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Unraveling behavioral factors influencing the adoption of urban air mobility from the end user's perspective in Tehran – A developing country outlook

Hossein Karami [a], Mohammadhossein Abbasi [b], Mahdi Samadzad [a,*], Ali Karami [c]

[a] School of Civil Engineering, College of Engineering, University of Tehran, Tehran, Iran
[b] Department of Civil and Environmental Engineering, Tarbiat Modares University, Tehran, Iran
[c] Faculty of Civil Engineering, K. N. Toosi University of Technology, Tehran, Iran

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ABSTRACT

The integration of shared, autonomous, electric, and on-demand mobility services introduces urban air mobility (UAM) as an emerging intra-city transportation service operated by vertical take-off and landing aircraft. Despite the potential benefits of UAM limited literature exists on the end user's perception and the challenges to its societal acceptance, especially in developing economies. This paper addresses this gap in the literature by investigating the factors influencing UAM usage intention in Tehran, a developing country capital. Within the framework of the extended technology acceptance model, the study collected 828 valid questionnaires through a face-to-face survey. Structural equation modeling is employed to highlight the effects of a wide range of factors associated with individual differences, system characteristics, and social influence. The findings indicate that attitude, subjective norms, trust, perceived usefulness, perceived enjoyment, personal innovativeness, ecological awareness, and price evaluation are positively associated with UAM usage intention, while perceived safety correlates with the attitude toward UAM negatively. These findings provide valuable insights for policymakers and industry stakeholders, fostering a deeper understanding of end-user perspectives in developing countries, and prudently promising the potential for its targeted implementation. The study suggests that although its widespread adoption in developing countries is unlikely to occur in the near future, UAM should be regarded as a viable early and timely solution to persistent issues such as chronic congestion in metropolitan areas of the global south.

1. Introduction

With advancements in technology, various emerging travel modes are being introduced. One of these modes is urban air mobility (UAM) which is the culmination of shared, autonomous, electric, and on-demand mobility services (Long et al., 2023). In recent years, the development of UAM has been driven by advancements in technology with the prospect of revolutionizing urban transportation (Long et al., 2023). Significant investments have been made in various aspects of the UAM ecosystem, ranging from vehicle design to airspace integration and its integration into existing transportation systems (Ahmed et al., 2023). UAM offers the potential for passengers to bypass congested streets by flying, which can lead to fundamental changes in travel behavior (Ariza-Montes et al., 2023). As an early entrant into the UAM market, Voom as an Airbus company provided on-demand traditional helicopter services. However, a new generation of rotorcraft known as electric vertical take-off and landing (eVTOL) aircraft are introduced in recent years. These eVTOL aircraft are equipped with electric motors, making them safer, quieter, more environmentally friendly, and cost-effective compared to traditional rotorcraft (Al Haddad et al., 2020). They can perform vertical take-off and landing as well as level flight using electric power.

UAM offers various advantages including an on-demand and sharing mobility system, low noise pollution, very low emissions, the possibility of using renewable energies, increasing access to the city's central business districts, and autonomy that increases safety due to the elimination of human errors (EASA, 2021; Al Haddad et al., 2020; Fu et al., 2019; Binder et al., 2018).

* Corresponding author.
E-mail address: msamadzad@ut.ac.ir (M. Samadzad).

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Aside from all the potential benefits of UAM, there are many challenges and concerns about UAM deployment such as regulation and legal issues, integration with other travel modes, safety, security, required infrastructure, air traffic control, and trust (Vascik, 2017; Goyal et al., 2018). However, similar to other new emerging technologies such as autonomous vehicles, it is argued that the biggest barrier to the widespread adoption of UAM is psychological, not technical, in nature (Shariff et al., 2017; Xu et al., 2018).

The study investigating the factors influencing usage intentions and adoption of UAM has yielded significant findings, yet it has also raised a series of unresolved inquiries that necessitate further investigation. Therefore, research is needed to provide insight into the psychological factors underlying the public acceptance of UAM (Al Haddad et al., 2020; Rohlik and Stasch, 2019; Kalakou et al., 2023). To begin with, an individual should ask what factors influence the intention to use UAM. When it comes to individuals, how is heterogeneity manifested? Concerning the intention to use UAM, what is the relative contribution of the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM) to understanding the factors affecting UAM usage intentions? Finally, what are the most important factors within this general framework?

