

Article

Delivery Drone Dilemmas: Prioritising the Sustainability Concerns of Citizens and Practitioners

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Abstract

In a time of rapidly rising home deliveries, the introduction of drones as part of a future logistics system could enhance the efficiency of some goods movements, but brings with it the prospect of a change to the environment and society. This study seeks to identify how varied the concerns are amongst both practitioners and citizens and also how different the concerns of the public are from those of practitioners. The research uses Q-Sort methods to understand the critical variables and clusters of opinions which reflect potential policy controversies. A Q-Sort was first conducted with 53 professional stakeholders before a common but reduced size Q-Sort was undertaken with a representative sample across three different local geographies (N = 610) in the UK. The findings suggest many common clusters of viewpoints across the expert and citizen samples, with the key interactions being between the degree of in principle support for drones for delivery and the degree of practical control over their introduction. However, the citizen group was dominated by drone sceptics worried about privacy, terrorism and environmental impacts in a way which was not manifested in the experts. Few differences occurred between places suggesting that simple urban–rural dichotomies do not define the key controversies.

Keywords: drones; sustainability; governance; Q-Sort; transport policy

1. Introduction

The electrification of transport systems is central to achieving a reduction in carbon emissions [1]. The integration of uncrewed aerial services (UASs), (from here on referred to as “drones”), into transport systems has been explored with respect to their potential to contribute to this transition for last-mile logistics [2]. Government agencies are supporting the development of drone delivery services through the modernization of airspace use and their support for pilot initiatives. A strategic priority of EASA (European Union Aviation Safety Agency) is the implementation of “U-space” across member states [3] and similarly, in the UK, civil aviation systems are being developed to allow for the integration of more routine drone flights as part of the CAA (Civil Aviation Authority) Airspace Modernisation Strategy [4]. These developments aim to support the widespread operation of drone services with the potential to bring environmental and social changes to communities.

Existing examples of drone delivery services operating in the Global North are currently small scale. For example, Manna operates within two suburbs (Blanchardstown, Dublin, Ireland and Pecan Square, TX, USA) and delivers packages of up to 4 kg which



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are largely comprised of takeaway food and groceries [5]. Each drone can make up to eight deliveries per hour with an average flight time of around 4 min, and their operations have been estimated to cut local emissions associated with the delivery of food via road vehicle by 150 tonnes of CO₂ per annum [6]; this is alongside various trial services focused on the transportation of medical items such as diagnostic samples; see for example Project CAELUS [7].

However, all aspects of urban delivery are electrifying. It is important to ask whether the introduction of drones, which constitutes a major social change, is really an advance in sustainability. To be able to answer this question, it is necessary to look across the wider social, economic and environmental goals for places. Public acceptance of drone services is a key factor in ensuring their longer-term viability, with evidence that pushback in response to localised impacts has forced the cessation of services in some places [8,9]. The use of drones for the transport of medical items is often justified with respect to providing time-savings; however, the business case and the need for urgency warrants greater scrutiny [10]. The general public is understood to be more accepting of the local impacts of drone delivery services where there is potential for environmental or social gain [11], and promoters place emphasis on these aspects as part of their legitimising strategies [12]. However, such gains are not always demonstrable, reductions in emissions have been limited [13,14], and services may create a new type of transport demand [8]. Perceptions of potential services amongst the public draw heavily on media framings, particularly where there is limited direct experience, which can act to perpetuate misconceptions around environmental and social benefits [15]. Representations are also formed around existing and more familiar drone applications such as photography and warfare with related concerns over privacy and terrorism [16]. Research framings have acted to conflate various drone applications and as such, understandings of perceptions may relate to a range of applications [17]. Smith et al. (2022) argue that the implications for the use of drones for delivery are very different to those that take place in locations which are largely away from the public domain (e.g., powerline inspection) or represent single events (e.g., photography) [17]. As such, there is a call for research to be specific to drone delivery applications, noting that even within this application, there are diverse forms of potential services. Moreover, there is a need to recognise the context within which perceptions are formed, including the positioning of the participant, with different types of places being valued differently and responses being linked to individual knowledge and values [18].

Whilst there is a substantial literature on the public acceptance of drones, rather less attention is paid to the governance challenges which these new technologies face, beyond those which act as an immediate impediment to their adoption [19]. Stilgoe and Mladenovic [19] suggest that it is critical to step back from the presumption that these technologies are inevitable and where the only relevant questions are about how to ensure acceptance. Instead, they argue that we need to explore the politics of new technologies, which means engaging with who wins and loses from their introduction and who has power to decide [19,20]. Fischer suggests that we cannot know the full nature and diversity of issues which different groups will hold as important, and the extent to which these “differences become disputes” [21] (p105). It is therefore critical to understand how different policy communities might respond to the problem at hand as this will shape their assumptions and routes to engagement with citizens. This paper also considers the differences between policy communities and citizens, and the interaction between the key societal impacts and the approaches to governing drones to understand whether the debates of policy elites align with the concerns of local communities.

The key questions that this paper sets out to explore are therefore: (1) What are the key policy dilemmas surrounding the introduction of drones for delivery? (2) How

different are those dilemmas between policy communities and citizens? (3) Do these differences vary across local contexts? Understanding these questions allows research and practice to reconcile the technical potential gains of drones (e.g., to the environment or cost-effectiveness) with the dilemmas surrounding adoption. This, ultimately, shapes whether any such potential comes to pass. To explore this, the study uses the Q-Sort methodology, which is finding significant application in exploring transport policy dilemmas [22–24]. Q-Sort presents participants with a series of statements which are ordered by degree of agreement (and disagreement). Through the relative placement of statements, groups can be clustered together who share similar opinions which are significantly distinct from other groups. The focus is on establishing clusters of shared viewpoints rather than on establishing differences by means of age or education. It seeks to identify the nature of key dilemmas rather than to provide averages which show general support or criticism.

The paper proceeds as follows. Section 2 sets out the approach to Q-Sort and how it was first applied across the policy community and then reduced and applied in three local contexts in the UK. Section 3 presents the results of the Q-Sort method for the policy community and the citizens separately. Section 4 then discusses the joint implications of the analysis structured by the main research questions set out above. Section 4 concludes with a discussion of the implications of the work not only for the on-going debates about the introduction of drones for delivery but also more broadly as a reflection on how we understand the critical dilemmas surrounding uncertain new technologies.

