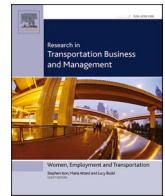




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## Delivering tomorrow today: The role of cutting-edge technologies such as Artificial Intelligence in drones in shaping new business models

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### ABSTRACT

Drone delivery services, which enable faster and more efficient deliveries, reduce costs, minimize environmental impacts and increase satisfaction, have revolutionized global logistics services. Despite these advantages, there are still obstacles to consumers' acceptance of these services, so it is necessary to understand their motivations. This study evaluates how acceptance of the technology influences the perceived usefulness of drone delivery services and the intention to adopt them, considering consumer attitude as a mediating factor. A total of 1108 answers were collected from Portuguese citizens and the Partial Least Square method was applied to a proposed research model. The drone delivery service in Portugal is not yet available in logistics chains. As such, the participants in this study do not yet have an opinion based on experience already carried out. The results indicate that the perceived usefulness of drone delivery services influences consumer attitudes and intention to use them. The technological and task characteristics of drone parcel delivery services positively influence consumers' perceived usefulness of this service. It was also found that consumers are more willing to adopt these services if they are perceived as useful. From the perspective of technology acceptance model (TAM) theory, this study brings empirical insights to extend the literature to drone parcel delivery service technology, and a new model for consumer acceptance of this service is proposed. This study is pioneering in the Portuguese context. Some practical implications are left to help companies and policymakers in faster introducing these services worldwide, namely in Portugal.

### 1. Introduction

Nowadays, a delivery drone is an unmanned aerial vehicle (UAV) used to transport packages, including medical supplies, food, or other goods, during the last-mile delivery process (Eskandaripour & Boldsai-khan, 2023). The shared autonomous drone delivery concept involves a user purchasing goods from an e-commerce platform or a fast-food restaurant, and the drone delivers the package to the consumer (Benarbia & Kyamakya, 2022). Several real-world companies have successfully implemented drone delivery services, showcasing the practicality and effectiveness of this technology. Wing, a subsidiary of Alphabet Inc., launched a drone delivery service in Australia, allowing customers to receive goods from local retailers within minutes (Post & Parcel, 2019). Zipline has made significant strides in medical supply

deliveries using drones in Rwanda and Ghana, facilitating over 450,000 deliveries (Korosec, 2022). Amazon has been testing its Prime Air program for drone delivery, successfully completing pilot deliveries in Lockeford, California, and College Station, Texas with the goal of providing delivery within 30 min for packages weighing up to five pounds (Amazon, 2022). Additionally, Domino's Pizza partnered with drone delivery services to test pizza deliveries in New Zealand, aiming to enhance delivery speed and customer experience, receiving positive feedback from customers regarding the innovative service (Domino's, 2023). These examples highlight the diverse applications of drone delivery across various industries, demonstrating its potential to improve efficiency and customer satisfaction.

According to research conducted by Raivi et al. (2023), drone delivery services, due to the increasing demand for quicker deliveries and

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the growth of e-commerce have become a feasible alternative for many businesses. Projected growth in the drone delivery services market indicates significant expansion in the forthcoming years. The market is estimated to increase from \$359.6 million in 2023 to \$3090.5 million in 2033 at a Compound annual growth rate (CAGR) of 24.0 % (Fact.MR, 2023). Additionally, the drone package delivery market is predicted to grow from \$1522.4 million in 2021 to \$31,188.7 million by 2028 at a CAGR of 53.94 % as per Fortune Business Insights (2021). Moreover, Insider Intelligence (2023) projects that the retail drone market will rise from approximately 35,000 in 2022 to over 110,000 in 2024. In the modern world, drone delivery services are becoming increasingly vital, as evidenced by these statistics.

Using drones for delivery provides faster service, a smaller environmental impact, and reduced costs compared to traditional methods (Chi et al., 2023). Currently, drones can transport various items, from medical supplies to food; however, concerns about package safety, security, and confidentiality have emerged with the rise of drone delivery (Lee et al., 2022; Tu & Piramuthu, 2023). Additionally, factors like inclement weather or equipment failures can affect drone efficiency (Sziroczak et al., 2022). Potential risks related to mishandling and privacy must be addressed for broader acceptance of drone delivery services. The use of these services is influenced by factors such as technology characteristics, perceived usefulness (USF), and consumer attitudes (ATT), which directly affect behavioral intentions (Perera et al., 2020). Key determinants of ATT and inclination towards drone food delivery include perceived innovation, gender, and age (Hwang et al., 2019; Mathew et al., 2021), while attitude, perceived attributes, gender, and COVID-19 are highlighted as strong predictors of intention to use drone delivery (Frazier, 2021). Furthermore, Edwards et al. (2023) note that the USF of delivery drones significantly impacts behavioral intentions towards adopting new technology.

Despite the growing interest in drone theme delivery services, there are still gaps in the literature. Cargo capacity, airspace safety, and government regulations pose challenges in the largely uncharted territory of drone delivery logistics (Benarbia & Kyamaky, 2022). Despite an influx of investment into drone technology research and development, little is known about the intricacies of delivery through drones. To enhance parcel delivery beyond battery life limits, examining the problems that need fixing and establishing drone stations is crucial. Avenues for exploration are promising with last-mile drone delivery development (Benarbia & Kyamaky, 2022). Unfortunately, there's a distinct lack of research on the population in Europe and America who would benefit from such delivery services. To emphasize this lack of information, the study by Aurambout et al. (2022) highlights the issue. To fully capitalize on delivery drones, it's essential to enhance comprehension regarding their advantages (Kellermann et al., 2020). This emphasizes how drones could provide substantial benefits for various industries.