It is widely acknowledged that the successful implementation of any policy requires the public's acceptance. Hence, this paper seeks to contribute to the nascent literature by exploring factors that have not been examined previously and analyzing them according to different causal connections simultaneously within one single model.

2. Literature review

The introduction of UAM has the potential to revolutionize the urban transportation sector, providing faster connections within various facilities such as residential areas, businesses, and medical centers (Garrow et al., 2021). The historical and ongoing developments of UAM can be categorized into six stages. During the early 1910s–1950s, "flying car" concepts emerged, but none of them achieved commercial success. In the second stage, which spanned from the 1950s–1980s, scheduled helicopter services were attempted but faced challenges related to safety and fuel costs. The third stage took place in the 2010s when on-demand helicopter services resurfaced through smartphone apps, providing reserved access. The fourth stage, predicted to occur in the 2020s, focuses on the utilization of vertical take-off and landing (VTOL) technology for specific air routes. Medium-term developments involve the establishment of hub and spoke services, while in the long term, UAM is expected to offer point-to-point services (Cohen et al., 2021). While UAM has made significant technological advancements, it is crucial to consider public expectations and concerns (Yedavalli and Mooberry, 2019). As a result, numerous studies have been conducted to forecast the future adoption of UAM.

Many efforts have been made to inform the different aspects of spreading UAM. For instance, Garrow et al. (2021) in a comprehensive review discussed different articles related to demand modeling, operations, and integration with existing infrastructure to inform future UAM research. Some studies have focused on the demand for commuters in different cities. For example, Haan et al. (2021) in their study among commuters for the 40 most populous areas in the US found sensitivity to the location of existing vertiports, existing ground infrastructure, and congestion levels on competing modes. Also, some policies were proposed for aircraft manufacturers and city planners for identifying where investments in port infrastructure may be needed to support a commuter air taxi service. Furthermore, a qualitative analysis by Pons-Prats et al. (2022), accessed relevant aspects of UAM development and implementation. They also discussed the main challenges and multidisciplinary constraints that might slow down the pace of the successful application of the subject concept.

In order to identify the scope of research on the adoption of UAM by end users, previous studies have found that a wide range of factors, spanning from individual differences to societal influence and system characteristics, are important. For example, Shaheen et al. (2018) revealed that individual and socioeconomic variables, trip purpose, and familiarity with the UAM concept influenced respondents' willingness to fly. Yedavalli and Mooberry (2019) identified safety as the primary concern related to UAM, followed by the type and volume of sound generated by the aircraft. Furthermore, various studies investigated the UAM from a Psychological perspective (Kim et al., 2022; Al Haddad et al., 2020). Al Haddad et al. (2020) investigated the factors affecting the use and adoption of UAM using multinomial and ordered logit discrete choice models. Their findings highlighted the importance of social attitude, perceived usefulness, trust, familiarity with self-driving, concerns related to information, and a number of socioeconomic characteristics.

Various studies investigated the UAM from a psychological perspective (Kim et al., 2022; Al Haddad et al., 2020). For instance, Al Haddad et al. (2020) investigated the factors affecting the use and adoption of UAM using discrete choice models such as multinomial and ordered logit. Their findings highlighted the importance of social attitude, perceived usefulness, trust, familiarity with self-driving, concerns related to information, and some socioeconomic characteristics.

Research has also related some potential barriers to UAM implementation from the point of view of users and non-users. Goyal et al. (2018), for instance, examined three different alternatives of air shuttle, air ambulance, and air taxi in the United States. Factors such as safety, noise pollution, travel cost, and privacy were the key factors of intention to use UAM. Moreover, the socio-economic profile shows that men are more likely to use UAM than women, and millennials are the most likely users compared with other generations (Goyal et al., 2018). Using 2500 responses gathered by conducting a stated preference survey among high-income employees Binder et al. (2018) determined the willingness to pay for eVTOL in the US.

