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Consumer Acceptance of Drones for Last-Mile Delivery in Jeddah, Saudi Arabia

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Abstract: The number of industries using drones is increasing. Although early research was conducted on drones, the prior literature has not emphasized consumer adoption of drones for item delivery. Consequently, this study investigates whether customers are open to receiving packages from drones. This study also examines the elements that influence customers' willingness to adopt drone package delivery. This study fills a gap in the logistics and service research by examining people's concerns regarding using drones. The unified theory of acceptance and use of technology (UTAUT2) serves as the basis for the conceptual framework. A self-administered online survey is deployed. The results demonstrate that perceived privacy risks negatively influence performance and effort expectancy as well as facilitating conditions and social influence. This study further validates the UTAUT2 by confirming the influence of performance expectancy and facilitating conditions on attitudes toward adopting drones. Moreover, this study confirms the positive influence of attitude on behavior. This study has managerial implications, one of which is the suggestion that the deployment and use of drones should minimize interference with people's privacy.

Keywords: consumer acceptance; UTAUT2; drones; last-mile delivery; Saudi Arabia

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1. Introduction

The unprecedented growth of technology has led to the application of innovations such as drones across a variety of different industries, including the service industry, logistics, the military, the security industry, agriculture, aviation, and the entertainment industry. The number of industries using drones is increasing. According to recent global market research, the size of the market for drones for delivery purposes is growing exponentially and is forecasted to reach USD 3.47 billion by the end of 2026 [1]. In particular, growing economies such as Saudi Arabia are experiencing a rapid growth in logistics, as emphasized in the country's Vision 2030. The primary objective of the Vision 2030 is to boost the Saudi economy by expanding the manufacturing, mining, energy, and logistics sectors. In addition to embracing revolutionary innovations, the country has made substantial investments in the pursuit of sustainability. The Saudi government is now undertaking numerous initiatives and innovative projects aimed at mitigating the environmental impact of climate change. These efforts were achieved by implementing clean and renewable energy and investing in cutting-edge technologies.

Recently, policy-makers have made substantial efforts to implement innovative technologies with the aim of reducing the impact of human activities on the environment. Previous research has demonstrated that the use of emerging technologies within the

logistics sector significantly contributes to the reduction of carbon emissions and hence contributes to reducing the detrimental environmental effects caused by human activities [2,3]. In particular, a recent study used discrete event stimulation to investigate the influence of incorporating drone-based delivery on the efficient use of energy and the environment. The study found that a decrease in CO_2 emissions and energy consumption is achieved when drones are implemented in last-mile delivery [3]. Nevertheless, an alternative body of research presents a contrasting perspective, asserting that despite the potential utility of drones in logistics, several challenges must be acknowledged. These challenges include regulatory complexities, cost implications, reservations regarding privacy, and the need for improvements in delivery efficiency. In particular, a few studies have suggested that drone-based delivery could minimize greenhouse gas emissions and energy consumption only if carefully implemented [4]. Advocates of this perspective contend that the utilization of unmanned aerial vehicles (UAVs) should be limited to essential purposes rather than luxury purposes, and it is imperative to consider consumers' views on the incorporation of drones in commercial delivery services [5].

Previous research has illustrated the implementation of revolutionary technologies such as drones [6], the Internet of Things (IoT) [7], and robots [8]. Furthermore, the recent COVID-19 pandemic has encouraged logistics businesses to embrace recent technologies to mitigate the negative influence of the pandemic on their businesses. Previous studies have shown how novel technologies such as the IoT [9], drones [10–12], and robots [13] are used. In particular, a few studies have investigated the factors associated with drone usage in delivering items during difficult events, such as the COVID-19 pandemic [10–12]. However, only a few studies have been conducted to measure consumers' acceptance of drones in item delivery [14].

Preliminary studies have investigated the applicability of drones in a variety of industries in Saudi Arabia, including archaeology, agriculture, and the environment [15–17]. Despite previous attempts to measure the applicability of drones in last-mile delivery, studies investigating the acceptability of drones for commercial delivery have not been a major focus of the literature thus far [18]. A recent study by Alroobaea [19] recommended measuring the acceptance of drones in Saudi Arabia using the technology acceptance model (TAM). A body of literature has emphasized the importance of privacy risks in relation to individuals' acceptance of drones for item delivery [20]. The aims of this study are the following:

1. To evaluate whether customers are open to receiving packages delivered by drones.
2. To investigate the elements that influence customers' willingness to adopt drone package delivery.

This study fills a gap in the logistics and service research by examining people's concerns regarding the use of drones in the context of traditional parcel delivery. Thus, this study provides further insight into this topic. Most exploratory research on the factors that affect the use of drones for service delivery has been conducted in developed economies such as the United States, Canada and Australia. However, Saudi Arabia has a small but growing body of literature on this topic [19]. The unified theory of acceptance and use of technology, often known as UTAUT2, serves as the basis for the conceptual framework of this research project.

The subsequent sections of this research are organized as follows. First, a comprehensive examination of the literature is presented to foster the formulation of hypotheses and the construction of the conceptual model. Then, a detailed description of the methodology is provided, followed by a thorough assessment of the measures. This section is followed by the data analysis and discussion. This paper proceeds with the study's conclusions as well as implications for managers, and decision- and policy-makers, followed by theoretical contributions, limitations, and suggestions for future research.

2. Literature Review

Unmanned aerial vehicles (UAVs), or drones, have increasingly gained momentum in both military and civilian settings [21]. Drones are remotely piloted or unpiloted aircraft that can follow a preprogramed flight path and return to base once their job is complete [22]. More than a million unmanned aircraft are anticipated to be used for retail deliveries in the near future, more than the estimated 20,000 in 2020. The current global COVID-19 pandemic has seen an explosion in the use of drones for delivery, particularly for medical supplies, and for spraying and monitoring to lessen the impact of the pandemic on humanity [23]. Furthermore, retail giants such as Walmart, DHL, Google, and Amazon have shown considerable interest in UAVs [24]. This anticipated growth is due to the cost efficiency, higher speed, and lower energy consumption of drones compared to trucks [24]. In addition, a study that looked at how efficient three different parcel delivery scenarios were—traditional parcel delivery by trucks, a combination of drones and trucks, and the use of only drones—found that the hybrid method was the most efficient in terms of transportation costs, CO_2 emissions, and traffic [25].

