Upcoming drone delivery services: a perceptions-based clustering of citizens in Lisbon

Abstract

Drones are an emerging technology that promises numerous benefits for delivery services. As e-commerce evolves and citizens become more familiar with parcel delivery services to their homes, drone services could become an alternative for last-mile logistics service providers. However, the potential diffusion of drone services will also be influenced by the public opinion. This study addresses the issue of citizens´ perceptions of drone delivery services and uses the Metropolitan Area of Lisbon as a case study. Data was collected though a survey and analysed using a clustering approach. Six citizen clusters were identified: the drone-service supporters, the concerned about the package, the concerned with legal aspects, the drone-service neutrals, the likely supporters, and the non-supporters. The clusters vary according to socio-economic characteristics and members' current satisfaction with the home delivery services. Logistics stakeholders can use the results of this study to successfully introduce drones into their logistics systems and benefit from the added value to the public.

Keywords: Drone deliveries, citizens perceptions, consumers preferences, logistics services, drone service development, clustering, technology management.

1. Introduction

E-commerce has grown fast in the last years with sales increasing from 15% in 2010 to 33% in 2019 (35% in 2020) (Statista Research Department, 2019) and posing pressure to operators to implement feasible and sustainable solutions to the last mile logistics problem while ensuring customer satisfaction [1]. Drones are fast and precise delivery modes able to fly over ground obstacles and avoid traffic jams [2]. Unlike the usual modes of transport, drones are not limited by ground infrastructure and can be an eco-friendly solution for small package deliveries [3]. Especially during special occasions, such as pandemics when human contact should be avoided, drone delivery services can play an important role in maintaining the public's health and safety and satisfy citizen needs. However, the mass adoption and diffusion of this emerging technology at a large scale depends heavily on the society´s welcomeness. For this reason, it is important to study citizens´ perceptions and attitudes towards drone delivery services and analyse heterogeneity in views and behaviour.

Using drones to deliver goods has been discussed for long time but only recently, companies and organisations started to consider it as an option and plan their own drone delivery services [4]. In general, a delivery with a drone is executed through the following steps: a drone is deployed from a cargo station and flies at a specific altitude, once it reaches its destination, it either lands or drops off the package to a predetermined area and after the delivery is complete, the drone returns to the station [5]. Currently the choice of using the technology for a delivery is not dependent on the consumers preferences but on the logistics operator. However, when drone deliveries become widely available to the market, customers will also influence the decision-making over which mode of transport to be used for their purchases [6].

To prepare well for the advent of drone deliveries in cities, it is, hence, imperative to consult public opinion for the design and planning of last-mile delivery services. For example, previous research has concluded that the public perceptions of drone use may differ depending on the type and location of use. In a study in Switzerland, people supported the use of drones for military and police purposes but were more reluctant to the use of drones for commercial applications or hobbies due to privacy issues [7]. In a more recent study [8], it was highlighted that although EU citizens are very positive about Urban Air Mobility (UAM), their acceptance is subject to guaranteed levels of safety, security and environmental protection [9]. In general, it is shown that the public's understnading of benefits and risks can influence their attitudes and behavioural intentions towards drone deliveries [10]. As Watkins et al. (2020) mentions "in democratic societies, it is the greater public sentiment towards a technology that will ultimately determine the governance of the sector" [11].

Building on the European Commission's Drone strategy 2.0, our goal is to help future policy-makers to create "an innovative, cost-efficient and market-led business environment for the development and take-up of new drone services and technologies within the EU's internal market". There is currently no market for new drone services and technologies in the EU single market and the regulatory environment is evolving. Understanding public perceptions is key to the success of such implementation. The current study analyses the opinions of citizens of the Metropolitan Area of Lisbon (AML – Área Metropolitana de Lisboa) on drone deliveries. In particular, this study focuses on exploring and understanding of the unobserved heterogeneity in the population being studied, identifies citizen clusters and discusses their drone perceptions and socioeconomic characteristics. Through the analysis, profiling variables that characterise those segments are identified.

After reviewing past research and identifying the key dimensions affecting public perceptions of drone delivery services (Section 2), a survey is designed and the methods to be applied in the analysis are presented (Section 3). The results are presented by describing and discussing the six citizen clusters identified (Sections 4 and 5). This study concludes with a summary of the main conclusions and a discussion of future research (Section 5).

2. Background on drone delivery services

As drone technologies evolve and become available to the market, the interest on their business potential in logistics is growing. Several studies have explored the effects of drone deployment at a large-scale from a societal and business perspective. Through the literature review, it is aimed to search for concepts relevant to this new research direction. We review a complete list of concepts (and indicators) from the literature that could play a role in public perceptions of drones.

2.1. Review of aspects analysed in drone delivery services

The intention to use drone services, the expected benefits from using the new service, safety and privacy concerns, the conditions of the packages at the time of delivery, public awareness on drone technologies, and the willingness to pay for drone services were aspects of drone delivery services analysed in past studies. The following paragraphs summarizes previous research findings of the afore-mentioned aspects. A summary of the studies most relevant to the current work is shown in Table 1.

Intention to use is a term that commonly indicates the willingness to proceed with an action. It

does not guarantee that an action will take place, but it does somehow determine the likelihood of it actually taking place. It can be enhanced by the perceived innovativeness [12], and more generally a positive attitude towards drone delivery services results in higher intention to use [13]. A positive attitude is generally driven by the benefits of drone delivery, usability, perceived risks, environmental impact and individual innovativeness [13,14]. Other factors affecting the intention to use are the desire for the delivery, outcome expectancy and lifestyle compatibility [15].

Past research has designated speed, accuracy, ability to reach remote locations and environmental impacts as the most beneficial aspects of drones [2,5,11,16–21]. Such analysis of the benefits is vital as the acknowledgment of the possible benefits can lead to a higher level of public acceptance which is believed to be a decisive factor regarding the diffusion of drone delivery services at a large scale.

Despite the potential benefits, there is also a lot of scepticism about the deployment of drones for delivery services. Concerns refer to the degree of safety, security, privacy of citizens and package integrity during the delivery process. Safety is clearly one of the main concerns for drone delivery services since they will be used above the city infrastructure like private and public buildings, streets and parks, and in some cases, they can fly very close to people. The need of high safety measures is essential for their integration into the urban environment [21]. Moreover, cybersecurity and data protection, as well as the prevention of malicious and criminal activities through drones are important issues that regulators need to address [22]. Another issue is the potential invasion of privacy. Drones are equipped with data collection devices such as sensors and cameras and have the potential of operating in urban territories, raising legitimate concerns about violation of privacy and trespassing [11]. Other types of concerns are related to possible occasions of unauthorised filming and surveillance [5,11,23], and the possibility of package theft and drone malfunctions [10,13,24]. When people consider such risks, negative attitudes may emerge, leading to lower intention to use.

Other important topics for the design and implementation of drone delivery services are awareness and willingness to pay. Awareness reflects the level of knowledge and familiarity individuals have with regards to drone technology and applications. The degree of one's awareness can affect the acceptance of the technology [25]. Finally, the associated cost to the user can also affect the willingness to use a new service. According to Kotler and Keller [26] price perception can affect the intention to use, while shipping fees and prices influence the order incidence and expenditure [27]. For drone deliveries, negative perceptions over drone uses can influence the willingness to pay an additional amount for a delivery [28].

Table 1. Summary of aspects analysed in drone delivery studies

Drone service examined aspect	Study	Variable Focus
Intention to use	Reddy and DeLaurentis (2016) [14]	Risks, applications, environment and benefits
	Osakwe (2021) [15]	Desire for delivery, outcome expectancy, lifestyle compatibility
	Hwang (2019) [12]	Perceived innovativeness
	Yoo et al. (2018) [13]	Positive attitude
Benefits of drone deliveries	Joerss et al. (2016) [17]	Delivery speed
	Mohamed et al. (2020) [21]	Drone accuracy and targeted actions

	Lee et al. (2016) [2]	Ability to reach difficult places
	Stolaroff et al. (2018) [16]	Environmental impact
	Yaprak (2021) [28]	Perception of benefit and risk
Concerns	Soffronoff et al. (2016) [5]	Invasion of privacy
	Watkins et al. (2019) [11]	Invasion of privacy
	Zhu (2019) [24]	Malfunction, criminal and illegal use
	Yoo et al. (2018) [13]	Criminal and illegal use
	Yaprak (2021) [28]	Perception of benefit and risk
	Tan et al. (2020) [23]	Fears and concerns
Awareness	Aydin (2019) [25]	Awareness (perceived and actual)
Willingness to pay	Kotler and Keller (2016) [26]	Price perception
	Lewis (2006) [27]	Shipping fee and prices
	Kim (2020) [6]	Time and cost

2.2. Conclusions from literature review

To successfully design a service logistics network (at the tactical decision-making level), to quantify resource requirements (at the operational decision-making level), and to quantify usage intent and its determinants, service planners should explore market perceptions and potential user profiles, enabling actual needs estimation and driver specification. Several studies focusing on the relationships of variables concerning different aspects of drone delivery services that follow approaches that aim to confirm these relationships. However, despite the growing interest and literature in drone delivery services, there is currently little research on the profiles of people who hold these views and their socioeconomic characteristics. Since the technology has not yet been deployed, this is a new research area and exploratory research can provide useful insights for future confirmatory studies. There is still a lack of research exploring citizen heterogeneity in the field of drone delivery services, but current research could help fill the gaps and gain a deeper understanding of different citizens´ views on drone technology and applications. Through the current study, citizens´ views are analysed in an integrated way to determine the citizen profile of drone services. This has the potential to provide insights to policy and logistics stakeholders, as well as other entities active in the field of drones, so that they can make more informed decisions in the future in the field of logistics services.