Additionally, Fu et al. (2019)) proposed a multinomial logit model model for four alternatives including the private car, public transportation, autonomous taxi, and autonomous flying taxi. Their findings suggest that along with safety, travel time and travel cost are influential explanatory factors in UAM adoption. Potential UAM users are younger individuals and elderly with higher incomes. Finally, they found that potential consumers are more likely to use UAM for non-commuting trips.

In a study conducted by EASA (2021), a review of UAM studies from 2017 to 2021 was carried out. The study identified various risks associated with the acceptance of UAM, including noise, safety, privacy, visual pollution, job losses, environmental concerns, and affordability. Additionally, acceptance of UAM in six European Union cities (Barcelona, Budapest, Hamburg, Milan, Oresund, and Paris) was assessed through an online survey involving 3690 participants. The questionnaire explored factors such as perceived benefits, concerns, and the social acceptance of UAM for passenger transportation and goods delivery. The results of the conjoint choice analysis revealed a generally positive attitude towards UAM, with individuals expressing a preference for using this technology in emergency situations and for medical purposes. However, respondents also expressed concerns related to safety, noise pollution, environmental impacts, and security. Alongside these concerns, the main anticipated advantages of UAM were identified as improved connectivity that is faster, environmentally friendly, and capable of extended reach.

Eiβfeldt et al. (2020) examined the acceptance of civil drones in Germany through a telephone interview. They found that there is a balanced but slightly positive attitude toward civil drones. After examining people's attitudes, they found that men have a more positive attitude toward this technology than women, and in terms of age, 14- to 24-year-olds had the most positive attitude, and 55-64-year-olds had the least positive attitude. Using online questionnaires, Rohlik and Stasch (2019) investigated the acceptance of UAM using 321 questionnaires from different cities. Estimation results of structural equation modeling

showed that attitude is strongly influenced by perceived usefulness, and along with subjective norms, the travel cost and consumer innovativeness are among the most critical factors affecting the behavioral intention to use air taxis.

The aforementioned review described several studies that attempted to fill the gap in the literature regarding the factors affecting the intentions to use UAM. However, the different aspects of factors are subject to several gaps. For example, (i) most of the previous research has focused on socioeconomic characteristics that influence the intention to use UAM (Fu et al., 2019; Eißfeldt et al., 2020; EASA, 2021) but there is a limited number of studies that focused on psychological factors (Rohlik and Stasch, 2019); (ii) previous studies only considered Attitude, Behavioral Intention (BI), Perceived Usefulness (PU), Subjective Norms (SN), Trust, and Consumer Innovativeness (CI), while we have also considered other psychological factors that have been proven to have a significant effect such as Ecological Awareness, Price Evaluation, Compatibility, and Enjoyment; (iii) Existing studies also lack a systematic framework for incorporating system characteristics, and individual differences and social influence at the same time.

3. Conceptual model and hypotheses

We use the extended version of the Technology Acceptance Model (TAM3) proposed by Venkatesh and Bala (2008) and depicted in Fig. 1 to determine the factors that explain the intention toward UAM adoption.

The proposed conceptual model consists of four parts including the TAM model (in green), with three enriched components including individual differences (in red), system characteristics (in blue), and social influence (in oranges) as shown in Fig. 2. It is notable that compared to the original TAM framework devised by Davis et al. (1989) we have only retained PU in our model which directly affects BI and excluded PEU as suggested by Al Haddad et al. (2020).

3.1. Technology acceptance model

In TAM, three latent constructs including perceived usefulness, perceived ease of use, and behavioral intention are considered to determine whether a technology is accepted by a customer (Davis, 1989; Davis et al., 1989; Venkatesh and Davis, 2000; Venkatesh and Bala, 2008; Karami et al., 2023). Individuals' intentions to use were determined using attitude similar to Ajzen and Fishbein (1980) in the theory of reasoned action and Ajzen (1991) in the TPB model. According to the literature, the following hypotheses are proposed:

H1. The intention to use UAM is positively influenced by the attitude toward it;

H2. The intention to use UAM is positively influenced by its perceived usefulness;

H3. The attitude toward UAM is positively influenced by its perceived usefulness;

