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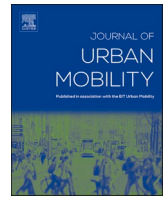
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Willingness to use urban air mobility (UAM) as an airport shuttle across levels of automation

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ABSTRACT

Urban Air Mobility (UAM) is an emerging transportation solution aiming to alleviate congestion and enhance sustainability in urban areas. Automation capabilities are evolving from manned control to full autonomy, and at each stage of this progression, the willingness to use each system represents a behavioural intention toward adoption. This study investigates willingness to use UAM for airport shuttle services across three levels of automation: Manned control, Remotely piloted, and Fully autonomous. The study employed survey data from 1613 respondents in South Korea. Using ordered logit models, we examine how socio-demographic and current airport travel behaviour influence adoption. Results show that approximately 60% of respondents were willing to use manned control UAM, whereas only about 30% expressed willingness under remotely piloted or fully autonomous UAM. Adoption patterns and predictors of adoption vary depending on the level of automation. While current travel time to the airport and the primary purpose of airport use are prominent predictors of willingness to use UAM at the manned control level, demographic characteristics, particularly gender and age, become more significant at remotely piloted and fully autonomous UAM, as the level of automation increases. The frequency of international travel consistently predicts a higher willingness to adopt UAM, regardless of the level of automation. These findings highlight the need for level-specific adoption strategies and suggest that trust and risk perception need to be addressed as automation increases. This study contributes empirical evidence for policymakers, service operators, and urban planners informing differentiated communication and integration strategies tailored to user profiles and system maturity.

1. Introduction

Urban Air Mobility (UAM) is a low-altitude air transport system that operates within urban and suburban environments. It encompasses various emerging technologies and aircraft types, including electric vertical take-off and landing (eVTOL) vehicles, autonomous air taxis, and drones designed for intra-city travel. UAM has gained attention as a potential solution to several pressing transportation challenges, including ground traffic congestion (Brauchle et al., 2019; Shaheen et al., 2018), increasing urban travel demand (Rice et al., 2022), and the need for sustainable mobility (Afonso et al., 2021). A key challenge in realising the societal and operational benefits of UAM is promoting widespread user adoption by addressing public perception barriers. Understanding how the public perceives UAM and what influences adoption decisions is needed to identify target users, inform strategic planning, and support broader implementation. Future UAMs are

expected to operate at progressively higher levels of automation (Cohen et al., 2021; Pons-Prats et al., 2022; Straubinger et al., 2020), ranging from manned control to remotely piloted, and ultimately to fully autonomous control. Consequently, user adoption is likely to vary across these different levels of automation. Recognising these differences is necessary for designing effective policies and service strategies that ensure successful UAM adoption and integration.

However, most existing research approaches UAM as a monolithic concept, without adequately distinguishing between different levels of automation. Therefore, this study aims to provide an empirical exploration of how the willingness to use UAM varies across three levels of automation (manned control, remotely piloted, and fully autonomous), and how socio-demographic and airport travel behaviour variables influence this willingness in the context of airport shuttle services. By exploring these relationships, this study provides practical insights that can help shape deployment strategies, regulatory planning, and service

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design for the future of urban air travel.

1.1. UAM as an airport shuttle service

UAM offers efficient, flexible, and environmentally sustainable alternatives to traditional ground transportation, particularly in congested urban centres (Airbus, 2017). Notable early examples include Voom, an Airbus subsidiary, which offered on-demand helicopter services in metropolitan areas such as Mexico City and São Paulo, laying the groundwork for broader UAM adoption (Airbus, 2018). Such services align with trends in shared, electric, automated, and on-demand mobility (Long et al., 2023).

Since UAM can avoid ground traffic, reduce travel time, and offer predictable, high-demand routes, it is seen as a promising solution for airport shuttle services (NASA, 2018; Thippavong et al., 2018). For example, ongoing pilot projects in cities like Rome (Volocopter, 2021) and Osaka (JobyAviation, 2022) aim to demonstrate the feasibility and public appeal of UAM airport shuttles. In addition, Coppola et al. (2024a) found, through a stated preference survey conducted in Milan, that travellers exhibited a greater willingness to pay for UAM in airport-related travel than for general daily commuting. This highlights the strategic importance of airport shuttle services as early entry points for UAM.

According to previous empirical studies on transport automation, the relationship between factors influencing UAM and the intention to adopt it may vary depending on the specific application scenario. Demographic factors, such as age and gender, have been shown to influence the acceptance of automated transport contextually. For example, Nordhoff et al. (2018) reported that men were more accepting of automated vehicles. However, in a different scenario involving shared autonomous vehicles in an urban setting, Kyriakidis et al. (2015) found that men were less willing to use them than women. These findings suggest that the significance and direction of influencing factors can vary across different automation use cases, thereby limiting the generalisability of practical implications from one scenario to another. Given that airport shuttle services are considered a promising use case for UAM, this study examines the adoption of UAM in airport shuttle services.