2. Materials and Methods

2.1. Q-Sort Method Overview

The Q-methodology involves the development of a set of subjective statements which participants are required to sort into levels of agreement (hence the use of the term Q-Sort to describe the application of the method). The research method comes from a tradition which suggests that we cannot objectively know how people perceive a problem, but we can gain insights through the way in which they interact with subjective statements [25]. However, “Q-method is not a tool designed for reaching consensus; on the contrary it is suited for stimulating heterogeneity in opinions on subjects on which a more or less mature developed debate has evolved” [22] (p4). Rather, the Q-methodology brings together a quantitative interpretation of the response to the set of qualitative statements by clustering similar groups of statements found within the sample using factor analysis [25]. It is the statements which are found to cluster together which have primacy, with the nature of the respondents associated with each cluster of statements then subject to reflection. For this reason, the Q-methodology is useful in the context of planning controversies in which there is dissensus across a range of stakeholders.

The process for developing a Q-Sort is to build a “concourse”, which is a body of text which captures the current state of debates and discussions on a topic. This can be from sources such as newspaper articles, podcasts and government reports. These are then refined using a set of criteria relevant to the study in question (e.g., González-González et al. [22] used visioning reports to identify relevant terms, and Tsigdinos et al. [23] used a systematic review). The refined short list is then turned into statements which the participants in the study can agree or disagree with. The task is then for participants to quickly review the statements and group into three intuitive piles (agree, disagree, neutral/not sure) before placing them on a Q-Sort grid (see Figure 1 for this study). Fewer options are given at either end of the grid to force choices into the strength of opinion people hold on topics. Whilst the grids often have a numeric value along the scale, the numbers are there to enable the researchers to describe where statements sit along the axis and have no scalar value analytically. It is also important to note that participants are sorting

their statements in relative order. It would, for example, be possible to agree with every statement and still place them on a grid from most agreed with to most disagreed with.

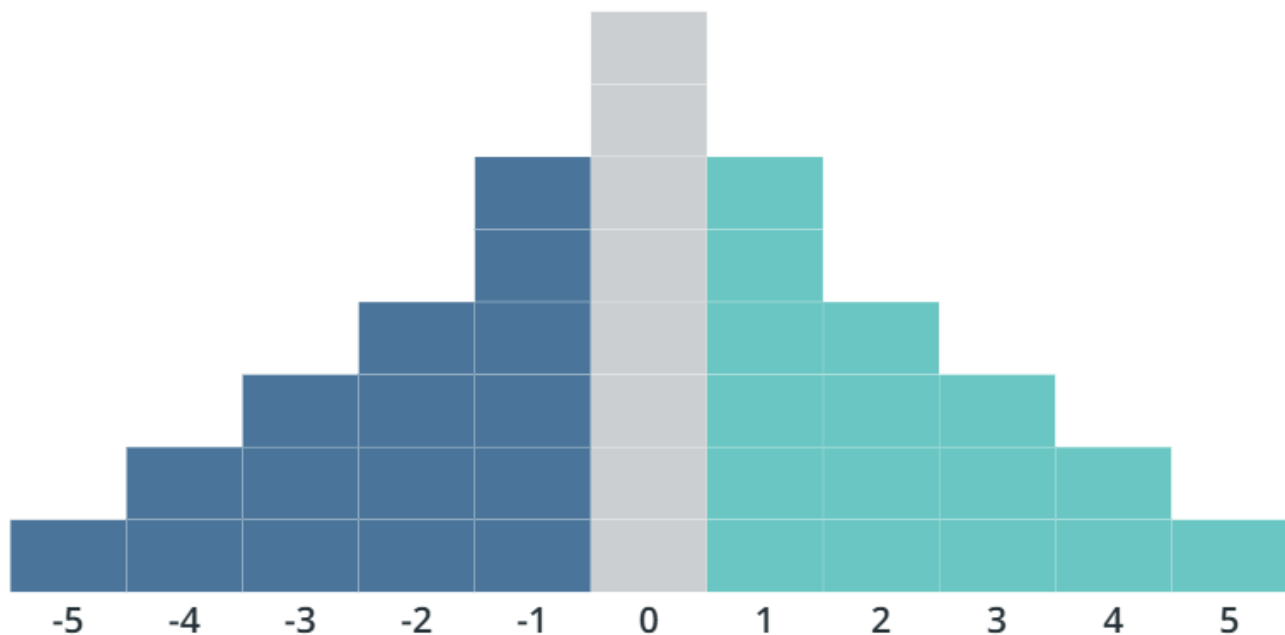


Figure 1. Expert Q-Sort grid.

For this research, the team used Qmethod (<https://qmethodsoftware.com/>), a commercially available software which provided a robust platform for sending out links to participants. It also enabled the software to be linked to the on-line citizen recruitment panel rather than having to specifically programme the Q-Sort within the panel provider's own in-house platform. Further details about our specific application of the methods are provided below.

2.2. Recruitment

We adopted a two-staged approach to the Q-Sort in this study. The first stage involved the recruitment of a purposive sample of expert stakeholders ($n = 53$ —hereafter referred to as “experts”, although they were in the field of transport planning and logistics rather than specifically drone experts) who undertook a Q-Sort on a set of 40 statements. “Expert stakeholder” was defined as an individual working in planning or policy context, at a local or national scale, whose organisation would be impacted by delivery drones or whose work might influence the planning and policy space regarding regulation of delivery drones. The experts could be classified into the following groups:

- Government (19);
- Consultant (15);
- Academic (5);
- Industry (4);
- Non-Governmental Organization (8).