3.2. Social influence

Subjective norms: The media, as well as family members, friends, and teachers, can significantly affect technology users (Ma et al., 2018). The idea that an important individual or group would endorse and support a specific behavior is referred to as a subjective norm (Ham et al., 2015; Davis, 1989; Ajzen, 1991; Venkatesh and Davis, 2000; Venkatesh and Bala, 2008; Karami et al., 2022). For example, SN affects both perceived usefulness and intention concurrently, based on findings by Venkatesh and Bala (2008). In the context of UAM adoption, Al Haddad et al. (2020) found that SN could positively affect UAM adoption. Moreover, Kusumawardhani et al. (2019) found that SN positively affects consumer trust in green products. Therefore, the following hypotheses are postulated:

H4. The trust toward UAM is positively influenced by subjective norm;

H5. The intention to use UAM is positively influenced by subjective norm;

3.3. Individual differences

Ecological awareness: this factor is among the latent constructs which influence the acceptance of innovations (Al Haddad et al., 2020; EASA, 2021). As outlined in the literature review section, there are very limited studies that examine the psychological factors that affect the intention to use UAM (EASA, 2021); while respondents believe that UAM vehicles are fast and sustainable, they also have concerns related to noise pollution and environmental impacts. In regards to the acceptance of electric autonomous cars, Wu et al. (2019) pointed out that environmental concerns can influence not just the intention to use electric autonomous cars but also their green perceived usefulness. Accordingly, we hypothesize that:

H6. The perceived usefulness of UAM is positively influenced by ecological awareness;

Trust: As an enabler and driver of advancement, trust remains a fundamental concept in change and development; however, mistrust can act as an obstacle (Fox, 2020). According to Al Haddad et al. (2020), one of the key factors contributing to technology adoption and use is trust, which is considered as the willingness to accept vulnerability (Rousseau et al., 1998). Moreover, they have outlined the impact of trust on perceived usefulness positively. Hence, we put forth the subsequent hypotheses:

H7. The attitude toward UAM is positively influenced by trust

H8. The perceived usefulness of UAM is positively influenced by trust;

Personal innovativeness: The tendency of consumers to buy newly released products more often and more quickly than others is defined as consumer innovativeness (Roehrich, 2004). It has been shown in different studies that perceived usefulness is positively influenced by consumer innovativeness (Lin et al., 2007; Kuo and Yen, 2008). Thus, the following hypothesis is proposed:

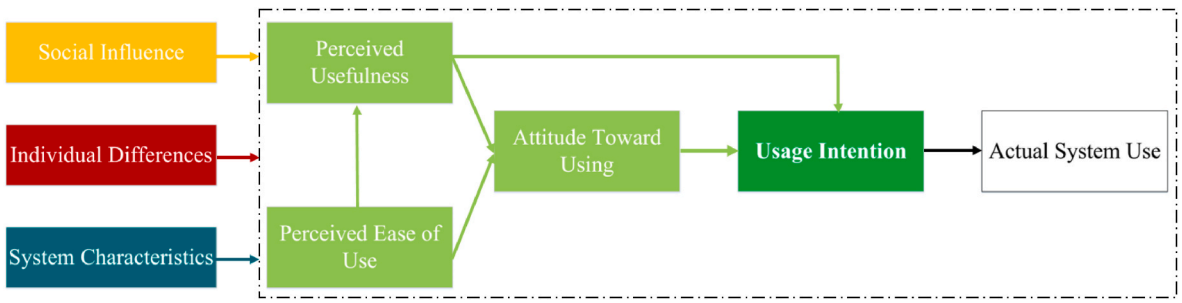

Fig. 1. Theoretical framework (adapted from Venkatesh and Bala, 2008).

