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IMPLEMENTING UNMANNED AERIAL VEHICLES (UAVS) DELIVERY SYSTEM IN THE COURIER SERVICES INDUSTRY: A SYSTEMATIC REVIEW AND RESEARCH TRENDS

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Abstract: *Unmanned aerial vehicles, or drones, are becoming increasingly popular and are impacting package delivery services by presenting both opportunities and challenges. This research aims to explore the potential of UAVs for last-mile deliveries, their capability to reach remote locations, and the new business opportunities they can generate, particularly in the courier services industry. To gain a competitive edge, courier service companies in emerging markets need to be proactive in understanding the key factors contributing to the acceptance of last-mile UAV delivery services. Hence, the goal of this study is to review the existing literature related to UAV implementation in the courier services industry. A systematic review was employed to gain insight and evaluate the literature. The PRISMA review method was utilized to classify the articles obtained from two reputable bibliographic databases, Web of Science and Scopus, resulting in a limited dataset of 64 articles published between 2014 and 2024. The findings revealed that numerous articles were found in the Web of Science database, with the highest number of publications coming from the USA and China. Additionally, most of the articles have been published in International Transactions in Operational Research and Transportation Research Part E: Logistics and Transportation Review. Furthermore, a substantial number of publications are from the business and economics research domain. The study also highlights several research directions to enhance UAV delivery in the courier service industry in the future.*

Keywords: *Unmanned aerial vehicle, courier services industry, drone, systematic review*

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Introduction

Unmanned Aerial Vehicles (UAVs), commonly known as drones, are remote-controlled flying robots that can provide immediate delivery of aid packages to cut-off regions, overcoming many difficulties associated with traditional last-mile delivery modes (Ghelichi et al., 2022). The use of UAVs for delivery is growing in popularity as technology advances, offering advantages over traditional delivery techniques. Unrestrained by established road networks, drones can deliver urgently needed packages in a timely manner. Drone delivery is faster, more accurate, and cost-efficient, reducing the possibility of packages being misplaced or delivered to the wrong address, which is particularly beneficial for courier service companiesdelivering goods to hard-to-reach locations (Kirschstein, 2020).

Drones provide a more comprehensive view of the environment, can be equipped with multiple sensors, and can work in swarms to perform various perceptual tasks (Blaga et al., 2024). Consequently, courier services need to enhance their logistics systems by adopting drone technology to stay competitive in the global market. Leading companies, such as Amazon, UPS, and DHL, have publicized their plans to use drones for package delivery to customers' premises (Iranmanesh & Raad, 2019). By 2030, drone delivery services are predicted to save online merchants close to $50 million in delivery charges and increase e-commerce revenues by 25% (Born Techies, 2022). Research indicates that 47% of American customers are interested in using last-mile drone delivery services (Statista,2017). Many industry players, including Amazon, DHL, FedEx, and Google, have been exploring the potential of drone technologies in logistics and package delivery (Lee and Choi, 2016; Wang, Poikonen and Golden, 2017) The changes in industrial and commercial activities, such as the growth of online trading and purchasing from remote locations, have enhanced the role of courier service companies within the supply chain in terms of guaranteeing quality and on-time service for each customer. Moreover, the intensifying competition in the courier services industry, driven by the expansion of e-commerce, has emphasized the necessity for logistics companies to improve the quality of their courier services (Ejdys and Gulc, 2020). However, due to regulatory and technical issues, there are currently few officially operational drone delivery services. Most countries have legal restrictions preventing drones from flying beyond visual line of sight or from flying automatically without a pilot, which hinders the widespread implementation of drone delivery services (Paszror and Ferek, 2021).