Recruitment was done primarily through LinkedIn and introductory emails. The sample was not random. Indeed, early open recruitment attempts proved difficult as many practitioners did not (yet) see drones as part of their planning concerns. More bespoke recruitment with an explanation of why it was important to engage with the issues surrounding the introduction of drones was required. Whilst this could impact the results, care was taken to ensure that there was a balance of people working on the introduction of drones and those who had little engagement. During the Q-Sort, a researcher was available

on line to answer any queries about how the software worked. This Q-Sort was used to map out the most pertinent policy dilemmas and groupings of opinions in the expert community and data collection occurred between December 2022 and June 2023. All of the Q-Sorts were completed using the on-line software. The second set of Q-Sorts were to be conducted with members of the public using the same on-line software. However, it was felt that the practical challenge of sorting 40 statements was too onerous in unfamiliar software (and there was no scope for a researcher to be available for help as in the expert work) and so a reduced form of Q-Sort was established using 25 statements. In order to select the statements which should be sorted by citizens, the research team analysed the outcomes of the expert Q-Sort and removed statements which were not important in assigning experts to different clusters. Attention was also paid to ensuring a suitable coverage of themes (see 2.3) and a balance of positive and negative statements to avoid biasing the respondents. Recruitment for the citizen Q-Sort was undertaken in three places (Coventry ($n = 206$), parts of Cornwall ($n = 203$) and Bournemouth and surrounding areas ($n = 201$)). Trials of drone technology were being undertaken in both Falmouth (a town in Cornwall in the selected area) and Coventry, and so it was felt that at least some respondents would have familiarity with the idea of drones for deliveries. The sites also represented different settings with Coventry predominantly urban, Cornwall predominantly rural and Bournemouth containing a mix of settings.

2.3. Developing the Q-Sort Question Set

Whilst the topic of drones is commonplace within news, media, and research, the use case of drones for delivery purposes is an emergent issue with limited attention or information beyond those already working on it. There was an initial wide scope for all literature—including news and media—related to drones, but little to none engaged with the question of drones as a logistics technology yet to come. Therefore, the literature informing the development of the Q-Sort concourse was deliberately restricted to private and public sector (policy) reports dealing with expanding the case for uncrewed traffic management systems (UTMs) (e.g., the CAA review of airspace management [4]), future transport more generally and/or the changing demands of urban space and how best to regulate it (e.g., guidance on Parking and Loading Legally). The topics that emerged for the Q-Sort were therefore those which the concourse identified as important.

Whilst there was no year constraint on the document search, it yielded reports and documents from approximately 2019–2023, reflecting the relative nascence of the topic. Concurrent to the policy and document search was that of scholarly research that focused on the question of regulating transport and/or logistic technologies yet to come. Seven government reports and two academic papers dealing with drones and/or the regulation of urban space more generally were chosen to help build the set of statements used within the concourse. Discourse analysis was used to identify initial thematic categories that spoke to the justification of introducing drones into the last-mile logistics arena or categories that represented issues around regulatory concerns and issues. These were: Actors, Automation, Climate, Congestion, Cost, Data, Decision-making, Demand, Efficiency, Innovation, and Regulation. These categories were subsequently revisited and combined into Environment, Regulation, Innovation, Logistics, Safety, and Society with the aim of providing a balance of questions in each theme. These then had to be turned into question statements which people could agree or disagree with.

Positive and negative versions of questions which matched the original set of statements were developed to produce a balance of positive and negative statements for each theme, (e.g., if you liked the environment you would have to disagree with some statements and agree with others). The framing of statements also paid attention to whether it was

appropriate to use absolutes (e.g., “is”) or conditional statements (e.g., “should be”). For example, a statement describing the problems of a slow regulatory environment in one policy report was “flipped” and simplified into the following statement:

The approach to regulating drone use is too fast.

The table was iterated upon six times by the research team, with a few mock Q-sorts with colleagues outside the project to find a total of 40 statements that represented a balance of sentiment and thematic. Table 1 shows the full battery of 40 statements with the reduced form set used in the citizen Q-Sort marked with an asterisk.

Table 1. Q sort statement set.

Statement (* If Also Used in Citizen Q-Sort)	Main Theme
Drones should not need to demonstrate carbon benefits before being introduced *	Environment
Emissions from the manufacture of drones and batteries must be considered in assessing their impacts	Environment
To minimise noise and disruption, drones will need to operate within fixed permissible times for delivery *	Environment
The impacts of drones on wildlife are not significant *	Environment
Regulation of drones should be the same in rural and urban areas *	Regulation
Drones will negatively impact overall noise pollution	Environment
Innovation in drone technology for deliveries does not have enough societal benefit to make it worth it	Society
Government has a duty to protect the tranquillity of less developed areas *	Regulation
The approach to regulating drone use is too fast	Regulation
Increasing drone use is essential to the growth of the UK economy *	Innovation
It is up to businesses to decide if drones are going to be useful *	Innovation
Government should not be acting to facilitate commercial drone use	Regulation
Government should be planning for the introduction of air taxis	Innovation
The rising number of home deliveries is a problem *	Logistics
A national strategy for managing growth in deliveries is needed before the case for delivery drones can be considered	Logistics
Drones should only be allowed to deliver some types of products to people’s homes *	Regulation
Companies must better organise their deliveries to combat the wastefulness of multiple home deliveries *	Logistics
Robot delivery carts are more suitable for home deliveries than drones	Innovation
Airspace is too complex for management at a local scale	Regulation
Local authorities do not currently have the capacity and skills to regulate drones	Regulation
Local authorities should have a role to play in the regulation of the use of drones for delivery in their area *	Regulation
Leisure drone users need different regulation to those operating drones for delivery	Regulation
Drones for deliveries should be allowed to land in people’s gardens *	Society
Towns and cities are too busy for delivery drones to safely operate *	Safety
Delivery drones should not be allowed to fly over schools during the school day *	Safety
Drones should not be restricted on safety grounds so long as they are safer than vans *	Safety
Drones pose no additional risk from terrorism *	Safety
Camera technology on drones is not a significant privacy issue *	Society
Public taxes should not be funding drone development trials *	Innovation
People have a right to limit drone flights over their house *	Society
Delivery drones are a solution looking for a problem	Logistics
Avoiding negative impacts on vulnerable citizens should be key to whether or not new technologies are approved	Society

Table 1. Cont.