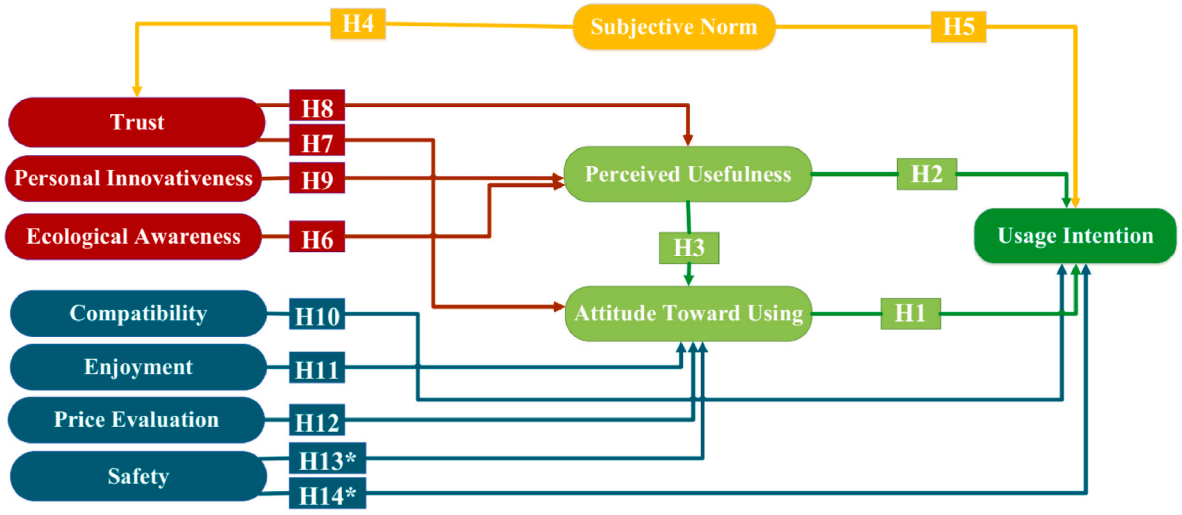

Fig. 2. Research conceptual model with hypotheses to investigate the intention to use UAM - Note: The asterisk (*) denotes a factor that has a negative impact.

H9. The perceived usefulness of UAM is positively influenced by consumer innovativeness.

3.4. System characteristics

Compatibility: It is defined as the perception of how well an innovation matches existing values, past values, and needs of potential adopters (Ramanathan et al., 2020). In the case of UAM, no study has considered this psychological factor so far, however, Wu and Wang (2005) and Karahanna et al. (2006) have found a positive association between behavioral intention and compatibility. In this regard, we propose that:

H10. The intention to use UAM is positively influenced by compatibility;

Perceived enjoyment: It is defined as how enjoyable the experience of working with a specific system is in its own right, regardless of any performance consequences (Ogunsola and Adekola, 2021). Based on a review by Hornbæk and Hertzum (2017), a positive impact of perceived enjoyment on attitude has been confirmed. This leads to the following hypothesis:

H11. The attitude toward UAM is positively influenced by perceived enjoyment;

Price evaluation: It describes consumers' subjective assessment of the perceived benefits of a particular service compared with its monetary cost (Venkatesh et al., 2012). Nastjuk et al. (2020) found that price evaluation was positively related to usage intentions for a new product. Hence, the following hypothesis is formulated:

H12. The attitude toward UAM is positively influenced by price evaluation;

Perceived safety: A consumer's perception of risk is based on his/her exposure uncertainty and to situations that may incur unwanted outcomes (Dowling and Staelin, 1994). As evidenced in many studies, the perception of safety/risk has been shown to significantly mitigate the intention to use/attitude of individuals (Kim et al., 2008; Nasri and Charfeddine, 2012; Min and Kim, 2015; Cheng et al., 2019; Kim et al., 2020). The following hypotheses are proposed accordingly:

H13. The attitude toward UAM is negatively influenced by perceived safety;

H14. The intention to use UAM is negatively influenced by perceived safety.

4. Method

4.1. Data

After designing a comprehensive questionnaire to determine the factors associated with the intention to use UAM, a face-to-face survey was conducted for 73 days, from June 11, 2021, to August 22, 2021. From the population of Tehran in Iran, a random representative sample of 828 individuals was collected.

Before administering the questionnaire, our survey assistants, who were trained in this regard, were instructed to provide respondents with a brief description of UAM. This was done because it was anticipated that many respondents may not be familiar with UAM. The descriptions were communicated in a neutral and simple language to ensure that respondents felt confident in their responses. It should be noted that the original description was in Persian but a translation into English by the authors is provided in Appendix 1.

