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Attitudes towards Urban Air Mobility for E-Commerce Deliveries: An Exploratory Survey Comparing European Regions

André Teixeira Silva [1,2,*], Sérgio Pedro Duarte [3], Sandra Melo [1], Adriana Witkowska-Konieczny [4], Michele Giannuzzi [5,6] and António Lobo [3]

1 CEiiA—Centro de Engenharia e Desenvolvimento, 4450-017 Porto, Portugal
2 Departamento de Engenharia e Gestão Industrial, Faculdade de Engenharia da Universidade do Porto, 4405-614 Porto, Portugal
3 CITTA—Centro de Investigação do Território, Transportes e Ambiente, Faculdade de Engenharia da Universidade do Porto, 4405-614 Porto, Portugal
4 Gornosląsko-Zagłębiowska Metropolia, 40-053 Katowice, Poland
5 Distretto Tecnologico Aerospaziale S.C. a r.l., 72100 Brindisi, Italy
6 Department of Innovation Engineering, Campus Ecotekne, Università del Salento, 73047 Monteroni di Lecce, Italy
* Correspondence: andre.tsilva@ceiia.com

Abstract: This study explores attitudes towards urban air mobility (UAM) for e-commerce deliveries. UAM, which utilizes drones, has the potential to revolutionize transport services and logistics, leading to economic benefits and reductions in congestion and pollution. However, public acceptance is crucial for a successful implementation; thus, understanding the people's perspective is key. Descriptive statistics were employed to evaluate survey results from three different European regions, followed by a cluster analysis to define potential user profiles. This study revealed slightly different perceptions towards UAM between the analyzed regions, but also a generally positive attitude. The most important expected identified benefits from UAM were a decrease in congestion and pollution in city centers. High-acceptance segments are gender-balanced and correspond mostly to active population and frequent online shoppers that perceive value in drone deliveries, especially related to an increased convenience and speed. They support public investment in UAM and are willing to pay more for these services and to have their home flown over. Opposite attitudes were expressed by low-acceptance segments, which are female-dominated and include mostly non-frequent online shoppers. The identified user profiles in this study can support the development of public policy and marketing strategies to increase acceptance and adoption.

Keywords: urban air mobility; drones; e-commerce delivery; acceptance; cluster analysis

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1. Introduction

Recent years have shown that urban air mobility (UAM) has the potential to become the next big thing in transportation. UAM is made possible with the use of unmanned aerial vehicles (UAVs), commonly known as drones, and aims at developing air transport services to enable efficient and ground-breaking travel connections between and within cities, suburbs, rural areas, and hard-to-access regions. Previously a military-only privilege, these capabilities are now rapidly being used in civic spheres. Thus, drones can now be used for various purposes, including passenger transportation, innovative logistics, surveillance operations, and many more [1].

The topic of UAM has been gathering much attention, due to its great potential for innovative solutions and the disruptive nature of the concept itself. There is potential for great economic benefits, more efficient air travel, increased safety, and reduced congestion and pollution [2,3]. The increasing prevalence of e-commerce has also led to a greater

demand for cost-effective and sustainable delivery options, which in turn requires logistics operators to develop more complex and diverse solutions to meet this demand [4].

The adoption of UAM as a part of everyday life is a highly complex subject as it concerns technical, regulatory, and infrastructural issues. Still, one of the main barriers to a successful implementation is public acceptance, that being one of the main topics currently being discussed [5]. Kellermann et al. [1] point out that, even though the public is a central stakeholder in the development of this field, the people's perspective on UAM has played a minor role so far, therefore suggesting that the potential of drone technology can only unfold if it benefits society and leaves the academic circles of discussion.

Overall, there are many studies focused on understanding public perceptions towards new technologies, thus identifying the most important factors towards acceptance and adoption. However, there is a lack of studies on the value perception regarding UAM, with most research about mobility technology acceptance focusing on autonomous ground-based vehicles [6–8]. Without a significant emphasis on UAM acceptance and understanding the main factors that play a role in it, UAM might be doomed to fail, no matter how revolutionary the technology and the services it enables are.

This paper aims to research people's attitudes towards the use of drones for e-commerce deliveries by analyzing non-expert opinions of potential users and their online shopping habits. The research is supported by a survey that explores the connections between societal acceptance, technology, and integration of UAM into the urban logistics ecosystem. The study comprises a cluster analysis to identify potential users' profiles and their tendency to accept UAM in addition to the identification of the most relevant as expected benefits. We hypothesize that there are diverse potential user segments and that regional habits and cultures can motivate differentiated actions to ensure a successful implementation of UAM for e-commerce deliveries across different regions. With this view, we aim to contribute to the existing literature on UAM by providing insights for policy-makers and service designers, supporting informed decision-making in the development of UAM-based services and targeting specific markets and segments. Understanding and catering to these segments is crucial for driving the acceptance and adoption of UAM. Tailoring strategies and offerings based on attitudes within distinct user segments and regional contexts increases the likelihood of successful implementation and enhances the overall user experience, contributing to the long-term sustainability and growth of the UAM industry. To ensure success in the current environment, UAM technology and innovation must adhere to the prevailing trend of *servitization* and embrace comprehensive service integration, incorporating elements of service design. Failing to do so poses a significant risk, as solely focusing on technological advancements without building a robust service infrastructure around it can lead to failure in meeting the evolving demands and expectations of users and stakeholders [5,9].

