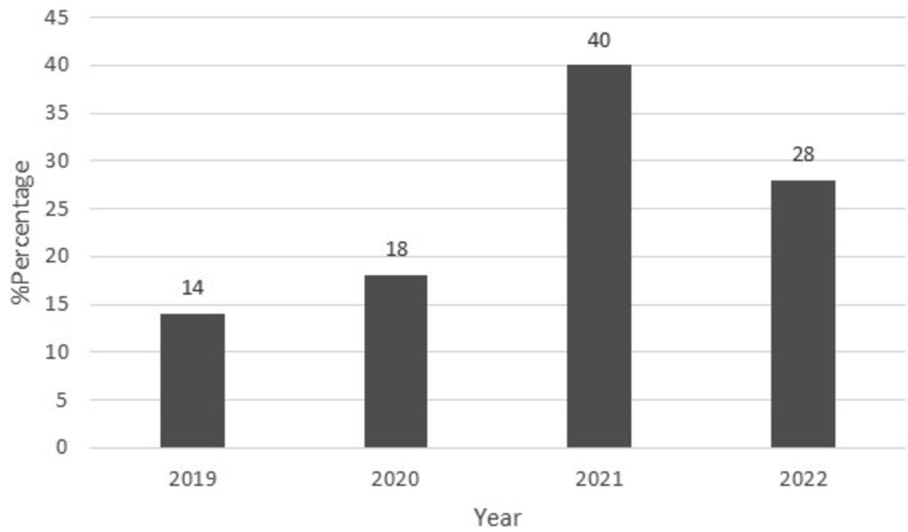

FIGURE 2
Articles by year.

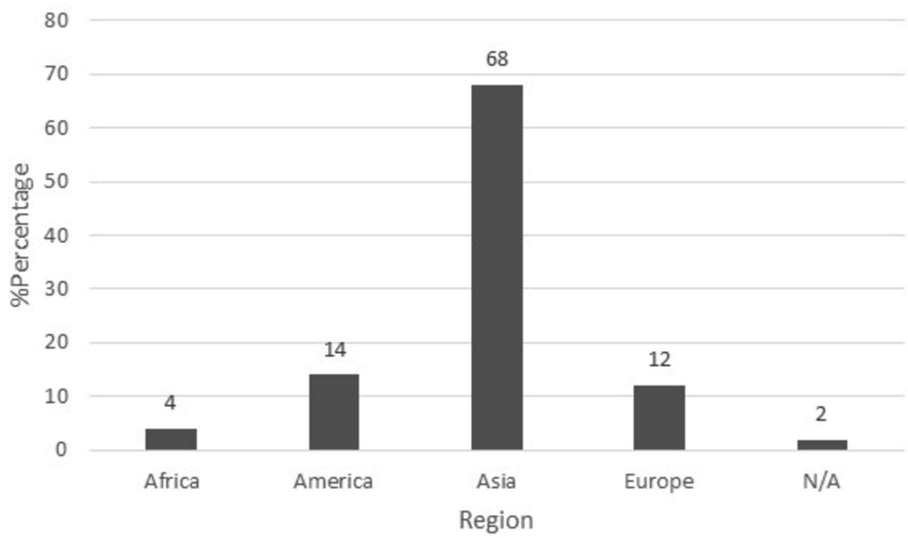

FIGURE 3
Articles by region.

3.1 Demographic data

3.1.1 Articles published by year

The frequency of articles based on factors affecting drone adoption in the food supply chain published between 2019 and 2022 is presented in Figure 2. According to the results, 14% of the articles were published in 2019 and 18% in 2020. The year 2021 had the highest number of published articles (40%) and the year 2022 had 28% of the published articles. It is important to note that the study was conducted in 2022 and the published articles for 2022 were not complete. The study results suggest an increase in published articles on factors affecting drone adoption in the food supply chain published between 2019 and 2022. The results indicate a rise in published articles in the year 2021 at 40%. The lowest recorded research output happened in 2019 at 14%.

3.1.2 Articles published by region

The frequency of publications based on factors influencing drone adoption in the food supply chain published between 2019 and 2022 is depicted by region in Figure 3. The regional trends are important to identify which regions are more actively researching or implementing drone technology in the food supply chain. According to the results, Asia had the highest reported percentage of papers published (68%), followed by America (14%), and Europe (12%). Furthermore, Africa, had 4%, followed by articles with mentioned regions at 2%, the fewest articles published. The frequency shows that the Asia region had more than half of all published research from 2019 and 2022 on the variables that affect drone adoption in the food supply chain.