As drone delivery services keep improving, it becomes more important to conduct research that delves into their advantages and drawbacks (Aurambout et al., 2019; Chi et al., 2023; Eskandaripour & Boldsaikhan, 2023). One particular area that requires investigation is how consumers perceive these services, as noted by Osakwe et al. (2022) and Chi et al. (2023). Thus, it is important to ask two questions: i) What is the level of acceptance of drone delivery technology among consumers? And ii) How is the perceived usefulness of drone delivery services affected by the acceptance of the technology? The insights gained can guide businesses in developing effective marketing strategies, designing user-centric services, informing policy and regulatory frameworks, advancing theoretical models, and enhancing competitive advantage, all of which are critical for successful adoption and integration of drone delivery services in the marketplace.

Based on the framework of the Technology Acceptance Model (TAM), this manuscript aims to study how acceptance of the technology influences the perceived usefulness of drone delivery services and the intention to adopt them, considering consumer attitude as a mediating

factor. For this purpose, a sample of 1108 Portuguese citizens was collected, and a research model was proposed, whose relationships were estimated by applying the Partial Least Square method.

The study offers significant contributions that enhance the understanding of drone delivery services within the TAM framework while providing actionable insights for companies. It emphasizes the importance of task characteristics (TAC) (e.g. speed, accuracy, and reliability) in shaping USF, suggesting that companies should promote these features to align with consumer priorities. Additionally, the findings highlight the critical role of ATT in adoption intentions, indicating that addressing safety and privacy concerns can foster trust and improve acceptance. Furthermore, the dynamic nature of USF is underscored, pointing to the need for continuous technological advancements to meet evolving consumer expectations. The study also emphasizes the significance of communication and education in shaping positive attitudes, recommending investment in initiatives that clarify the benefits and safety of drone deliveries. Moreover, customization and adaptability are recognized as essential for enhancing perceived value, suggesting that flexible service offerings can meet diverse consumer needs and drive enthusiasm. The role of partnerships and collaboration is highlighted, indicating that alliances with research institutions and regulatory bodies can enhance service reliability and consumer trust. Finally, the study points to the importance of affordability and accessibility in influencing adoption, urging companies to explore cost-effective models and incentives to broaden consumer access. Collectively, these insights provide a comprehensive framework for understanding consumer perceptions and intentions regarding drone delivery services, helping companies effectively promote and scale their offerings.

## 2. Literature review

### 2.1. Consumer attitude and intention to adopt drone services

Drone technology, or UAVs, is a new trend that will revolutionize parcel delivery (Yoo et al. (2018). Battery-powered multirotor drones are already being used in parcel delivery services (Lee et al., 2016). The experience of using drones to deliver parcels has demonstrated their potential due to their characteristics: the ability to transport parcels of some weight (up to 5 kg), they can deliver parcels up to 50 km away, average speeds per hour from 15 to 65 km and a high altitude (up to 120 m).

Acceptance of drone technology for parcel delivery has been controversial, given the benefits versus problems it has triggered for customers (Yoo et al., 2018). In this context, the technology acceptance model (TAM) theory introduced by Davis (1989) is widely used to assess the acceptance of drone technology by assessing attitudes and intentions at the level of consumer behavior (Hwang et al., 2019).

In drone delivery, consumers value speed, time, and cost savings, the flexibility of receiving orders anywhere, anytime, delivery security, and generating satisfaction (Waris et al., 2022). In addition, consumers also associate some ecological benefits with CO2 reduction, meeting their environmental concerns (Joerss et al., 2016). According to Mathew et al. (2021), the use of drone technology for delivering orders is accepted by companies and businesses given the USF that consumers associate with these services and because they imply instant benefits for their business models, such as financial savings, the satisfaction of the customer and reduction of the environmental footprint (Joerss et al., 2016). In addition, since drones use the air, they are not affected by road traffic and can optimize logistic routes, saving time and money and offering a better parcel delivery service. While acceptance of parcel delivery technology is a strong predictor of consumer decision-making to adopt this service, drone parcel delivery services are considered a future-proof solution. In this way, consumers' acceptance of drone technology translated by their attitude towards these services can be designated as an important antecedent of consumers' intention to adopt drone delivery services.

**Hypothesis 1.** (H1). Consumers' attitude towards adopting drone delivery services positively influences the intention to adopt this type of service in the future.

## 2.2. Technology acceptance and perceived usefulness

The perceived usefulness (USF) of adopting drone delivery services has been studied in recent years. According to Bafouni-Kotta et al. (2023), the intention to use these services is based on the positive perception of consumers of the benefits associated with the use of this technology. Security issues of drone parcel delivery and the exploration of the background for greater public acceptance of these services have recently been studied.

Bafouni-Kotta et al. (2023) argues that, despite the potential benefits perceived by consumers, they are still sceptical about the safe implementation of drones for parcel delivery services. This scepticism is supported by concerns about security, privacy, and maintaining the integrity of packages during the delivery service. Safety is sometimes associated with the fact that drones use airways and, as such, fly over residential and public infrastructure, as well as pedestrian areas, putting the safety of citizens at risk (Khan et al., 2019). Legislation that guarantees measures for the safe movement of drones are essential for their use in urban spaces (Mohamed et al., 2020). In addition to physical security, cybersecurity, data privacy protection, and the fight against fraud and crime are aspects that policymakers must legislate (Bafouni-Kotta et al., 2023). In this context, and according to Aydin (2019), greater public awareness of the USF of drone parcel delivery services can enhance consumer familiarity and knowledge with these services and greater acceptance of this technology. Consequently, the acceptance of the technology will enhance its USF and lead to a positive attitude towards adopting drone parcel delivery services.