The paper is structured as follows: the introduction is followed by a literature overview about the analysis of behaviors and attitudes towards new technology, in particular UAM, as well as the gaps and motivations for this study. Next, the survey conducted in three European regions is described, followed by the cluster analysis and discussion of potential users' profiles. The paper concludes with key takeaways and considerations for future research.

2. Literature Review

Statistical methods such as cluster analysis, structural equation modelling (SEM), binary logit models, and ordinary least squares regression are invaluable for modelling behaviors, attitudes, and market segmentation. These techniques provide a systematic approach to uncovering relationships, identifying segments, and understanding decision-making factors. By leveraging these methods, it is possible to gain valuable insights into user behaviors, attitudes, and intentions, enabling targeted strategies and interventions. In this sense, statistical approaches are crucial for analyzing and interpreting data, increasing the knowledge of human behavior, supporting decision-making processes in various contexts, and contributing to the validity of the methods themselves.

Cluster analysis has been widely employed for market segmentation, for instance in the tourism sector. Duncan et al. [10], used factor analysis and k-means clustering to identify groups of casual dining restaurant patrons to enable businesses to enhance the efficiency and effectiveness of their marketing efforts. In an application to the hospitality industry, Crawford-Welch [11] advocated for the adoption of multivariate techniques, and specifically cluster analysis, over descriptive methods to achieve a more comprehensive knowledge of marketing segments. Perri et al. [12] utilized SEM to gain insights into the adoption of innovation in the energy sector, particularly regarding the attitudes towards smart grids.

In the context of urban logistics, Le and Ukkusuri [13] developed an integrated model using statistical methods. They employed a binary logit model to examine factors influencing willingness to work and an ordinary least squares regression model to understand the factors affecting travel time decisions of potential workers in crowd-shipping. Their approach showcased the effectiveness of statistical methods in analyzing these factors. Giglio and De Maio [14] also applied statistical methods based on innovation diffusion theory to investigate the determinants affecting adoption intention in crowd-shipping for last-mile delivery. Through structural equation modelling, the authors identified five key determinants and demonstrated the value of these methods in understanding adoption behaviors. Similarly, Yuen et al. [15], also grounded in innovation diffusion theory, used confirmatory factor analysis and hierarchical regression to examine factors influencing user intention to use self-collection services.

The application of drones in logistics presents a transformative opportunity for various industries, streamlining the transportation of goods and providing humanitarian aid and emergency medical care, such as the efficient delivery of medical supplies to remote areas with inadequate road infrastructure [16–20]. Driven by innovation, the potential applications of drones continue to expand, while still sharing the common ambition of developing autonomous flight systems to reduce costs, time, labor, and complexity of operations. Those include, among many, agricultural usages [21], structural inspection [22], people transport [23,24], and package delivery [1].

Most literature on UAM includes studies (i) focusing on the technical side of VTOL (Vertical Take-Off and Landing) vehicles, (ii) investigating how to incorporate drones into air traffic management (ATM), (iii) investigating users' perceptions and potential demand for UAM, and (iv) considering various types of services, such as urban logistics, airport shuttles, and other types of urban applications. In this section, we make brief considerations about the current literature on the last two topics.

In a literature review study, Bauranov and Rakas [25] provided recommendations for further research in UAM, including risk analysis, data management, co-creation of new technologies, psychoacoustic effects of drone noise on humans, and the impact of ground infrastructure on urban planning. Sah et al. [26] utilized Fuzzy Delphi Method (FDM) and the Analytic Hierarchy Process (AHP) to identify and prioritize the barriers to the implementation of drone logistics based on their level of criticality. They found that regulations and threats to privacy and security are the most critical barriers to implementing drones in the logistics sector. Other barriers include public perception/psychological effects, environmental issues, economic aspects, and technical issues. In relation to technical issues, Straubinger et al. [5] reviewed the main aspects to be addressed, namely concerning vehicle design, infrastructure requirements, and integration of UAM on multimodal transport modelling. The authors also pointed out the need for robust business cases and regulations for an acceptable deployment.

Social-demographic indicators such as gender, age, income, and education impact individuals' perspectives on UAM [27–32], and urban residents are more likely to participate in UAM compared to those in rural areas [29]. This is consistent with the analysis of Sabino et al. [27] that identified the main factors that influence public opinion on the usage of drones: age, gender, geographical location, technological expertise, type of drone mission, and familiarity with the technology. Fully employed and high-income individuals

show greater interest and positive perceptions of UAM. However, women exhibit less immediate adoption interest, lower trust and perceived usefulness of automation, and higher security and safety concerns [30,31].

People's openness to having their homes flown over by drones is generally positive, albeit with variations based on specific factors. The purpose of the drone flight and the time of day play a significant role in shaping individuals' acceptance levels. For instance, drones used for recreational or leisure purposes during the daytime tend to be more readily accepted compared to drones used for surveillance or delivery purposes at night. Additionally, studies suggest that residents of larger cities exhibit higher levels of openness compared to those residing in rural areas, with industrial zones representing the most receptive group [30].

Regarding the operating conditions of drones, Al Haddad et al. [33] presented a study that assesses users' acceptance and adoption of urban air mobility by analyzing a stated preference survey. Factors concerning the acceptance of both technology and automation found in the literature (notably on autonomous vehicles) were projected for UAM and were included in an extended technology acceptance model. The analysis highlighted the importance of socio-demographic parameters and their attitudes for UAM adoption, but also trust and safety were found to be key components. Particularly, the presence of in-vehicle cameras and operators, as well as performance expectancy in terms of service reliability and on-time performance, was noted. Data and ethical concerns, the value of time savings and costs, and social attitudes, including a high affinity to social media, were also found as highly influential for UAM adoption. Finally, public transportation as a commute mode was found to be rather related to late adoption.