Given the growing interest and potential of drone delivery systems, it is necessary to systematically review the existing literature to examine this research domain, which appears to have been previously unobserved in the courier services industry literature. Therefore, the objective of this study is to systematically review the literature on drone technology adoption in the courier services industry, analyzing the articles based on country, year of publication, research area, and journal of publication over a ten-year period. The PRISMA statement (Preferred Reporting Items for Systematic reviews and Meta- Analyses) review method was employed to guide the review of drone technology adoption articles published between 2014 and 2024. The remainder of this paper is organized as follows: Section 2 outlines the methodology; Section 3 puts forward results for the study; and Section 4 concludes the study and discusses future research directions.

As mentioned above, there are limited studies that have been carried out on UAVs adoption. However, most of the study focused on aviation and engineering research domain. Hence, the systematic review on UAVs implementation in the context of the courier service industry is highly necessary to increase the understanding of research trends and opportunities of UAVs in

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the industry. Despite that, as the trend of UAVs implementation is new in the courier service industry, therefore, the findings of this research are useful to various parties like consumers, manufacturers, and logistics providers.

Literature Review

UAVs Technology Implementation

Unmanned Aerial Vehicles (UAVs) or drones have gained significant attention across various industries, particularly in logistics, agriculture, environmental monitoring, and urban planning. The integration of UAVs technology has revolutionized operations by enhancing efficiency, reducing costs, and improving accessibility to remote areas. The use of drones has both commercial and humanitarian purposes that so far received limited attention by the logistics service providers, possibly due to technological constraints in terms of the weight that can be carried, limited battery life, and interference with commercial jet operations (Rao et al., 2016). UAVs are versatile technologies that can be equipped with different tools (e.g., cameras, sensors, scanners, and robotic arms), yet they do not qualify as "general purpose" technologies (Brynjolfsson et al., 2021). There are some potential business cases for UAVs in operations regarding drones fit with economic and strategic factors that identify and compare measurable benefits and costs of the technology option (Burcher et al., 1999). For example, when integrated with other technologies such as cameras, sensors, and barcode readers, drones can reduce labor- and risk-intensive manual work at heights (e.g., counting inventory stored high up in warehouse racks) or in dangerous places (e.g., an inspection of structures of great height). However, the business cases are limited by current UAVs capabilities, such as limited payload, level of automation, and sight times especially for indoor applications. The business case for UAVs remains unclear compared with traditional investment options such as forklifts, mounted cameras, and material handling systems (Maghazei et al., 2022). In addition, UAV applications piloted and implemented as externally managed drone-as-a-service systems have lower entry barriers (Maghazei et al., 2022).

The logistics industry has increasingly adopted UAVs for package delivery, inventory management, and last-mile logistics. Drones for package delivery have already been tried locally by logistics firms and retail behemoths like Amazon, FedEx, and UPS, who prioritized safety over all other considerations (Cary and Bose, 2016). Research by Kirschtein (2020) highlights that UAVs delivery systems can significantly reduce transportation costs and minimize delivery time, particularly in congested urban areas. Additionally, Motlagh, Taleb and Arouk (2016) emphasize that UAVs help optimize supply chain management by providing real-time tracking and automation in stock inventory.

Despite their numerous benefits, UAV implementation faces challenges such as regulatory restrictions, privacy concerns, and technical limitations. Wang, Poikonen and Golden (2017) note that legal frameworks governing UAV operations vary across countries, posing hurdles for widespread adoption. Additionally, he also emphasizes the need for advanced AI and machine learning algorithms to enhance UAV autonomy and improve decision-making capabilities. As UAV technology continues to evolve, its integration across industries is expected to expand further. Future research should focus on improving UAV battery life, enhancing AI-driven automation, and addressing ethical considerations in UAV operations.

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Methodology

The Review Protocol – PRISMA

This systematic review adhered to the PRISMA statement review protocol (refer Figure 1). PRISMA is commonly applied within the management and social sciences field. According to Sierra-Correa et al. (2015) and Shaffril et al. (2020). PRISMA offers three key advantages: (1) defining clear research questions that allow systematic research; (2) identifying inclusion and exclusion criteria; and (3) allowing the examination of large databases of scientific literature within a defined timeframe. The PRISMA statement facilitates a rigorous search of terms related to drone technology in courier services, as well as the coding of information for future management reviews. The process began with formulating an appropriate research objective, followed by a systematic search strategy that considered identification, screening, and eligibility elements. Subsequently, a quality assessment was conducted to ensure the quality and relevance of the articles to be reviewed. Finally, the data were abstracted, analyzed, and validated.