3.1.3 Articles published by research method

The frequency of research methods used in published articles on factors that affect drone adoption in the food supply chain published from 2019 and 2022 is presented in Figure 4. The results show that 62% of publications used the quantitative research method, followed by 22% for the qualitative research method and 16% for the mixed-method research method, which was the lowest frequency. The quantitative research method was the most popular in published articles on factors that affect drone adoption in the food supply chain published from 2019 and 2022.

3.1.4 Articles published by research design

Figure 5 illustrates the frequency of research designs used in publications on the factors affecting drone adoption in the food supply chain between 2019 and 2022. The statistics reveal that, among publications from 2019 to 2022, surveys were the most commonly used method at 58%, followed by systematic literature reviews at 26%, and case studies at 10%. Additionally, the findings imply that conducting experiments was the least popular sort of study, as only 6% of publications published from 2019 and 2022, on factors affecting drone adoption in the food supply chain, employed this approach.

3.1.5 Articles published by the framework

The frequency of research frameworks used in publications based on variables influencing drone adoption in the food supply chain published over the period 2019 and 2022 is shown in Figure 6. The

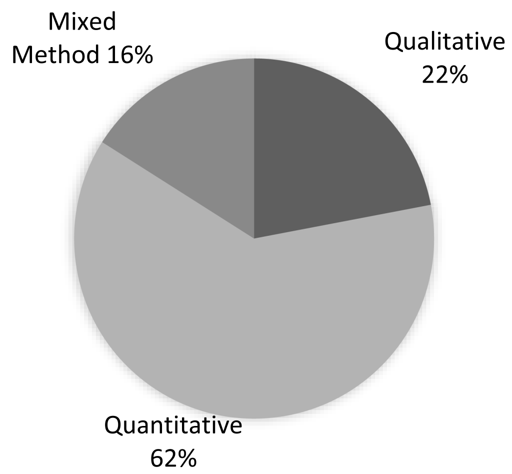

FIGURE 4
Articles by research method.

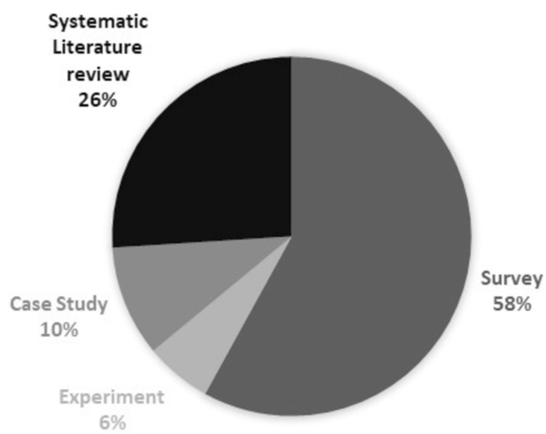

FIGURE 5
Articles by research design.

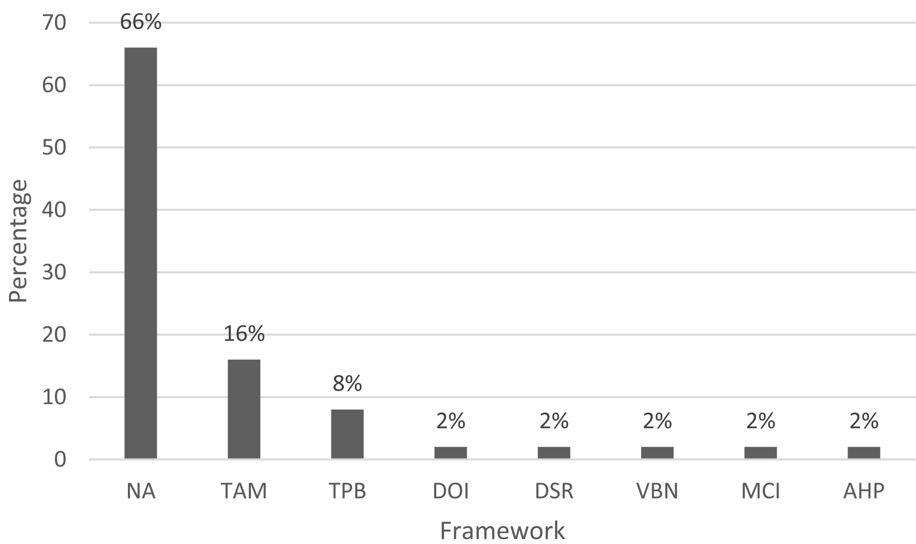

FIGURE 6
Articles by framework.