1.2. Willingness to use UAM

Despite rapid technical developments, the adoption of UAM remains constrained by regulatory uncertainty, infrastructure limitations, environmental considerations, and public acceptance (Vascik, 2017). Adoption is not merely a function of availability but is shaped by psychological, demographic, and experiential factors (Gounaris & Koritos, 2008). Because UAM represents a disruptive shift from conventional transport, understanding user acceptance is important for demand forecasting, service design, and informing policy. Some studies (Ariza-Montes, 2023; Janotta & Hogreve, 2024; Karami et al., 2024; Vongvit et al., 2024) have mainly focused on examining the psychological factors of UAM adoption using frameworks such as the Technology Acceptance Model (TAM) (Davis, 1989) or the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). Collectively, these findings highlight the importance of psychological factors, such as trust or social norms, in user acceptance. However, most studies do not incorporate socio-demographic or airport travel behavioural variables.

Socio-demographic and airport travel behavioural variables also influence willingness to adopt UAM. Gender differences in UAM adoption have been frequently reported. For example, males, especially younger men, tend to express higher comfort levels and a greater willingness to adopt UAM than females (NASA, 2018; Yedavalli & Mooberry, 2019). Al Haddad et al. (2020) also found that women expressed lower short-term interest in UAM. Age and income can also be predictors of UAM acceptance. Coppola et al. (2024a) showed that younger travellers and

those with higher incomes are likely to choose UAM over traditional modes in a stated preference survey focused on the Milan airport scenario. Similar findings were reported in the Munich metropolitan area, where high-income young adults demonstrated a greater likelihood of adopting UAM, especially for non-commuting trips (Fu et al., 2019). Karimi et al. (2024) also emphasised the importance of affordability and cost sensitivity in UAM adoption decisions, noting that individuals with higher disposable income exhibit stronger preferences for urban air taxis. In addition, education level is a relevant factor. Castle et al. (2017) and Yedavalli and Mooberry (2019) reported that individuals with higher education levels were more likely to express interest in UAM services. Furthermore, UAM seems more desirable for performing trip purposes, such as business trips, rather than using them for daily commutes (Fu et al., 2019; Johnson et al., 2022).

Socio-demographics and travel behaviour variables are more than passive indicators. These are specific, observable, and measurable variables that influence attitudes toward UAM and contribute to individuals' willingness to use such services. Davis (1989) and Ghazizadeh et al. (2012) suggested that socio-demographics mediate psychological factors such as trust and perceived usefulness, thereby affecting behavioural intention. Incorporating socio-demographic and airport travel behavioural predictors into adoption models thus offers practical relevance. These variables are stable, measurable, and easily integrated into transport planning databases, enabling more targeted deployment strategies.

When analysing willingness to use UAM for a specific service, as an airport shuttle, it is important to focus on travel behaviours related to airport access rather than general daily travel behaviours. Previous studies have neglected airport-specific travel patterns, despite the distinct conditions involved in airport access compared to everyday mobility. For example, air travellers tend to have different modal preferences, more rigid time constraints, and greater sensitivity to travel time and reliability (Shafabakhsh et al., 2014; Tam et al., 2011). These differences suggest that conventional travel behaviour variables may not fully explain preferences for airport shuttle applications of UAM. Therefore, in this study, we examine respondents' existing airport travel behaviours, such as how often they travel internationally, their primary mode of airport access, and travel time to the airport, and assess how these factors relate to their willingness to use UAM for airport access.

1.3. Levels of automation of UAM

UAMs vary in their degree of automation, from manned control to fully autonomous. Although the aviation industry lacks a formalised level of automation taxonomy like the SAE levels (SAEInternational, 2021) for road vehicles, industry and regulatory bodies such as the European Union Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA) typically recognise three broad categories: (1) manned control, (2) remotely piloted, and (3) fully autonomous flight (Lascara et al., 2018).

In ground transport, a higher level of automation generally offers increased convenience but also introduces concerns about safety and control. For example, trust in automated vehicles tends to decrease as the level of automation increases (Kim & Kelley-Baker, 2021). In aviation, passengers preferred traditional cockpits with a human pilot over fully automated aircraft (Mehta et al., 2017; Rice et al., 2014). Chancey and Politowicz (2020) further elaborated on these dynamics by investigating trust across five levels of pilot-in-command distance: Onboard pilot, remote control pilot, dedicated remote operator, remote operator, and system manager. Their findings showed that trust diminished as the human pilot's remoteness increased, reducing willingness to use.

UAM is rapidly evolving, and like automated vehicles, passengers may encounter and choose among different levels of automation. However, most current studies treat UAM as a single, uniform concept without distinguishing automation levels. Moreover, there is a lack of comparative studies that examine the willingness to use UAM across

different levels of automation within the same respondent group. The level of automation may also interact with user characteristics; for example, younger users may be more receptive to full automation, while older users prefer manned control options. Addressing these interactions is necessary for developing targeted communication strategies, regulatory policies, and system designs that are tailored to public sentiment. Therefore, we explore willingness to use UAM across different levels of automation within the same sample, highlighting how adoption shifts with operational configuration.