3. Methodological approach

Exploratory studies can shed light on barriers and enabling factors of drone delivery services [42]. We aimed to explore citizens´ view based on the most frequent topics analysed in past literature that assumes that there is one citizen profile. Previous studies using theoretical basis (such as Technology Acceptance Model) aimed to ultimately analyse the intention to use and assume that a homogenous population, so results for socioeconomic factors are rarely available. We collected data from Lisbon´s population with the aim to designate citizen profiles and explore heterogeneities in citizens views. By segmenting the population in different clusters based on their views on drone deliveries, we aim to identify how they also differ based on their socioeconomic (eg. gender) and behavioural characteristics (eg. frequency of online shopping).

3.1. Survey design

The public´s perceptions before the technology is launched to the market are analysed and the respondents are asked how they perceive the expected benefits, what concerns they have about using drones for deliveries and express their intention to use them. These three concepts appear in the majority of previous studies. The topics of awareness and willingness to pay are used in fewer studies but are considered important for the characterization of the expected citizen profiles. Information on sociodemographic data and ecommerce behaviour were also collected with the aim to enrich the characterisation of citizen profiles and designate relevant aspects that induce heterogeneity. Table 2 presents the concepts and aspects from the literature analysed in this study.

Table 2. Topics addressed in the survey and their connection to the state of the art.

Literature		
Concepts	Aspects	References
intention to use	I would use drone delivery to receive my order.	[12,13,15]
	Using drone delivery to receive some products is something I would use.	[12,13,15]
	I could see myself using drone delivery to receive my package.	[12,13,15]
	I think drone delivery is an innovative technology and I feel excited to try it.	[12,13]
	I feel motivated to try a new technology as a drone delivery.	[12]
	I think that using drone delivery is a good idea.	[13]
	I intend to use drone delivery services in the future immediately when they will be available.	[12,13]
	Drone delivery service is (will be) enjoyable.	[12]
expected benefits	Drone deliveries will be beneficial for people living in remote regions.	[5,11]
	Drones can reach places where road transport can’t reach.	[2]
	I can have my products delivered precisely at my exact location.	[21]
	I can have my products delivered faster than any other means of transport.	[2]
	Drone delivery is more environmentally friendly than traditional delivery methods.	[16–20]
legal concerns	Drone delivery will lead to a loss of privacy for me.	[13]
	Drone delivery might not be used in a way that respects my privacy.	[5,10,11]
	I feel concerned about drones trespassing my property.	[5,10,11]
package concerns	I am worried about the possibility of the package being violated or stolen by others.	[15,24]
	I am worried about the possibility of the package being damaged while it is transported.	[24]
awareness	I am familiar with how a drone works.	[15]
	I am familiar with the use of drones in the area I live.	
	I have used a drone before.	[15]
	I am aware that some big firms like Amazon, Google and Uber are doing drone delivery.	[15]
	I am aware that drones have more applications other than military uses.	[15]

3.2. Collected sample

Experts argue that by 2040 drones will be a mature technology that will enable lower noise levels, increased operational safety and reduced operating costs [43]. To ensure the representativeness of the target population, a sample was drawn with non-probabilistic techniques (quota sampling). This allows for an over-representation of young adults in the total of 304 observations obtained[1]. Research shows that young people are more receptive to e-commerce and innovative delivery solutions. For these reasons, we overrepresented the young adult group with 68.1% of the sample aged 25-44 (Table 3), as this is demographic group with the highest market potential for this technology. The survey was shared on social media by four different people via face-to-face, personal emails, and work-related emails. In addition, four different field work contact points were set up in parallel. Thus, these four researchers used social media and e-mails to reach different segments of the target population.

The age of the respondents ranged from 18 to 65 years, as the e-commerce users predominantly belong to this age group according to Eurostat [30]. Moreover, young and highly educated people make up the largest group of internet users [31]. Characteristics such as age, gender, employment status, educational background, income, area of residence, owning a driver's license and car availability were considered. The views of the respondents on perceived benefits, perceived concerns and the intention to use drones were assessed, as well as the level of awareness on drones. From the sample 48.4% was male and 51.8% was female, which is very similar to the population of Portugal [32]. The majority of respondents was aged between 25 and 44, 68.1% of the respondents were currently in full-time employment and 74% held a driver's license. The demographic characterisation of the sample is shown in Table 3.

Moreover, citizens´ willingness to pay for innovative services was also examined, with prices ranging from 0.50€ to more than 8€. In general, it is the expensive goods and small electronics categories that tend to favour high prices. Surprisingly, most people are not willing to pay more than 3€ for medicine deliveries. This also applies to food, drinks, mail, books and small household items. There is also a quite high proportion (26.6%) of individuals willing to pay 3-8€ for clothes delivery.

Table 3. Survey demographics

Characteristic		Percentage
Age	18-24	9.6
	25-34	48.0
	35-44	20.1
	45-54	13.5
	55-65	8.9
	65+	0.0
Gender	Male	48.4
	Female	51.8

[1] As our study is exploratory, we are not constrained by sample size given by confidence level or margin of error. Nevertheless, it is important to have an appropriate sample size that covers the full heterogeneity of the population

Education	Primary/secondary	0.0
	High school	1.3
	Technical school	12.5
	Bachelor's degree	47.0
	Master's degree	36.5
	Doctoral degree	2.6
Employment	Fully employed	69.4
	Part-time employed	3.6
	Student	9.5
	Retired	3.6
	Currently unemployed	5.9
	On lay-off	2.3
	Other	5.6
Monthly income	Less than 500 €	7.2
	501-1000 €	20.7
	1001-1500 €	28.0
	1501-3000 €	28.3
	3001-5000 €	12.5
	More than 5000 €	3.3
House building	House	35.2
	Apartment	64.8
Area of residence	City centre	37.6
	Urban environment	51.6
	Suburban environment	9.2
	Rural environment	1.6
Cars available	0	23.7
	1	42.8
	2	21.4
	More than 2	12.2

3.3. Data analysis methods

This study follows a quantitative descriptive research design, the data obtained is measurable and can be used for statistical analysis. For the data analysis, IBM-SPSS software and R, as a programming language suitable for statistical computations, were used. First, we use principal component analysis, which is a descriptive parametric technique that makes no distributional assumptions (unlike factor analysis) and can identify groups of variables that are highly correlated. Gaussian Mixture Models (GMM) are then used to group respondents and identify one or more clusters.

Principal component analysis (PCA) is often used to reduce the dimensionality of data sets, especially in large data sets that contain underling concepts to a set of items. PCA attempts to do this with minimal loss of information. Additionally, cluster analysis is a common statistical method to organise sample data into meaningful groups or clusters. Clustering survey participants into groups is a useful tool to better understand specific subpopulations. In this way, the attitudes and

characteristics of population groups can be defined more clearly and analysed in depth. Previous research has used exploratory factor analysis with survey data to analyse passenger profiles in transport-related topics [44, 45, 46] and other markets [47].

Different clustering algorithms are currently available in different software packages. Hierarchical and k-means are two common ways to perform “hard” clustering, meaning that each element is assigned to only one cluster [33]. Another type of grouping is finite mixture modelling. This is a way of performing “soft” clustering, meaning that respondents have different probabilities of belonging to different clusters. Finite mixture models have been used in transportation research and are mainly latent class models [48, 45, 46, 48, 49]. Latent class modelling assumes that observed measures are independent conditional on the clusters, hence it estimates means and variances (continuous data) or proportions (categorical data). Since it assumes covariances to be zero, we need to use the bivariate residuals to test whether the assumption is true. GMMs directly model the covariance matrix of the multivariate normal distribution. Unlike heuristic clustering methods like hierarchical or k-means, which use subjective methods to set the number of clusters, GMM uses information criteria (e.g., Akaike Information Criterion and Bayesian Information Criterion) [50].

Based on finite Gaussian mixture modelling and using the EM (expectation-minimization) algorithm, mclust is a popular package for performing mixture modelling using Gaussian conditional distributions in R software. The mixture modelling approach using Gaussian mixtures was chosen for this research because the scores from PCA are treated as continuous data [34]. The identification of unobserved heterogeneity requires that at least two clusters or segments are present. These methods assume that each group or cluster is given by a unimodal distribution. That is, each cluster corresponds to an observed peak or are of high density (bell-shaped surface). Model selection was based on the Bayesian Information Criterion (BIC). A parsimonious balance between goodness of fit and model complexity needs to be achieved [51,52].