The descriptive analysis of socioeconomic characteristics (Table 1) shows that the proportion of men and women is balanced and we tried to collect a representative sample of the population. Also, according to the latest census of the Statistics Centre of Iran in 2016,[1] men and women constituted 50.30% and 49.7% of the total population of Iran, respectively, which is very similar to the collected responses.

Similarly, we have tried to collect the questionnaire of the different age groups according to the data from the Statistics Centre of Iran in 2016. For example, regarding the respondents' age, about half of the responses were gathered from people aged 25–44 years old which is very close to the 2016 census. Fifty percent of respondents have bachelor's or master's degrees. Full-time employed and housewives account for about 26% and 22% of the sample, respectively. According to the respondents' main commute mode, there is an approximately similar share (38%) for users of transit and passengers in car. In the case of income, we have tried to collect a symmetric sample of the population and avoided any potential bias in income levels.

4.2. Questionnaire

The questionnaire consists of several sections. In the first section, socioeconomic characteristics including gender, age, education, income, and main occupation were asked. Afterward, using a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree, psychological factors were measured. A modified and standardized framework,

[1] https://www.amar.org.ir/english.

Table 1
Summary of demographic characteristics of the sample.

Variable		Frequency		
		Count (out of 828)	% Total	*% in 2016 Census of Tehran City*[a]
Gender	Female	416	50.24	*50.26*
	Male	412	49.76	*49.74*
Age	18–24	105	12.68	*12.75*
	25–34	228	27.54	*29.37*
	35–44	185	22.34	*23.62*
	45–54	143	17.27	*18.52*
	55–64	94	11.35	*13.44*
	65+	73	8.82	*11.67*
Education	Under high school diploma	94	11.35	
	High school diploma	144	17.39	
	Apprenticeship diploma	129	15.58	
	Bachelor	293	35.39	
	Masters	129	15.58	
	Doctorate	39	4.71	
Main occupation	Housewife	178	21.50	
	Student	41	4.95	
	Self-employed	40	4.83	
	Full-time employed	215	25.97	
	Part-time employed	138	16.67	
	Unemployed	56	6.76	
	Retired	66	7.97	
Main commute mode	Walk	71	8.57	
	Public transportation	316	38.16	
	Car as a driver	89	10.75	
	Car as a passenger	322	38.89	
	Bike	30	3.62	
Income compared with Tehran residents' average income	Very lower	61	7.37	
	Lower	151	18.24	
	Moderate	390	47.10	
	High	153	18.48	
	Very high	73	8.82	

[a] Only the population aged 18 years old or more from the census are considered and the percentages are rescaled accordingly.

introduced by Ajzen and Fishbein (1980) and Venkatesh and Bala (2008), was used to measure the components of the TAM including attitude, behavioural intention, and perceived usefulness. Additionally, instruments that have been considered in previous research were modified to use in measuring the three components of individual differences in UAM. Trust was measured using items proposed and validated by (Choi and Ji, 2015; Nees, 2016), and items measuring ecological awareness were adopted from Roberts (1995). To measure personal innovativeness a standardized three-item instrument was obtained from Parasuraman (2000). In terms of system characteristics, enjoyment was measured using a two-item instrument introduced by Venkatesh and Bala (2008). Moreover, three items associated with price evaluation were derived from Venkatesh et al. (2012) and Nees (2016). Finally, three indicators proposed by Moore and Benbasat (1991) measured compatibility, and two indicators introduced by Vijayasarathy (2004) were used to measure safety concerns.

5. Data analysis and results

SmartPLS software (Ringle et al., 2022), which follows a two-step modelling approach, was used for data analysis. Based on a partial least squares structural equation model (PLS-SEM), the conceptual model of the study was assessed. In the following subsections, the measurement model along with the structural model will be evaluated.