Systematic Search Strategy

Two reputable databases were used in this systematic review, namely Scopus and Web of Science (WoS). These databases were selected due to their robust coverage of over 250 fields of study and more than 30,000 journals. They offer extensive peer-reviewed abstract and citation databases across various disciplines such as environmental studies, interdisciplinary social sciences, social issues, development and planning, and others. Moreover, these databases have some of the largest repositories of business-related research, making them commonly used for systematic literature reviews (Durach et al., 2014). The keywords were developed based on their search question as suggested by Okoli and Schabram (2010) and the identification process relied on online thesaurus, keywords used in past studies, keywords suggested by Scopus and WoS, as well as input from subject matter experts. The authors were able to enrich the existing keywords and develop a comprehensive search string using these two main databases.

Table 1: The Search String

Database	Keywords used
Scopus	TITLE-ABS-KEY ("Drone") OR ("Unmanned Aerial Vehicles") AND ("Courier Services") OR ("Delivery Services")
Web of Science	TS=(("Drone") OR ("Unmanned Aerial Vehicles") AND ("Courier Services") OR ("Delivery Services"))

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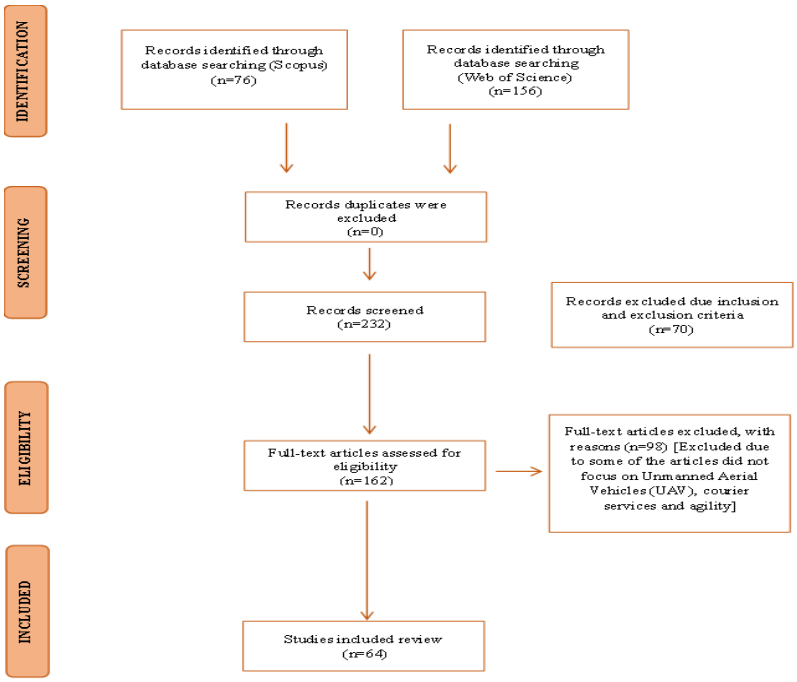

Figure 1: The flow diagram of the study is adopted from PRISMA

In Table 1, the search string was constructed based on the list of the identified keywords. The search was conducted using combinations of exact keywords on titles and abstracts, as these addressed the review objective. The search strategy resulted in a total of 232 articles, where 76 articles came from Scopus and 156 articles were from WoS. Interestingly, there was no duplication of records. The data were then exported to an Excel spreadsheet for cleaning and sorting. After careful inspection, 168 additional articles were excluded due to eligibility issues, leaving 64 articles for further analysis.