1.4. The current study

This study aims to investigate how the level of automation affects the adoption of UAM, particularly in the context of airport shuttles. The following research question led this study:

RQ1. Is the willingness to use UAM different among levels of automation?

RQ2. Which and how do socio-demographic and airport travel behaviour variables shape the adoption across these levels of automation?

To address these questions, we examine three distinct levels of automation: manned control, remotely piloted, and fully autonomous, within the response from a single individual. This approach allows us to isolate the effects of the automation level on the willingness to use UAM services. Additionally, we assess how socio-demographic and airport travel behaviour variables influence the willingness to use UAM across different levels of automation. Our findings are expected to contribute to the design, marketing, and governance of UAM by identifying population segments with varying levels of willingness to adopt.

2. Method

2.1. Survey

Data were collected through an online survey conducted in Korea. Before the survey, a pilot study was conducted on a small sample to ensure the clarity of questions. Following the pilot survey, the survey was conducted through the Incheon International Airport Policy Research Team and distributed via a professional survey agency. The survey was written in Korean.

In this study, we used the following questionnaires to collect data. First, screening questions were used to determine whether respondents had previously used Incheon International Airport. It also captured gender and age to ensure quota-based sampling. As a result, the final sample consisted of respondents aged 18 and older who had used the airport, with relatively balanced gender representation and a broad distribution across age groups.

After, respondents answered the airport travel behaviour (Yearly abroad travel frequency, Primary travel mode when accessing the airport, Travel time to the airport (for primary travel mode), Travel purpose to use the airport) questionnaire.

Following this, respondents were presented with an explanation of Urban Air Mobility (UAM) and its levels of automation to ensure a sufficient understanding of the subject matter before answering questions about their willingness to use it. To help respondents differentiate between levels of automation, a table, as shown in Table 1, was included describing the key features of UAM in each level.

Urban Air Mobility (UAM) is a next-generation air transport service that uses electric-powered aircraft capable of vertical take-off and landing within urban areas, enabling congestion-free travel within metropolitan regions (30–50 km). Among these, a drone taxi can be seen as a type of aerial transport smaller than a helicopter, safely transporting people and commonly envisioned as a 'flying electric car'. The number of fatalities per one billion kilometres travelled by aeroplane is approximately 0.05, demonstrating

Table 1

Main features of the UAM airport shuttle at each level.

Level	Period	Speed	Available travel distance	Operation Type
Level 1	2025 onward	150 km/h	100 km	Manned control
Level 2	2030 onward	240 km/h	200 km	Remotely piloted
Level 3	2035 onward	300 km/h	300 km	Fully Autonomous

higher safety compared to trains (0.6), ships (2.6), and private cars (3.1). Drone taxis are also expected to achieve a safety level comparable to aeroplanes before commercialisation. Incheon International Airport, which will oversee the demonstration flights of drone taxis, holds a record of 170,000 accident-free flight hours in its air navigation safety system, and plans to support the safe and successful operation of drone taxis.

Following the description, respondents were asked to indicate their willingness to use UAM as an airport shuttle service at each level of automation. Responses were recorded using a five-point Likert scale: “Not willing to use at all,” “Unwilling to use,” “Neutral,” “Willing to use,” and “Definitely will use.”

At the end of the survey, respondents were asked about their socio-demographics, including education level and monthly income.

2.2. Samples

Initially, 1634 respondents answered the survey. After verifying the data quality, we removed the responses that selected ‘others’ for the question on ‘Primary travel mode when accessing the airport’, since they accounted for less than 1 % of the total respondents. As a result, 1613 respondents were included in the analysis. Detailed feature descriptions and associated statistics are presented in Table 2.

2.3. Data analysis

Descriptive analyses were conducted to identify the willingness to

Table 2

Descriptive characteristics of survey respondents (n = 1613).

Variables	Code	Frequency	%
Gender	Male = 1	922	57.16
	Female = 2	691	42.84
Age	19~29 = 1	315	19.53
	30~39 = 2	334	20.71
	40~49 = 3	415	25.73
	50~59 = 4	337	20.89
	60 and above = 5	212	13.14
Education level	High school diploma = 1	200	12.40
	College = 2	172	10.66
	Bachelor degree = 3	1042	64.60
Monthly Income (KRW)	Master degree and above = 4	199	12.34
	<3 million = 1	309	19.16
	3million < x < 7 million = 2	724	44.89
	3million < x < 7 million = 2	580	35.96
Yearly abroad travel frequency	≤ 1 time = 1	855	53.01
	1 < x ≤ 3 = 2	684	42.41
	> 3 = 3	74	4.59
Primary travel mode when accessing the airport	Car dependent user (e.g., private car, taxi) = 1	438	27.15
	Public transit (e.g. bus, metro, highspeed rail, any combination) = 2	1175	72.85
Travel time to the airport (for primary travel mode)	1 h = 1	795	49.29
	1 ~ 2 h = 2	538	33.35
	≥ 2 h = 3	280	17.36
Travel purpose to use the airport	Travel/leisure trips = 1	1275	79.05
	Business trips = 2	246	15.25
	Others = 3	92	5.70

use UAM at each level of automation and to determine the differences in response distribution across levels. To further explore the underlying factors associated with willingness to use UAM, the ordered logit model was applied. This modelling approach is appropriate because the willingness to use (dependent variable) is ordinal, measured on a five-point Likert scale. The ordered logit model extends the binary logit model by accounting for the ordinal nature of response categories while preserving the proportional odds assumption, making it suitable for identifying how independent variables affect the likelihood of more favourable adoption responses. Significance levels were used to evaluate the results, with thresholds set to $p < .05$. These thresholds indicate the strength of statistical evidence supporting each effect in the model.