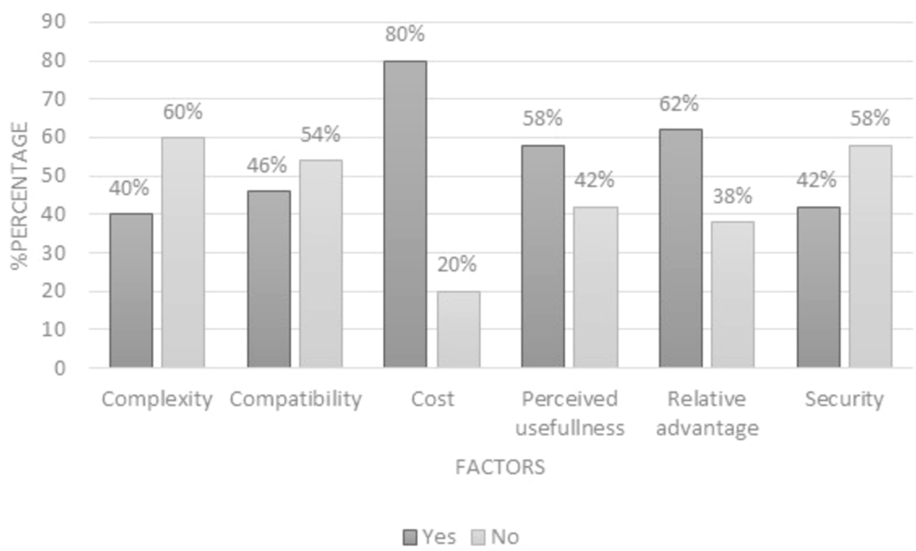

FIGURE 7
Frequency of technology factors.

diffusion of innovation theory (DOI), motivated consumer innovativeness (MCI), the theory of planned behavior (TPB), value belief norm theory (VBN), design science research framework (DSR), analytic hierarchy process (AHP), and the technology acceptance model (TAM) are among the frameworks. NA denotes articles that did not utilize a framework or that instead proposed their framework. The findings show that most articles at 66% either did not utilize a framework or suggested a new framework (NA). Additionally, the findings imply that TAM was the second most popular research framework at 16%, after TPB at 8%. Additionally, the findings imply that the DOI, DSR, VBN, MCI, and AHP frameworks, at 2% each, were the least often used frameworks in studies based on variables affecting drone adoption in the food supply chain published from 2019 and 2022.

3.2 Factors affecting the adoption of drone usage in the food supply chain

This section demonstrates how technological, organizational, and environmental aspects influence the use of drones in the food supply chain.

3.2.1 Technological factors

This study examined six technological variables that affect drone adoption in the food supply chain. These variables were complexity, compatibility, cost, perceived usefulness, relative advantage, and security. The findings are shown in Figure 7. The findings show that cost, which was mentioned in 80% of the 50 articles, was thought to be the most crucial technological aspect influencing drone adoption in the food supply chain. This was followed by relative advantage at 62% and perceived usefulness at 58%. This finding implies that organizations should utilize drone technology while maintaining financial stability and relative advantage. Waris et al. (2022) support the findings by highlighting that drone technology is a breakthrough that enhances company efficiency and reduces costs. The drone adoption costs include both the acquisition of the equipment and the ongoing maintenance of logistics and supply chain integration. Additionally, compatibility was mentioned in 46% of the articles as an influencing factor, with security coming in at 42%. Even though it was referenced in 40% of the articles, complexity was the least addressed characteristic. As a result of these findings, organizations should view complexity as the least important aspect when considering whether to use drone technology in the food supply chain.

3.2.2 Organizational factors

The study examined six organizational variables that affect drones used in the food supply chain. These variables were organizational readiness, resource capacity, firm size, technical skills, management support, and strategic objectives. The evaluation of the organizational characteristics was done using 50 articles that were published between 2019 and 2022, and the findings are shown in Figure 8. The findings show that 50% of articles spoke about strategic objectives as an influencing element, followed by 34% of articles about resource capacity, and 30% of articles for firm size. These findings suggest that organizations considering the adoption of drone technology should align their strategic objectives with the implementation process. Effective use of the technology requires clear purpose statements to develop a comprehensive vision, set targets, and establish measurable milestones. Additionally, 28% of the publications highlighted technical skills as a key factor, while 26% discussed the importance of management support. The factor with the least frequency that affects the adoption of drones in the food supply chain is organizational readiness, which was mentioned in 19% of the publications.