An existing body of literature has explored public acceptance of drones in a variety of contexts, such as logistics and commerce. Public acceptance research assists in informing policy-makers, understanding stakeholders' concerns about drone use, and creating a regulatory framework for guiding the future use of drones [26]. For instance, Clothier and colleagues [27] conducted a study on the Australian public's perception and acceptance of drones and found that the Australian public perceives the risk associated with drones as equivalent to the risk associated with traditional manned aviation, where privacy, military use, and misuse are among the public's concerns. Another research investigation examining the public reception of civilian drones discovered that noise and NIMBYism (Not in My Back Yard), a phenomenon where individuals may approve of drone usage but object to them flying near their residences, are key obstacles impeding the widespread acceptance of civilian drones [28]. Despite the fact that public acceptance research helps in drawing a roadmap for using drones in logistics, it is still challenging to rely on them, given the fact that knowledge, awareness of drones, and the actual uses of drones are still in their infancy [26]. Consequently, studies examining the general public's opinion on drones have not yet reached a consensus.

Advocates of employing drones for commercial deliveries assert that this practice holds potential for both economic prosperity and environmental sustainability; however, this potential has not yet been demonstrated [4,5]. Although a body of research supports the utilization of drones for commercial deliveries, another stream of research has identified significant factors that must be addressed to overcome the challenges associated with drone delivery. These factors include regulatory issues, cost considerations, privacy concerns, and efficiency improvements. A study that measured the efficiency of using drones for commercial package delivery found that additional warehouse energy consumption due to per-package drones travelling longer distances increased the life-cycle influence [4]. Hence, for the efficient use of drones in delivery, extra warehousing and the size of drones should be minimized [4]. Critics of the use of drones for commercial deliveries believe that drones should be used for 'necessity, not indulgence' [5]. Opponents also cite citizens' opinions regarding the right to occupy the skies over their heads to deliver unnecessary items such as coffee and donuts.

Proponents of drones believe that they have tremendous promise as instruments for smarter cities, but this potential cannot be realized unless they are widely accepted by society [18]. The popularity of using drones for last-mile delivery has grown recently; however, little is known about the challenges of this usage from the consumer perspective. Privacy, safety, accuracy, noise, and performance risk are among consumers' concerns when using drones for deliveries [19,24]. Although studies have examined the many ways in which context affects the likelihood of drone use, researchers in Saudi Arabia have yet to identify what elements influence customer adoption of this technology [19,24]. As a result, it is of paramount importance to understand the elements that impact customer approval

of the use of drones in last-mile delivery services and its implications for this industry. Last-mile delivery refers to logistical operations associated with the transportation of packages to private customer residences in urban areas [29].

Organizations looking to integrate drone technology into their operations face several challenges. The primary challenge highlighted in the literature is the cybersecurity vulnerabilities inherent in drone systems. Drones often collect sensitive data during operations, such as aerial imagery, video footage, or sensor readings [30]. Unauthorized access to these data can lead to privacy violations, intellectual property theft, or exposure of confidential information. Furthermore, drones rely on communication protocols and software interfaces that can be exploited by a third party to gain unauthorized access [30]. Weaknesses in encryption, authentication mechanisms, and network security make drones susceptible to hijacking attempts. According to Floreano and Wood [31], jamming devices are increasingly accessible, allowing unauthorized individuals to interfere with drone operations. This interference can result in loss of control, erratic behavior, or even complete shutdown of drones, posing safety hazards and operational disruptions for organizations. Drones deployed in unsecured environments, such as public spaces or remote locations, are susceptible to tampering by individuals seeking to take over their control [32]. Tampering can involve accessing onboard systems, manipulating firmware, or attaching external devices to intercept control signals. In some cases, employees might intentionally compromise drone operations or leak sensitive information [33]. Defending systems from insider threats requires implementing stringent access controls, monitoring user activities, and conducting regular security audits. The risk of a third-party takeover extends to data privacy concerns.

Another significant challenge highlighted in the literature is the high initial cost of acquiring drones. According to a report by PwC [34], the price of drones varies widely depending on their capabilities and specifications, with advanced models used for commercial purposes costing anywhere from USD 10,000 to USD 100,000 or more. Beyond the initial acquisition, drones also incur ongoing operational and maintenance costs. Maintenance involves regular software updates, repairs, and battery replacements, which can add up over time. The environmental conditions in which drones operate can significantly impact their maintenance needs. Drones used in harsh environments, such as construction sites or agricultural fields, are more prone to wear and tear [30]. Dust, moisture, and extreme temperatures can cause damage to drone components, necessitating more frequent servicing. On the other hand, delays in obtaining necessary components can lead to extended downtimes, impacting organizational operations that rely on drones [35]. Additionally, these operational costs can be a significant burden, especially if the organization lacks existing expertise in drone technology. The rapid advancement of drone technology has outpaced the development of a workforce with the requisite skills, such as drone programming, maintenance, and operation. Organizations must consider the costs associated with hiring or training personnel to operate and manage drone fleets. Studies indicate that comprehensive training programs are required to equip employees with the technical knowledge and practical skills needed for drone management and programming [35]. These programs can be costly and time-consuming. Nevertheless, challenges in finding qualified personnel lead to delays in deployment and increased costs for recruitment and training [36].

Ensuring the accuracy, reliability, and real-time updating of drone data is essential for effective route planning. Organizations often rely on multiple data sources, including GPS data, traffic information, customer locations, and delivery schedules [37]. On the other hand, balancing multiple objectives, such as minimizing delivery times, vehicle maintenance, and reducing fuel consumption, requires advanced algorithms and optimization models. Constraints such as inventory levels, vehicle capacities, delivery constraints, and service priorities add complexity to route optimization, as discussed by Haider [38].