**Hypothesis 2.** (H2): Perceived technology characteristics of drone services positively influence the perceived usefulness of drone delivery services.

Furthermore, tuning the acceptance of task technology influences the USF by consumers of adopting drones in parcel delivery services. The USF of using drone parcel delivery technology by consumers tends to increase when there is a fit between consumer needs and the characteristics of drone delivery technology. This is due to the fact that this articulation allows it to be perceived by consumers as being more efficient and effective and to be a useful assistant in consumer tasks (Koh et al., 2023). Thus, utility to consumers tends to be greater when the task characteristics (TAC) provided by the technology meet their delivery needs. According to Park et al. (2019) with the adoption of multimedia technology, for example, concluded that the task-technology adjustment would positively influence its USF.

**Hypothesis 3.** (H3): Perceived task characteristics of drone services positively influence the perceived usefulness of drone delivery services.

It has been shown that the USF of consumers in adopting drone delivery services is one of the main predictors of consumers' intention to adopt this service (Leon et al., 2023). The usefulness perceived by consumers in the adoption of drone delivery services is influenced by the acceptance of the technology, which in turn depends on the characteristics and adjustment of the same tasks to the needs (Waris et al., 2022). The acceptance of drone technology for parcel delivery services will translate into practice in the attitudes and intentions of consumers to adopt this service. Several studies have demonstrated a positive relationship between the USF of consumers in adopting drone delivery services and the attitude and intention to adopt these services. By way of example, Hwang et al. (2019) who explored the impact of USF on drone food delivery services in Korea based on the TAM framework and the Theory of Planned Behavior. Also, Mathew et al. (2021) contemplated in their study USF as an antecedent of consumers' attitudes towards food delivery by drones in India in the context of TAM. Yaprak et al. (2021)

studied the impact of Covid on changing parcel delivery methods, with USF being used as an influencer on the attitude and intention of Turkish consumers to adopt drone delivery services. Yoo et al. (2018) who carried out a study for the US on the factors that affect the attitude and public intention of adopting drones, with USF being used as an antecedent. Marketing managers play a critical role in promoting the benefits of drone delivery services. In this sense, this topic could initiate some research into understanding the socially responsible and sustainable benefits of global marketing initiatives.

**Hypothesis 4.** (H4): The perceived usefulness of drone delivery services positively influences a) consumers' attitude towards adopting drone delivery services and b) the intention to adopt this type of service in the future when mediated by consumers' attitude.

Fig. 1 contains the research model and hypotheses.

## 3. Methods

### 3.1. Sample

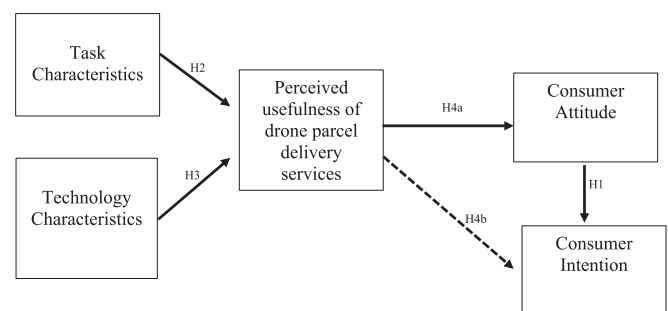
Data for this study were collected through an online questionnaire made available between January and April 2023. The target audience was the Portuguese population over 18 years old. All participants were informed of the purpose of the study, and their informed consent was obtained. A pre-test was carried out in which 15 Portuguese citizens participated to assess their understanding of the responses and the response time to the questionnaire.

1108 valid responses were obtained. The responses were collected for convenience, a non-probabilistic technique since the questionnaire link was shared with the authors' contacts and social networks. Considering that the Portuguese population over 18 years old in 2021 amounted to 8.512 million inhabitants (Prodata, 2021) and a margin of error of 3 %, we needed to collect at least 1.067 responses for the sample to be representative. Although the sample is large, it is not representative of Portuguese citizens.

In terms of characterization of the participants that make up the sample (Table 1), the majority are women (61.4 %), and the average age of the participants is 32.1 years (minimum of 18 years and maximum of 78 years). Regarding academic qualifications, 42.9 % of participants have at most completed secondary education, 42.2 % have a degree, and the remaining master's (13.4 %) and doctorate (1.4 %). As for professional occupation, 44.8 % are employees, 28.4 % are students, 11.6 % are student-workers, 9.7 % are self-employed, and the rest (5.5 %) are unemployed and retired. In terms of average monthly income, 44.9 % earn between €761 and €1500; 18.8 % earn up to €760, and 19.9 % earn more than €1501 a month. 22.4 % have no monthly income, corresponding to almost the entire student population.

### 3.2. Measures of constructs

The applied questionnaire was adapted from Cai et al. (2021), Manis



**Fig. 1.** Research model.

Note: Direct Effect (→); Indirect Effect (↔).