4. Analysis results

4.1. Principal Component Analysis (PCA)

Among the concepts explored in past studies, the intention to use, the expected benefits and the concerns raised by the respondents are the most common ones. These form the basis for exploratory research to understand the unobserved heterogeneity of society regarding these important concepts.

First Principal Component Analysis (PCA) was used in order to reduce the dimension of the variables by grouping them into components. In Table 4, a PCA conducted using IBM-SPSS software identified four perception-related components: intention to use, expected benefits, legal concerns, and package concerns. The total variance explained by these components is 74.44% of the entire data set. The items used in this analysis use a 5-point Likert scale (1-stronly disagree, 5-strongly agree) and negatively expressed items are coded inversely. The reliability analysis with Cronbach alpha shows good reliability for all components. To achieve simplicity and semantic meaning of each component of the PCA, the varimax method of orthogonal rotation was used [35]. The Kaiser-Meyer-Olkin (KMO) measure is 0.891 indicating that correlation structure is good for PCA [36]. Using the Bartlett's Test of Sphericity with p-value < 0.001 and a KMO greater than 0.6, it is confirmed that PCA is suitable for this analysis.

231 Table 4. Components of perceptions on drone services

Principal Component Analysis				
	intention to use	expected benefits	legal concerns	package concerns
I would use drone delivery to receive my order.	0.897			
Using drone delivery to receive some products is something I would use.	0.884			
I could see myself using drone delivery to receive my package.	0.843			
I think drone delivery is an innovative technology and I feel excited to try it.	0.837			
I feel motivated to try a new technology as a drone delivery.	0.815			
I think that using drone delivery is a good idea.	0.760	0.322		
I intend to use drone delivery services in the future immediately when they will be available.	0.750			
Drone delivery service is (will be) enjoyable.	0.730			
Drone deliveries will be beneficial for people living in remote regions.		0.835		
Drones can reach places where road transport cannot reach.		0.809		
I can have my products delivered precisely at my exact location.		0.803		
I can have my products delivered faster than any other means of transport.	0.316	0.756		
Drone delivery is more environmentally friendly than traditional delivery methods.		0.717		
Drone delivery will lead to a loss of privacy for me.			0.914	
Drone delivery might not be used in a way that respects my privacy.			0.858	
I feel concerned about drones trespassing my property.			0.821	
I am worried about the possibility of the package being violated or stolen by others.				0.879
I am worried about the possibility of the package being damaged while it is transported.				0.835
Cronbach alpha	0.94	0.87	0.879	0.799

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

232 **4.2. Cluster Analysis**

233 A popular R package for model-based clustering, classification, and density estimation based on
234 finite Gaussian mixture modelling is mclust [37] which allows the use of continuous variables. The
235 components of PCA (intention to use, expected benefits, legal concerns, package concerns) were used
236 to segment the population. After estimating mixture models for one to nine components and 14

different covariance matrix configurations, mclust provides the best model according to different covariance structures and the numbers of clusters. The identification of unobserved heterogeneity assumes that we have at least two clusters or segments. Thus, we use model-based clustering to identify sources of heterogeneity. In particular, these procedures assume that each group or cluster is given by a unimodal distribution, i.e., each cluster corresponds to a peak or high density area of observations. The general rule is to choose the solution with the highest BIC (in mclust), as shown in Figure 1. In this case, a solution with six clusters is selected. A graphical representation of the 6-class solution is shown in Figure 2 and is explained below.

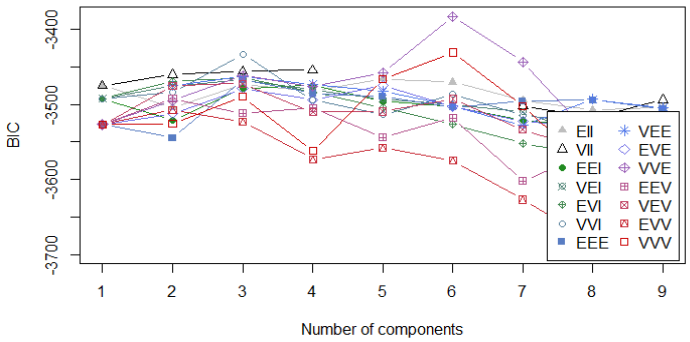

Figure 1 Selection of latent class model

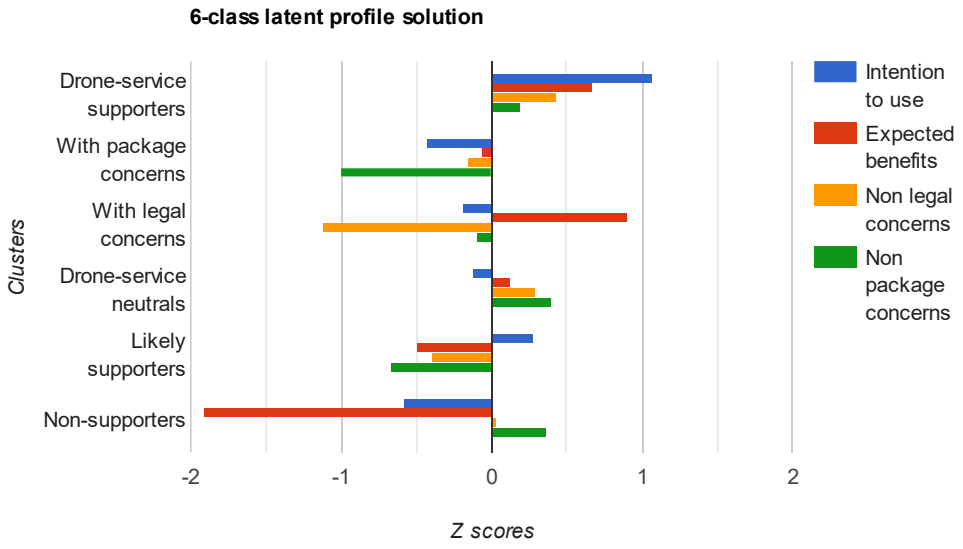

Figure 2. Graphic presentation of the 6-class latent profile solution.

The individuals in the **first cluster** make up 15% of the sample. They show a high intention to use, appreciate the potential benefits of drone services, and do not seem particularly concerned with legal and packaging issues. These respondents were labelled as **"Drone-service supporters**" because of

their positive attitute towards all the aspects analysed and their stated intention to use them.

Respondents beloninging to the **second cluster** make up 15% of the sample. They are less willing to use the service, have yet to express their appreciation for the service's potential benefits, and seem a little worried about legal issues. Respondents in this cluster appear to be very concerned about the condition of their packages upon delivery. In particular, it shows that the packages are the biggest concern compared to all other clusters. For this reason, this cluster was named **"Concerned with package"**.

The respondents grouped in the **third cluster** (11%) show very little intention to use, but give the highest rate to the potential benefits compared to all the other clusters. They have very low concerns about the package delivery conditions. However, this group is very concerned about legal issues (privacy and security). Because of this trait, this cluster was called **"Concerned with legal aspects**".

Respondents in the **fourth cluster** (39% of the sample) do not display any strong opinions, as the values for all variables are close to zero. While there are no particular concerns about parcel delivery or legal issues and some benefits are recognized, the intention to use drone delivery services is somewhat negative. Due to the neutral attitude of these respondents, this cluster was named "**Drone-service neutrals**".

The **fifth cluster** consists of 10% of the sample and includes people with positive intentions to use despite negative perceptions of benefits, legal and packaging issues. This cluster was called "**Drone service likely supporters''** because they are willing to use it despite their concerns.

Finally, the **sixth cluster** (10%) includes people who show no willingness to adopt the service, see no benefits or have no particular concerns. They are named "**Drone-service non-supporters**" for the negative attitute they demonstrate towards the new service.

4.3. Profiling of citizens´ clusters

Understanding the heterogeneous groups and the size of each group can provide insights to decision makers when joined with a deeper understanding of their characteristics. Addressing the socio-economic characteristics of each cluster can lead to more targeted engagement plans, awareness campaigns, or similar strategies developed by policymakers to engage citizens in more informed discussions. For this reason, characteristics such as age, gender, educational background and place of residence are compared for each group as shown in Table 5 and discussed using these figures. The values corresponding to the full sample are also provided in the Table to assist the identification of the differences among all the clusters. The discussed values are marked in bold. For variables representing respondents' satisfaction with the delivery service they currently use, the mean (M) and standard deviation (SD) of cluster member responses measured on a Likert scale (1-5).