Cohen et al. [34] employed a multi-method approach with 106 interviews with transportation industry experts and two stakeholder workshops to construct the history, ecosystem, state of the industry, and potential evolution of UAM, as well as potential barriers for growth and acceptance, infrastructure needs, and environmental impacts. The acceptance challenges identified are distributed in four categories: (i) noise, visual, pollution and privacy, (ii) social equity, (iii) personal safety, and (iv) operational safety and security. The authors suggested mitigation strategies, such as restrictions on the use of photo and video equipment, for the first category number one, ensuring fair treatment for all and community engagement for the second category. This study also highlighted the importance of non-user impacts and social equity.

Eker et al. [35] offered insights into people's perceived benefits and problems associated with the future usage of UAM, which might have a significant impact on the adoption by the commuting population and the establishment in the traffic fleet. The essential components of public perception were determined using data from an online poll, in terms of advantages and problems stemming from different travel times, and environmental, financial, or operational aspects. Among the conclusions, the study draws are about how future policy interventions might try to raise public knowledge of the autonomous aspects of UAM.

Leon et al. [36] assess consumers' perception of last-mile drone delivery by observing if factors such as privacy, usefulness, legislation, and trust would affect the adoption of these services. The authors found that drone acceptance increases if people perceive drone delivery to be useful and if they trust the service provider. This is consistent with the notion that perceived usefulness is the strongest mediator on acceptance of UAM, as stated by Yavas and Tez [37].

Kalakou et al. [38] conducted a k-means cluster analysis to study attitudes towards technological innovation in the case of UAM. Their findings revealed three clusters of people that are more open to accept UAM-based services (early adopters, open-minded, and pollution-sensitive), and another three with respondents with mixed feelings or misgivings (emergency supporters, skeptics, and deniers). The authors concluded that receptiveness towards UAM is expressed by perceived societal benefits, translating into usefulness at a community level, and adding that there is a common understanding on the potential

benefits of usage on healthcare issues. Furthermore, the authors suggested that data collection should be expanded to understand how socio-demographic factors and mobility behaviour may affect the views of citizens.

Despite the previous studies on UAM acceptance, the literature continues to highlight the need for further studies to overcome the barriers related to negative public perception [5,26] by engaging the prospective users in the co-creation of UAM-enabled services [25]. In addition, different attitudes from one region to another arising from economic, lifestyle, and cultural differences have been acknowledged by other researchers [27,38], motivating the importance of evaluating UAM acceptance in unstudied locations.

3. Survey

To deepen the understanding of public acceptance and identify the potential for new drone delivery services, a survey was conducted. The survey consisted of an online questionnaire with three parts:

1. Socio-demographic characterization;
2. Attitudes towards online shopping and home delivery services;
3. Acceptance of UAM technology and UAM delivery services.

After cleaning the data and harmonizing the variables from the different countries (e.g., categories for the level of education were created using EU equivalent levels), the results from the questionnaires were analyzed. In this section, we describe the data collected and compare survey results.

3.1. Data Description

The survey was conducted online, firstly in Portugal, and later replicated in a large metropolitan area in the upper Silesian region of Poland, Górnośląsko-Zagłębiowska Metropolia (GZM), and Bari, in Italy. From the Portuguese responses, 72% come from some of the most populated areas of the country (Porto, Aveiro, Braga, and Coimbra). The sample sizes for the Portuguese, Polish, and Italian surveys are 300, 500, and 125 respondents, respectively. The Portuguese sample is not representative of the entire country, being concentrated around the larger Porto metropolitan area. The same applies to the Polish results in relation to GZM, and the Italian responses in Bari.

The surveys were structured around topics such as: (i) online shopping habits (frequency, location, types of products, motives for online shopping, and satisfaction), (ii) preference for physical/online store, (iii) most used delivery methods (e.g., truck, van, bike, etc.), (iv) knowledge about and intention-to-use drone delivery, (v) willingness-to-pay for drone deliveries, and (vi) attitudes towards public investment in UAM infrastructure, expected benefits, and safety and security. The sociodemographic characteristics of the sample are presented in Table 1 for both Portugal and Poland and Table 2 for Italy.

The sample in Portugal (PT) is not evenly gender-distributed, as females account for 45% of the sample while the rest is divided between males (33%) and N/A (22%). Regarding age, the 18–24 and 25–34 groups account for a cumulative majority of the sample, with 52%. In the Poland (PL), both gender and age are more evenly distributed. About 64% of PT respondents have a higher education, among which 10% have a doctoral degree, whilst the bigger group for PL is secondary education, with 57%. Approximately 44% of the PT sample is employed in comparison with 54.3% in the PL sample. The second largest group of the PT respondents are students, in contrast with PL which are retirees.

As for the Italian sample, it is composed mainly by males (79%), young adults (42%), and people with higher education (64%). Employed respondents can be divided in manual labor and office workers. In terms of professional status, the second most selected option was “other”, which may include retirees since this option is not available.

Table 1. Distribution of respondents' sociodemographic characteristics for Portugal and Poland.