**Table 1**  
Socio-demographic characterization of the participants.

	Frequency (%)
Gender	
Male	38.3
Female	61.4
Others	0.3
Age	
Between 18 and 24 years	24.8
Between 25 and 34 years	39.7
Between 35 and 44 years	12.1
Between 45 and 55 years	14.3
> 56 years	9.1
Education	
Primary education	0.4
Secondary education	42.9
Tertiary education	56.7
Professional Occupation	
Students	28.4
Students-Workers	11.6
Employees	44.8
Self-Employees	9.7
Net Monthly Income	
0 euros	22.4
Between 1 and 760 euros	18.8
Between 761 and 850 euros	14.6
Between 851 and 1.000 euros	14.4
> 1.001 euros	29.8

and Choi (2019), Wang et al. (2021), Zhou et al. (2010), and Koh et al. (2023). This questionnaire was structured in six sections (Table 2): i) perceived usefulness (USF) with five questions; ii) task characteristics (TAC) with five questions; iii) technology characteristics (TECH) with five questions; iv) consumer attitude towards the adoption of drone delivery services (ATT) with five questions; v) consumers' intention regarding the adoption of drone delivery (CI) services with six questions and vi) general sociodemographic characterization of the participants. All questions were measured on a five-point Likert scale, ranging from 1 – strongly disagree to 5 – strongly agree.

### 3.3. Data analysis methodology

In this study, a quantitative methodology was implemented. Initially, a statistical description of the variables included in the research model and the indicators that measure them was carried out using the SPSS software (v.25). Then, in the same software, a factor analysis was performed, and an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) were implemented. EFA was performed with varimax-rotated factor matrices to divide the indicators of latent variables by factors, and CFA aimed to confirm the reflective nature of the model. Then, to test the relationships established in the research model, the Partial Least Square (PLS) method was applied using the Smart PLS (3.0) software. The PLS method is suitable for the purpose of the study since it combines factor analysis with regression estimation (Ringle, 2019). Furthermore, the application of this method does not require data normality. As the study data were collected through questionnaires, their normality was tested, and the kurtosis and skewness statistics were calculated. The results of these tests confirmed that our study data do not have a normal distribution. The model obtained after implementing the logarithm of the PLS method was validated in terms of reliability,

**Table 2**  
Constructs and items description.

Perceived Usefulness (USF)
USF1 - I would find drone delivery services useful in my daily life.
USF2 - I believe that using drone delivery services would increase my productivity.
USF3 - I believe that using drone delivery services would improve my efficiency.
USF4 - I believe that using drone delivery services could help me to maintain a normal life.
USF5 - I believe that using drone delivery services could satisfy my excitement when trying something
Task Characteristics (TAC)
TAC1 - I wish to receive my parcels without having direct contact with delivery personnel.
TAC2 - I wish to avoid unnecessary social contact in my daily activities, including receiving parcels.
TAC3 - I wish to receive parcels while staying at home as much as possible.
TAC4 I wish to know my parcel's location in real time.
TAC5 - I wish to be able to pick up my parcel at any place and time.
Technology Characteristics (TECH)
TECHC1 - Drone delivery technology helps me avoid unnecessary human contact.
TECHC2 - Drone delivery technology helps me to comply with safe management measures.
TECHC3 - Drone delivery technology enables me to stay at home as much as possible.
TECHC4 - Drone delivery technology can provide real-time delivery information.
TECHC5 Drone delivery technology can allow me to receive my parcel at any place and time.
Consumer Attitude (ATT)
ATD1 - I feel that O would like drones as a delivery method
ATD2 - I would be glad to be offered the option of using drone delivery.
ATD3 - I think that using drone delivery technology would be a good idea.
ATD4 - I think that using drone delivery technology to receive parcels would be a wise idea.
ATD5 - I have positive feelings towards engaging drone delivery technology as part of my delivery
Consumer Intention (CI)
CI1 - I intend to use drone delivery services to obtain my parcel in the future
CI2 - I would try to use drone delivery services in the future even if it could be tough.
CI3. Given the resources, I predict I would use drone delivery
CI4 - I am willing to pay for drone delivery.
CI5 - I believe I would recommend others to use drone delivery.
CI6 - I believe it would be likely for me to use drone delivery frequently.

convergence, and discriminant validity using the measures proposed by Hair et al. (2019): (i) Cronbach's Alpha ( $C\alpha > 0.70$ ); (ii) composite reliability ( $CR > 0.70$ ); (iii) Average Variance Extracted ( $AVE > 0.50$ ) and (iv) discriminant validity tested by the Fornell-Larcker criterion. Finally, a bootstrap analysis was implemented in Smart PLS (3.0) to test the hypotheses formulated in the research model.

## 4. Results

### 4.1. Statistical analysis of variables and indicators

Table 3 contains the statistical analysis (mean and standard deviation) of the constructs that appear in the research model and the indicators that measure them.

On average, the construct in the research model that generated the most agreement by the participants was TECH ( $M = 3.78$ ), with the most valued issues being the possibility of having access to real-time information about the order ( $M = 4.04$ ) and security management related to parcel deliveries ( $M = 3.98$ ). The construct that generated the lowest agreement was CI ( $M = 2.98$ ), with the lowest agreement regarding the willingness to pay for the drone delivery service ( $M = 2.68$ ) and the frequent intention to use these services ( $M = 2.95$  contributing to this.). Regarding USF ( $M = 3.17$ ), participants' greater agreement on the use of drone delivery services to maintain daily routines ( $M = 3.75$ ) stands out. In the TAC ( $M = 3.59$ ), the most valued questions were the possibility of knowing the location of the parcel in real-time ( $M = 4.37$ ) and picking up the parcel at any time and place ( $M = 4.21$ ). In the ATT construct ( $M = 3.27$ ), participants mostly agreed with the idea of using drone technology ( $M = 3.34$ ) and that it is a good idea to use it for delivering parcels ( $M = 3.32$ ).