Drone falls also pose a risk of injury to individuals, including bystanders, workers, and drone operators. Factors such as equipment malfunctions, battery failures, adverse weather conditions, and operator errors can contribute to drone falls [39]. These incidents can lead to property damage, including damage to buildings, vehicles, and other infrastructure.

Larger and heavier models of drones can cause significant harm if they collide with people or objects during a fall. This risk is particularly concerning in crowded or urban areas where drones are commonly used for various purposes [40]. Organizations must ensure compliance with the regulations to minimize the risk of drones falling into homes or infrastructure, leading to significant liabilities.

Ensuring collision avoidance is also a critical challenge when defining drone movement routes. Different jurisdictions have varying regulations governing drone flights, including altitude limits, no-fly zones, and flight path restrictions [37]. Organizations must ensure compliance with these regulations to avoid legal issues and ensure the safety of drone operations. Floreano and Wood [31] emphasize that drones operating in shared airspace, particularly in urban or crowded areas, must have effective collision avoidance systems to prevent accidents with other aircraft, buildings, or obstacles. Developing and implementing reliable collision avoidance algorithms and technologies are essential but complex.

2.1. Theoretical Background

Several theoretical models have been extensively employed to examine how people respond to new innovations in technology. The unified theory of acceptance and use of technology (UTAUT), the technology acceptance model (TAM), and the theory of planned behavior (TPB) have all been used to gauge consumers' openness to novel technologies such as robots, IoT, AI, and drones in fields as diverse as service delivery, tourism, hospitality, security, and entertainment.

Theoretically, the TAM developed by Davis [41] builds upon the theory of reasoned action as a stable base [42] to empirically validate the connections among essential concepts, including perceived usefulness and perceived ease of use, and users' attitudes, intentions, and actual computer adoption behavior. The TPB [43], another extension of the TRA, focuses on measuring behavior by including measures of perceived behavioral control. This variable was added to the model primarily so that it could be used to predict behaviors that were not completely under the control of the individual [43]. Furthermore, the UTAUT model is a novel contribution to the field of technology acceptance that deliberately comprises elements of the TAM, TPB, and innovation diffusion theory (IDT) to predict individuals' acceptance of technology [44]. The UTAUT provides a more extensive framework for evaluating behavioral intentions to utilize technology-related services than the TPB, TAM, or IDT [45]. Despite the unprecedented use of the UTAUT in the literature, the framework was criticized for being limited to organizational settings. Since employees are different from consumers, the need for a user behavioral model to represent the consumer perspective is evident in the literature. To address the aforementioned constraints of the UTAUT, researchers have enhanced the model through the development of the UTAUT2, with the aim of augmenting its explanatory capacity regarding user behavior [46]. The UTAUT2 was further expanded by eliminating the concept of 'voluntariness of use' and incorporating three additional constructs, namely, hedonic motivation, price value, and habit [47]. Since this theory was developed, it has been used extensively in the literature to investigate individuals' acceptance of technologies in a variety of contexts, such as e-learning [48], e-banking [49], e-government [50], mobile payment [51] and mobile banking [52,53]. This theory has also recently been used to investigate the adoption of novel technologies such as the IoT [54], drones [55], and robots [56].

Hence, this study uses the UTAUT2 framework to examine consumers' adoption of drones for last-mile delivery. Our study conforms to the trends in the literature on technology adoption by defining a model that directly captures several constructs of the UTAUT2 model, including attitude and behavioral intention (the plan to use drones), performance expectancy (the functional value of using drones), effort expectancy (the learning cost of using drones), social influence, facilitating conditions and privacy risk. Given that drones have not yet been applied for last-mile delivery in Saudi Arabia, the

other factors of the theory, namely, hedonic motivation, price value, and habit, are not incorporated into this study.

2.2. Privacy Risk

Given the critical role of consumers' perceived risk of using new technology, the current study measures whether perceived risk matters to consumers' adoption of drones for last-mile delivery. Risk perception is widely utilized as an extra variable in the TAM, UTAUT, and DOI frameworks [20,21]. Given the novelty of new technologies, consumers with limited knowledge of products or services may feel at risk due to uncertainty or a lack of trust [21]. As described by Featherman and Pavlou [57], perceived risk is the likelihood of losing when attempting to use an e-service. The previous literature found that risk can be determined by several dimensions, such as financial, performance, time, privacy, and psychological risk [24,58,59].

One of the primary concerns of consumers regarding the use of new technologies is the potential invasion of their privacy. Customers worry about their privacy whenever they are asked to use a novel technology that requires them to reveal personal data. According to Featherman and Pavlou [57], privacy risk is the possibility of losing control over personal information, such as when personal information is utilized without one's knowledge or consent. Regarding drones, people are concerned not only about information privacy but also about physical privacy breaches due to drones' ability to navigate freely over private places and their ability to take photos and videos without people's permission [60].

Prior research has shown that an increase in perceived privacy risk decreases the intention to adopt drones for last-mile delivery [20]. Furthermore, a study by Xu and Gupta [61] found that privacy concerns about using location-based services negatively influence performance expectancy. In the context of drones used in service delivery, we propose that perceived privacy risk negatively influences consumer perceptions of the performance of drones in service. Theoretically, this connection is supported by the privacy literature, which contends that privacy concerns have negative effects on cognitive responses, particularly process expectancies [61]. In a recent study by Yoo et al. [24], privacy risk was among the factors that negatively influenced the adoption of drone delivery. Hence, this study proposes the following:

H1. *Privacy risk is negatively related to performance expectancy.*

Moreover, prior research has found that privacy concerns influence effort expectancy in the context of location-based services [61]. Consequences such as tension and anxiety are emotional expenses associated with compromised privacy [62]. Hence, we propose the following hypotheses:

H2. *Privacy risk is negatively related to effort expectancy.*
H3. *Privacy risk is negatively related to facilitating conditions.*
H4. *Privacy risk is negatively related to social influence.*

2.3. Performance Expectancy

According to the UTAUT2, performance expectancy refers to the extent to which an individual will achieve his or her goals when using a system. It is recognized as a powerful predictor of consumer behavioral intentions [44]. The literature has shown that performance expectancy is a strong predictor of attitudes toward technology [63]. Prior studies have also shown that the greater the practicality of technologies, the more motivated people are with regard to them [51]. Similarly, in logistics, people tend to adopt technologies such as smart lockers, buy-online-and-pickup-in-store (BOPS) options, and drones that simplify their daily lives [55]. Therefore, we argue that the benefits of drones in the package delivery sector will be well received in Saudi Arabia. Thus, the following hypothesis is developed:

H5. *Performance expectancy is positively related to attitude.*

2.4. Effort Expectation

Effort expectancy refers to the simplicity with which a system is expected to operate [44]. This approach is equivalent to perceived ease of use in the TAM and ease of use in the IDT [44]. Prior studies have demonstrated the positive influence of effort expectancy on attitudes in a variety of contexts, such as e-banking service adoption [55,64,65]. In the context of drone item delivery, a growing body of literature has measured consumer acceptance using the TAM and UTAUT models. A recent study examined consumer acceptance using the TAM and found that perceived ease of use (PEOU), which is equivalent to effort expectancy, has a significant effect on the intention to use drones for service delivery [66]. Furthermore, a recent study that measured the acceptance of drones for last-mile delivery showed that effort expectancy significantly affects the intention to use drones in item delivery [13]. Given that individuals in the post-pandemic era are more likely to embrace online applications, services, and delivery, we predict that the convenience of drone deliveries will increase individuals' positive attitudes [55]. Thus, the following hypothesis is developed:

H6. *Effort expectancy is positively related to attitude.*

2.5. Facilitating Conditions

Facilitating conditions refer to individuals' perceptions of supportive circumstances and infrastructure that enable them to utilize new technology [44]. Accordingly, individuals who are more knowledgeable and live in resourceful environments are more receptive to adopting new technologies. Previous studies have also shown that facilitating conditions positively influence attitudes toward accepting and using novel technologies [54]. In particular, a recent study that measured consumer acceptance of the use of logistics technologies such as drones found that facilitating conditions influence attitudes toward their use [55]. Hence, we argue that people who are equipped with compatible technologies and enabling infrastructure are more likely to accept drones for item delivery.

H7. *Facilitating conditions are positively related to attitude.*

2.6. Social Influence

Being influenced by other important people in terms of technology acceptance is called social influence according to the UTAUT [44,46]. The concept of social influence refers to the extent to which individuals perceive that people who are important to them believe that they should use new technology. Research has shown that social influence exerts a significant influence on attitudes toward using technology [51,53]. Our argument posits that individuals are more inclined to receive items delivered by drones if they are surrounded by a supportive social environment. Thus, the following hypothesis is developed:

H8. *Social influence is positively related to attitude.*

2.7. Attitude

Numerous scholarly investigations have been conducted to examine the significance and impact of attitudes on the behavioral intentions of individuals [59].

Attitude refers to a person's favorable or unfavorable feelings about adopting drones for delivery [41], while behavioral intention is 'a measure of the strength of one's willingness to exert effort when undertaking certain behaviors' [67] (p. 132). An existing body of literature has emphasized the influence of attitudes on behavior in the field of service technology. In particular, Leong and Koay [68] found that positive attitudes toward using drones to deliver food have a significant positive influence on intentions. Moreover, recent research that has attempted to measure the critical factors that influence the use of drones

for delivery in Vietnam showed that positive attitudes toward drones have a positive impact on intention to use them [69]. The following is therefore proposed:

H9. *Attitude is positively related to behavioral intention.*

3. Methods and Materials

The methodology used to collect the data for this study is rooted in positivism. The positivist approach is grounded in the hypothetico-deductive model of scientific inquiry, which adheres to a theory-verification framework. According to the positivist paradigm, research follows a circular process that develops a theoretical basis beginning with the formulation of hypotheses, continuing with the operationalization of variables, proceeding to empirical testing, and finally, confirming or challenging the extant theory. Specifically, variables that have previously been validated serve as the independent variables. On the other hand, the dependent variables are chosen to focus the study on the researchers' areas of interest. This leads to the development of hypotheses that link the independent variables to the dependent variable relationships to be tested [70] (see Figure 1).

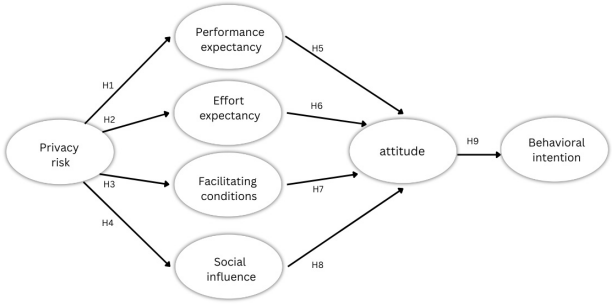

Figure 1. Hypothesized relationships between the constructs in the study.

According to the positivist paradigm, the researcher is isolated from the participants, which means that the researcher is independent and maintains an objective role [70]. Furthermore, quantitative research is typically linked with positivists since it requires data collection, data transformation, and statistical analysis to yield meaningful results [71]. This study was cross-sectional; hence, data were collected from the respondents at one time using an online questionnaire.