The first cluster, "***Drone-service supporters***" demonstrates high drone technology awareness. Compared to other clusters, this group entails more people in the age group of 18-24 and a slightly higher proportion of women. Due to the high proportion of young people, this cluster has the highest proportion of students. In terms of education, 97.8% of individuals have an educational level equivalent to a bachelor's or master's degree. Analysing respondents' current experiences with delivery services, a relatively high percentage of them (61.7%) shops online at least once a week and these are the most satisfied respondent in terms of the level of additional fees they currently pay to get their packages delivered at their home and the condition of their delivery.

The second cluster, "***Concerned with package***"**,** includes people who are not familiar with this technology and more than half (54.5%) of them shop online 1-3 times per month. In this cluster, 63.9% of the members belong to the 25-34 age group and 61.4% are female. Compared to other clusters, this group has more unemployed people (11.4%) and people who stated they have other kind of occupations. Concerning income levels, there are more people in the low-income group (38.6% with an income between 0 and 1000 €/month) and fewer in the medium income group (1000 to 1500 €/month) (15.9%). In what concerns education, this cluster has a higher-than-average proportion of respondents with bachelor degrees and a lower proportion of respondents with master degrees. Finally, regarding residence and transport behaviour, compared to other clusters, it has the least percentage (27%) of people living in houses (namely in rural and suburban areas) and the highest proportion of people without a driving license (36.4%).

The individuals of the third cluster "***Concerned with legal aspects,***" appear to be the most aware about drone deliveries than other clusters. As far as their current ecommerce experiences, they are the least satisfied with the current extra price paid for home delivery prices (average = 2.85), with 66.7% shopping online 1-4 times per month. More than half of the members of this cluster are between 25 and 34 years old, and 18.2% are between 45 and 55, a percentage slightly more than the average. The gender dimension appears balanced and 45.5% of individuals have a master's degree. This cluster has the highest percentage of members (42.4%) who stated to have an income between 1000-1500 €/month. Only 27.3% of the members of this cluster live in the city centre which might also be related to the dominant percentage of people with a driving license (90.9%) and, in fact, 27.3% has more than 2 cars available in the household.

The members of the fourth cluster, "***Drone-service neutrals***" demonstrate medium awareness levels. In general, the characterisation of this sample is similar to the characterisation of the whole sample values for the majority of the variables except for few exceptions. Namely, this cluster consists of 58% by men which is the highest observed percentage. Regarding age, there is a higher percentage of young people (12.6%) and in education, 5% hold a doctoral degree.

The cluster "***Drone-service likely supporters***" having a positive view towards drone deliveries and their awareness levels are similar to the average of the sample. If their concerns are addressed and the positive characteristics of the drone delivery services are promoted, it is very possible that they will be happy to adopt this service. The members of this group are the most satisfied with the amount of time it currently takes to receive an order and they seem to use ecommerce with the lowest frequency compared to the other clusters, as 23.3% of them shops online 2-4 times a year and only 10% at least once a week. The online shopping frequency could be related to the very percentage of members (90%) living in the city-centre. The age group 18-34 is underrepresented is this cluster, while there are many people in the 35-44 (30%) and 55-64 (16.7%) age groups, and 13.3% of the members are retired. Women make up 63.3% of the cluster and 13.3% of the members are retired. Compared to the other groups, "*Likely supporters*" have the highest proportion of graduates from a technical school (33.3%) and the lowest proportion of graduates with bachelor degree (23.3%). Regarding income, extreme cases are seen, as this cluster has the lowest proportion of people in the lowest income level (13.3% at 0-1000 €/month) and the highest proportion of people in the highest income level (26.7% at 3000+ €/month). Finally, 50% of the members have a car available in their household, a very low percentage compared to the other clusters.

Finally, the cluster "***Drone-service non-supporters***" consists of individuals with the lowest awareness levels. Non-supporters are the least satisfied with the condition in which their orders arrive and shop online slightly more than the "*Likely supporters*" cluster, but less than the other groups. It contains fewer people aged 18-34 than the other clusters and more people aged 55-64 (19.4%). Gender is balanced, with slightly more retirees in this group than average. This group appears to be above average wealth: 61.8% earn more than 1500 €/month (35.5% earns 1500-3000 €/month and 25.8% earns more than 3000 €/month). More people (45.2%) live in a house and 35.5% have access to two cars.

Table 5. Socio-economic characterisation of the clusters

		Full sample	Cluster 1 Drone-service supporters	Cluster 2 Concerned with package	Cluster 3 With legal concerns	Cluster 4 Drone-service neutrals	Cluster 5 Drone-service likely supporters	Cluster 6 Drone-service non-supporters
Variables								
Satisfaction with time required to receive my order (M (SD))		3.31 (1.00)	3.40 (0.99)	3.34 (1.14)	3.24 (1.06)	3.24 (0.94)	**3.53** (0.86)	3.19 (1.08)
Satisfaction with price paid extra for the home delivery (M (SD))		3.09 (1.00)	**3.38** (1.03)	3.02 (1.11)	**2.85** (1.23)	3.07 (0.84)	3.23 (0.94)	2.90 (1.14)
Satisfaction with condition at which the order arrives (M (SD))		3.81 (0.88)	**4.13** (0.80)	3.95 (0.86)	3.97 (0.53)	3.75 (0.90)	3.53 (0.82)	**3.45** (1.12)
Easiness to reach the market (M (SD))		3.88 (0.81)	3.88 (0.80)	4.07 (0.73)	**4.20** (0.83)	3.71 (0.81)	4.02 (0.57)	3.81 (0.96)
Awareness (z-scores)		0.24	0.24	-0.38	0.33	0.10	0.19	-0.75
Frequency of online purchase	Never	0%	0%	0%	0%	0%	0%	0%
	2-4 times a year	10.9%	6.4%	9.1%	6.1%	10.1%	23.3%	16.1%
	5-10 times a year	9.9%	4.3%	9.1%	9.1%	10.1%	13.3%	**16.1%**
	1-3 times per month	39.5%	**19.1%**	**54.5%**	**48.5%**	39.5%	36.7%	41.9%
	Less than once a week	12.8%	8.5%	6.8%	**18.2%**	16.0%	16.7%	6.5%
	At least once a week	27.0%	**61.7%**	20.5%	18.2%	24.4%	**10.0%**	19.4%
Age	18-24	9.5%	**14.9%**	6.8%	6.1%	12.6%	3.3%	3.2%
	25-34	48.0%	42.6%	**63.9%**	51.5%	47.1%	40.0%	41.9%
	35-44	20.1%	21.3%	15.9%	18.2%	18.5%	30.0%	22.6%
	45-54	13.5%	12.8%	6.8%	**18.2%**	16.0%	10.0%	12.9%
	55-64	8.9%	8.5%	6.8%	6.1%	5.9%	**16.7%**	**19.4%**

	65+	0%	0%	0%	0%	0%	0%	0%
Gender – Male		48.4%	42.6%	38.6%	48.5%	**58.0%**	36.7%	45.2%
Main employment status	Employed	73.0%	70.2%	68.2%	69.7%	74.8%	76.7%	77.4%
	Student	9.5%	**17.0%**	9.1%	15.2%	7.6%	0.0%	9.7%
	Retired	3.6%	6.4%	0.0%	6.1%	0.0%	**13.3%**	6.5%
	Unemployed	8.2%	2.1%	**11.4%**	9.1%	10.1%	6.7%	6.5%
	Other	5.6%	4.3%	**11.4%**	0.0%	7.6%	3.3%	0.0%
Educational background	High school	1.3%	0.0%	0.0%	0.0%	1.7%	3.3%	3.2%
	Technical school	12.5%	2.1%	9.1%	12.1%	13.4%	**33.3%**	9.7%
	Bachelor	47.0%	**57.4%**	**59.1%**	42.4%	47.1%	23.3%	41.9%
	Master	36.5%	40.4%	29.5%	**45.5%**	32.8%	40.0%	41.9%
	Doctor	2.6%	0.0%	2.3%	0.0%	**5.0%**	0.0%	3.2%
Net income (€)	0-1000	28.0%	29.8%	38.6%	18.2%	31.9%	**13.3%**	19.4%
	1000-1500	28.0%	27.7%	15.9%	**42.4%**	28.6%	36.7%	19.4%
	1500-3000	28.3%	27.7%	31.8%	27.3%	26.9%	23.3%	**35.5%**
	3000+	15.8%	14.9%	13.6%	12.1%	12.6%	**26.7%**	**25.8%**
Type of residence	City centre	37.5%	34.0%	40.9%	27.3%	35.3%	50.0%	45.2%
	House (VS apartment)	35.2%	40.4%	27.3%	36.4%	31.9%	40.0%	**45.2%**
Driving license – Yes		74.0%	70.2%	63.6%	90.9%	73.1%	83.3%	71.0%
Cars available	Cars = 0	23.7%	25.5%	25.0%	15.2%	25.2%	23.3%	22.6%
	Cars = 1	42.8%	36.2%	40.9%	48.5%	45.4%	50.0%	32.3%
	Cars = 2	21.4%	**31.9%**	18.2%	9.1%	18.5%	20.0%	**35.5%**
	Cars = 3+	12.2%	6.4%	15.9%	**27.3%**	10.9%	6.7%	9.7%

Note: Highlighted cells indicate notable values

4.4. Clusters´ willingness to pay

Figures 3-10 bellow show the willingness-to-pay (WTP) for each cluster for different types of products. In the "***Drone-service supporters***", there is higher willingness-to-pay in the range of 3-8€ for food, drink, clothes deliveries, small sized electronics than average and less willingness-to-pay in the range of 1.5-3€ for food, medicine, small sized electronics than average. For postal items, small household items and books the willingness-to-pay is close to the average for all price categories. In the case of valuables, the lowest price ranges (0.5-1.5€ and 1.5-3€) show a lower willingness-to-pay, while the higher price ranges (3-8€ and 8+ €) show a higher willingness-to-pay than average.