Statement (* If Also Used in Citizen Q-Sort)	Main Theme
Delivery drones will be more useful for rural communities than urban communities *	Society
Small scale drone trials are important to understand the overall impacts of drones on society	Innovation
The public cannot understand how drones for deliveries will impact them *	Society
Drones used by the emergency services should be treated differently to drones for delivery by retail companies *	Regulation
The public should not be asked to decide if drones for logistics are desirable *	Society
It is okay if some groups in society are not able to benefit from drone use for delivery *	Society
Social acceptance of drones for deliveries will increase as their use becomes more commonplace	Society
The introduction of drones for delivery in the UK is inevitable	Innovation

2.4. Operationalising the Q-Sort

The Q-Sort was programmed into the Q Methods Software (<https://qmethodsoftware.com/>). Participants first sorted the statements into three piles of Agree, Disagree and Neutral and were instructed to do this intuitively as they would have a chance to revisit their relative positions when placing the cards on the sort grid. They then placed the cards on a Q-Sort grid (shown in Figure 1). Participants were instructed that the right-hand side of the chart indicated strength of agreement and the left, strength of disagreement. Cards were placed and then adjusted until the participants were happy that this reflected a spectrum from most agreed with to most disagreed with. It is important to note that the numeric values have no significance in the analysis but simply allow people to see that they are placing something as more or less important than the next statement. Participants are assumed to have no preference among the items stacked vertically on the grid.

For the citizen groups, the reduced form set of questions was used. Participants were recruited by YouGov to match the demographic characteristics of the areas and, following some initial screening questions, were sent to the external Q Methods Software package to complete the task. The average time for completion of the expert/stakeholder surveys was 11 m 29 s and between 5 m 28 s (Bournemouth) and 6 m 30 s (Cornwall) for the citizens, reflecting the smaller task and the more limited engagement with institutional remits and planning logics and a more intuitive approach to responding.

3. Results

This section first reports the results from the expert/stakeholder surveys. The results from the citizen data set are then analysed by area.

3.1. Expert/Stakeholder Q-Sort

Q-method uses Principal Component Analysis (PCA) to identify the components that enable the matching of similar response grids and therefore allow clustering of response groups. PCA produces:

- “A measure of how each variable is associated with one another (covariance matrix).
- The directions in which our data are dispersed (eigenvectors).
- The relative importance of these different directions (eigenvalues)” [26].

Extracted factors were rotated using the Varimax method rather than by hand, as there was no theoretical basis on which to base a manual rotation, and this provided a set of orthogonal factors. In line with Tsigdinos et al., (2022) [23], we identified the number of extracted factors by ensuring the following two conditions were met:

- The eigenvalue of each factor should be >1;

- At least two Q-Sorts should significantly load onto each factor.

The task of deciding which solution is preferable is to select a relatively low number of factors which describes the maximum amount of variance. The hyperplane analysis function in the Q Methods software was used to help determine the final solution. Hyperplane seeks to identify solutions where there is one high factor loading and numerous low factor loadings, where higher values of hyperplane percentage are indicative of simpler solutions [26]. Different numbers of factors were explored and the extent to which the conditions set out above were met dictated if they were considered further. For those meeting both conditions, the hyperplane percentage was analysed. Table 2 shows the table of eigenvalues and Table 3 the matrix of factor loadings for the five factors.

Table 2. Factor rotations, exclusions and hyperplane analysis.

Factors	Minimum Sorts Assigned to Factor	Number of Sorts Unassigned	Hyperplane
8 Factor Rotation	0 (factor 8)		
7 Factor Rotation	1 (factor 2)		
6 Factor Rotation	2 (factor 5)	23	26.1%
5 Factor Rotation	4	17	26.8%
4 Factor Rotation	6	14	19.8%

Table 3. Eigenvalues of the unrotated factor matrix.

Factors	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Eigenvalue	18.8	4.5	3.4	2.8	2.1

The analysis suggested that the hyperplane percentage dropped off at four-factors, meaning that the six- and five-factor rotations performed better than the four-factor rotation. As more sorts loaded to each factor in the five-factor solution and there were fewer unassigned sorts, the five-factor solution was taken forward and the results presented in Table 4.

Table 4. Z scores and sort values for expert sort.

ID	Statement	What Is the Question		Drone Advocates		Drones Are a Problem		Drones Are Coming Do It Right		Just the Details	
		Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score
15	A national strategy for managing growth in deliveries is needed before the case for delivery drones can be considered	5	2.125 *	0	−0.193	1	0.571	0	−0.286	0	0.122
14	The rising number of home deliveries is a problem	4	1.947 *	−4	−1.717	−1	−0.343 *	3	1.488 *	−2	−1.183
32	Avoiding negative impacts on vulnerable citizens should be key to whether or not new technologies are approved	4	1.455	−1	−0.762 *	1	0.708	3	1.434	2	0.769
20	Local authorities do not currently have the capacity and skills to regulate drones	3	1.444	5	2.048 *	1	0.461	2	1.276	0	0.294

Table 4. Cont.

ID	Statement	What Is the Question		Drone Advocates		Drones Are a Problem		Drones Are Coming Do It Right		Just the Details	
		Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score
21	Local authorities should have a role to play in the regulation of the use of drones for delivery in their area	3	1.366	0	−0.204	2	0.961	2	1.190	0	0.041
2	Emissions from the manufacture of drones and batteries must be considered in assessing their impacts	3	1.206	2	0.558	3	1.149	3	1.308	3	1.184
17	Companies must better organise their deliveries to combat the wastefulness of multiple home deliveries	2	1.159	−3	−1.175 *	4	1.455	2	1.193	3	1.051
36	Drones used by the emergency services should be treated differently to drones for delivery by retail companies	2	1.022	4	2.012	5	1.585	1	0.839	3	1.421
34	Small scale drone trials are important to understand the overall impacts of drones on society	2	0.938	3	1.554	0	0.313 *	4	1.515	2	0.922
8	Government has a duty to protect the tranquillity of less developed areas	2	0.732	1	0.488	0	0.181	1	0.555	1	0.376
30	People have a right to limit drone flights over their house	1	0.551	0	−0.220	0	0.355	−1	−0.650	2	1.023
3	To minimise noise and disruption, drones will need to operate within fixed permissible times for delivery	1	0.496	−2	−0.955 *	0	−0.040 *	4	1.622 *	1	0.734
22	Leisure drone users need different regulation to those operating drones for delivery	1	0.438	3	1.028	0	0.183	2	1.142	4	1.583
6	Drones will negatively impact overall noise pollution	1	0.402	1	0.259	2	0.778	1	0.605	0	0.058
25	Delivery drones should not be allowed to fly over schools during the school day	1	0.250	−2	−0.968 *	1	0.436	0	0.095	5	2.038 *
33	Delivery drones will be more useful for rural communities than urban communities	1	0.140 *	4	1.807	2	0.719 *	−2	−0.749 *	4	1.479
16	Drones should only be allowed to deliver some types of products to people's homes	0	0.108	2	0.924	3	1.269	1	0.295	1	0.537
19	Airspace is too complex for management at a local scale	0	0.107	2	0.625	−1	−0.193	1	0.219	−4	−1.381 *
40	The introduction of drones for delivery in the UK is inevitable	0	0.101	−1	−0.269	−3	−1.306 *	1	0.172	2	1.047 *

Table 4. Cont.