5.1. Measurements validity

Several aspects of measurement validity have been considered including the content, convergence, and discriminant (Fornell and Larcker 1981b; Hair et al., 2011). We have derived the items from previous studies which confirms the content validity. Moreover, when the Persian questionnaire was submitted to experts for confirmation, we developed the final questionnaire following their confirmation of the accuracy of the translation. As proposed by Fornell and Larcker (1981b) and Hair et al. (2011), three indices were used to evaluate the convergent validity including the reliability of indicators, average variance extracted (AVE >0.5), and composite construct reliability (CR > 0.7). A convergence validity test (Table 2) is performed on the items to determine their mean values, factor loadings, t-statistic, AVE, CR, and Cronbach's alpha. A factor loading greater than 0.6 highlights the adequate representation of the construct's variability (Bagozzi and Yi, 1988; Chin, 1998). Furthermore, according to the *t*-test values, all the items have a significant effect on the latent constructs' measurement. In addition, according to the calculated CR and AVE values which are significantly greater than the acceptable thresholds, the convergent validity has been confirmed. To assess the reliability of the questionnaire, Cronbach's alpha was used, which has to be at least 0.6–0.7 for indicating acceptable reliability while values of greater than 0.8 show excellent reliability (Eisinga et al., 2013).

To determine whether latent constructs are distinguished, discriminant validity is examined. As can be seen in Table 3, all AVEs have square roots greater than the correlation values in their corresponding columns and rows, indicating that discriminant validity has been passed (Fornell and Larcker, 1981a). Accordingly, the measurement model is generally considered valid and reliable, and it fits well with the data.

5.2. Structural model

In Table 4 and Fig. 3, the structural model results are shown. A bootstrapping experiment with 6000 samples was conducted for the evaluation of the structural path of the model (Hair et al., 2011).

According to the path coefficients, trust ($\beta = 0.542$, $p < 0.05$), personal innovativeness ($\beta = 0.303$, $p < 0.05$) and ecological awareness ($\beta = 0.130$, $p < 0.05$) are contributing factors to perceived usefulness in a descending order. Based on the significance level of mentioned constructs, it can be concluded that hypotheses 8, 9, and 6 are accepted with a confidence level of 95%. Explanatory factors of attitude, trust ($\beta = 0.323$, $p < 0.05$), enjoyment ($\beta = 0.312$, $p < 0.05$), perceived usefulness ($\beta = 0.287$, $p < 0.05$), and price evaluation ($\beta = 0.080$, $p < 0.05$), and safety ($\beta = -0.021$, $p < 0.1$) are the most influential factors in a descending order which support the hypotheses of 7, 11, 3, 12 and 13, respectively. Moreover, subjective norm ($\beta = 0.740$, $p < 0.05$) significantly affects trust, which supports hypothesis 4.

The main objective of this research is to understand the determinants behind the acceptance of UAM. Accordingly, the significant determinants in a descending order are attitude ($\beta = 0.588$, $p < 0.05$), perceived usefulness ($\beta = 0.198$, $p < 0.05$), and subjective norm ($\beta = 0.142$, $p < 0.05$), which support the hypotheses 1, 2, and 5, respectively. However, the impact of compatibility ($\beta = 0.065$, $p > 0.05$) on usage intention is not significant and hypothesis 10 is rejected. Due to the fact that in a fully automated system, there is no need for any required effort from the end user, the perceived ease of use (for UAM: service booking or boarding) did not have a significant impact on usage intention, which is in accordance with Al Haddad et al. (2020). Therefore, perceived ease of use was removed from the proposed model.

In terms of indirect effect, some factors are related to usage intention. Among the significant factors, trust ($\beta = 0.388$, $p < 0.05$), subjective norm ($\beta = 0.287$, $p < 0.05$), enjoyment ($\beta = 0.183$, $p < 0.05$), perceived usefulness ($\beta = 0.169$, $p < 0.05$), personal innovativeness ($\beta = 0.111$, $p < 0.05$), ecological awareness ($\beta = 0.048$, $p < 0.05$), and price evaluation ($\beta = 0.047$, $p < 0.05$) were related to usage intention in descending

Table 2
Reliability and validity assessment of latent constructs.