Table 2: The Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Literature type	Journal article, review, conference paper, book, book chapters,	Proceedings, early access
Language	English	Non-English
Timeline	Between 2014 to 2024	<2014
Indexes	Social Sciences Citation (SSCI), Emerging Sourcing Citation Index (ESCI), Science Citation Index Expanded (SCI-Expanded), Book Citation Index – Social Sciences & Humanities (BKCI – SSH), Book Citation Index – Science (BKCI – S)	Arts & Humanities Citation Index (A&HCI), Conference Proceedings Citation Index Social Science & Humanities

Quality Assessment

A combination of qualitative and quantitative methods was employed to assess the articles. 70 articles were removed after the inclusion and exclusion process (e.g. Table 2), resulting in 162 articles remained for further assessment. The quality of the articles was thoroughly assessed by

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the authors, who ranked them based on three quality categories namely high, moderate, and low. Articles were only accepted if all authors agreed on the assessment. As a result, 98 articles were removed due to eligibility issues, and the remaining articles were deemed eligible for the subsequent review.

Data Abstraction and Analysis

The remaining 64 articles from Scopus and WoS were thoroughly evaluated and analyzed. The researchers first extracted relevant data by carefully reviewing the abstracts. Then, each individual reviewer delved into the full text of the articles to identify the appropriate themes. Using thematic analysis, the researchers systematically explored themes related to drone technology and courier services. In the process of developing these themes, the researchers discussed any inconsistencies or emerging ideas associated with the interpretation of the data until they reached a consensus on the developed themes.

Results

A detailed systematic review of the literature reveals an increasing trend in studies related to drone technology and courier services over the past ten years. The results in Figure 2 show that 2024 had the highest number of published articles on these topics, with 22 articles, followed by 2022 with 16 articles. This upward trend suggests growing academic and industry interest in the potential of drone technology to revolutionize the courier services industry. The early years from 2014 to 2018 saw fewer than 3 articles published per year, indicating that this research area was still in its beginning stages. However, a significant shift occurred in 2022 when most of the country started to support the usage of drone technology, which appears to have spurred increased research activity in this domain, as evidenced by the rising number of published articles on the topic.