3.1. Study Population

This cross-sectional survey yielded 323 valid responses. Study participants were recruited from March to April 2023. A self-administered online questionnaire using Google Forms was utilized to collect the data. An invitation message was placed on social media accounts such as X (i.e., Twitter), Instagram, and Snapchat, which included the title of the study as well as two links (i.e., Arabic and English versions) to the questionnaire. The faculties at two public universities (i.e., the University of Jeddah and Taif University) also received invitation messages via the instant messaging service WhatsApp. Academics were encouraged to share the invitation message with their students via WhatsApp student groups. Participants were encouraged to share the invitation message with family members and friends. According to recent statistical reports using Unified National data, the population of Jeddah was 2,867,446 in 2019 [72]. Hence, in order to achieve enough statistical power, a sample size of 267 was necessary, with a 5% margin of error, a 90% confidence level, and a response distribution of 50% [73]. Hence, the sample size of Jeddah residents, which was 265, is considered representative. This study was approved by the Bioethics Committee of Scientific and Medical Research, University of Jeddah, Saudi Arabia (UJ-REC-107).

3.2. Study Questionnaire

Two versions of the questionnaires were developed in English and Arabic. The Arabic version of the questionnaire was a translation of the English version in which the items were translated to Arabic and back to English. Back translation is frequently utilized in the social sciences to ensure that no meaning is lost during translation [74].

A brief explanation of the importance of the study and the research objectives was provided at the beginning of the survey. A consent form was added to the questionnaire to assure the participants of their anonymity and confidentiality. After providing consent, the participants were given the option to participate voluntarily.

Given that drones for package delivery are not yet widely utilized in Saudi Arabia, a detailed description of the service was provided at the beginning of the questionnaire, along with a photo displaying a drone with a package. The questionnaire was divided into four sections: demographic information; closed-ended questions about drone acceptance; questions on concerns about drones used in delivery; and a single open-ended question about challenges and concerns regarding receiving shipments via drones.

After the first version of the questionnaire was completed, it was distributed to scholars specializing in the domain of logistics for critical evaluation and feedback. Several modifications were implemented to improve the legibility of the items and to guarantee the participants' thorough understanding of the items.

The survey was administered to a sample of ten participants to pilot test its effectiveness. Feedback was gathered, and several modifications were made to the items to enhance their readability and improve the clarity of their intended message. The pilot data were removed from the analysis. The scales measuring adoption were adopted from Cai et al. [55], whereas the items measuring privacy risk were adopted from Yoo et al. [24]. The questionnaire items were measured via a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The data for this investigation were analyzed using Structural Equation Modeling (SEM) with the software SPSS and AMOS, specifically version 25. Mediation was invoked to simultaneously test the direct and indirect effect so that relations could be holistically tested. Table 1 below displays a detailed description of the primary concepts measured in this study. Details of the questionnaire items are presented in Appendix A.

Table 1. Concepts in the study.

Construct	Definition	Source
Privacy risk	'The potential loss of control over personal information, such as when information about you is used without your knowledge or permission'	Featherman and Pavlou [57] (p. 455)
Performance expectancy	'The degree to which an individual believes that using the system will help him or her to attain gains in job performance'	Venkatesh et al. [44] (p. 447)
Effort expectancy	'The degree of ease associated with the use of the system'	Venkatesh et al. [44] (p. 450)
Facilitating conditions	'The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system'	Venkatesh et al. [44] (p. 453)
Social influence	'The degree to which an individual perceives that important others believe he or she should use the new system'	Venkatesh et al. [44] (p. 451)
Attitude	An individual's positive or negative feelings about performing the target behavior	Davis [41]; Venkatesh et al. [44] (p. 456)
Behavioral intention	'a measure of the strength of one's willingness to exert effort while performing certain behaviors'	Lee [67] (p. 132)

4. Results

Table 2 presents the sociodemographic data, which show that the study sample varied in terms of age, gender, marital status, educational attainment, and monthly income. The majority of the participants (74%) were young adults ranging between 18 and 34 years old. A total of 14.6% of the sample was between 35 and 44 years old. However, 11.5% of the participants were aged 45 and older. Moreover, 71.2% of the sample were female, whereas 28.8% of the participants were male. The majority of the sample (61.3%) were single, whereas 36.2% were married, 1.9% were divorced, and 0.6% were widowed. More than half of the sample (57.9%) had obtained graduate degrees, whereas only 15.5% of the participants had high school diplomas. In addition, 6% of the sample reported 'other' when responding about the education level they had obtained. Another interesting finding was that over half of the sample (54.5%) earned less than SAR 5000, whereas approximately 30% earned between SAR 5000 and SAR 14,999. However, only 16% earned between SAR 15,000 and more than SAR 20,000 per month. The findings in Table 2 show that Jeddah was the home of the majority of the study's participants, with 82% overall. The fact that the survey was carried out at the university in Jeddah may have contributed to the high response rate there. However, 18% of the participants resided in other cities in the Kingdom.

Table 2. Sociodemographic characteristics.

Variable	Criteria	Frequency	Percentage
Age	18–24	165	51.1%
	25–34	74	22.9%
	35–44	47	14.6%
	45 and over	37	11.5%
Gender	Male	93	28.8%
	Female	230	71.2%
Marital status	Single	198	61.3%
	Married	117	36.2%
	Divorced	6	1.9%
	Widowed	2	0.6%
Education	High school	50	15.5%
	Bachelor	187	57.9%
	Master	43	13.3%
	Ph.D.	25	7.7%
	Other	18	5.6%
Monthly income (SAR)	<5000	176	54.5%
	5000–9999	52	16.1%
	10,000–14,999	43	13.3%
	15,000–19,999	26	8%
	>20,000	26	8%
City	Jeddah	265	82%
	Other cities	58	18%
Total		323	100%

The percentages of the most common delivery methods utilized by the respondents are shown in Table 3 below. The majority of respondents (63.6%) preferred 'door-to-door' delivery, which is a more well-known and trusted method for home delivery in Saudi

Arabia. On the other hand, 29% of the respondents used a 'pick-up point' to receive shipments. Only 3.6% preferred 'designated locations' for receiving packages, and 2.9% utilized 'smart lockers'. Furthermore, only 0.9% of the respondents utilized alternative delivery methods. *t*-tests were conducted on all the variables to compare the sample from Jeddah with other cities. The results indicated that there were no statistically significant differences between the two groups, suggesting that they are generally similar. Furthermore, this suggests that the issues under investigation are not unique to Jeddah. The results of the *t*-tests are presented in Table A1, Appendix B.