Among the members of the "**Concerned with package**" cluster, there is an above-average number people in the second cluster who are willing to pay more for food in the price range of 3 to 8€. For drinks and books, this cluster is close to the average in all price ranges. For medicine and mail they are more willing to pay in the 3 to 8€ range, but only a minority are willing to pay between 1.5 and 3€ range. For clothes, there are people in this cluster willing to pay more than 8€. For valuables, few people are willing to pay in the lowest and highest price ranges (0.5-1.5€ and 8+€), while there is higher willingness-to-pay in the middle ranges (1.5-3€ and 3-8€) than average. For small sized electronics and small household items, there are less individuals willing to pay in the lowest and highest price range (0.5-1.5€ & 8+), while more people are willing to pay in the 3-8€ price range.

The cluster **"Concerned with legal aspects"** is in the middle range across all price ranges for the delivery of food and small household items. Respondents in this cluster are willing to pay between 1.5 and 3€ for drinks, medication, mail, and valuables. Fewer people are willing to pay more than 3€ for drinks, medicine, mail, small sized electronics and books. This cluster concentrates people willing to pay the lowest amount (0.5 to 1.5€) for clothes, valuable goods, small sized electronics and books, and fewer people compared to the other groups willing to pay in the range €1.5-3.

Respondents in the "**Drone-service neutrals**" cluster are more or less close to the average across all price ranges for food, drink, medication, mail delivery. For the rest of the cases, most of the respondents are not willing to pay high fees. A below-average number of people in this group are willing to spend between 0.5 and 1.5€ for clothes, valuable goods, small sized electronics. For small household items and books, more people are willing to pay 1.5 to 3€ and fewer people are willing to pay 3 to 8 euros€ for delivery.

In the "**Drone service likely supporters**" cluster, more respondents are willing to pay €0.5-1.5, while those willing to pay medium (1.5-3 and 3-8€) for food delivery are less. For drinks and valuable, this cluster is close to the average in all price ranges. "Likely supporters" are willing to pay the most for medicine (13.3% for 8+€), mail (10.0% for 8+€) and clothes (10.0% for 8+€), small household products (10.0% for 8+€) and books (10.0% for 8+€). For small sized electronics deliveries there are more people than average willing to pay in the 1.5-3€, and 8+€ price ranges and less in the 3-8€ price range. Fewer respondents are willing to spend 0.5 to 1.5€ for small household items and books, but an above average number of people are willing to spend 3 to 8 €.

In the "**Drone- service non-supporters**" cluster, more people are willing to pay 0.5-1.5€ and 3-8€ for food and fewer are willing to pay 1.5-3€ for food. Non-supporters are also the ones most willing to pay for food and drink 8+€ compared to other clusters. For medicines, the non-supporters are above-average more willing to pay 0.5-1.5€ and 3-8€ and below-average for price range 1.5-3. For mail, they are willing to pay more than average in the price range of 3-8€. For clothes, valuable goods, small sized electronics and books there are significantly more people than other groups willing to pay 0.5-1.5€. Also, for clothes there are less people willing to pay 1.5-3€ and 3-8€. For valuable goods, there are significantly less people willing to pay 3-8€ for delivery and for small sized electronics there are less people willing to pay 1.5-3€ & 3-8€. For small household products, less non-supporters are willing to pay 1.5-3€ & 3-8€ for delivery by drone, but slightly more people than average are willing to pay 8+ € for the service. Finally, for books they are less people willing to pay 1.5-8€, but more people willing to pay 3-8€ & 8+ € for delivery.

5. Discussion on implications of population´s heterogeneity

"**Drone-service supporters**" show the highest intention to use and in general have a positive view of drone deliveries. Regarding their willingness to pay, they seem to be keen on the medium price range for most product categories. This is also justified by the socio-economic status, since a significant number of students and young people are included in this cluster.

Individuals at the second cluster, "**Concerned with package**", have low awareness, which is accompanied with concerns about the packages being damaged or stolen during shipping, and a consequent lower intention to use. In order to increase their willingness to adopt the service, it is

important to gain their trust by showcasing the security measures taken while delivering a package by drone and familiarize them with this new way of delivering products with demonstrations and information campaigns. For the individuals in the "Concerned with package" cluster, the amount they are willing to pay depends on the category of the item as they have different opinions for different item categories. They generally have lower incomes and higher unemployment than other clusters.

Respondents in the "**Concerned with legal aspects**" cluster have the highest awareness. This can also be explained by the high benefits realisation. However, despite the benefits, they are so concerned about privacy and safety that they are reluctant to adopt the service. In order to engage them more with drone services it is essential to have their concerns addressed through effective regulation during deployment that protects them from malicious use of drones. In this cluster, respondents' willingness to pay is in the lower price range for most purchasing items. This behaviour may also be related to an increased awareness and perceived potential benefits. This cluster generally consists of people who are not too young, nor too old, with very low or very high income, but almost all of them have a driving license and many of them own more cars than other groups.

The largest cluster is the "**Drone-service neutrals**", which more or less corresponds to public opinion. They have no advanced knowledge or concerns, but are not convinced to adopt the service. Demonstrating the benefits of drone delivery services and addressing various issues arising from the large-scale that deployment of drones are necessary steps if public acceptance of drones is the goal. "Drone-service neutrals" is the larger cluster, which explains why more values in this cluster are closer to the average.

The **"Drone-service likely supporters"** show a positive attitude towards the adoption of drone delivery services, despite their concerns. With proper education and if their concerns are addressed, they are likely to become supporters in the early phases of drone related services. A campaign formulating useful information about the benefits of the service and general concerns such as privacy and safety upon arrival of package can provide an answer to their last concerns. They also seem willing to pay higher fees for the delivery of products of various categories, showing their willingness to spend more for an innovative service especially when it comes to medicines. They are older and have a higher income share, showing their ability to spend more money on services like drone delivery.

Finally, it is important for "**Drone-service non-supporters**" to demonstrate all the beneficial parts of a drone delivery services and run an information campaign to familiarize the group with the technology. They are most likely the most difficult cluster to engage because they have the lowest intention of using drones. About half of the respondents in the "Non-supporters" cluster is willing to pay the lowest price in all categories of product delivery. Their financial status appears to be the best of all the clusters, but their reluctance to pay high shipping costs can be justified by their general reluctance to adopt the service. It is noteworthy however that a share of them seems willing to pay the maximum of the fees for a possible delivery.

From policymakers and government regulators to business leaders and logistics providers, these findings can be used to better understand citizens´ views and plan policy-making. Engagement plans and awareness campaigns should be designed differently for each population cluster to address different perspectives more effectively and collect information for the design of socially acceptable and responsible drone services. The means used for each campaign also vary by group (cluster targeting and positioning). For example, a strategic engagement way for students could be through

open-days or other campaigns at the university campus demonstrating the reality of drone deliveries, while for younger people, who are the biggest users of social media [38], social networks could be the appropriate way of spreading awareness. A physical or hands-on experience with a drone might be more effective for people who are older or more unwilling to adopt the service. This is intended to bring future drone experiences closer to people and familiarise them with the service. Mainstream media such as television and radio should not be neglected either, because a large part of the population still uses them on a daily basis. Local Authorities, as well, could benefit to identify the type of engagement suited for each cluster according to their views [53], this would allow faster overcome of the barriers that pose challenges on technology deployment and diffusion.

It is also important to take into consideration that context could also affect public's views, as pointed out by Tan et al. [23]. For this reason, it is necessary for stakeholders and entities active in the field of Urban Air Mobility to provide a clear image of what they are asking the public to accept and use. As reported by Smith et al. [39], public acceptance should not be treated as a "rubber stamping exercise", but as a vehicle for a more meaningful debate. Drone deliveries is a market-oriented topic and citizens´ characteristics need to be analysed to better understand the key concept of mode of delivery, namely the heterogeneity of perceptions of humans on board drones in order to ensure proper use of drones and smooth introduction to the market. This is the first study about heterogeneity on the perceptions of people on drones, their associated characteristics, e-commerce behaviour and willingness to pay. Considering these results and their implications, the contributions of the study are summarized as follows:

1. Designation of heterogenous citizen profiles for which policy-makers and businesses could identify targeted actions so that barriers of adoption are confronted and appropriate services are designed
2. Evidence that satisfaction with current ecommerce experiences characterizes consumers´ views
3. Evidence that age, gender, employment, income, the type of residence area and car availability to the household are aspects that characterise consumers views on drone deliveries

Up to date, many studies have given insights on adoption and network characteristics but user views and willingness to pay are less analysed. We suggest an extension of the willingness to pay work and further qualitative analysis of the needs of each cluster. B2C applications could consider the designated aspects that vary across cluster to design properly personalised deliveries. By analysing willingness to pay, companies could make decisions on which product areas should be the first ones for which drone deliveries would be available and for each cluster design different delivery solutions.