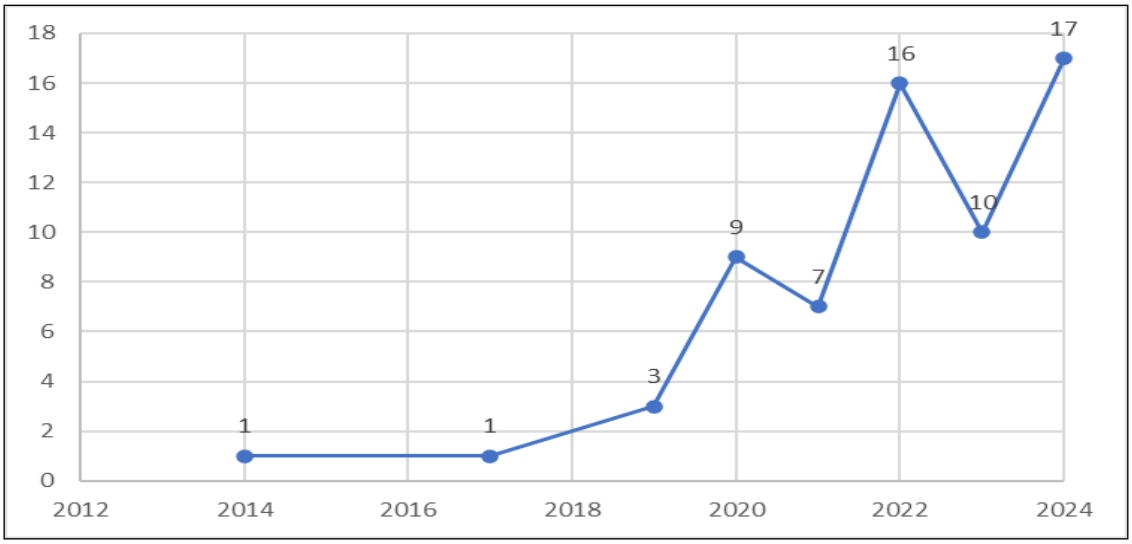

Figure 2: Publication distribution of reviewed articles by year

Meanwhile, the analysis of publication distribution by journal is shown in Figure 3. From the review, the journal with the highest number of published articles is International Transactions in Operational Research, with 5 articles. This was followed by Transportation Research Part E: Logistics and Transportation Review, which published 4 articles. Additionally, three journals which are Sustainability, Transportation Research Part C: Emerging Technologies, and Cogent Business & Management each published 2 articles respectively.

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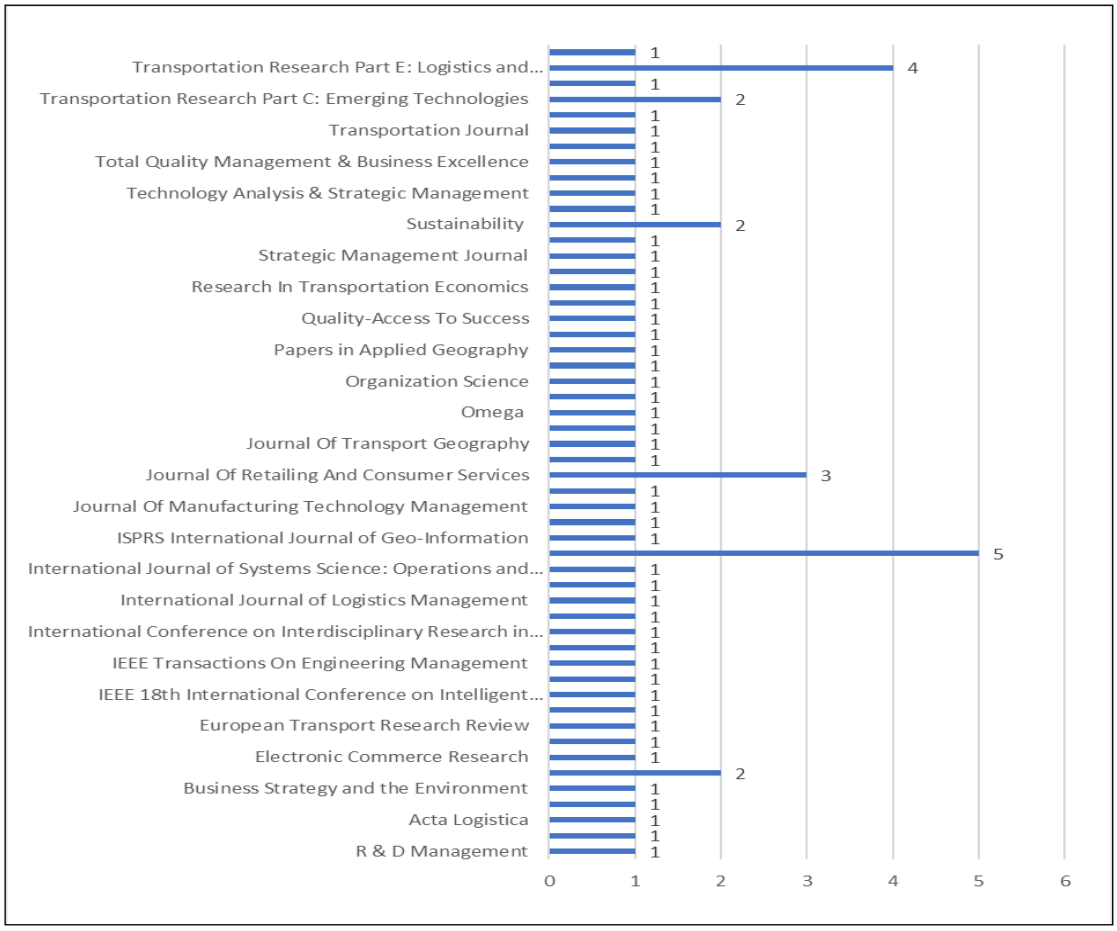