ID	Statement	What Is the Question		Drone Advocates		Drones Are a Problem		Drones Are Coming Do It Right		Just the Details	
		Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score
35	The public cannot understand how drones for deliveries will impact them	0	0.041 *	3	1.731 *	−1	−0.643	−1	−0.657	−4	−1.561 *
13	Government should be planning for the introduction of air taxis	0	−0.011 *	1	0.538	−4	−2.190 *	−3	−1.253 *	1	0.730
31	Delivery drones are a solution looking for a problem	0	−0.219	0	−0.126	1	0.693	−5	−1.695 *	0	0.259
23	Drones for deliveries should be allowed to land in people's gardens	0	−0.229	1	0.553	−1	−0.448	0	−0.152	1	0.398
9	The approach to regulating drone use is too fast	0	−0.281	−5	−2.044 *	0	0.087	−1	−0.669	−3	−1.305 *
24	Towns and cities are too busy for delivery drones to safely operate	−1	−0.358	−2	−0.850	3	1.381 *	−4	−1.500 *	−1	−0.296
18	Robot delivery carts are more suitable for home deliveries than drones	−1	−0.422	1	0.425 *	−1	−0.190	−2	−0.886	−1	−0.693
39	Social acceptance of drones for deliveries will increase as their use becomes more commonplace	−1	−0.443	0	−0.045	2	0.720	5	1.867 *	1	0.354
29	Public taxes should not be funding drone development trials	−1	−0.451	−1	−0.736	0	0.191 *	0	−0.490	−2	−1.243
7	Innovation in drone technology for deliveries does not have enough societal benefit to make it worth it	−1	−0.556	−3	−1.231	0	−0.034 *	−2	−0.756	−2	−1.165
26	Drones should not be restricted on safety grounds so long as they are safer than vans	−1	−0.711	−1	−0.254	−2	−0.917	0	0.141	−1	−0.474
37	The public should not be asked to decide if drones for logistics are desirable	−2	−0.785	0	−0.091	−2	−0.992	0	−0.473	−1	−0.434
10	Increasing drone use is essential to the growth of the UK economy	−2	−0.954 *	−1	−0.263	−5	−2.278 *	−1	−0.511	0	0.083
28	Camera technology on drones is not a significant privacy issue	−2	−0.982	0	−0.078 *	−4	−1.696	−4	−1.424	−3	−1.265
11	It is up to businesses to decide if drones are going to be useful	−2	−1.042	0	0.232	−2	−0.810	0	0.030	0	0.119
12	Government should not be acting to facilitate commercial drone use	−3	−1.064	−2	−0.991	4	1.500 *	0	−0.477	−2	−1.071

Table 4. Cont.

ID	Statement	What Is the Question		Drone Advocates		Drones Are a Problem		Drones Are Coming Do It Right		Just the Details	
		Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score
38	It is okay if some groups in society are not able to benefit from drone use for delivery	−3	−1.186 *	2	0.686	1	0.541	−1	−0.514 *	0	0.217
27	Drones pose no additional risk from terrorism	−3	−1.323	−3	−1.014	−3	−1.214	−1	−0.668	−3	−1.261
5	Regulation of drones should be the same in rural and urban areas	−4	−1.342	−4	−1.233	−2	−0.938	−2	−0.740	−1	−0.972
4	The impacts of drones on wildlife are not significant	−4	−1.492	1	0.329 *	−1	−0.717	−3	−1.071	−1	−0.951
1	Drones should not need to demonstrate carbon benefits before being introduced	−5	−2.181 *	−1	−0.380 *	−3	−1.285	−3	−1.365	−5	−1.583

* Significant at 95% confidence interval.

The Q value indicates where on the sort grid the statement was placed for each cluster and the significant z values show which statements were significantly different for that particular cluster. The next step was a narrative sense-making exercise which looked at the most and least important statements for each group and also the statistically distinguishing statements. This led to the following five classifications:

- What is the question?—This group takes a macro planning approach asking how we can know whether drones for delivery are necessary in the absence of a national freight strategy. Yes, home deliveries are a problem, but are drones the answer relative to other interventions? Drones should bring carbon benefits and not exclude some groups. There are some risks and whilst this group is not anti-drone, it is far from clear that the benefits outweigh the risks. Whether or not to introduce drones is not an economic growth question for this group.
- Drone Advocates—This group sees drones as an economic growth opportunity and a solution to an already under-pressure set of delivery options. Regulation is going too slowly already, local authorities need to have minimal involvement, and the public does not need to be asked about how this is introduced. There are some risks like terrorism, but trials are the way to demonstrate how this will all work.
- Drones are a problem—This group does not want drones for deliveries and does not see them as inevitable. Our towns and cities are already too busy to safely accommodate them, there is no case for economic growth, and the government should not be promoting their use. There are concerns about terrorism and privacy, and they must demonstrate their carbon benefits.
- Drones are coming so do it right—This group sees drones as definitely part of the future, so there is a need to engage with them and plan responsibly for their introduction. Rising home deliveries are a problem and maybe this is part of the answer. However, there are concerns over terrorism, disruption to wildlife and impacts on vulnerable people. Perhaps we need to restrict what times they operate. Trials are part of the way forward.
- Just the details—This group has some similarities to the previous group in that they see drones as being inevitable but are less concerned over some of the risks like terrorism. Whilst appearing to be more laissez-faire, they do still prioritise restricting use over

schools and people's houses. They support trials as a way forward for working out what to do.

Q-Sort focuses on clustering opinions rather than clustering by socio-demographics. The expert group was also small in size. The main differences the analysis of respondents' answers showed was that, unsurprisingly, those in the drone industry or who were currently promoting drone trials in their local area fell into the advocates category. However, transport planning professionals fell across all of the different categories. The gap between the views of advocates and many other members of the wider professional body presents real risks in those developing drone policy overlooking issues which ultimately will impact on deployment. This suggests a need for much better, broader and more open engagement around new technologies such as delivery drones.