The outcome indicates that organizations should consider organizational readiness as the least important factor when using drone technology since it might affect their competitive advantage. This suggests that organizations should prioritize other factors over organizational readiness when adopting drone technology. Focusing too much on how prepared the organization is might detract from its

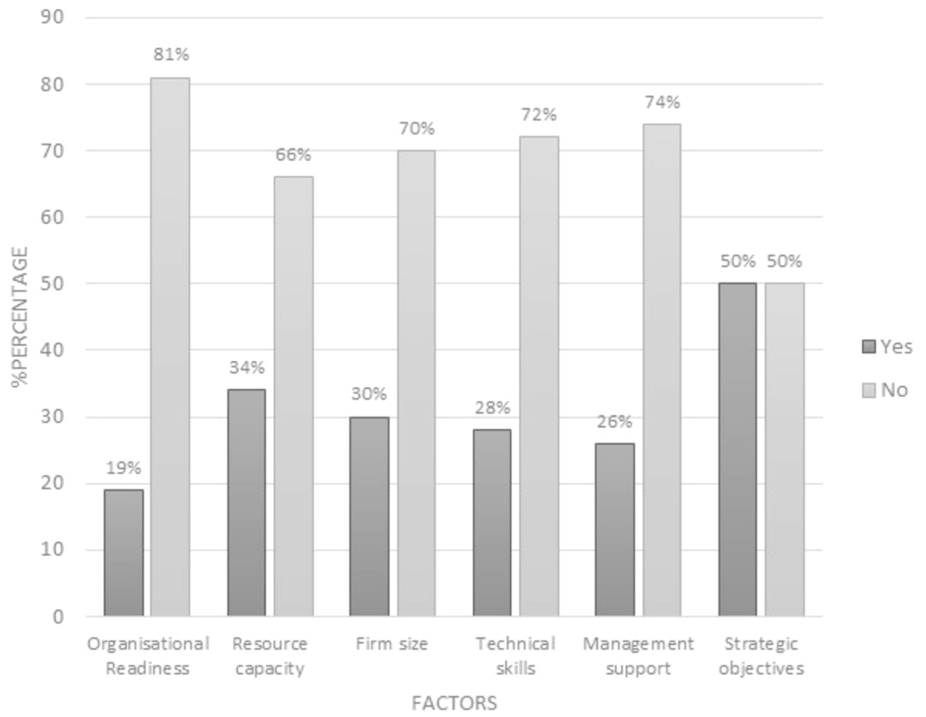

FIGURE 8
Frequency of organizational factors.

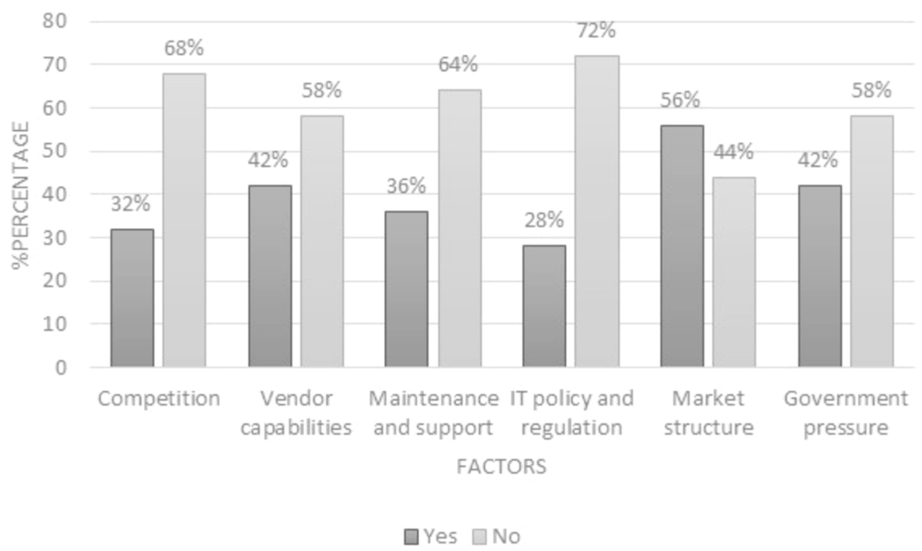

FIGURE 9
Frequency of environmental factors.

ability to leverage drone technology effectively, potentially harming its competitive edge. While readiness is important, it may not be as crucial as other factors in drone adoption.