3. Results

3.1. Descriptive analyses

Fig. 1 presents a response distribution of willingness to use UAM as an airport shuttle at Levels 1 (Manned control), 2 (Remotely piloted), and 3 (Fully autonomous). A downward trend is observed in the response distribution: as the level of automation increases, the proportion of respondents reporting a lower willingness to use such a level of UAM also increases. A Chi-square test for independence was conducted to compare the distribution of willingness to use UAM across the three levels of automation. The result showed a highly significant difference in the distribution of responses across levels of automation ($\chi^2(8) = 282.06, p < .001$). As shown in Fig. 1, approximately 58 % of respondents expressed a positive willingness to use (combining "Definitely willing to use" and "Willing to use") at Level 1, whereas this figure decreases to around 31 % at Levels 2 and 3. Notably, while the response distributions for Level 1 differ considerably from those of Levels 2 and 3, the distributions for Levels 2 and 3 are nearly identical.

3.2. Ordered logit model

Table 3 presents the results of the ordered logit models estimating the factors influencing respondents' intention to use UAM at three levels of automation. The models include eight independent variables: gender, age, education, monthly income, yearly abroad travel frequency, primary travel mode when accessing the airport, travel time to the airport (for the primary travel mode), and travel purpose. Fig. 2 illustrates the conceptual model of the results from the ordered logit model. The detailed analysis results are discussed in the following section.

3.2.1. Level 1 automation (Manned control)

At Level 1 automation, yearly abroad travel frequency, travel time to

the airport, and travel purpose variables significantly influenced willingness to use UAM as an airport shuttle. Frequency of international travel was a strong predictor: respondents who travelled abroad more frequently (more than once per year) were significantly more willing to adopt Level 1 UAM, with those travelling 1–3 times per year (Odds ratio = 1.495) and those travelling more than three times per year (Odds ratio = 2.042). In addition, respondents who have longer primary travel mode times (1–2 h) were more likely to adopt Level 1 UAM than those with travel times to the airport less than 1 hour. Furthermore, compared to other purposes, those travelling primarily for leisure (Odds ratio = 1.794) or business purposes (Odds ratio = 1.597) were more likely to adopt piloted UAM. However, in terms of social demographics, gender, age, education, income, and primary access mode did not show substantial differences, and none of the coefficients reached significance.

3.2.2. Level 2 automation (Remotely piloted)

At Level 2 automation, gender and age emerged as significant factors. Female respondents were significantly less willing to use Level 2 UAM than males (Odds ratio = 0.693, $p < .001$). In addition, older groups (30–39, 40–49, and 60 and above) show lower willingness than the 19–29 reference group. As with Level 1, respondents who travelled internationally more than once per year were more likely to adopt Level 2 UAM, with particularly high odds ratios (e.g., 2.323 for more than three trips per year). However, travel purpose was less influential at this level, with neither leisure nor business travel showing strong statistical significance. Education, Income, primary travel mode, and travel time to the airport variables also remained insignificant.

3.2.3. Level 3 automation (Fully autonomous)

At Level 3 automation, the highest level tested, trends observed at Level 2 became even more pronounced. Gender differences were even stronger, with females being substantially less willing to use Level 3 UAM (Odds ratio = 0.541, $p < .001$). The effect of age difference remained significant, with all age groups over 30 displaying lower willingness than younger respondents. International travel frequency remained a robust positive predictor of willingness, with odds ratios reaching 2.468 for those travelling abroad more than three times per year. However, education, income, primary travel mode, travel time to the airport, and travel purpose did not significantly affect willingness to use.

4. Discussion

This study examined the adoption of Urban Air Mobility (UAM) across three levels of automation: manned control (Level 1), remotely piloted (Level 2), and fully autonomous (Level 3). This section discusses

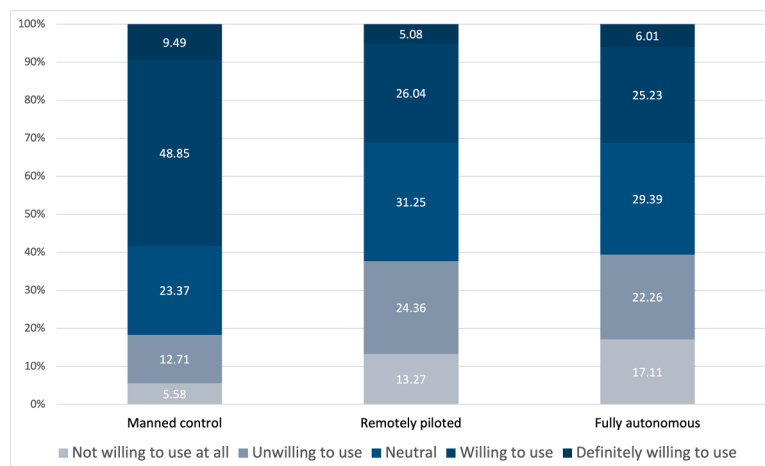


Fig. 1. Response distribution of intention to use at each level of automation.