	Portugal (*n* = 300)	**Poland (*n* = 500)**
Gender		
Female	45.3%	51.2%
Male	32.7%	48.8%
N/A	22.0%	-
Age group		
Under 18	1.3%	-
18–24	25.3%	9.6%
25–34	27.0%	16.4%
35–44	14.7%	20.0%
45–54	11.7%	16.2%
55–64	2.3%	16.2%
65 and over	0.7%	21.6%
Education level		
Basic	4.3%	2.0%
Secondary (grades 10–12)	31.0%	56.6%
Higher education (Bsc, Msc)	54.3%	40.0%
Doctorate/PhD	10.0%	1.6%
Other	0.3%	-
Professional status		
Employee	44.0%	54.3%
Self-employed	2.7%	8.5%
Student	42.0%	4.2%
Student-worker	8.3%	2.4%
Unemployed	2.0%	3.8%
Retired	0.7%	26.8%
Other	0.3%	-

Table 2. Distribution of respondents' sociodemographic characteristics for Italy.

	Italy (*n* = 125)
Gender	
Female	20.0%
Male	79.2%
N/A	0.8%
Age group	
0–20	4.8%
20–40	42.4%
40–60	40.0%
60 and over	12.8%
Education level	
No education	5.6%
Secondary	30.4%
Higher Education (Bsc, Msc)	54.4%
Doctorate/PhD	9.6%
Professional Status	
Employee	45.6%
Self-employed	8.8%
Student	18.4%
Student-worker	1.6%
Unemployed	2.4%
Other	23.2%

3.2. Survey Results

This section outlines the key takeaways from the survey responses and compares the results between Portugal (PT), Poland (PL), and Italy (IT).

More than 90% of respondents in the three regions stated that they have shopped online before. While most respondents shop online at least once a month, in all three regions,

the second most selected option shows that Polish respondents shop more frequently than Portuguese and Italian.

Regarding shoppers' motivations, in both PT and PL, the ones who shop online are driven by convenience, others by easy access and speed of purchase, and diversity of choice. In the case of PT, this contrasts with a preference for physical stores, that is the least selected option in PL. In Italy, there is no clear preference for online shopping, as 39% refer that it is indifferent to shop online or in a physical store.

When it comes to awareness and attitudes towards drone delivery, the results show that there are significant differences between Portugal, Poland, and Italy. Of the three countries, Portuguese and Polish showed the least knowledge about drone delivery services, whereas a majority of Italians are quite aware of drone deliveries (83%). The stated knowledge in Italy is remarkably high, as the existing literature refers that the awareness of drone deliveries and overall usage outside of media creation or military usage is limited [39].

When presented with the scenario of using drone delivery services, PT and PL respondents are willing to pay an added value if the solution is more flexible than other delivery modes. Other drivers for opting for this kind of delivery are environmental concerns. Flexibility and environmental benefits contrast with the criterion of time as a motivator for online shopping, as both samples are divided in terms of paying for a faster delivery by drone (approximately 55% in both countries) and do not show a clear preference for faster deliveries. More than just a representation of the potential users, this may present a portrait of the online delivery markets, as one-day deliveries are currently offered independently of the transport mode.

In general, regardless of the acceptance of drone delivery services, there is a positive perception of using drones in the city centers, especially among the Portuguese respondents. The most significant expected benefits are lower congestion and pollution levels. Italians are the most supportive of public investment in these services and more open to have their home flown over by drones. In Portugal, people are less receptive to both situations. Therefore, it is interesting to note that although Portuguese respondents see more benefits in drone delivery, they are less open to facilitate the implementation of these services, while exactly the opposite happens with the Italian respondents. The main results about the shopping habits and perceptions towards drone deliveries are described in Table 3.

Table 3. Shopping habits and perceptions towards UAM.

	Portugal	**Poland**	**Italy**
Has shopped online	90.0%	96.8%	92.7%
Online shopping frequency			
One to four times a year	40.0%	18.2%	23.2%
Once a month	44.1%	38.4%	53.6%
Once a week	12.6%	29.0%	19.2%
Two or more times a week	3.3%	11.2%	4.0%
N/A	-	3.2%	-
Motives to shop online			
Convenience	71.9%	80.2%	-
Ease of access and speed	61.5%	75.2%	-
Diversity of choice	48.1%	66.5%	-
Store preference			
Online	24.1%	43.4%	31.2%
Physical	42.6%	18.0%	29.6%
Indifferent	33.3%	38.6%	39.2%
Had previous knowledge of drone deliveries	33.0%	39.6%	83.9%
Willingness-to-pay extra for drone delivery			
If faster	44.7%	54.8%	45.2%
If more flexible	65.7%	60.2%	67.2%
If more environmentally friendly	69.0%	52.0%	-
Expected benefits			
Decreased congestion	92.0%	81.0%	66.8%
Lower pollution	86.0%	74.1%	55.2%
Openness to public investment	52.5%	66.8%	81.6%
Openness to having their home flown over by drones	62.0%	70.8%	76.8%

4. User Profiles

4.1. Cluster Analysis

To create a prospective users' classification of drone delivery according to shopping habits and potential acceptance, the partitioning around the medoids clustering algorithm (PAM), also known as k-medoids, was used. The algorithm was applied separately to the responses of the Portuguese and Polish surveys to highlight the differences between both regions. Due to some differences in the Italian survey in relation to its counterparts, a direct comparison was not possible, and thus the clustering algorithm was only applied to the Portuguese sample (300 responses) and the Polish sample (500 responses). Each respondent was considered as an observation, and the variables included in the cluster calculations represented sociodemographic characteristics, online shopping habits, and perceptions towards UAM (Table 4). Still, data cleaning and homogenization of specific variables were required. Examples of data treatment were the uniformization of types of higher education and age groups, which were treated equally in both countries despite depicting different categories in each country's survey. Higher education was aggregated according to European classifications.