Table 3. The results of multiple responses of the means for last-mile delivery.

Variable	Criteria	Frequency	Percentage
Means for last-mile delivery N = 445	Pick-up point	129	29%
	Smart locker	13	2.9%
	Door-to-door	283	63.6%
	Designated locations	16	3.6%
	Other	4	0.9%
Total		445	100%

Note: N represents the total number of times all the options were selected combined.

Table 4 shows that the average variance extracted (AVE) values were greater than 0.50, confirming the convergent validity. As demonstrated in Table 4, the construct reliability values for all the latent constructs were greater than 0.70, ranging from 0.849 to 0.932, as shown below. The correlation between the constructs was estimated, and the values varied from −0.164 to 0.881. The findings of testing the full model were as follows: X^2 = 406.044; df = 98; $p < 0.001$); CMIN/DF= 3.512; GFI = 0.85; AGFI = 0.81; NFI = 0.91; TLI = 0.90; CFI = 0.91; RMSEA = 0.08.

Table 4. Correlation, square root of average variance extracted, and reliabilities.

	1	2	3	4	5	6	7
1. Performance expectancy (PE)	0.744						
2. Effort expectancy (EE)	0.681 **	0.640					
3. Social influence (SI)	0.658 **	0.698 **	0.768				
4. Facilitating conditions (FC)	0.713 **	0.755 **	0.768 **	0.587			
5. Privacy risk	−0.177 **	−0.199 **	−0.164 **	−0.206 **	0.730		
6. Attitude	0.772 **	0.709 **	0.725 **	0.794 **	−0.185 **	0.753	
7. Behavior	0.781 **	0.734 **	0.724 **	0.803 **	−0.233 **	0.881 **	0.820
Composite reliability	0.921	0.877	0.909	0.849	0.890	0.859	0.932
Cronbach's alpha	0.920	0.883	0.908	0.858	0.888	0.849	0.931

** $p < 0.01$. Figures on the diagonal are the square root of the AVE.

Table 5 above presents the results of testing the relationships between the primary concepts in the study, while Table 6 provides additional insights through the indirect effect.

Table 5. The relationships among privacy risk, performance expectancy, effort expectancy, facilitating conditions and social influence, attitude, and behavioral intention.

Hypothesis	b	se	t Value	*p* Value	Support/ No Support
H1 Privacy risk relates negatively to performance expectancy	−0.225	0.058	−3.892 ***	<0.001	Support
H2 Privacy risk relates negatively to effort expectancy	−0.216	0.053	−4.071 ***	<0.001	Support
H3 Privacy risk relates negatively to facilitating conditions	−0.243	0.052	−4.706 ***	<0.001	Support
H4 Privacy risk relates negatively to social influence	−0.212	0.063	−3.366 ***	<0.001	Support
H5 Performance expectancy relates positively to attitude	0.351	0.031	11.204 ***	<0.001	Support
H6 Effort expectancy relates positively to attitude	−0.063	0.094	−0.666	0.505	No Support
H7 Facilitating conditions relate positively to attitude	0.797	0.148	5.405 ***	<0.001	Support
H8 Social influence relates positively to attitude	0.003	0.071	0.045	0.964	No support
H9 Attitude relates positively to behavioral intention	1.118	0.059	18.919 ***	<0.001	Support

Note: *** $p < 0.001$; B Coefficient refers to the unstandardized regression coefficient, and the standard error is shown in brackets.

Table 6. The indirect effect.

Hypothesis	B	*p*-Value	Relations Implied by the Model: Support/ No Support
Privacy risk influences attitude through several mediators	−0.260	0.006	Support
Privacy risk influences behavioral intention through several mediators	−0.290	0.005	Support
The relationship between performance expectancy and behavioral intention is mediated by attitude	0.393	0.009	Support
The relationship between effort expectancy to behavioral intention is mediated by attitude	−0.070	0.713	No support
The relationship between facilitating conditions to behavioral intention is mediated by attitude	0.891	0.01	Support
The relationship between social influence to behavioral intention is mediated by attitude	0.004	0.93	No support

Testing for a mediation effect showed that the model explains 87.1% of the variance in attitude. Furthermore, the model explains 94.4% of the variance in behavioral intention. These findings (Table 6) suggest that the model captures the major variation in attitude toward drones and even more so the variance in behavioral intention. These results suggest that the main mediators in the relationships between privacy risk and behavioral intention are facilitating conditions, performance expectancy and attitude. From a pragmatic perspective, this suggests that to significantly increase behavioral intention, the focus must be placed on positively changing attitudes toward the use and deployment of drones in last-mile delivery.

5. Discussion

The findings in Table 2 show that males had lower participation in the survey compared to female participants, and this might be attributed to their being less concerned than their female counterparts. The findings in Table 2 (above) also show that the city of Jeddah was the home of the majority of participants in the study, with 82% of the participants overall. The fact that the survey was conducted at the university in Jeddah may have contributed to the high response rate there. However, 18% of the participants resided in other cities in the Kingdom.

Furthermore, the findings of the most common delivery methods utilized by respondents are shown in Table 3 above. Out of the respondents, a significant majority (63.6%) expressed a preference for 'door-to-door' delivery, which is a widely recognized and reliable way for delivering goods to homes in Saudi Arabia. This can be attributed to the favorable consumer encounters with human logistics personnel.

As displayed in Table 5 above, privacy risk exerts a significant negative influence on performance expectancy (b = −0.225; t = −3.892, $p < 0.001$), which supports H1. This finding confirms prior studies in which perceived privacy risk negatively influences individuals' perceived benefits of technology performance [61]. People's concerns about privacy may be warranted, given that drones can fly freely over private property, can capture pictures of individuals without their permission, and can be hacked during delivery. The results also demonstrate that privacy risk significantly influences effort expectancy (b = −0.216; t = −4.071, $p < 0.001$), which supports H2. This result also corroborates previous studies that demonstrate the negative impact of privacy risk on effort expectancy [61]. One possible explanation is that the fatigue associated with the potential invasion of privacy may outweigh the convenience of drone package delivery.