3.2.3 Environmental factors

This study examined six environmental elements, including competition, vendor capabilities, maintenance and support, IT policy and regulation, market structure, and government pressure, that affect the use of drones in the food supply chain. Based on 50 publications that were published between 2019 and 2022, Figure 9 shows the findings of the evaluation of the environmental conditions. The findings show that 56% of publications highlighted market structure as an influential element, followed by 42% of articles that discussed government pressure and another 42% of articles that discussed vendor capabilities. The results suggest that organizations are motivated by the market structure to adopt drone technology in the

TABLE 2 Technology, organizational and environmental factors by year.

		Sum of Squares	df	Mean Square	*F*	Sig.
Environmental-Government pressure	Between groups	3.10	3	1.03	5.24	0.003
	Within groups	9.08	46	0.20		
	Total	12.18	49			
Technological factors total	Between groups	33.17	3	11.06	5.60	0.002
	Within groups	90.91	46	1.98		
	Total	124.08	49			

TABLE 3 Technology, organizational and environmental factors by research method.

		Sum of squares	df	Mean square	*F*	Sig.
Technological factor-cost	Between groups	1.23	2	0.61	4.25	0.020
	Within groups	6.77	47	0.14		
	Total	8.00	49			
Organizational factor-Resource capacity	Between groups	3.42	2	1.71	10.32	0.000
	Within groups	7.80	47	0.17		
	Total	11.22	49			
Organizational factors-total	Between groups	12.68	2	6.34	4.03	0.024
	Within groups	73.90	47	1.57		
	Total	86.58	49			

food supply chain. In addition, maintenance or support was mentioned as an influencing element in 36% of publications, followed by competition at 32%. Finally, just 28% of the publications listed IT policy/regulation as an important factor that influences drone adoption in the food supply chain.

3.3 Technology, organizational, and environmental factor analysis of variance

This section presents the analysis of variance (ANOVA) and correlation analysis results of technology, organization, and environmental factors variables across several demographic variables such as year published, research method, research type, research framework, and study region. Only variables with significant differences are presented on the factors affecting the adoption of drones in the food supply chain.

3.3.1 Analysis of variance (ANOVA)

3.3.1.1 Technology, organizational, and environmental factors by year

The analysis of variance (ANOVA) results of the year variable and the technology, organizational and environmental factors, are shown in Table 2. The results show that there was significance difference on the environmental factor (government pressure) and technology factors total at below 0.05, environmental factor (government pressure) at 0.003, and technological factors total at 0.002. According to the results, the only factors that exhibited significant differences when assessed against the demographic variable of the year in which articles were published were environmental factor (government pressure) and technology factors total. In summary, the prevalence of the two factors varied significantly over the years under review.

3.3.1.2 Technology, organizational, and environmental factors by research method

Table 3 presents an analysis of results of the research method variable and the technology, organizational and environmental factors. The results reveal significant differences between the technology factor (cost) and organizational factors (resource capacity and organizational factors total), all of which are below 0.05: cost at 0.020, resource capacity at 0.000, and organizational factors total at 0.024. The findings indicate that there are significant differences between the factors and the demographic variable research method. According to the findings, the only factors that revealed significant variations when compared to the demographic variable of the research method in which articles were published were technological factor (cost), and organizational factors (resource capacity) and the organizational factors total. In summary, the prevalence of the three factors varied significantly over the 4 years studied.

3.3.1.3 Technology, organizational and environmental factors by region

Table 4 presents an analysis of variance (ANOVA) of the demographic region, and TOE framework constructs technology, organizational, and environmental factors. The results revealed significant differences, with the technological factor (complexity) at 0.042, the organizational factor (resource capacity) at 0.002, the organizational factor (technical skills) at 0.002 and organizational

TABLE 4 Technology, organizational and environmental factors by region.

		Sum of Squares	df	Mean Square	*F*	Sig.
Technological factor-complexity	Between groups	2.69	5	0.54	2.55	0.042
	Within groups	9.31	44	0.21		
	Total	12.00	49			
Organizational factor-resource capacity	Between groups	3.76	5	0.75	4.44	0.002
	Within groups	7.46	44	0.17		
	Total	11.22	49			
Organizational factor-technical skills	Between groups	2.37	5	0.47	2.71	0.032
	Within groups	7.71	44	0.18		
	Total	10.08	49			
Organizational factor-total	Between groups	30.01	5	6.00	4.67	0.002
	Within groups	56.57	44	1.29		
	Total	86.58	49			

TABLE 5 Correlation of TOE factors.