There were however a series of consensus statements which suggest there are some issues around which all parties either agreed that something needed to be done or where it was not an issue. There was some agreement that this would negatively impact on noise pollution and that the tranquillity of less well-developed areas needed protecting. There was general weak agreement that urban and rural areas should be regulated similarly. It was uncontroversial that emergency services are a different use case from deliveries and should have their own rules and also that the emissions from drone manufacture should be considered as part of impact assessments.

3.2. Citizen Q-Sort

The same analytical procedures were undertaken for the three sites as for the expert/stakeholder data to determine the number and nature of the clusters in each area. The results of the factor rotations and hyperplane analysis are shown in Table 5.

Table 5. Factor rotations, exclusions and hyperplane analysis – Citizen Q-Sort.

Factors	Minimum Sorts Assigned to Factor	Number of Sorts Unassigned	Hyperplane
Coventry (<i>n</i> = 206)			
8 Factor Rotation	2 (factor 8)	105 (51%)	34.1%
7 Factor Rotation	6 (factors 3, 5, 6)	96 (47%)	31.2%
6 Factor Rotation	7 (factor 3)	78 (38%)	29.1%
5 Factor Rotation	7 (factor 4)	69 (34%)	27.8%
4 Factor Rotation	12 (factor 3)	73 (35%)	24.0%
Cornwall (<i>n</i> = 203)			
8 Factor Rotation	2 (factor 5)	107 (52%)	32.7%
7 Factor Rotation	5 (factor 3)	83 (41%)	32.5%
6 Factor Rotation	6 (factor 3)	78 (38%)	30.3%
5 Factor Rotation	8 (factors 3, 4)	69 (34%)	28.2%
4 Factor Rotation	10 (factor 4)	71 (35%)	22.6%
Bournemouth (<i>n</i> = 201)			
8 Factor Rotation	3 (factor 4, 7)	81 (40%)	33.9%
7 Factor Rotation	3 (factor 7)	66 (33%)	32.6%
6 Factor Rotation	8 (factor 5)	46 (23%)	31.5%
5 Factor Rotation	10 (factor 3)	43 (21%)	30.0%
4 Factor Rotation	9 (factor 3)	48 (24%)	27.6%

For each of the sites, a six-factor rotation achieved the best balance of assigning sorts and hyperplane values, although a five-factor rotation might also have been selected. In each of the sites, of the six factors, one dominated the clustering (as indicated by the number of sorts assigned to each factor in Table 6) and this group shared similar characteristics

in terms of key statements across the three sites. Results for all of the sites are available in additional materials, but for simplicity, the results for the Coventry sort are presented below in Table 7, along with a narrative comparison of differences found in the other areas. Given the dominance and similarity of the first factor, and the sizes of the allocations of Q-Sorts to other factors, it is possible that some of these differences would disappear with an even larger sample.

Table 6. Sorts assigned to each factor by area.

Area	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Coventry	78	15	7	12	8	8
Cornwall	83	11	6	11	7	7
Bournemouth	101	16	9	10	8	11

Table 7. Z scores and sort values for citizen sort—Coventry.

ID	Statement	Drone Sceptics		Drone Positive		Tranquillity Matters		Libertarian Accepters		Maybe Elsewhere		Slowly Slowly	
		Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score
23	Drones used by the emergency services should be treated differently to drones for delivery by retail companies	4	1.401	4	2.195 *	−2	−0.665 *	3	1.176	2	0.778	2	1.290
19	People have a right to limit drone flights over their house	3	1.215	0	−0.226	3	1.320	−1	−0.802	0	0.042	−1	−0.675
18	Public taxes should not be funding drone development trials	3	1.113	−2	−1.084 *	0	−0.283	2	1.035	0	−0.228	−4	−1.751 *
14	Delivery drones should not be allowed to fly over schools during the school day	2	1.101	0	0.067 *	4	1.588	1	0.817	−3	−1.256 *	3	1.351
2	To minimise noise and disruption, drones will need to operate within fixed permissible times for delivery	2	0.962	2	0.763	1	0.597	2	0.862	3	1.410 *	−1	−0.544 *
11	Local authorities should have a role to play in the regulation of the use of drones for delivery in their area	2	0.929	2	0.825	2	0.969	−1	−0.763 *	0	−0.009 *	3	1.434
10	Companies must better organise their deliveries to combat the wastefulness of multiple home deliveries	1	0.867	3	1.633 *	−1	−0.485	1	0.400	−1	−0.254	1	0.545
20	Avoiding negative impacts on vulnerable citizens should be key to whether or not new technologies are approved	1	0.812	0	−0.256	2	0.876	−2	−0.855	0	−0.164	−2	−0.821
5	Government has a duty to protect the tranquillity of less developed areas	1	0.708	1	0.742	3	1.224 *	0	−0.210	4	2.043 *	0	0.004
13	Towns and cities are too busy for delivery drones to safely operate	1	0.693	−3	−1.490	−1	−0.537 *	0	0.063 *	2	0.916	−2	−1.161
8	The rising number of home deliveries is a problem	0	0.482 *	−1	−0.831	−4	−2.327 *	−3	−1.331 *	−1	−0.590	2	0.989 *
9	Drones should only be allowed to deliver some types of products to people's homes	0	0.398	−4	−1.754 *	0	0.359	1	0.520	1	0.216	4	2.024 *

Table 7. Cont.