Figure 3: Publication distribution of reviewed articles by journal

The distribution of reviewed articles by research area, as shown in Figure 4, reveals that the majority of the published articles, approximately 36, are from the Business and Economics research area. This finding suggests that the Business and Economics discipline is the most suitable and accurate research area to explore the relationship between drone technology and the courier services industry, compared to other research areas. Apart from the Business and Economics domain, most of the studies were also published in the areas of Engineering (20 articles) and Computer Science (19 articles), as drone technology involves the development of digital computational code that powers both the hardware and software components of these systems (Anthony and Timothy, 2012). Interestingly, the review also identified the least represented research areas, each with only 1 article, which includes Social Issues, Science Technology, Physics and Astronomy, and Geography, indicating that these domains have not yet received significant attention in the context of drone technology and courier services.

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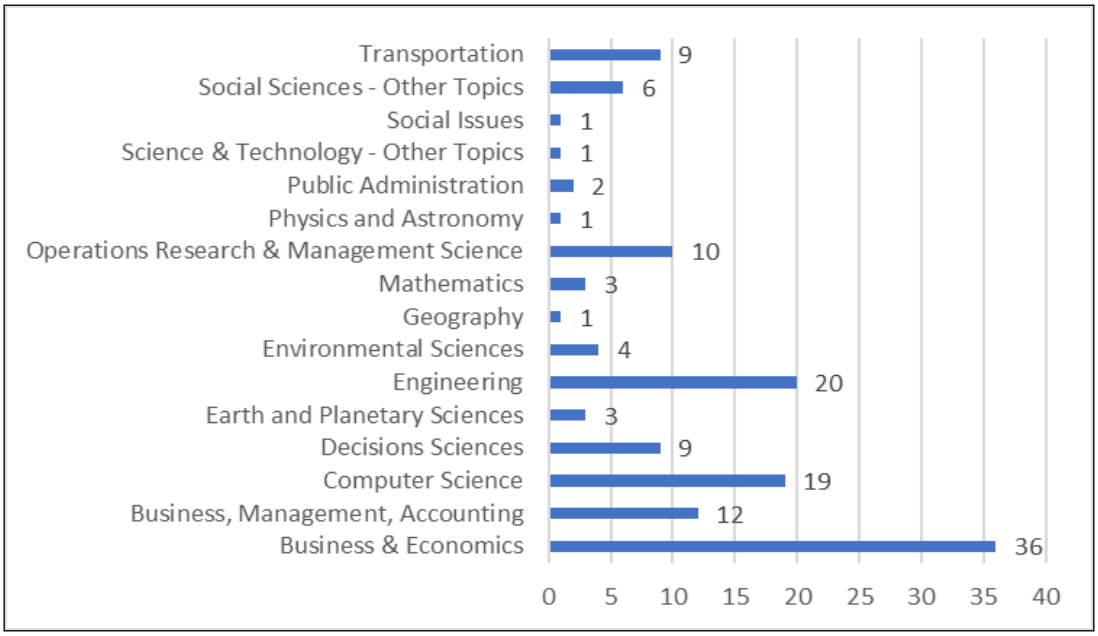

Figure 4: Publication distribution of reviewed articles by research area

The distribution of reviewed articles by country reveals a global reach, with publications originating from 22 countries around the world (e.g. Figure 5). Most of the articles, 18 in total, were from the United States of America, demonstrating its leadership in research related to drone technology and courier services. China emerged as the second highest contributor, with 8 articles published, solidifying its growing research presence in this field. In contrast, several other countries, such as Austria, India, Malaysia, Romania, Saudi Arabia, and Vietnam, had a much lower publication count, with only 1 article each compared to the top contributors. This disparity suggests that the awareness and readiness of these countries in adopting drone technology, particularly in the courier service industry, is still at an early, or "infant," stage of development. The uneven distribution of research across countries highlights the need for more global collaboration and knowledge-sharing to foster a more comprehensive understanding and widespread implementation of UAV delivery systems in the courier services industry.