### 4.2. Factor analysis

Table 4 shows the factor analysis results (EFA and CFA) for the constructs and indicators that measure them. Implementing the EFA

**Table 3**  
Descriptive statistics of constructs and indicators.

	Mean	Std. Deviation
Perceived Usefulness (USF)	<b>3.17</b>	<b>1.195</b>
USF1	3.14	1.178
USF2	2.85	1.225
USF3	2.88	1.224
USF4	3.75	1.115
USF5	3.23	1.231
Task Characteristics (TAC)	<b>3.59</b>	<b>1.120</b>
TAC1	3.07	1.205
TAC2	2.91	1.295
TAC3	3.41	1.21
TAC4	4.37	0.906
TAC5	4.21	0.986
Technology Characteristics (TECH)	<b>3.78</b>	<b>1.109</b>
TEHC1	3.57	1.196
TEHC2	3.98	1.055
TEHC3	3.37	1.207
TEHC4	4.04	1.006
TEHC5	3.95	1.08
Consumer Attitude (ATT)	<b>3.27</b>	<b>1.195</b>
ATD1	3.16	1.206
ATD2	3.30	1.192
ATD3	3.34	1.193
ATD4	3.32	1.198
ATD5	3.22	1.187
Consumer Intention (CI)	<b>2.98</b>	<b>1.238</b>
CI1	3.09	1.231
CI2	2.98	1.236
CI3	3.12	1.203
CI4	2.68	1.266
CI5	3.03	1.216
CI6	2.95	1.273

resulted in five factors referring to each of the constructs (ESF, TAC, TECH, ATT, and CI). No bookmarks or items have been deleted. The five factors have a cumulative variance of 72.34 %, with none of the factors explaining more than 50 % of the variance. Regarding the CFA implementation, all indicators or items have high factor loads ( $> 0.70$ ), confirming the reflective nature of the model obtained after applying the PLS method.

### 4.3. Reliability, convergence, and discriminant validity of the PLS model

The model obtained after applying the PLS method processed in SmartPLS 3.0 was validated in terms of reliability, convergence, and discriminant validity (Table 5). The model is reliable and convergent since the results for Cronbach's Alpha, composite reliability, and Average Variance Extracted are higher than the reference values suggested by Hair et al. (2019), that is,  $C\alpha > 0.70$ ;  $CR > 0.70$  and  $AVE > 0.50$ . There was also discriminant validity between the constructs and the items measured according to the Fornell-Larcker criterion (AVE square in bold in Table 5). Additionally, the model presents a good fit according to the following measures calculated in SPSS: i) the Goodness-of-Fit Index (GFI) (0.956; reference value  $> 0.90$ ); ii) Comparative Fit Index (CFI) (0.935; reference value  $> 0.90$ ); iii) Incremental Fit Index (IFI) (0.908; reference value  $> 0.90$ ) and iv) Root Mean Square Approximation Error (RMSEA) (0.074; reference value  $< 0.08$ ).

### 4.4. Hypothesis tests of the research model

The results of the tests of the relationships established (direct and indirect) in the research model after implementing the bootstrapping analysis in Smart PLS 3.0 are described in Table 6.

The results demonstrate that consumers' attitude towards the drone parcel delivery service positively influences CI to adopt this service ( $\beta = 0.878$ ), confirming H1. The TECH and TAC of drones positively influence the USF of the drone delivery service ( $\beta = 0.354$  and  $\beta = 0.393$ ), confirming H2 and H3. The USF of the drone delivery service positively and significantly influences consumers' attitudes towards the drone delivery service ( $\beta = 0.756$ ), confirming H4a. Finally, when mediated by consumers' attitudes, the USF of the drone delivery service positively influences CI to adopt this service ( $\beta = 0.663$ ), confirming H4b.

## 5. Discussion of results and implications

### 5.1. Discussion of results

The potential of implementing drone delivery services has proven challenging for consumers and retailers. The results of the study demonstrate that the attitude and intention to adopt drone delivery services are positively related to the acceptance of the technology, which depends on the USF of consumers regarding the technological and TAC of these services, corroborating studies by Koh et al. (2023) and Hwang et al. (2019). In this way, consumers' USF of adopting drone delivery services is an important predictor of consumers' attitudes towards adopting these services and their intention to use them in the future (Mathew et al., 2021). Higher levels of USF of drone technology for parcel delivery positively influence adopting these services (Yoo et al. (2018). Understanding the attitudes and intentions of adopting these innovative technological services for new ways of delivering orders paves the way for marketers to create conditions to establish deeper and more intense relationships with customers (Hung & Lu, 2018). In addition, the results demonstrate that consumers' attitude towards the drone parcel delivery service positively influences CI to adopt this service, as found by (Waris et al., 2022). In this way, when consumers perceive the USF of these services, they tend to adopt attitudes accordingly that can enhance feelings about this innovative technological service, generating deeper feelings of satisfaction about the efficiency and quality of the service (Ramadan et al., 2017; Rodrigues et al.,