ID	Statement	Drone Sceptics		Drone Positive		Tranquillity Matters		Libertarian Accepters		Maybe Elsewhere		Slowly Slowly	
		Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score	Q	Z Score
21	Delivery drones will be more useful for rural communities than urban communities	0	0.214	1	0.263	−2	−0.618 *	0	0.210	3	1.686 *	1	0.163
4	Regulation of drones should be the same in rural and urban areas	0	0.007	−1	−0.296	2	1.172 *	0	−0.111	−4	−1.990 *	1	0.332
12	Drones for deliveries should be allowed to land in people’s gardens	0	−0.149	3	1.257 *	0	−0.308	−1	−0.420	0	−0.235	0	0.118
22	The public cannot understand how drones for deliveries will impact them	−1	−0.279 *	−3	−1.193	1	0.681	−2	−0.915	2	0.927	2	1.283
25	It is okay if some groups in society are not able to benefit from drone use for delivery	−1	−0.616	0	−0.028	0	−0.364	2	0.980 *	−1	−0.339	−1	−0.461
15	Drones should not be restricted on safety grounds so long as they are safer than vans	−1	−0.743	0	−0.024	−3	−1.853 *	−2	−0.806	−1	−0.251	−1	−0.453
7	It is up to businesses to decide if drones are going to be useful	−1	−0.961	2	1.230 *	0	0.304	0	0.080	−2	−0.832	−2	−0.757
6	Increasing drone use is essential to the growth of the UK economy	−2	−0.964	1	0.662	−2	−1.025	−1	−0.545	1	0.726	0	−0.126
24	The public should not be asked to decide if drones for logistics are desirable	−2	−1.164	1	0.318	1	0.684	3	1.428 *	1	0.705	−3	−1.436
1	Drones should not need to demonstrate carbon benefits before being introduced	−2	−1.171	−1	−0.357	−3	−1.108	4	2.168 *	1	0.328 *	0	−0.257
3	The impacts of drones on wildlife are not significant	−3	1.516 *	−2	−0.945	1	0.686	1	0.461	−2	−1.066	0	−0.209 *
16	Drones pose no additional risk from terrorism	−3	−1.604	−2	−0.965 *	−1	−0.480 *	−4	−1.909	−3	−1.545	−3	−1.410
17	Camera technology on drones is not a significant privacy issue	−4	−1.736	−1	−0.505	−1	−0.408	−3	−1.534	−2	−1.017 *	1	0.530 *

* Significant at 95% confidence interval.

The dominant group (Factor 1) are described as “Drone Sceptics”. Drone Sceptics worry about privacy, terrorism risks, impacts on wildlife, carbon impacts and strongly believe that there should be limits to where they are used. Whilst they tolerate the idea of emergency services being treated differently, they do not see this as part of an economic growth mission and do not support the government part funding the development of drones for delivery.

The “Drone Positive” group (Factor 2), whilst recognizing some of the same risks as the Drone Sceptics see these as less important. They think it is up to businesses to decide if they are useful and would be happy for any type of goods to be delivered to people’s houses. They do not think towns and cities are too busy for drones.

The “Tranquillity Matters” (Factor 3) group, as the name suggests, is most sensitive to noise and surveillance risks with preferences for people to be able to limit the right to fly over their property, over schools and to protect less-developed areas. They do not see the rising number of home deliveries as a problem and would rather not have drones instead of vans irrespective of whether or not they were safer.

“Libertarian Accepters” (Factor 4) do not believe that the public should be asked about the introduction of drones nor that local authorities should have much of a say in their regulation. Whilst they are concerned about terrorism, they do not hold strong views that the introduction of drones should have limits placed on them or that there is a need to be concerned about vulnerable citizens or wildlife.

The “Maybe Elsewhere” (Factor 5) group have many of the concerns of the Drone Sceptics but feel that limits can be put on when they can be used and that towns and cities are too busy for them. They think they will be most useful for rural areas, even though the government should protect tranquil areas.

The “Slowly Slowly” group (Factor 6) sees a significant role for government in managing the introduction of drones. They support the use of taxes to fund trials, think local authorities should have a say as well as the public, although they also think there is limited understanding. They are not so concerned about wildlife and privacy but do worry about terrorism risk.

The groups which emerged in Cornwall and Bournemouth were similar with a slightly different set of priorities over rights and regulation. Interestingly, there was no Tranquillity Matters group in either place despite the more rural and coastal nature of these two sites. This might reflect concerns of those living in a bigger city (Coventry) where noise is already felt to be an issue. There was also no Drone Positive group in Cornwall, whereas there was in Bournemouth. Whilst the study had initially imagined that it would identify a range of place-based differences, because the vast majority of respondents were sorted onto a Drone Sceptics cluster, the numbers of people being compared between groups in these other clusters were too small for more than a short narrative reflection.

4. Discussion

The first research question which the paper set out to answer was what the key policy dilemmas were around the introduction of drones for delivery. Taking all of the data together, there seems to be two sets of concerns which interact in ways which could shape the nature of the responses that emerge. These relate to the extent to which a group agrees with the idea of drones in principle and the extent to which they consider drones to be manageable in practice. This is shown in Figure 2, where groups from the stakeholder and citizen groups are placed across the axes in an indicative manner. Figure 2 reflects the clusters which show those groups to the bottom right who are staunch advocates of drones and believe that there should be very few barriers put in the way of their introduction. Whilst they might tolerate discussions on regulation, these are of low salience in their debates about what should happen.

By contrast, the groups that are sceptical of drones and do not like them in principle do not prioritise topics around how to regulate them, as this could perhaps be seen to acknowledge their possibility. We see no groups placed in the very top left or top right of Figure 2. No groups are strongly in favour of drones and want high regulation. The closest group is the expert/stakeholders who see the need to manage drones as inevitable and so will seek to regulate in ways which achieve best overall outcomes. No group dislikes drones so much that they also prioritise regulation but the closest to this are citizen groups who focus on tranquillity issues and who suggest that drones might be OK but their wider response set also implies that this OK might also mean somewhere other than their area. There are other nuances in play, with, for example, the Libertarian Accepters being less keen on drones per se than the advocates but not being particularly supportive of regulatory intervention.