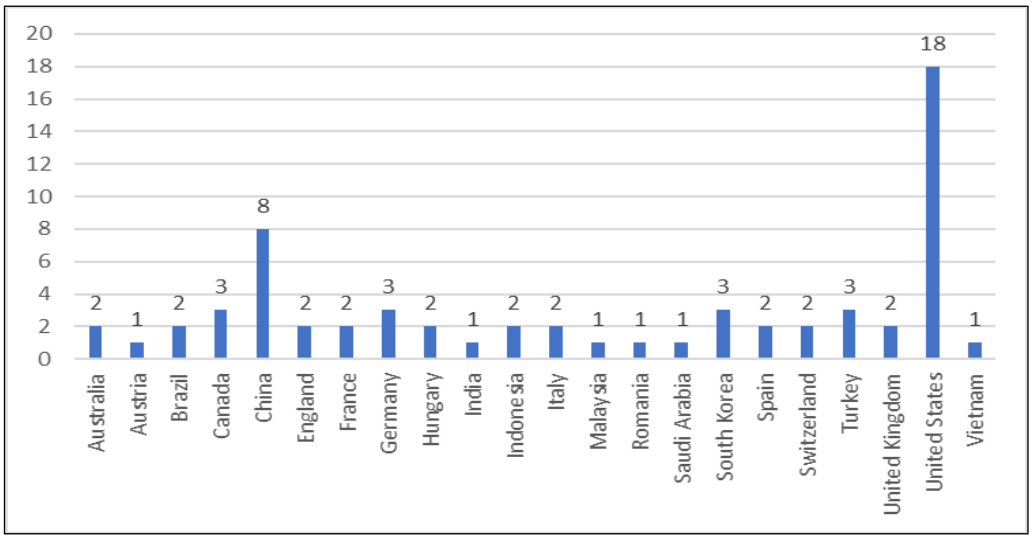

Figure 5: Publication distribution of reviewed articles by country

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Conclusion and Future Research Directions

This systematic literature review has provided a comprehensive overview of the current state of research on the implementation of unmanned aerial vehicle delivery systems in the courier services industry. The analysis reveals a growing trend in publications on this topic, with a particular focus on business and economic aspects. It reveals a steadily increasing trend in the number of publications on UAV delivery systems in the courier services industry over the past decade. This suggests a growing interest and recognition of the potential of drone technology to transform the logistics and transportation sector.

However, the review also highlights several key research gaps that warrant further exploration. First, more empirical studies are needed to examine the real-world implementation and performance of UAV delivery systems in various courier service contexts (Zhang & Li, 2023; Scott &Scott, 2017). Second, there is a need for more interdisciplinary research that integrates perspectives from engineering, logistics, and business management to address the multifaceted challenges of UAV integration. Third, the review underscores the importance of considering the social and environmental implications of UAV delivery, such as public acceptance, privacy concerns, and environmental impacts.

To address these research gaps, future studies should adopt a more holistic and multidisciplinary approach, leveraging a range of methodologies (e.g., case studies, simulations, field experiments) to provide a comprehensive understanding of the opportunities and challenges of UAV delivery in the courier services industry. Additionally, research should explore the regulatory frameworks, infrastructure requirements, and business models needed to facilitate the widespread adoption of UAV delivery systems. This interdisciplinary collaboration could lead to more holistic and impactful solutions for the integration of drone technology in the courier services industry.

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Conflict of Interest

It is confirmed that there are no conflicting interests and that the research was conducted impartially and ethically. The conclusions presented in the manuscript are solely based on the analysis of the data collected during the study.

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