		Articles by year	Total technology factors	Total organizational factors	Total environmental factors
Articles by year	Pearson correlation	1.000	0.467	0.914	−0.138
	Sig. (2-tailed)		0.001**	0.016*	0.340
	N	50	50	50	50
Total technology factors	Pearson Correlation	0.467	1.000	0.367	0.266
	Sig. (2-tailed)	0.001**		0.009**	0.062
	N	50	50	50	50
Total organizational factors	Pearson Correlation	0.016*	0.367	1.000	0.231
	Sig. (2-tailed)	0.914	0.009**		0.107
	N	50	50	50	50
Total environmental factors	Pearson Correlation	−0.138	0.266	0.231	1.000
	Sig. (2-tailed)	0.340	0.062	0.107	
	N	50	50	50	50

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

factors total at 0.032, all of which are below 0.05. The results imply that the technological factor (complexity), organizational factors (resource capacity and organizational factors total) and the demographic variable of the Region in which articles were published has a strong link.

3.3.2 Correlation between TOE factors (technology, organizational, and environmental)

Table 5 shows the relationship between TOE factors (technology, organizational, and environmental) and the year the articles were published. A correlation relationship is significant at the 0.01 and 0.05 levels. The correlation between year and technological factor variables indicated a positive significance at 0.001**. In addition, the correlation between year and organizational factor is positively significant at 0.016** but with no significance for environmental factor. Furthermore, the correlation between the technological factor variable and organizational factor variables indicated a Sig (2-tailed) value of 0.09. The environmental factor variable, however, showed no significant correlations with the year, technological factor, and organizational factor variables. Thus, we can conclude that there is a statistically significant relationship between the year, technological factors, and organizational factors.

4 Conclusion

The study adopted a systematic literature review to explore factors affecting the adoption of drones in the food supply chain from articles published between 2019 and 2022. The study selected 50 peer-reviewed articles adoption of drones in the food supply chain. The study results indicate an increase in published articles on factors affecting the adoption of drones in the food supply chain during the years under review. This indicates more interest from researchers in the research area. The results also indicate that the quantitative research method was the most used and Asia region has the highest number of published articles in the research area.

The results showed that technology-related factors such as complexity, compatibility, cost, perceived usefulness, relative advantage, and security were the dominant factors affecting drone adoption in the food supply chain. In addition, the study results indicated that the strategic objectives of organizational resources are a key factor for drone adoption in the food supply chain. Furthermore, the study suggests that the market structure variable of the environmental factors is an important factor affecting the adoption of drones in the food supply chain. As a result, the findings of the study indicate that technological factors (cost, relative advantage, and perceived usefulness), organizational factors (strategic objectives), and environmental factors (market structure) all affect the adoption of drones in the food supply chain.

The ANOVA analysis revealed significant differences between the year and the environmental factors, specifically government pressure and technological factors. Consequently, the findings indicate that both government pressure and overall technological factors varied throughout the study period regarding their impact on drone adoption in the food supply chain. The inferential statistics indicated a positive significance correlation between the year variable, technological factor variable, and organizational factor variable but no significance for the environmental factor. The results suggest that technological and organizational factor complement each other in drone adoption in the food supply chain. Organizations are therefore more likely to view technological and organizational factor as associated factors that affect drone adoption in the food supply chain.

To conclude, the study indicates that technological factors (cost, relative advantage, and perceived usefulness), organizational factors (strategic objectives), and environmental factors (market structure) affect the adoption of drones in the food supply chain. The study implications are that as organizations gain experience and knowledge over time, their technological and organizational readiness for drone adoption improves. In addition, external pressures can shift organizational priorities and readiness for adopting new technologies. Decision-makers considering drone technology adoption within sustainable food systems should understand these factors to enhance strategic planning and implementation.

The study adds to the body of knowledge on the factors affecting the adoption of drones in the food supply chain. While the study contributes valuable insights for academia and organizations considering drone adoption in the food supply chain, it has limitations due to its lack of empirical data and use of non-random sampling. Consequently, the findings are not generalizable to the broader field of the food supply chain. However, decision-makers should still consider these findings when evaluating drone adoption. Future research may use different frameworks (such as diffusion of innovation theory (DOI) and institutional theory) and methodologies (such as empirical research, qualitative or mixed methods) to explore factors affecting drone adoption in this context. The study's limitations highlight opportunities for additional empirical research. Overall, the study successfully met its objective of examining factors influencing the adoption of drones in the food supply chain.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

HU: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. OJ: Conceptualization, Investigation, Resources, Software, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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