**Table 4**  
Results of factor analysis (EFA and CFA).

Set of items	Factors					Communality	Confirmatory factor loads
	1	2	3	4	5		
	USF	TAC	TECH	ATT	CI		
<b>Perceived Usefulness (USF)</b>							
USF1	0,739					0,743	0.850
USF2	0,786					0,714	0.889
USF3	0,702					0,726	0.891
USF4	0,888					0,759	0.729
USF5	0,703					0,712	0.829
<b>Task Characteristics (TAC)</b>							
TAC1		0,725				0,786	0.853
TAC2		0,780				0,702	0.825
TAC3		0,744				0,766	0.736
TAC4		0,819				0,766	0.713
TAC5		0,893				0,751	0.795
<b>Technology Characteristics (TECH)</b>							
TECHC1			0,756			0,755	0.771
TECHC2			0,797			0,725	0.840
TECHC3			0,845			0,875	0.780
TECHC4			0,792			0,718	0.825
TECHC5			0,752			0,771	0.817
<b>Consumer Attitude (ATT)</b>							
ATT1				0,838		0,806	0.925
ATT2				0,839		0,816	0.934
ATT3				0,863		0,848	0.953
ATT4				0,855		0,842	0.945
ATT5				0,845		0,814	0.924
<b>Consumer Intention (CI)</b>							
CI1					0,877	0,86	0.924
CI2					0,780	0,785	0.865
CI3					0,864	0,845	0.939
CI4					0,723	0,732	0.811
CI5					0,860	0,824	0.933
CI6					0,849	0,813	0.927

**Table 5**  
Results of reliability, Convergence, and discriminant measurements.

	α	CR	AVE	USF	TAC	TECH	ATT	CI
USF	0.894	0.922	0.705	<b>0.840</b>				
TAC	0.740	0.820	0.586	0.614	<b>0.766</b>			
TECH	0.846	0.891	0.623	0.600	0.625	<b>0.789</b>		
ATT	0.965	0.973	0.877	0.756	0.568	0.555	<b>0.937</b>	
CI	0.953	0.963	0.812	0.778	0.578	0.499	0.678	<b>0.901</b>

**Table 6**  
Hypothesis test results.

Effects on Endogenous Variable	Path (β)	t Value (Bootstrap)	Confidence Interval	
			2.5 %	97.5 %
H1: ATT → CI	0.878	84.592*	0.857	0.897
H2: TECH → USF	0.354	10.652*	0.291	0.420
H3: TAC → USF	0.393	11.105*	0.322	0.462
H4a: USF → ATT	0.756	51.391*	0.726	0.786
H4b: USF → ATT → CI	0.663	37.020*	0.628	0.700

Note:  $p < 0.001$ .

2023). When mediated by ATT, the USF of the drone delivery service positively influences CI to adopt this service. According to Chen et al. (2022), the USF of this service should be disclosed by companies, namely on social networks, to create greater public awareness and, as such, a greater willingness to adopt these services. On the other hand, companies, in addition to creating new ways of satisfying their customers, realize that providing drone delivery services brings benefits to their business models, such as cost reduction, optimization of logistical routes, reduction of customer response times and can even boost more sales (Mathew et al., 2021).

Drone delivery services are not yet geographically widespread, an innovative concept in emerging economies. Adopting drone delivery services can be a source of competitive advantages for companies, and companies that are more proactive in implementing these services will tend to differentiate themselves from the rest. To this end, companies must promote the acceptance of drone technology by demonstrating its benefits and potential (Chen et al., 2022). In this case, marketing managers can play a crucial role by highlighting the usefulness of these services to influence consumers' attitudes and intentions.

Introducing drone parcel delivery services can improve the logistics process by making it more efficient and effective. In addition, it can promote a greater emotional connection between consumers and brands, creating loyalty (Rodrigues et al., 2023). Additionally, they can make consumers want to repeat, boosting repurchase intention and positive word of mouth (Ramadan et al., 2017; Rodrigues et al., 2023).

Based on the literature review and the results obtained in this study, we propose, in Fig. 2, a model of consumer acceptance of parcel delivery services using drone technology.

Consumers' permeability to parcel delivery services by drones begins with the acceptance of the delivery technology itself, that is, drones. For consumers to accept drone technology, they must evaluate it in terms technology and TAC. Consumers' acceptance of drone technology translates into a message of acceptance that will materialize in the USF

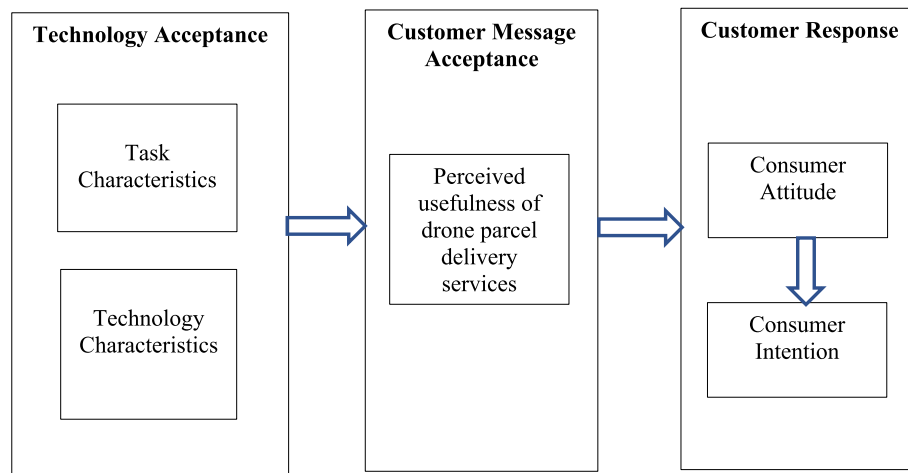


Fig. 2. Consumer acceptance model of delivery services by drone technology.

they attribute to drone delivery services. Consequently, consumers' acceptance of this message will influence their response through their attitude and intention to behave in relation to adopting this type of parcel delivery service.