In addition, the perceived privacy risk has a negative, statistically significant influence on facilitating conditions (b = −0.243; t = −4.706, $p < 0.001$), which also supports H3. This could be related to the fact that if participants are concerned about their privacy being violated, this might outweigh their perception of the need for facilitating conditions to use drones. Similarly, privacy risk has a statistically significant negative impact on social influence (b = −0.212; t = −3.366, $p < 0.001$), which supports H4. The participants' concerns about their privacy being compromised are more important than responding to peer pressure, which may also explain this finding.

Furthermore, the findings show that performance expectancy significantly impacts attitude (b = 0.351; t = 11.204, $p < 0.001$), which supports H5. These results also confirm the findings of previous studies, such as Cai et al. [55], Slade et al. [51], and Oliveira et al. [53].

Moreover, effort expectancy had an insignificant impact on attitude (b = 0.063; t = −0.666), which rejected H6. This result contradicts the findings of previous studies, which showed that the effort expectancy associated with drone delivery was positively related to attitudes toward it [13]. The findings also show that facilitating conditions exert a significant impact on attitudes (b = 0.797; t = 5.405, $p < 0.001$), supporting H7. This result corroborates the findings of previous studies that support the role of facilitating conditions in attitudes toward the adoption of drones in item delivery [53,55]. Not surprisingly, the impact of social influence on attitudes toward the use of drones is not statistically significant (b = 0.003; t = 0.045), which rejects H8. This result is in agreement with previous studies that investigated the use of drones in item delivery [55]. Due to the novelty of using drones to deliver packages and the limited number of people who have tried it thus far, no feedback or reviews should be provided just yet [55].

Finally, the findings show that attitude exerts a statistically significant influence on behavior (b = 1.118; t = 18.919, $p < 0.001$), which supports H9. This result also confirms prior studies supporting the influence of attitude on behavior [68,69].

Testing the mediation effect showed that facilitating conditions, performance expectancy, and attitude are the primary mediators between privacy risk and behavioral intention. This particularly means that ensuring adequate facilitating conditions (i.e., adequate resources, support and infrastructure) impacts how the perceived privacy risk can

influence the behavioral intention to adopt drones in delivery. In other words, facilitating conditions decrease the negative impact of privacy risk on individuals, making them more likely to adopt drones for delivery. This results corroborate previous studies where facilitating conditions were found to be significant predictors of behavioral intention to adopt drone delivery [75,76]. Moreover, the results also show that performance expectancy is one of the stronger mediators between privacy risk and behavioral intention. This means that if the performance expectancy of drones is high, the negative effect of privacy risk will be decreased, leading to a stronger behavioral intention to use drones in delivery. The results also indicate that attitude mediates the relationship between performance expectancy and facilitating conditions and behavioral intention. This means that the influence of performance expectancy and facilitating conditions on the behavioral intention to adopt drones is strengthened by the positive attitude toward adopting drones in delivery.

6. Conclusions

Innovations such as unmanned aerial vehicles (UAVs) or drones have found new homes in fields as diverse as the service sector, logistics, the military, security, agriculture, aviation, and entertainment. Over a million unmanned aerial aircraft are expected to be used for retail deliveries in the near future. This projected expansion is attributable to the lower operating costs, greater speed, and lower energy consumption of these vehicles compared to trucks. Although early research was conducted on drones, the prior literature did not emphasize consumer adoption of drones for last-mile delivery. Consequently, this study aimed to determine whether customers are receptive to receiving packages via drones. The UTAUT2, or unified theory of acceptance and use of technology, provides the theoretical foundation for this study. An online questionnaire was developed to collect the data. A total of 323 completed questionnaires were retrieved. SPSS V. 25 and AMOS software were used to analyze the data. Among the prevailing results, 63.6% of the participants preferred door-to-door delivery for receiving items. Furthermore, privacy risk was found to be a strong precursor to technology adoption. This is attributed to the major results of this study, which show the statistically significant negative influence of perceived privacy risk on the four antecedents of the UTAUT2 (i.e., PE, EE, FC and SI). The study findings further validate the UTAUT2 by confirming the influence of both performance expectancy and facilitating conditions on attitudes toward adopting drones for last-mile delivery. Moreover, this study confirmed the positive influence of attitude on behavior. Furthermore, the mediation analysis revealed that facilitating conditions, performance expectancy, and attitude serve as the central mediators in the relationship between privacy risk and behavioral intention.

The results of this research contribute to the existing body of knowledge on UAVs by providing evidence of consumer acceptance of this technology in Saudi Arabia. The findings also contribute to the field of logistics as a whole, specifically the applicability of drone usage in the delivery of commodities. The results demonstrate how privacy risk can influence the acceptance of drones for last-mile delivery. This is because people are more worried about having their personal information leaked than they are about making use of new technology for the sake of its intrinsic qualities (such as performance and effort expectancy) and the enabling conditions or social influence that accompany it.

7. Managerial Implications

7.1. Implications for Managers

According to the main findings of this study, people are concerned about drones, which usually collect large amounts of personal data without permission. This concern is justified as the unauthorized use or sale of drone-collected data can undermine clients' trust. Additionally, drones can be hacked or used to hack other electronic devices. As an implication, managers should increase the privacy protection procedures when delivering items to customers and show customers that they care about their privacy by doing the following:

1. Warranties should be clearly identified in the event of a privacy violation during item delivery.
2. Supportive customer service should be well constructed and designed to promote effective communication with consumers to reduce privacy risks during service delivery.
3. Companies that provide drones for last-mile delivery should invest more in drone software protection to mitigate the likelihood of drone hacking during delivery.
4. Customers must be explicitly legally informed by the company of their data protection rights with respect to the use of personal data in relation to drones.
5. Customers must consent to the terms and conditions related to the delivery.