Table 4. Cluster analysis variables.

Variable	Categories
Demographics	
Gender	Female, Male, N/a
Age	Under 25, 25–55, 55 and over
Education level	Basic/secondary and higher education
Professional status	Active population, retired, student
Online shopping frequency	Does not shop, not frequently, frequently
Types of stores and products used and bought online	Binary (Yes/No)
Motives for shopping online	Convenience, diversity of choice, economy/cost, comparability between choices and speed of delivery
Store preference	Online, physical, and indifferent
Online shopping satisfaction	Likert scale (1–5)
Perceived security when shopping online	Likert scale (1–5)
Knowledge of drone utilization for deliveries	Binary (Yes/No)
Willingness-to-pay extra for drone delivery	If faster, more flexible, and environmentally friendly
Perception of the added value of drones in urban logistics	Binary (Yes/No)
Expected benefits in cities from drones	Pollution reduction, congestion reduction, reduction of noise, improved deliveries, and better access to hard-to-reach locations
Openness towards public investment	Binary (Yes/No)
Willingness to have drones fly over their homes	Binary (Yes/No)

The PAM cluster algorithm minimizes the distance between the points in their assigned cluster and the point designated to be the center of the cluster (medoid). The medoid is the data point in the cluster with a minimal average dissimilarity to all the other points in the same cluster [40], i.e., it is the most centrally located data point in the cluster. There are several advantages of using PAM clustering over other algorithms, such as the k-means: it is intuitive, less sensitive to noise and outliers, and copes with categorical variables compared [41].

The Gower distance [42] is a common measure applied to clustering with mixed data, fitting well with PAM [40,41]. We used the Gower distance to measure the dissimilarity

between observations. It ranges between 0 and 1 and can be defined as the mean of variable-specific dissimilarities across observations, as depicted by Equation (1):

$$d_{ij} = \frac{1}{p}\sum_{i=1}^{p} d_{ij}^{f} \quad (1)$$

where d_{ij} is the dissimilarity between observations i and j, d_{ij}^{f} is a partial dissimilarity between i and j for variable f, and p is the number of variables. d_{ij}^{f} is standardized using Equation (2) when f is numerical, such as:

$$d_{ij}^{f} = \frac{\left|x_{if} - x_{jf}\right|}{R_f} \quad (2)$$

where x_{if} and x_{jf} are the observed values for the two individuals and the same variable f, and $R_f = |max(n) - min(n)|$ is the maximum observed range from all individuals for variable f, with n being the number of individuals in the dataset. When f is categorical, the partial dissimilarity is equal to 0 only if observations x_{if} and x_{jf} belong to the same category, and to 1 otherwise. Missing values are allowed, as the dissimilarities for a given feature are computed considering only the non-missing values [43].

However, when running the PAM algorithm, the number of clusters must be provided beforehand. Performance measures such as the silhouette coefficient indicate an optimal number of clusters. Based on pairwise differences between and within cluster distances, the silhouette coefficient represents the contrast between the average distance between data points within the same cluster and the average distance to data points in the nearest cluster. For a good partitioning, this coefficient should be maximized [41]. On the one hand, interpretability is key to the presentation of meaningful insights, as a low number of clusters may produce uninformative results, while a high number can lead to over-segmentation, isolating small groups that cannot be considered representative of general patterns [43].

Thus, to define the number of clusters for the segmentation of the Portuguese and Polish respondents, we ran several iterations, starting with two clusters and increasing, using the software R, R version 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria) [44]. The number of clusters to retain in each case was determined considering a balance between interpretability and cluster performance.

4.2. Cluster Results and Discussion

Using the above-mentioned criteria and procedures, we first computed the silhouette coefficient and selected the number of clusters that fit our purpose. In both Portuguese and Polish datasets, the maximum silhouette coefficient values were observed for two clusters (0.21 for Portugal and 0.28 for Poland). However, in both cases, the option for three clusters, corresponding to the second highest silhouette values (0.11 for Portugal and 0.17 for Poland), favored interpretability and provided better knowledge on different user profiles without incurring over-segmentation. Particularly, it allowed for the representation of the respondents that do not reject but are not early adopters of drone deliveries. Both in Portugal and Poland, the clusters characterize the following profiles:

- Cluster 1: low acceptance;
- Clusters 2: potential acceptance;
- Clusters 3: high acceptance.

4.2.1. Portuguese Profiles

Cluster 1, the smallest cluster of the Portuguese sample (30%), is predominantly composed of female (55%) and young respondents under the age of 25 (52%). Interestingly, respondents in this cluster correspond to the highest percentages of non-online shoppers (16%) and non-frequent shoppers (76%), preferring to shop in physical stores (59%).