### 5.2. Theoretical implications

This paper provides theoretical insights into drone delivery services and TAM. First, consumers' attitudes towards adopting drone delivery services are crucial in deciding whether or not to adopt such services in the future. Therefore, if consumers have a positive attitude towards drone delivery services, they will be more likely to adopt them. The study findings support this claim by demonstrating a significant positive correlation between consumers' favorable attitudes and their intention to adopt drone delivery services. Consumers who expressed positive views on the convenience and innovative nature of drone deliveries were consistently more likely to indicate a high intention to use such services in the future (Hwang et al., 2021; Silva et al., 2023), confirming that attitude is a key factor in adoption.

Second, the USF of drone delivery services is positively influenced by customers' perceptions of its technical features and specific tasks. This means that the speed, accuracy, and efficiency of drones are deemed crucial by consumers in determining the service's value. In addition, the capability of drones to perform particular tasks, like safe and fast package delivery, is also viewed by customers as a determining factor for its usefulness. As such, leveraging these characteristics can effectively enhance consumers' perceived value of drone delivery services. The findings align with this aspect of the theory, showing that USF is indeed driven by attributes like speed and precision (Li et al., 2023; Song et al., 2023). The consumers indicated that these technical features were essential to their perception of drones as a valuable delivery option. This result highlights the importance of technical capabilities in shaping consumer views on usefulness and, by extension, the potential adoption of drone delivery.

Third, if drone delivery services are deemed advantageous, then consumers will probably hold a positive adoption stance and have a higher future intention towards this service. Therefore, the USF of drone delivery services coincides with consumers' attitudes and intent to adopt them. This means that efforts to improve this perception may also significantly impact future customer intentions to use these services. The study results support this relationship, as they indicate that consumers who perceive drone deliveries as advantageous not only have more positive attitudes towards the technology but also report stronger intentions to adopt it in the future. This finding validates the theoretical link between usefulness and adoption intentions. However, consumers have certain reservations, such as privacy and safety concerns, which

suggests that usefulness alone may not fully capture the range of factors influencing adoption (Aydin, 2019; Luppacini & So, 2016; Merkert & Bushell, 2020). This insight implies that while usefulness is critical, additional considerations may need to be addressed to maximize adoption intent.

Finally, these insights are relevant for researchers and practitioners who intend to adopt this new emerging drone-based technology successfully. Valuable insights on key variables were provided, with ATT, perceived technological features and TAC of drone services, and USF of these services playing important roles in the adoption and intention to adopt drone delivery services in the future. Overall, the study findings underscore the importance of ATT, TAC, and USF in influencing consumer adoption, enhancing the TAM model's practical application in predicting and driving consumer adoption of drone delivery services.

### 5.3. Practical implications

The results of this study bring practical insights for policymakers and companies. The practical insights pertain to 1) policy and regulatory frameworks; 2) technological advancement and innovation; 3) communication and education; 4) task customization and adaptability; 5) collaboration and partnerships; 6) user experience and feedback; 7) affordability and accessibility.

Regarding policy and regulatory frameworks, policymakers should develop clear and supportive regulations that address drone delivery services' specific technological and operational characteristics. These regulations should prioritize safety, privacy, and security while at the same time promoting innovation and flexibility. By creating an enabling policy environment, policymakers can encourage businesses to invest in drone delivery services and promote a positive attitude among consumers.

In terms of technological advancement and innovation, to make their mark with drone delivery services, companies need to prioritize enhancing different technological aspects continuously. Improving drone efficiency, safety features, reliability, and testing out advances like obstacle avoidance, autonomous navigation, and real-time tracking are vital components. By staying on the cutting edge of technological development, businesses can foster positive impressions of their services and elevate their perceived worth for consumers.

For communication and education, policymakers and companies can team up to promote drone delivery services through comprehensive communication and education campaigns that tackle misconceptions, highlight efficiency and sustainability benefits, and transparently explain safety measures and regulations. By doing so, they can positively influence ATT towards the usefulness of drones for communication and education.

As for task customization and adaptability, companies should prioritize tailoring their drone delivery services to cater to consumers' varied demands and desires. This involves providing versatile delivery alternatives, accommodating unique package specifications, and ensuring smooth integration with established transportation systems. By aligning the task attributes of drone services with consumer anticipations, companies have the potential to boost perceived practicality and generate consumer enthusiasm.

Through policymakers' support, partnerships and collaborations can be advanced between drone delivery firms, research institutions, and other relevant groups. These partnerships can enable the exchange of knowledge, drive the development of new initiatives, and fortify the enforcement of best practices. By tapping into shared expertise, drone delivery companies can refine technological advancements and expand their area of operation, leading to increased usefulness and wider acceptance.

As for user experience and feedback, companies should prioritize user experience and actively seek feedback from consumers who have used or are willing to use drone delivery services. This feedback can provide valuable insights into consumer preferences, concerns, and areas for improvement. Incorporating user feedback into the service design and implementation processes can improve the overall user experience, positively influence attitudes and drive future adoption.

Finally, concerning affordability and accessibility, policymakers and businesses should work together to ensure the affordability and accessibility of drone delivery services. This can be achieved by exploring cost-effective operating models, encouraging adoption through subsidies or tax incentives, and fostering healthy competition in the market. Ensuring affordability will increase consumers' perception of utility and positively influence adoption rates.