7.2. Implications for Policy-Makers and Drone Developers

Drones must not be allowed to collect any personal data, i.e., video, photo, or geolocation. If personal data collection must occur, the following recommendations are advised [77,78]:

1. Collaboration among regulatory, organizational and supervisory authorities must be established, including the Saudi Authority for Data and Artificial Intelligence, the Ministry of Transport and Logistic Services, represented by postal sector public policy, and the General Authority of Civil Aviation.
2. A drone can be provided with a camera that has a very low resolution. Thus, this means drones cannot capture clear images of a person's face or house.
3. In Saudi Arabia, privacy and data protection rights are legally stipulated. Thus, if personal data must be collected, doing so must follow the personal data protection law in Saudi Arabia.
4. Cybersecurity regulations must be followed, for example, regular updates, use of a virtual private network (VPN), or ensuring that the drone returns home if it loses its signal.
5. Policy-makers can promote favorable attitudes toward the deployment of drones by raising awareness of the prospective advantages of utilizing drones for traditional item delivery.

8. Theoretical Contributions

This study contributes to a number of theoretical advances. First, the empirical evidence concerning the UTAUT2 is expanded, and the literature on logistics technology utilization is extended through the analysis of customers' usage patterns. This research was conducted to contribute to the further development of the UTAUT2. Second, the Saudi Arabian community benefits from this research because it investigates the utilization of relatively new technology (drones for delivery) and the consequent repercussions of this usage for the community and the environment. In addition, the purpose of this research was to concentrate on one of the primary goals of the Vision 2030, which is to make better use of technology to foster the logistics and service industries in the Kingdom. By maximizing the value of its mining and energy sectors and unlocking the full potential of local content and the 4th Industrial Revolution (4IR), the Saudi government anticipates positioning the country as a global logistics hub and a leading industrial powerhouse through its National Industrial Development and Logistics Program (NIDLP) [79].

9. Limitations and Future Studies

This study has several limitations. First, the majority of the study sample was from one major city in the Kingdom of Saudi Arabia. Future studies need to be conducted in other major cities in the country, such as Riyadh, Makkah and Dammam. Second, due to the over-representation of respondents from one city, the findings may not represent the general population since it is dominated by fairly young respondents. Future studies should include a larger sample size representing the broader Saudi population. Third, the study was limited to a quantitative investigation; therefore, further exploration using a qualitative approach or mixed methodology should be conducted to uncover the underlying

motivations behind individuals' concerns about using drones in item delivery. Furthermore, the current study identified the perceived privacy risk as an inhibiting factor for using drones in service delivery. Further research is needed to identify in greater detail other privacy dimensions that might be of concern to consumers. Moreover, further exploration of the potential mediating and moderating factors that affect the relationship between privacy risk and the UTAUT2 constructs is needed. More specifically, some questions that could be addressed in future studies are: (a) whether perceived risk remains strongly related to these four factors if other predictor variables are added; and (b) whether these relationships could be moderated by gender, level of education, and consumer innovativeness, among many others.

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Institutional Review Board Statement: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all the procedures involving research study participants were approved by the Bioethics Committee of Scientific and Medical Research (UJ-REC-107).

Informed Consent Statement: Informed consent was obtained from all the subjects.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

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Appendix A

Sociodemographic characteristics
Gender Male Female
Age
18–24
25–34
35–44
45–54
55–64
65 and more
Marital status
Single
Married
Divorced
Widowed
Monthly income (SAR)
<5000
5000–9999
10,000–14,999
15,000–19,999
>20,000
Education
High school

Bachelor
Master
Ph.D.
How frequently do you receive shipments (e.g., products, postal shipments)?
Low (1–5)
Medium (6–10)
High (11 or more)
How frequently do you use the following means of last-mile delivery?
Pick-up point
Smart locker
Door-to-door
Designated locations
Questions asking about your acceptance to drones for service delivery:
(Performance expectancy)
I find that drone delivery is useful in my daily life
Using drone delivery increases my chances of achieving things important to me
Using drone delivery helps to accomplish things more quickly
Using drone delivery increases my productivity
(Effort expectancy)
Learning how to use drone for delivery is easy for me
It is clear and understandable to interact with drone delivery
It is easy for me to become skillful at using done delivery
I think picking up parcels by using drone delivery is simple
(Social influence)
People who are important to me think that I should use drone delivery
People who influence my behavior think that I should use drone delivery
People whose opinions that I value prefer that I use drone delivery
(Facilitating conditions)
I have the resources necessary to use drone delivery
Drone delivery is compatible with other technologies I use
I feel comfortable using drone delivery
I can get help from others when I have difficulties using drone delivery
(Attitude)
I like using drone delivery
I prefer using drone delivery than other logistics technologies
I am glad I have the option of using the drone delivery
(Behavioral intention)
I intend to using drone delivery in the future
I will always try using drone delivery
I plan to use drone delivery frequently
Questions about your concerns of drone delivery
Performance risk
The drone might malfunction and damage the package it is carrying
The drone might malfunction and damage property or injure someone
The drone might deliver my package to a different address
Delivery risk
The package the drone is carrying might be stolen
The package the drone is carrying might be damaged by others
Product delivery may take too long or be incomplete
Privacy risk
Drone delivery will cause me to lose control over my privacy
Drone delivery will lead to a loss of privacy for me
Drone delivery might not be used in a way

Appendix B

Independent sample *t*-test for Jeddah residents (n = 265) and non-Jeddah residents (n = 58)

Table A1. Results of Independent Sample *t*-test.

Variable	t Value	df	*p* Value
Privacy risk	−0.691	79.942	0.278
Performance expectancy	0.981	78.268	0.157
Effort expectancy	0.829	76.607	0.061
Social influence	0.310	76.803	0.038
Facilitating conditions	0.742	82.472	0.858
Attitude	0.883	81.318	0.753
Behavior	1.048	76.541	0.064

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