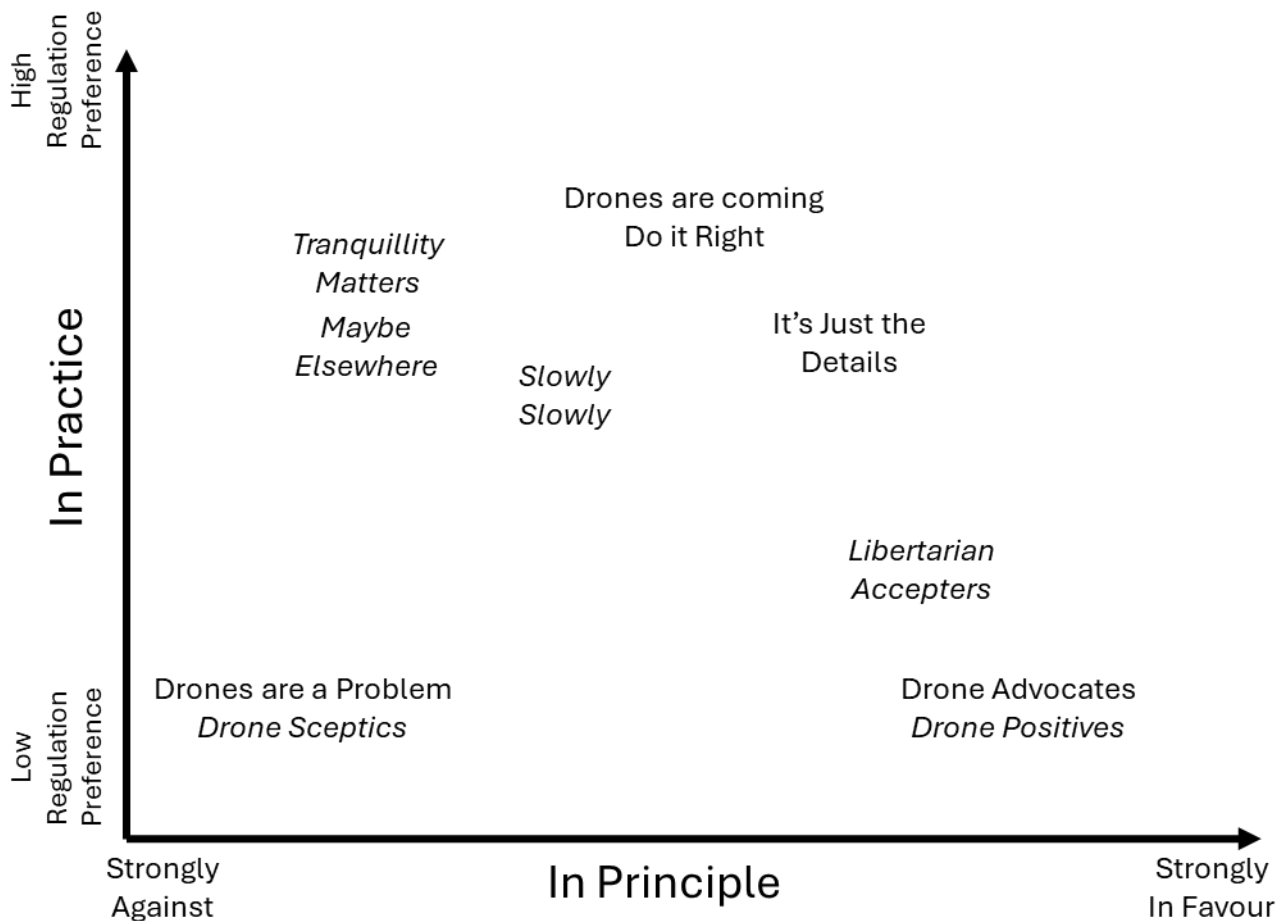


Figure 2. Indicative trade-offs across expert/stakeholder and citizen groups (citizen groups in italics).

It is important to see Figure 2 as a useful heuristic to think about different types of dilemmas and how this intersects with the wider perspectives of the clusters of respondents. It is useful to reflect this back to the literature and earlier discussion on asking questions of acceptance. Are people responding about their views on drones or their views on drones in the context of some assumption about how they might be managed? This further contributes to the debate around the utility of the predominant approach to understanding “technology acceptance” [17].

The second research question asked what the differences were between expert/stakeholders and citizens. In many respects both groups showed similar clusters of concerns. However, there are also important differences to consider. First, there is a dominance of the Drone Sceptics in the general population who have real concerns over privacy, terrorism, surveillance, wildlife intrusion and wider environmental impacts. Whilst this group existed amongst the expert/stakeholder group, it was not dominant. It is far from clear, therefore, that the case for drones, which appears to be a “no-brainer” to the parts of the expert policy community that is driving innovation in drone delivery, has widespread support across society. Glossing over these differences in views is potentially storing up problems for implementation. There was one group in the expert/stakeholder community which was absent from the citizen groups, the “What is the problem?” group. This group is not clear about what problem drones are supposed to solve nor does it understand how we can think about whether or not drones should be used in the absence of a basic national freight policy framework. The absence of this group could reflect the simpler Q-Sort framework that was presented to citizens, but it also talks very directly to strategic planning logics which would be expected to be strong in policy communities [27].

The final research question asked whether these concerns varied across local contexts. Whilst there were differences, the key finding was that the Drone Sceptics groups dominated in each of the places. Further research in the wider project from which this study emerged has established that people respond about impacts in the context of where they live, but that this may not necessarily neatly divide along urban–rural lines [17]. However, whilst noise might be quite place-specific, some of these concerns seem less likely to have place-specific characteristics. For example, attitudes towards regulation, risk [28] and the role of government seem less embedded in place. We suggest that this remains an area for further work as part of a general call for greater attention to be paid to contextualizing work on how we understand the potential impacts of new technologies [17,29].

This study is novel in both comparing the dilemmas around the introductions of drones for delivery between experts and citizens and also across places using the Q-Sort method. We see its key strengths as a way of breaking down the issues of concern to enable those tasked with governing the introduction of new technologies to have a more nuanced approach. Q-Sort does not focus on what proportion agrees with a specific question but instead shows how sets of priorities or issues fit together and, in this case, highlighted the mismatch in scale between citizen sceptics and the expert community driving the case for drones forward.

The implications for sustainability are important. The literature review suggested that some environmental and economic benefits could be found, although the evidence was not consistent. The narrative of growth opportunities for the economy is not a feature of public concerns, nor are environmental benefits seen to be a key factor in opinions around drones. Instead, it is the social change that drones imply that dominate, and much greater attention needs to be paid to the range of important practical concerns which are at large, both in principle and in practice. It is also important to consider that drones are just one of many different future pathways for last-mile logistics and by no means a universal solution [6]. These alternative options are also electrifying and so their environmental burdens will diminish over time. This suggests that the key trade-offs will be between economic gains (and who they fall to) and social impacts (and how they are distributed). In the UK, at the time of our research, the social case had not yet been made.

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