When asked about their previous knowledge of drones for delivery purposes, only 23% of respondents in this cluster reported having some, and only 16% perceived value in this service. In terms of willingness-to-pay an increased fee for drone delivery, only less than 8% of respondents in this cluster reported that they would do so if the delivery was faster, while 36% reported that they would be willing to pay more if the delivery was environmentally friendlier, and 18% would pay for increased flexibility (e.g., change the delivery point after the purchase). Overall, respondents in this cluster had low expectations of the benefits that drones could bring to cities, with more than 90% being against public investment in drone infrastructure and more than 80% being against having their houses flown over by drones. Thus, this cluster is considered to have low acceptance and low potential for adoption, as the respondents do not seem to believe in the concept.

Cluster 2 represents 35% of the total sample and includes most of the 25–55 age group (70%), and active population (68%). Concerning motives for shopping online, only convenience received a large majority of affirmative responses, while the responses to other options were mostly negative. The respondents appear to be environmentally cautious, as they would pay more for drone deliveries if they were better for the environment when compared with current options (81%), while they foresee the most important benefits in congestion and pollution reduction, at 88% and 78%, respectively. There is also a high acceptance towards having their home flown over (79%), but in contrast, the support of public investment is moderate (57%). The respondents in this cluster have the potential for acceptance, but do not see relevant benefits (e.g., for operations) besides the environmental ones, showing some reserve about public investment.

Finally, cluster 3, which is considered of high acceptance, also accounts for around 35% of the sample, and is gender-balanced and dominated by respondents with higher education (76%). An amount of 21% of the respondents claim to frequently use online stores, this being the cluster with a higher percentage of online shoppers. Regarding the motivation to shop online, this segment values convenience, speed, and diversity of choice over economic reasons and comparability between options. This group also has the highest ranking for online shopping satisfaction and perceived security, at 4.3/5 and 4.0/5, respectively. The respondents also show the highest previous knowledge (45%) and perceived value of drones (90%). They are most likely to pay extra for this type of delivery if it comes with environmental benefits (86%) or flexibility (91%). This segment is more positive about the potential benefits for city centers, with congestion (91%) and pollution (89%) reductions as the most expected benefits. Around 84% are open to both drone infrastructure public investment and have drones flying over their houses. Generically, this cluster is quite positive about UAM and its various implications.

4.2.2. Polish Profiles

Cluster 1, of low acceptance towards UAM application in e-commerce, is also female-dominated (63%), but in contrast with the Portuguese sample, includes a significant amount of people over 55 years of age (59%) and retired people (51%). These respondents prefer physical stores (39%), have fewer habits of shopping online, and the lowest levels of online shopping satisfaction and perceived security. They also report the lowest level of knowledge about drone delivery applications (11%) and perceive the lowest value in using drones (18%). Less than 6% of this segment is willing to pay more for drone delivery, even if it were faster, more environmentally friendly, or more flexible. In fact, 85% claim they would not pay for this service. This group is represented by respondents that do not expect any benefits for cities from drones, as 90% oppose public investment in drone infrastructure, and 86% oppose drones flying over their houses.

Cluster 2, which has some potential for acceptance, is dominated by males (58%) and by people without a higher education degree (66%). From this cluster, 78% claim that they are not frequent online shoppers, but when they do, they prioritize convenience (78%) and speed (70%). Approximately half of the respondents (52%) do not have any preference for either physical or online stores. Despite this, they still perceive value in drone usage for

deliveries (89%) and would pay more for this service if faster (73%) and more flexible (79%). The only expected benefit for cities that the majority expects is congestion reduction (83%). Even with that being the only expected benefit, they still support public investment in drone infrastructure (87%).

Cluster 3, of high acceptance, is comprised of individuals aged 25–55 (74%) and by the active population (82%). Approximately 70% of this segment shop online frequently and do prefer online to physical stores, primarily due to convenience (93%) and speed (88%). This group has also the highest level of satisfaction and perceived security when shopping online, scoring 4.6/5 and 4.1/5, respectively. Around 90% perceive value in using drones for delivery and the majority would pay more for faster, more environmentally friendly, or more flexible drone-enabled deliveries. The most expected benefits are the reduction of congestion (77%) and pollution (78%). Additionally, they are in favour of public investment in drone infrastructure (90%). This segment of high acceptance seems to value more the personal benefits this technology would bring, rather than the benefits for cities.

Generically, the sample distribution of the Polish respondents is similar to the Portuguese, with 28% of the respondents falling on the low-acceptance cluster, 36% on the potential-acceptance cluster, and also 36% on the high-acceptance cluster.

5. Discussion

The results of our study provide an overview of attitudes and intentions towards the acceptance of UAM. Based on the cluster analysis, it can be concluded that there are distinct groups with different attitudes towards urban air mobility for e-commerce.

Cluster 1, for both the Portuguese and Polish cases, represents a group with negative attitudes towards UAM deliveries. In both countries, this segment is female-dominated and, not surprisingly, contains most of the respondents who do not usually shop online. This predisposition of females to have lower UAM acceptance is consistent with the findings of previous research that revealed that women generally exhibit lower interest in immediate adoption and express greater security and safety concerns [30,31,38,39]. However, Del-Real and Díaz-Fernández [32] showed that the difference between men and women is minimal, while the nationality has a higher influence on UAM acceptance. The clusters contrast in terms of age, as the PT cluster is mainly composed of youth and the PL cluster is dominated by adults over 55 years of age. Another interesting characteristic of this cluster is that there is not a clear relation between drone delivery acceptance and the type of store or products bought online, but rather with the shopping frequency. The most important result to highlight in this cluster is the fact that PL respondents are more extreme in rejecting drone deliveries, while the PT results show some disbelief, but not a total rejection.