Table 3
Ordered logit model on willingness to use at different levels of automation of UAM (N = 1613).

	Level 1 (Manned control)		Level 2 (Remotely piloted)		Level 3 (Fully autonomous)	
	Coef. (SE)	Odds Ratio	Coef. (SE)	Odds Ratio	Coef. (SE)	Odds Ratio
Gender						
Male (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
Female	-0.093 (0.098)	0.911	-0.367 (0.095)	0.693	-0.614 (0.096)	0.541
Age						
19–29 (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
30–39	-0.248 (0.146)	0.780	-0.308 (0.141)	0.735	-0.314 (0.140)	0.731
40–49	-0.289 (0.145)	0.751	-0.351 (0.138)	0.704	-0.333 (0.138)	0.717
50–59	-0.184 (0.153)	0.832	-0.282 (0.146)	0.754	-0.285 (0.143)	0.752
60 and above	-0.165 (0.171)	0.848	-0.410 (0.165)	0.664	-0.398 (0.166)	0.672
Education						
High school diploma (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
College	0.135 (0.198)	1.144	-0.310 (0.189)	0.734	-0.310 (0.188)	0.733
Bachelor degree	-0.047 (0.149)	0.954	-0.178 (0.142)	0.837	-0.121 (0.143)	0.886
Master degree and above	-0.104 (0.194)	0.901	-0.401 (0.187)	0.670	-0.202 (0.191)	0.817
Monthly Income						
<3 million (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
3million < x < 7 million	0.197 (0.128)	1.218	0.068 (0.125)	1.071	0.002 (0.124)	1.002
3million < x < 7 million	0.153 (0.138)	1.165	0.196 (0.133)	1.087	-0.097 (0.133)	0.908
Yearly abroad travel frequency						
≤ 1 (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
1 < x ≤ 3	0.395 (0.102)	1.495	0.378 (0.097)	1.459	0.398 (0.097)	1.489
> 3	0.714 (0.243)	2.042	0.843 (0.242)	2.323	0.903 (0.236)	2.468
Primary travel mode when accessing airport						
Car dependent user (e.g., private car, taxi) (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
Public transit (e.g. bus, metro, highspeed rail, any combination)	0.050 (0.106)	1.052	0.037 (0.104)	1.038	0.045 (0.103)	1.046
Travel time to the airport						
1 h (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
1 ~ 2h	0.222 (0.105)	1.249	0.097 (0.100)	1.101	0.152 (0.100)	1.164
≥2h	0.230 (0.131)	1.258	0.196 (0.127)	1.216	0.198 (0.127)	1.219
Travel purpose to use the airport						

Table 3 (continued)

	Level 1 (Manned control)		Level 2 (Remotely piloted)		Level 3 (Fully autonomous)	
	Coef. (SE)	Odds Ratio	Coef. (SE)	Odds Ratio	Coef. (SE)	Odds Ratio
Travel/leisure trips	0.585 (0.201)	1.794	0.187 (0.198)	1.205	0.039 (0.196)	1.039
Business trips	0.468 (0.236)	1.597	0.162 (0.231)	1.176	-0.115 (0.229)	0.891
Others (ref.)	0.000	1.000	0.000	1.000	0.000	1.000
0/1	-2.093 (0.287)		-2.015 (0.270)		-1.982 (0.269)	
1/2	0.295 (0.070)		0.335 (0.047)		0.167 (0.049)	
2/3	0.166 (0.048)		0.287 (0.040)		0.236 (0.041)	
3/4	0.969 (0.033)		0.771 (0.050)		0.693 (0.050)	

Significance level =.

*** p < 0.001.

** p < .01.

* p < .05.

the findings and their implications, offering various perspectives on UAM adoption strategies.

4.1. Principal findings

In response to our research question, we identified the following findings.

4.1.1. RQ1. Is the willingness to use UAM different among levels of automation?

The results indicate that adoption patterns differ by automation level, with varying predictors influencing UAM adoption across each level. Specifically, compared to manned control (Level 1), fewer respondents expressed a willingness to use UAM under remotely piloted (Level 2) and fully autonomous (Level 3) conditions. Adoption strategies for different levels of automation are discussed in detail in Section 4.2.1.

Furthermore, the minimal difference in willingness to use and the similarity in predictor influences between Level 2 and Level 3 can be interpreted in two ways. First, it suggests that the physical presence of a pilot influences users' willingness to use UAM, and decisions about which operational level to deploy can be based on factors beyond public adoption, such as cost, safety, technological feasibility, and societal preferences. Second, the similarity may be due to a lack of experience with such scenarios. In other words, respondents' similar response patterns for Levels 2 and 3 may not reflect comparable concerns or expectations about the technologies themselves, but rather a general unfamiliarity. Most respondents likely had no direct or indirect experience (e.g., via other transport modes) with these scenarios, making it difficult for them to visualise or evaluate these situations. As a result, Level 1 may represent a clear threshold, but beyond this point, public perception appears not to differentiate between higher levels of automation in unfamiliar contexts such as Levels 2 and 3.