6. Conclusion

As drone technology advances and technical challenges decrease, citizens´ views and social engagement becomes the key to make urban air mobility a reality. In this context, the presented work aimed to analyse the perceptions of Lisbon residents on drone delivery, according to their expressed intention to use, concerns and expected benefits, and to present different opinions on drone delivery services. The respondents were grouped into 6 clusters. Studying the perceptions and concerns of

these clusters is of high importance as it can lead to more informed policy decisions at local, national or EU level which can accelerate the large-scale operationalisation and deployment of UAM.

Principal component analysis (PCA) and cluster analysis were useful tools in this study to deepen the existing knowledge about citizen behaviour and to draw conclusions about potential market clusters and their characteristics. Principal components are the intention to use, expected benefits, legal concerns, and packaging concerns, which explain 74.4% of the variance with a KMO of 0.891. A cluster analysis based on the principal component scores divided the sample into six clusters of individuals: the drone-service supporters (15%), the concerned about the package (15%), the concerned with legal aspects (11%), the drones-service neutrals (39%), the drone-service likely supporters (10%), and the drone-service non-supporters (10%). The composition of the clusters varies according to characteristics such as age, gender, income, type of employment, and place of residence.

The survey responses show mixed attitudes towards drone delivery services in the city of Lisbon. While a large portion of the sample has not yet formed a concrete opinion (Cluster 4 "*Drone-service neutrals*"), others see the new technology more positively (Cluster 1 "*Drone-service supporters*" and Cluster 5 "*Drone-service likely supporters*"). Finally, some respondents seem unwilling to try the service for various reasons (Cluster 2 "*Concerned with package*", Cluster 3 "*Concerned with legal aspects*" and Cluster 6 "*Drone service non-supporters*"). Logistics stakeholders can use the results of this study for the proper introduction of drones in logistics systems and for the uptake of these services. For example, the third cluster of respondents, "*Concerned with legal aspects*", may change its attitude towards the service by overcoming legal issues through an appropriate regulatory framework, increasing intention and perceived benefits. Similarly, when packaging issues arise in the second cluster, "*Concerned with package*", individuals are more likely to be willing to adopt the service. For "*Drone-service neutrals*", "Drone- service *likely supporters*", and "Drone- service *non-supporters*" we look for increasing acceptance by addressing regulatory concerns with specific and detailed information and appropriate training on this new technology. This also applies to the first cluster "*Drone-service supporters*" because, despite their willingness to adopt drone delivery services, their awareness is low at the same time.

In summary, the technical feasibility of large-scale drone deliveries is less and less of an issue as technological tools in the sector of drone logistics proliferate. However, social acceptance is not guaranteed as noise, safety and privacy are important factors to consider when developing services, leading to various restrictions [40,41]. The findings of this study are a stepping-stone to better understanding public opinion that will shape future decisions the context of urban air mobility. Future steps could enlarge this study by collecting a larger sample in other cities. Collecting more data is important for better understanding of public acceptance and useful for comparing different cities. Apart from understanding heterogeneity within cities, the extension would allow comparing heterogeneity between cities.

The study contributes with the exploration of heterogeneity in the population in which subsequent studies could define frameworks that are common to all subjects in the population. From a market perspective, in this study, the population was divided into different clusters based on their views on these three broad issues to see how they differ based on socioeconomic (e.g. gender) and behavioural characteristics (e.g. frequency of online shopping). These attributes can be analysed in

future studies to identify their moderating role between other concepts (i.e. Benefits, concerns and usage intentions) and use confirmatory techniques.

This study takes a market and social oriented perspective. In the future, we may need more specific perspectives to better understand the attitudes and intentions about the topic that show different demographic profiles. This means that consumer from different segments will look for distinct solutions and companies will need to identify these needs and the consumers characteristics. In terms of market segmentation in particular, our research shows that some segments are more attractive to start with than others while more insights are needed to explain the differences in the willingness to pay among clusters.

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691 Annex

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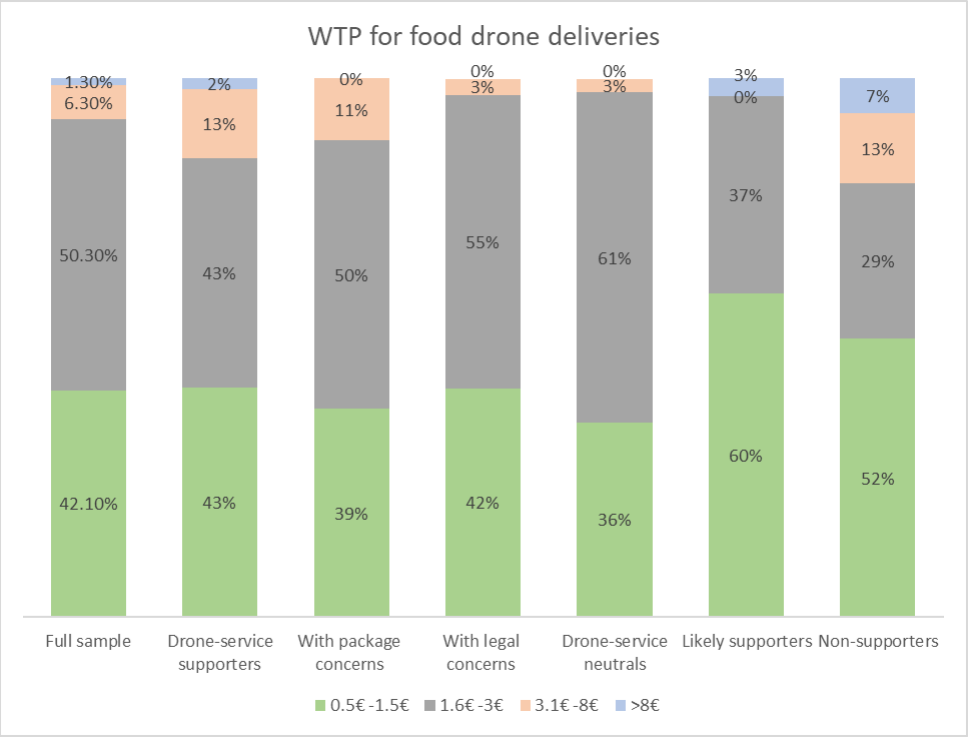

693

694 Figure 3. Cluster-based willingness to pay for drone deliveries of food

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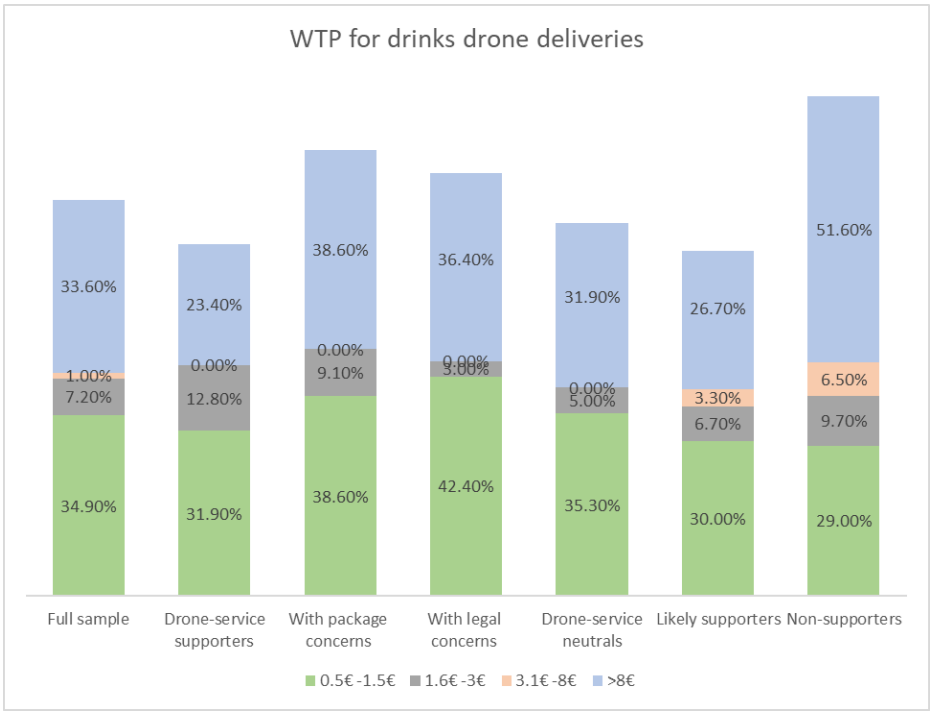