#### 5.4. Limitations of the study and future lines of research

Although the sample is composed of responses from a large number of participant, the sample was not collected due to convenience and is not representative of Portuguese citizens over 18 years of age. Furthermore, the majority are women, and as such, in future studies, we should consider a more representative sample of both genders and almost a quarter of the sample has no monthly income because they are students and are limited in purchasing power. For future studies, it is imperative to use probabilistic techniques to collect the sample. This approach will ensure that the study results can be generalized to a larger population, enhancing the validity and reliability of our research. This could have consequences for the adoption and acceptance of parcel delivery services, as this type of participant tends to have less financial availability for consumption. It would be interesting to introduce the socio-demographic characteristics (gender, age, income, and education) of the participants as moderating variables in the research model, with the aim of assessing their influence on the attitude and intention of consumers to adopt drone delivery services. In addition, the participants' personality traits, such as a propensity for risk and the big five (openness, conscientiousness, extraversion, agreeableness, and neuroticism), characteristics that can influence the acceptance of drone technology (Lu et al., 2019; Svendsen et al., 2013).

The questionnaire was adapted from Cai et al. (2021), Manis and Choi (2019), Wang et al. (2021), Zhou et al. (2010), Koh et al. (2023), and as such, the introduction of different indicators to measure the constructs contained in the research model may lead to different results. In addition, other constructs related to technology acceptance can be added to the research model, such as perceived safety, trust, and perceived privacy. Furthermore, other attributes could have been considered to characterize the drone delivery service, such as reliability and ease of use. Having said that, from the consumers' perspective, it would be interesting for future studies to answer the following research questions: 1) How does the perception of safety influence consumers' intention to use drone delivery services? 2) How does the frequency of

news about drone accidents or incidents impact consumers' perception of safety? 3) To what extent does trust in the delivery service provider affect the acceptance of drones as a means of delivery? 4) What are the factors that most contribute to consumer confidence in using drone services, and how do these factors vary by age group, gender, or region? 5) What technological features are most valued by consumers to guarantee their privacy when using drones? 6) How does the perceived reliability of drones as a delivery method affect customer satisfaction? 7) To what extent do consumers associate the accuracy of the delivery time with the reliability of the drone service? From the companies' perspective, it would be interesting for future studies to answer the following research questions: 1) What strategies could companies adopt to increase the safety of drones and, thus, consumer confidence?; 2) What communication measures could be effective in conveying confidence and reliability in drone delivery services? 3) What practices could companies implement to protect consumer privacy and thus improve acceptance of drones? 4) What metrics could companies use to assess the reliability of drone services compared to traditional delivery methods? 5) What are the main usability challenges faced by companies when implementing drone delivery systems?

In Portugal, the drone delivery service is not yet implemented. It would be interesting to test the research model on a sample of participants who already use this service and assess their differences. Finally, USF has been shown to be a significant consequence of acceptance of drone technology and a significant antecedent of consumers' attitudes and intentions to adopt drone parcel delivery services. In this way, in future studies, the role that retailers can play in consumers' USF of using drone delivery services can be assessed to outline marketing strategies to promote this delivery service.

## 6. Conclusion

Innovations have been revolutionizing business operations, particularly optimizing distribution through the rise of drone delivery services. Drone delivery services can allow faster and more efficient, reducing costs and enhancing customer satisfaction. As businesses adapt to this transformative trend, exploring new models and strategies becomes crucial to harnessing the full potential of drone delivery services and staying competitive in the evolving market. This paper explores the influence of technology acceptance on the USF of drone delivery services and CI to adopt them, considering their attitude.

Based on the results obtained in this research, it is concluded that adopting drone delivery services is directly related to ATT and perceptions of these services' technological and TAC. The USF of these services is a crucial factor for ATT towards adopting drone delivery services and their intention to use them in the future. Consumers are increasingly open to adopting drone delivery services, provided they perceive their usefulness. Furthermore, this research indicates that consumers' attitudes towards adopting drone delivery services are influenced by their perceptions of these services' technological and task features.

These conclusions are relevant on an international scale, as they provide insights that can guide businesses and policymakers in different regions looking to implement or regulate drone delivery services. Understanding the relationship between ATT and USF allows companies to tailor their marketing and service design to meet the specific needs and expectations of diverse consumer bases across various cultural and geographical contexts. Additionally, as countries worldwide explore the integration of drone technology into logistics and delivery systems, these findings can inform the development of educational and regulatory frameworks that address consumer concerns about safety, privacy, and service reliability. This research highlights the importance of aligning technological advancements with consumer perceptions, ensuring that drone delivery services can be effectively adopted globally, ultimately contributing to the efficiency and sustainability of supply chains. This manuscript presents some research paths for future research, namely in the reflection that is proposed on the importance of

the use of drones in services and in the socially responsible stance of organizations (for example, promoting sustainable attitudes, efficiency in distribution, access for people with reduced mobility or physical disabilities). This research may, in the future, develop complementary approaches from the perspective of consumer behavior and service management (in different contexts, in different sectors and in specific geographical characteristics).

### CRedit authorship contribution statement

**Sofia Gomes:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology. **João M. Lopes:** Writing – review & editing, Writing – original draft, Visualization, Resources, Investigation, Conceptualization. **Bruno Barbosa Sousa:** Writing – review & editing, Writing – original draft.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Data availability

Data will be made available on request.

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