4.1.2. RQ2. Which and how do socio-demographic and airport travel behaviour variables shape the adoption across these levels of automation?

The results show that the influence of socio-demographic and airport travel behaviour variables varies depending on the level of automation. While current airport travel behaviour remains a valuable indicator during the early stages of UAM deployment, its influence decreases as the level of automation increases, and age and gender emerge as primary indicators of adoption. These findings suggest that adoption strategies should adapt to meet not only practical travel needs but also users'

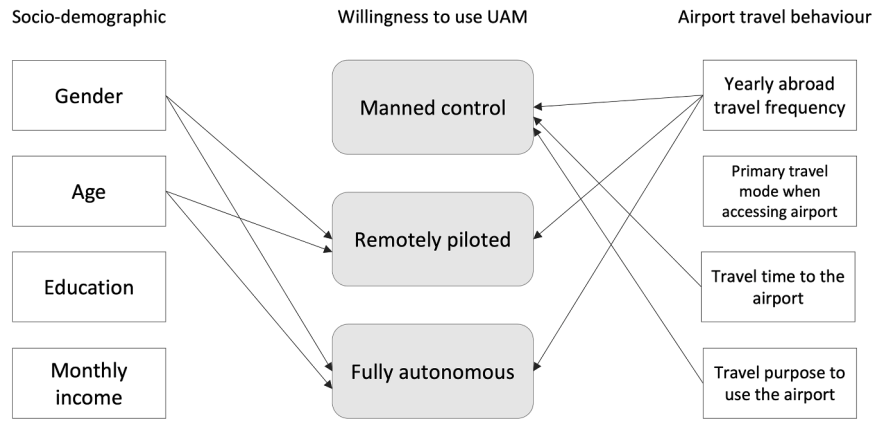


Fig. 2. Conceptual diagram on the relationship between socio-demographic, airport travel behaviour and willingness to use UAM across automation levels.

psychological attitudes.

At manned control (Level 1), airport travel behaviour variables, such as travel time to the airport and travel purpose, are significant predictors. However, at remotely piloted (Level 2) and fully autonomous (Level 3), demographic factors, such as gender and age, become more influential. This transition suggests that at the user convenience and existing airport travel behaviour primarily drive UAM acceptance under manned conditions, while safety and trust concerns emerge and become paramount when a pilot is absent. As a result, demographic characteristics that moderate psychological responses, such as risk perception and trust, play a more prominent role in shaping the adoption.

One consistent predictor across all levels of automation was international travel frequency. Respondents who travel internationally more than three times a year were consistently more open to adopting UAM. These results could be interpreted in two ways. First, respondents with extensive travel experience may possess greater confidence in navigating new transport systems. Second, frequent travellers may have a heightened need for efficient airport access, making UAM an attractive option. This group's higher adoption likelihood underscores the importance of targeting frequent travellers in early UAM deployment strategies.

As the UAM level of automation advances, the effects of gender and age become more pronounced. While gender has no significant effect at Level 1, female respondents are less willing to adopt UAM at Levels 2 and 3. This aligns with (Al Haddad et al., 2020; NASA, 2018), indicating that females were less willing to adopt autonomous UAM than males. Similarly, older age groups demonstrate progressively lower willingness to adopt UAM, particularly at higher levels of automation, suggesting that trust in automation may decline with age.

Interestingly, education and income are not strong predictors of UAM adoption across levels of automation in this study. While individuals with higher levels of education exhibit a marginally lower willingness to adopt Level 2 and 3 UAM, these effects are not statistically significant. One plausible explanation for this discrepancy lies in the distinct nature of UAM as a mode of transport. Unlike other ground-based innovations, such as ride-hailing or electric vehicles, where early adopters are often motivated by technological enthusiasm or environmental awareness (Mustafa et al., 2024; Sajid et al., 2022), UAM, particularly at a higher level of automation, introduces elevated psychological and safety concerns due to its airborne and pilotless nature. Therefore, traditional socio-economic advantages, such as education or income, may not translate directly into higher adoption intent in such contexts. Instead, users may prioritise affective responses, risk perceptions, and trust over rational cost-benefit considerations, diminishing the predictive power of education or income.