On the other hand, cluster 2 represents users that will potentially accept UAM. The similarities between the two regions are visible in the sense that users in cluster 2 support the introduction of UAM and see high value in it, but not as much of a positive or negative attitude as the other groups. Some differences between the regions are found in the motives to possibly accept UAM. For instance, the PT cluster was more environmentally cautious and showed some interest in drone delivery. This aligns with Eißfeldt et al. [30] and Kalakou et al. [38], who suggested that applications with benefits for all have a higher potential for agreement from the public. However, they are still somewhat reluctant, as suggested by their lesser positive attitude towards investment and expected benefits. The PL case for clusters is more pragmatic, as they also see a lot of value in application of UAM for e-commerce deliveries, but care mostly for the practical benefits it may bring, such as speed or flexibility of delivery, in addition to reducing congestion in cities. They also show the highest lack of preference for physical versus online stores and the highest acceptance of having their home flown over by drones.

In both regions, cluster 3 showed the most openness towards UAM application, showing high levels of satisfaction with online shopping and a strong willingness-to-pay for drone-enabled delivery. In both cases, the majority are young people, but there are mostly students in the PT sample, while in PL, there is mostly the active population (i.e.,

those of working age that are not currently studying). This confirms that age is a marker for acceptance of UAM [30–32]. However, the Polish seem to have a slightly more positive predisposition towards UAM acceptance than the Portuguese.

Figure 1 presents the obtained clusters in relation to the willingness-to-pay an additional fee for drone delivery and the openness to public investment in UAM infrastructure.

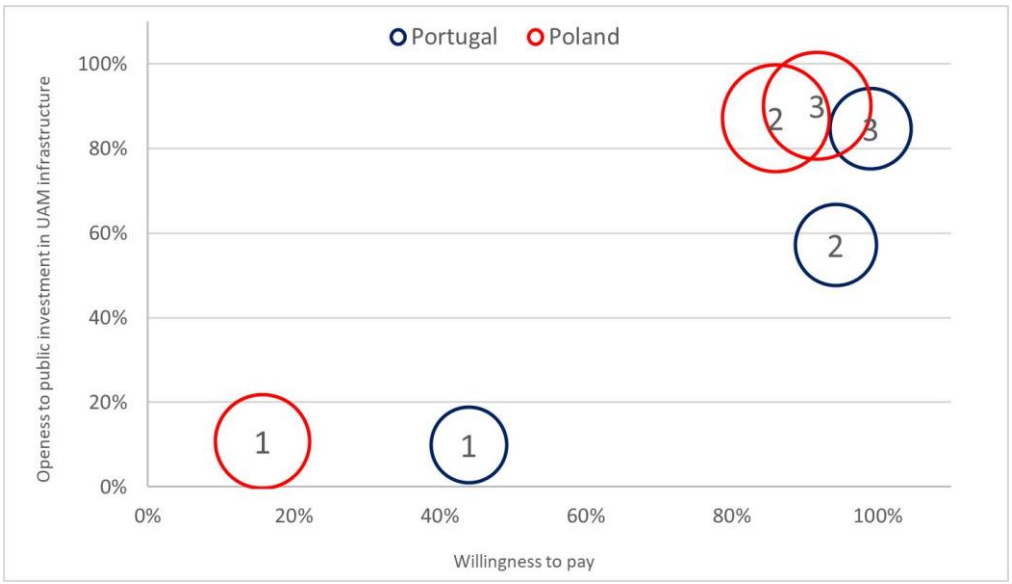

Figure 1. Willingness-to-pay vs. openness to public investment.

In both regions, cluster 1 (low acceptance) shares similar views on public investment, but the willingness-to-pay is much higher in PT. The Polish cluster representing potential acceptance is more open to public investment than its Portuguese counterpart (cluster 2). The high-acceptance clusters are more similar in both regions in relation to the depicted variables, as it is visible from the overlap between both clusters 3. Additionally, in the Polish sample, the potential-acceptance cluster is similar to the high-acceptance one, which makes it also very close to the high-acceptance Portuguese cluster regarding public investment and willingness-to-pay. This further strengthens the idea of the Polish being more open to spend money on drone-enabled services.

When it comes to the expected benefits for city centers (Figure 2), the overall reductions in traffic and pollution are the most anticipated, even by the clusters with low acceptance. This is consistent with the findings of Kalakou et al. [38] in regard to societal benefits dictating receptiveness of UAM and also aligned with the expected benefits of a study published by the European Union Aviation Agency [28]. In contrast, the reduction in noise is not expected, even by people belonging to the most optimistic clusters.

When studying attitudes towards UAM and its potential adoption, it is important to consider the attitudes of different groups of potential users. As represented by the clusters extracted in this analysis, there is a clear distinction between potential acceptors/potential acceptors and non-acceptors. However, all can have an impact on the deployment of UAM, but in different ways. Customer segments represented by cluster 3 will play an important role in the adoption of this innovative technology since they are likely to be early adopters and will naturally act as co-promoters of UAM. Their attitude can result in a word-of-mouth effect that spreads positive experiences and information about UAM technology, and may stimulate non-users in trying the technology [45]. In the case of cluster 1, non-adopters or late adopters should also be considered in deployment and marketing studies, since non-users can create implementation barriers regarding public policy or opinion, especially if negatively impacted.