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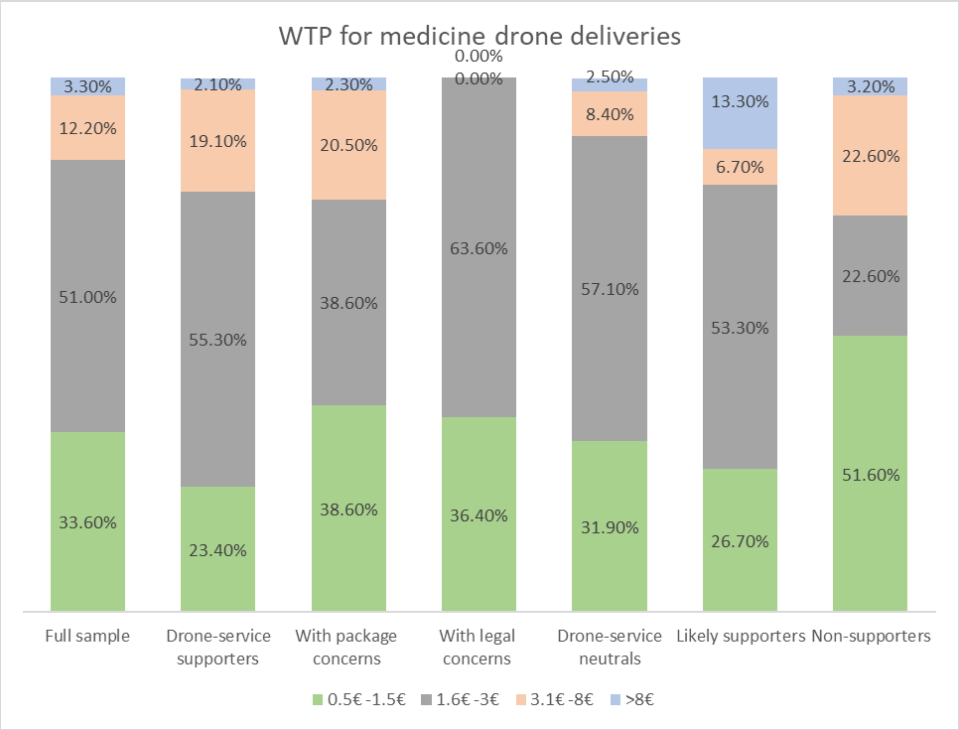

Figure 5. Cluster-based willingness to pay for drone deliveries of medication

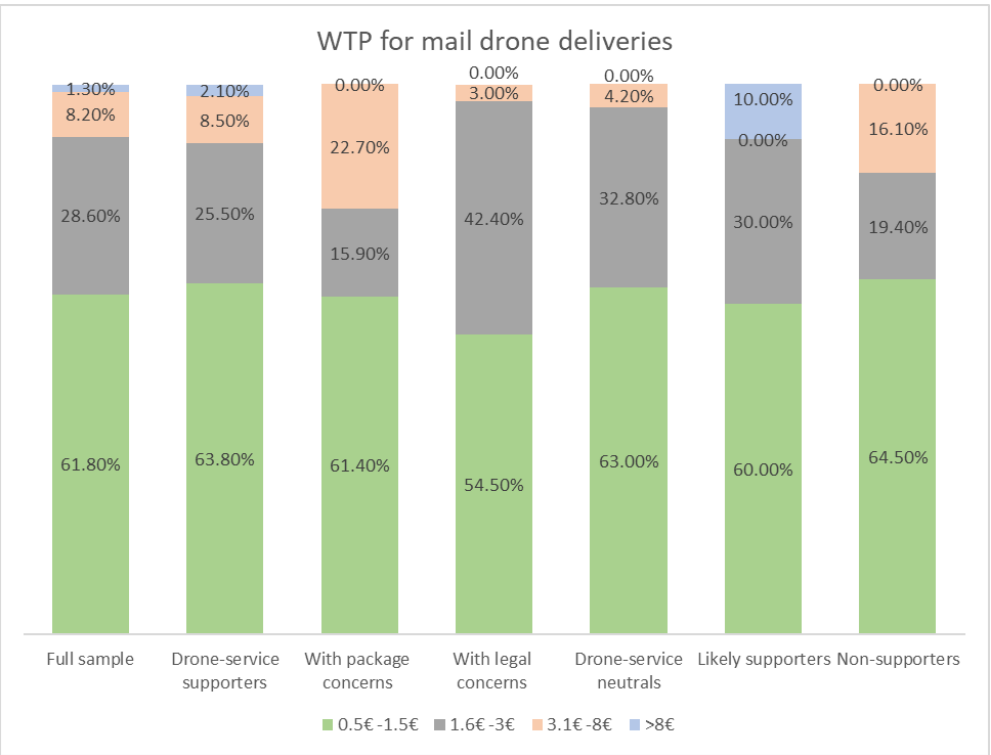

Figure 6. Cluster-based willingness to pay for drone deliveries of mail

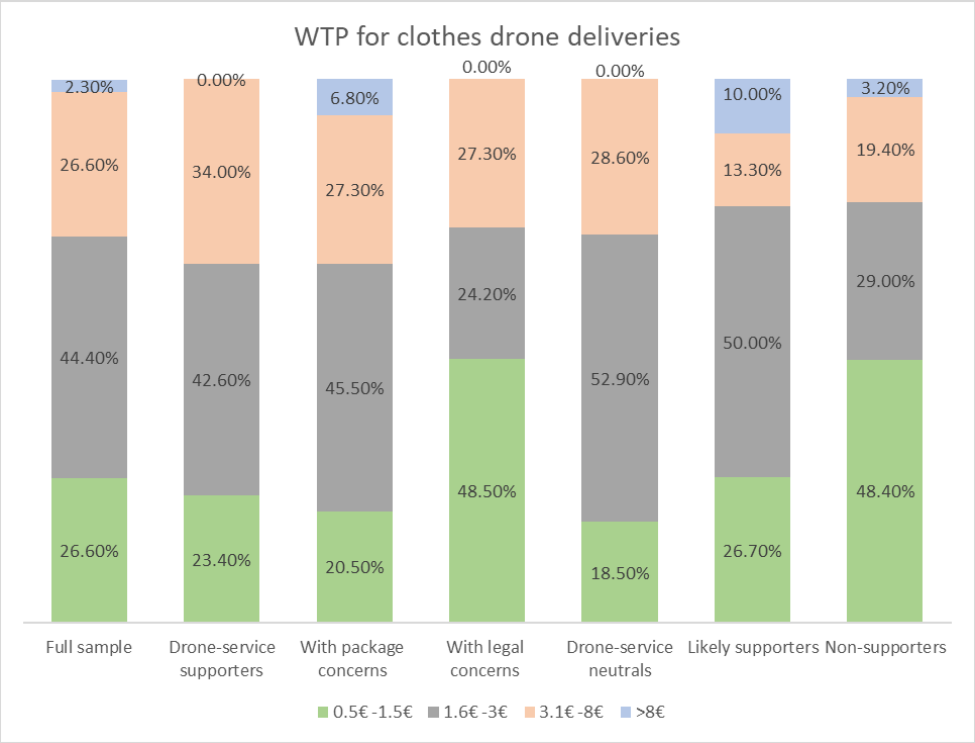

Figure 7. Cluster-based willingness to pay for drone deliveries of clothes

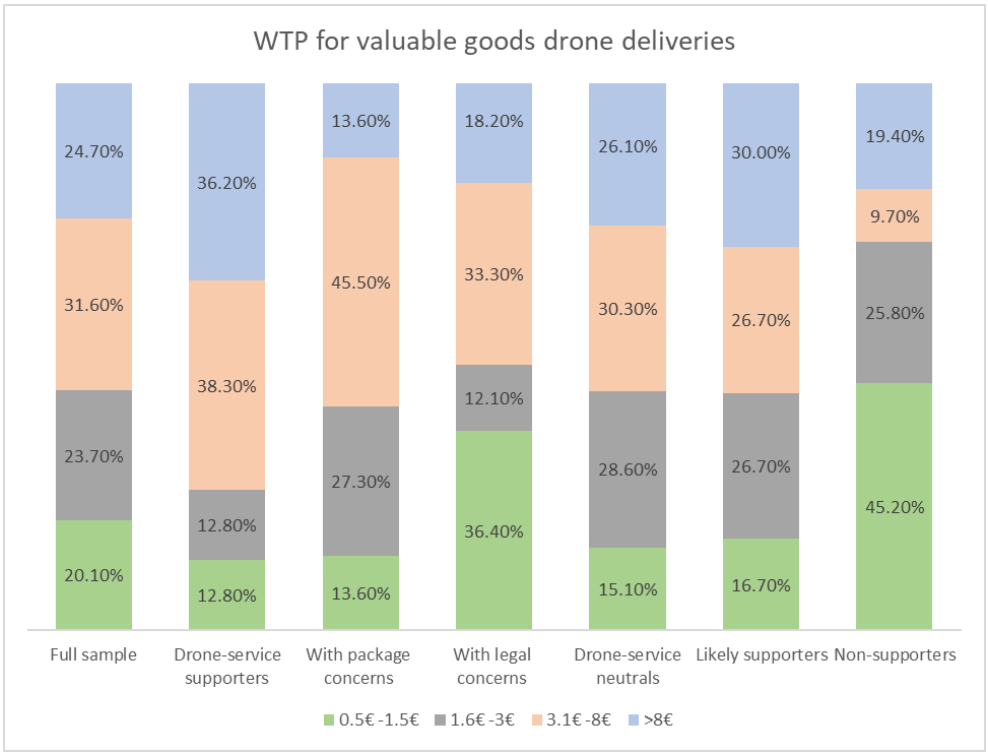

Figure 8. Cluster-based willingness to pay for drone deliveries of valuable goods