Regarding current airport travel behaviours, the results reveal that travel time to the airport and travel purpose to use the airport are predictors primarily at Level 1. Regarding the purpose of airport use,

travellers visiting the airport for pickup or airport-related employment (categorised as "others") appear less likely to adopt UAM compared to leisure and business travellers. This supports previous findings suggesting that UAM is less likely to be adopted for routine daily commuting purposes (Fu et al., 2019). However, no significant difference emerges between leisure and business travellers, suggesting that travel purpose alone may not adequately explain UAM adoption decisions. This highlights the need to consider the context of business travel more closely. Coppola et al. (2024b) reported that business travellers generally favour UAM services but noted reimbursement limitations could deter adoption among business travellers with budget constraints. Therefore, for business travellers, reimbursement policies may be more influential than travel purpose itself, indicating that the distinction between leisure and business travel alone may not adequately explain adoption behaviour. Additionally, travellers whose journey to the airport takes between one and two hours were significantly more likely to adopt UAM, with a similar (though not statistically significant) trend for journeys exceeding two hours, suggesting that extended access time may positively influence the likelihood of UAM adoption.

However, these airport travel-related predictors lose their statistical significance at higher levels of automation. This shift may be interpreted in several ways. First, it suggests that functional considerations such as travel time to the airport and travel purpose are relevant when human oversight is perceived as present, but become secondary when users relinquish full control to automated systems. Heightened automation may amplify perceived risks or discomfort, outweighing the original travel motivations, especially among travellers unfamiliar with high levels of automation. Second, it implies that psychological factors such as trust in automation and fear of technological failure might moderate or override behavioural predictors. Third, it highlights the need for targeted interventions. While business and time-sensitive travellers may be ideal early adopters at a lower level of automation, higher automation levels require interventions addressing trust-building measures, trial exposure, and safety assurances. Adoption strategies should therefore evolve accordingly, addressing not only practical travel needs but also user perceptions, trust in technology, and psychological readiness.

4.2. Implications for practice

From an airport operations perspective, UAM may represent a means to provide differentiated, premium services to airport travellers, while socially, it can contribute to more sustainable urban transport ecosystems. This study outlines practical implications for UAM deployment strategies.

4.2.1. Differentiating adoption strategies by level of automation

Strategies for encouraging adoption should be differentiated by the

level of automation. At Level 1, where traveller scepticism is lower and demographic differences are less pronounced, communication efforts can focus on raising awareness and highlighting convenience. Marketing campaigns may emphasise travel time savings, flexibility, and seamless integration with existing airport infrastructure, without needing to address safety concerns extensively.

As automation increases to Level 2 and 3, trust-building becomes critical. The decline in the adoption of UAM at a higher level of automation indicates a deeper psychological resistance, likely tied to a perceived loss of control and heightened safety concerns. Thus, strategies should prioritise providing users with a sense of security and autonomy. Several strategies can be employed to address this issue. One approach is the implementation of demonstration and trial programmes. Automated vehicles have shown experiential familiarity to reduce perceived risk and build trust (Walker et al., 2018). Offering supervised rides or simulations that gradually increase exposure to automation can help users develop confidence over time. Furthermore, incorporating human-machine interfaces that facilitate communication between the user and the UAM system may further build trust. For example, informing passengers about flight status, real-time system updates, obstacle detection, or navigation decisions can reinforce a sense of transparency and control, especially in early deployments. This mirrors findings in the aviation field, where pilot visibility into the decision-making processes of automation systems enhances trust (Sadler et al., 2016).

Another strategy involves addressing user diversity in risk perception. Women and older adults consistently exhibit greater reluctance toward higher levels of automation. Inclusive design of automated UAM systems can support adoption among these groups by accounting for their heightened safety concerns and specific usability needs. For example, involving women (Schuß et al., 2022) and older adults (Hong, 2023) in the design and testing phases of automated vehicles ensured that their specific needs and concerns were addressed. In the context of our study, relevant stakeholders such as the Korea Office of Civil Aviation (KOCA), pilots who have direct interaction with passengers, passengers who have used the UAM, and potential passengers themselves could be meaningfully involved in the design and testing phases. Adopting such inclusive strategies through design, communication, and co-creation can promote the equitable and broader acceptance of UAM.

4.2.2. Towards a seamless mode of mobility for airport access

Beyond adoption strategies tailored by the level of automation, this study offers insights for positioning UAM as a feasible and sustainable mobility option for airport access. Understanding the relationship between current airport travel behaviour and adopting emerging transport modes enables predictions about the evolution of new mobility services, identifies key development priorities, and anticipates how these modes will interact with existing established mobility systems (El Zarwi et al., 2017; Liao et al., 2024; Mehdizadeh & Klöckner, 2024). If there is a link between the airport travel behaviour and the likelihood of adopting UAM services, targeted strategies for early adoption can be formulated. For example, identifying user groups already predisposed to using time-efficient or premium transport services could guide targeted promotional campaigns. Furthermore, tailored strategies could encourage adoption among other modal users, such as private car commuters or traditional public transport users, helping to integrate UAM more effectively into the broader mobility ecosystem. Notably, although not statistically significant, users who access airports via public transport appear more likely to adopt UAM compared to car-dependent users across all three levels. This suggests a potentially complementary relationship between UAM and public transport, highlighting the benefits of integrating air and ground mobility into a seamless intermodal coordination system.

However, a notable finding of this study is the relatively weak association between current airport travel behaviour and the intention to adopt UAM services at remotely piloted and fully autonomous levels.