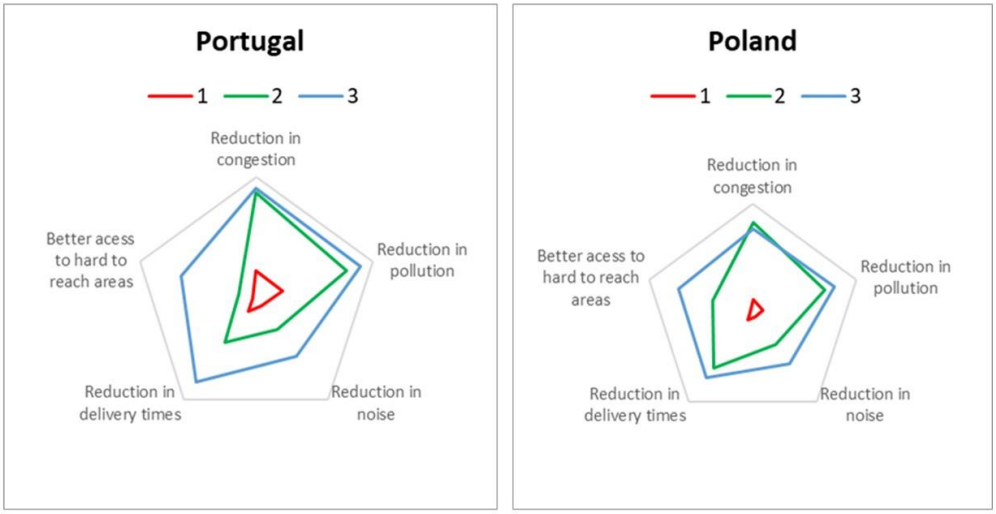

Figure 2. Radar charts for expected benefits in cities centers for Portuguese (**a**) and Polish (**b**) clusters.

6. Conclusions

This paper studied the perceptions of UAM using data from online surveys performed in three European countries (Italy, Poland, and Portugal), and proposes acceptance profiles in two of the three countries. This study revealed clear differences in acceptance profiles between the two regions towards e-commerce deliveries by drones, which was expected due to cultural differences between both countries.

In a first analysis of the survey in three countries, some interesting similarities were also found, as most respondents from the three countries view drone delivery as a positive development and support public investment in urban air mobility infrastructure. The anticipated benefits of drone delivery were a decrease in congestion and pollution in city centers. It is worth noting that online shopping habits, such as the type of online stores or purchased products, do not seem to have an impact on the potential acceptance of UAM. However, the frequency of online shopping might have a significant influence.

Afterwards, the cluster analysis in two of the three regions revealed an evident low-acceptance group and an evident high-acceptance group, with a third group positioned in the middle. This group presented serious concerns, but at the same time was open-minded. Low-acceptance clusters were characterized in both cases by females and people who do not typically shop online, while high-acceptance clusters were by frequent online shoppers.

The presence of low-acceptance clusters indicates a typical resistance to adoption. On the other extreme, the high-acceptance clusters refer to the common profile of early adopters. An interesting result when comparing Portuguese and Polish samples was the fact that the Polish are more extreme in their positions (more negative and more positive attitudes). The Portuguese clusters are also characterized by positive and negative clusters, but the middle position is clearer in this case, and negative positions are not as negative as the Polish. Furthermore, the concerns and the benefits that emerge from the two regions reflect the cultural and socio-demographic differences. Understanding and mapping these differences increases the current knowledge for policymakers.

The research did encounter some limitations, as the surveys, conducted by different entities, were not replicated exactly in all three countries, and data that could not be harmonized were not included in the cluster analysis. This includes the data from the Italian survey. Still, this study provides useful insights and contributes to the understanding of the public perceptions of UAM benefits.

The contributions of this paper include (i) a segmentation of prospective users based on acceptance profiles, and (ii) the identification of the main barriers and expected benefits of UAM. The segmentation of the users in terms of acceptance is helpful in supporting the

design of implementation plans. Users that fall in the low-acceptance clusters should be targeted in marketing campaigns and in the design of new tailored value offerings. At the same time, policymakers must address users' concerns and mitigate negative impacts when proposing UAM regulations. The identification of the main acceptance barriers can support a proper response to the concerns presented by the groups raising them. Not only can local authorities tailor their policies for the different groups, but our multi-region study can assist European authorities in accounting for the socio-demographic and cultural differences.

Since the low-acceptance groups can hinder the success of UAM implementation, their concerns should be prioritized. Possible actions include co-designing regulation and technological solutions, and clearly communicating the benefits of UAM and how their concerns are being addressed. Further research on this topic would aid in the validation of these actions, by adapting the methods proposed in a previous study by Duarte et al. [46].

Future research can also include going beyond the shopping and e-commerce experience and deepen the study of safety perceptions, mainly of people on the ground. Moreover, the authors plan to analyze the implementation of other specific UAM-enabled services in the near future, with focus on critical and time-sensitive scenarios, such as medical applications and healthcare support, which have demonstrated a higher potential for acceptance [38]. Therefore, researching and developing those use cases can be the starting point for introducing UAM. By demonstrating the usefulness and efficacy of such applications, stakeholders can not only address concerns, but also facilitate wider adoption and acceptance of UAM. On a more methodological perspective, future studies can provide guidelines on how to undertake inter-regional acceptance assessments that account for cultural and lifestyle differences, in order to overcome the limitations found related to data homogeneity. A more robust database will then allow for advanced statistical analysis models, such as structural equation modelling, to obtain comprehensive user profiles and scale the analysis further.

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