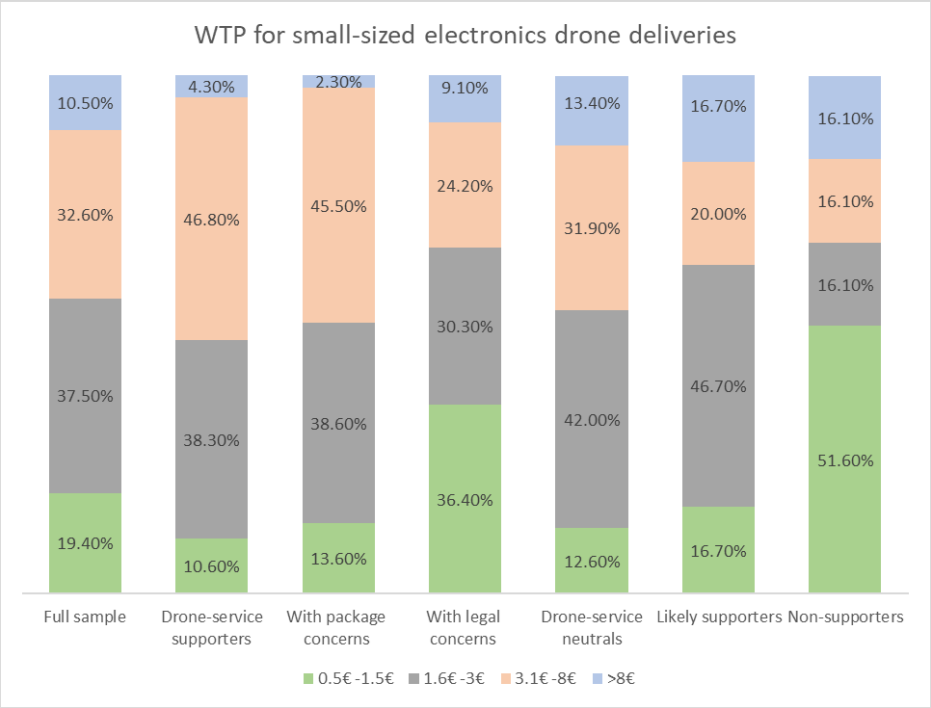

Figure 9. Cluster-based willingness to pay for drone deliveries of small electronic devices

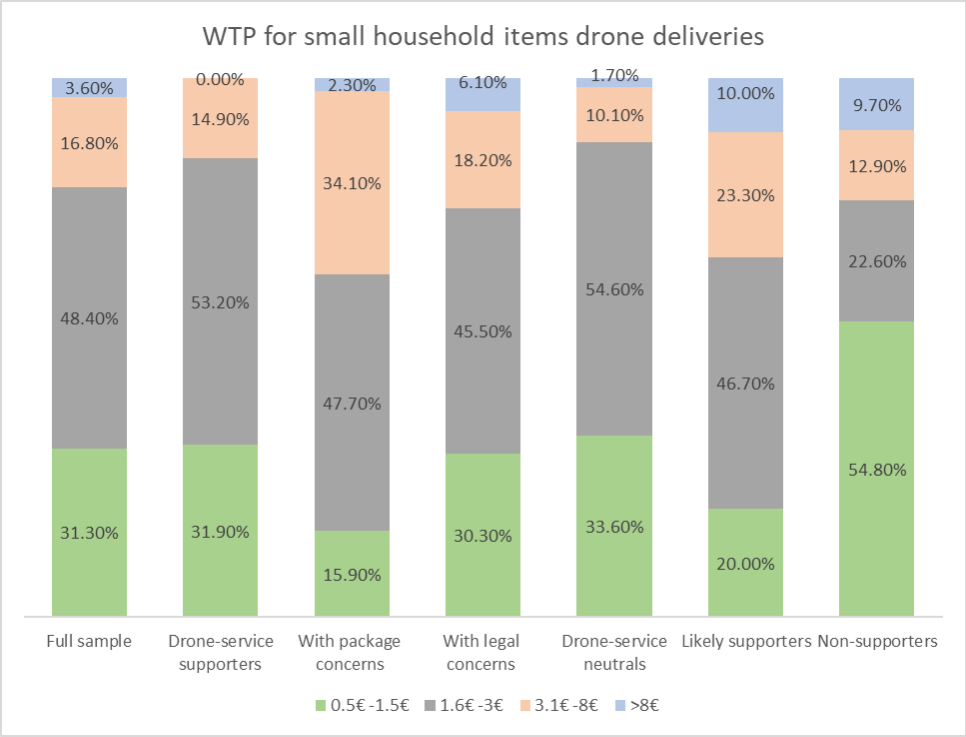

Figure 10. Cluster-based willingness to pay for drone deliveries of small household items

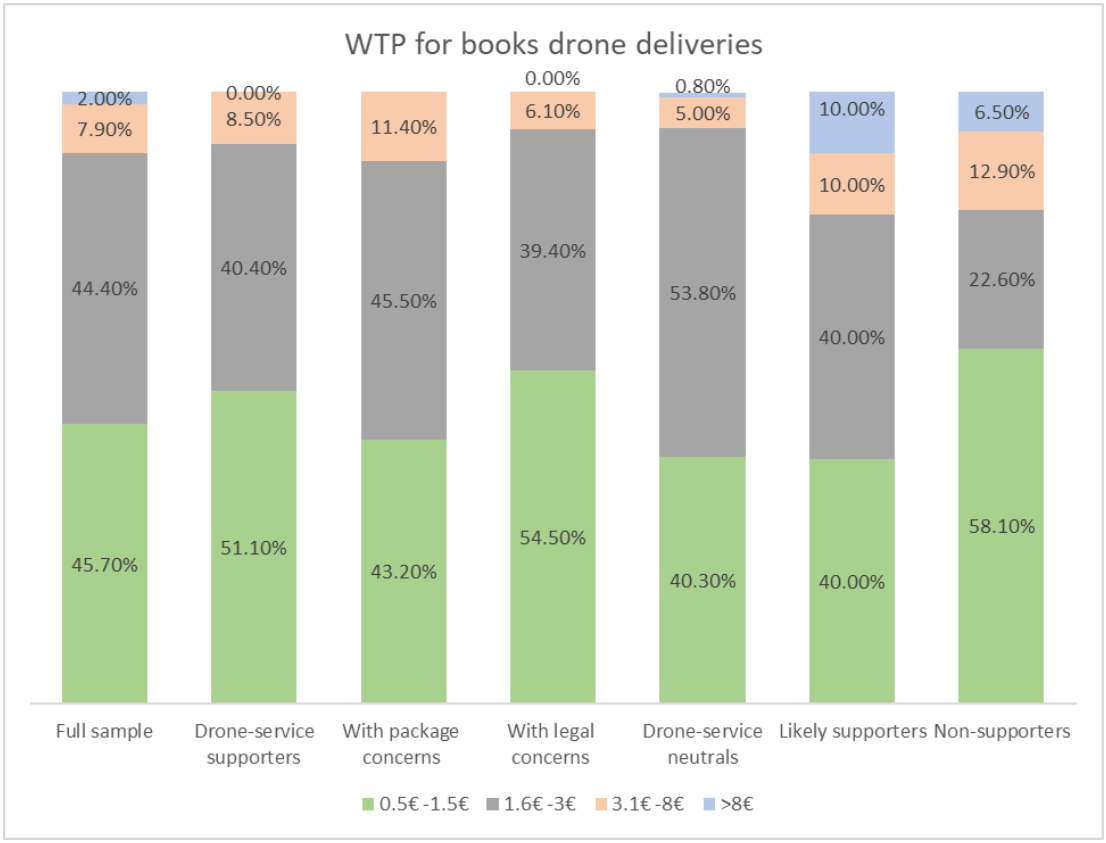

Figure 11. Cluster-based willingness to pay for drone deliveries of books