This insight offers two key implications. First, promoting UAM solely to improve convenience or reduce travel time to the airport may be insufficient to drive widespread adoption, particularly at higher levels of automation. In many metropolitan regions, such as Tokyo and Seoul, premium transit services, including high-speed trains and express metro lines, already provide efficient airport access. While these services are more costly than conventional public transport, they are perceived positively as offering reasonable value due to their ability to reduce journey time, ease congestion, and lower travel-related stress. Therefore, UAM must articulate a clear, distinctive value proposition beyond these well-established alternatives. Price competitiveness will be a key determinant (Al Haddad et al., 2020; Hwang & Hong, 2023), but overcoming safety and system reliability concerns will also be critical. One viable strategy may involve expanding user choice within the UAM ecosystem. As Shaheen et al. (2018) reported through focus group discussions, there is a strong user preference for coexisting operational models, such as manned control and autonomous vehicles, within the same service framework. Notably, users expressed a desire to select their preferred levels of automation and receive incentives or discounts when opting for a higher level of automation. This flexibility could mitigate safety concerns and increase trust, especially during the initial phase of adoption, characterised by user scepticism.

The second insight from the weak relationship between current airport travel behaviour and the intention to use remotely piloted or fully autonomous UAM is that this trend diverges from the adoption patterns of other emerging mobility technologies, such as ride-hailing (Shaheen & Cohen, 2019; Wali, 2023), which typically align with existing travel habits. Unlike these complementary innovations, UAM may function as a disruptive alternative, prompting users to reconsider their transport modal choices rather than simply extending current patterns. This divergence presents both opportunities and challenges. On one hand, UAM holds the potential to deliver leapfrog mobility solutions in areas with poor ground transport infrastructure. On the other hand, if UAM remains isolated from broader transport networks, it risks facing integration barriers. To address this issue, an approach that integrates UAM within the framework of urban mobility governance is required. One approach is designing UAM systems with multimodal interoperability in mind. Infrastructure planning should co-locate vertiports with existing mobility nodes, such as train stations or metro hubs, and ensure barrier-free access to facilitate seamless transfers. Additionally, regulatory coordination will be crucial. Early collaboration with city planners and transport authorities is necessary to pre-empt potential conflicts around zoning, airspace allocation, or accessibility standards. Comprehensive mobility planning should incorporate UAM into long-term urban development strategies, ensuring it complements rather than competes with sustainable transport objectives.

4.3. Limitations and future studies

While the study offers valuable insights, several limitations must be acknowledged. First, behavioural intentions do not always translate into actual behaviours. Respondents' willingness to adopt UAM may reflect hypothetical optimism, especially without direct experience with such systems. As UAM pilot services become available, stated preference models should be complemented with revealed preference data. Second, socio-cultural variables, such as cultural attitudes toward automation, institutional trust, or spatial planning norms, were not extensively modelled but may significantly moderate adoption. For example, Torrao et al. (2024) highlighted that the gender gap in the acceptance of automated vehicles is not universal, and the countries' progress in economics and gender equality are related to people's attitudes. In addition, pricing was not included in the survey instrument. Given the association between price sensitivity and transport choice (Fu et al., 2019), future research should incorporate cost dimensions to examine trade-offs users are willing to make. Furthermore, this study treated automation levels as technological classifications. However,

respondents may perceive them as psychological thresholds, reflecting changes in trust, perceived safety, and sense of control. Because the analysis focused on observable socio-demographic and airport travel behavioural factors rather than psychological ones, unmeasured affective variables may have mediated some of the relationships. Future research should incorporate psychological dimensions to provide a more comprehensive understanding of adoption across different levels of automation. Lastly, the models focus primarily on individual-level predictors. Future work could explore systemic factors and structural factors, such as public transportation accessibility, land use, local context variables (e.g., city-level geographical and demographic features), or airspace governance, as structural influences on UAM adoption.

5. Conclusion

This study explored the willingness to use Urban Air Mobility (UAM) as an airport shuttle service across three levels of automation: manned control, remotely piloted, and fully autonomous. The findings show that user preferences are not uniform across levels of automation. While airport travel behaviour variables such as travel time and purpose influence willingness at the manned control, these effects diminish at higher levels of automation, where demographic factors, especially gender and age, play a more dominant role. Notably, frequent international travellers demonstrate consistent willingness across all levels, highlighting a potential early adopter segment. The results suggest that trust, safety perception, and psychological comfort become increasingly critical. Consequently, strategies to promote UAM must be tailored not only to system capabilities but also to user characteristics. For manned control UAM, marketing can emphasise convenience and efficiency, whereas a higher level of automation may require trust-building initiatives such as trial programmes, transparency in system operations, and inclusive design. Furthermore, the weak association between current travel modes and UAM adoption at a higher level of automation implies that UAM may function as a disruptive mode, requiring integration strategies that consider multimodal connectivity. Ultimately, this study advances understanding of how the level of automation shapes adoption of UAM, providing valuable insights for policymakers, operators, and urban planners in designing equitable and effective air mobility systems.

CRedit authorship contribution statement

Soyeon Kim: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Kaihan Zhang:** Writing – review & editing, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

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

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