Constructs	Items	Mean	Loadings	t-statistic	CA[a]	CR	AVE
Attitude	I like the idea of using UAM.	3.46	0.954	164.45	0.96	0.97	0.92
	I think that using UAM is a good idea.	3.47	0.964	239.59			
	I think that using UAM is a wise idea.	3.42	0.962	207.42			
Perceived Usefulness	Using UAM saves me time.	3.49	0.965	251.82	0.93	0.96	0.93
	Generally, I think UAM are usefulness.	3.49	0.965	244.14			
Personal Innovativeness	I would like to try UAM.	4.65	0.952	186.55	0.95	0.97	0.91
	In general, I will not be hesitant to try out UAM	4.13	0.954	193.53			
	In general, I would like to experiment with UAM	4.37	0.955	175.44			
Compatibility	I think using UAM would be compatible with my mobility behavior.	3.47	0.970	285.61	0.97	0.98	0.95
	I think using UAM is compatible with all aspects of my mobility behavior.	3.46	0.975	324.01			
	I think using UAM would fit well into my mobility behavior.	3.46	0.973	295.92			
Enjoyment	I think using UAM will make me feel good.	3.49	0.971	241.72	0.94	0.97	0.95
	I think using UAM to be pleasant.	3.48	0.973	288.49			
Ecological Awareness	The impact of UAM on the environment would influence my usage decision.	3.47	0.928	187.52	0.94	0.96	0.88
	The degree to which UAM cause pollution would influence my usage decision.	3.54	0.944	222.61			
	If I understand the impact UAM have on the environment, it will influence my usage decision.	3.50	0.950	185.13			
Usage Intention	With the expansion of UAM in the future, I intend to use them.	3.42	0.962	257.37	0.95	0.97	0.91
	If I have access to UAM, I intend to use them.	4.50	0.942	222.52			
	Assuming I have access to UAM, I will use it.	3.47	0.959	266.31			
Price Evaluation	The benefits of UAM would outweigh the amount of money they would cost.	3.42	0.934	151.66	0.94	0.96	0.90
	Given the benefits of UAM, I think it would be reasonable to spend a little more on it.	3.42	0.958	271.83			
	Given the benefits of UAM, I think it worth to spend a little more on it.	3.48	0.947	201.92			
Subjective Norm	I think, if the people who are important to me consider the benefits of UAM, their opinion is that I would be better off using UAM in the future.	3.45	0.971	310.55	0.97	0.98	0.95
	I think, the people whose opinions are valuable to me, if they consider the benefits of UAM, their opinion is that I would be better off using UAM in the future.	3.48	0.978	403.73			
	I think, people who influence me, if they consider the benefits of UAM, think that I would be better off using UAM in the future.	3.46	0.974	331.64			
Trust	Overall, I would trust UAM.	3.39	0.963	241.03	0.96	0.97	0.93
	I expect UAM to be reliable.	3.41	0.956	211.48			
	I expect UAM to be dependable.	3.41	0.971	319.66			
Safety concern	I am worried about the general safety of UAM.	3.98	0.839	13.39	0.65	0.85	0.74
	I am worried about the occurrence of a catastrophe due to UAM malfunction.	3.92	0.879	17.38			

[a] CA abbreviates Cronbach's Alpha.

Table 3
Correlation matrix and discriminant validity.

	Construct	1	2	3	4	5	6	7	8	9	10	11
1	Attitude	**0.960**										
2	Compatibility	0.748	**0.973**									
3	Ecological Awareness	0.836	0.930	**0.941**								
4	Perceived Enjoyment	0.952	0.746	0.843	**0.972**							
5	Perceived Usefulness	0.947	0.744	0.837	0.941	**0.965**						
6	Personal Innovativeness	0.936	0.755	0.835	0.924	0.916	**0.953**					
7	Price Evaluation	0.858	0.889	0.921	0.846	0.845	0.848	**0.946**				
8	Safety concern	0.113	0.227	0.236	0.117	0.135	0.140	0.236	**0.859**			
9	Subjective Norm	0.741	0.963	0.907	0.736	0.733	0.749	0.882	0.217	**0.974**		
10	Trust	0.951	0.743	0.839	0.945	0.933	0.932	0.856	0.122	0.740	**0.963**	
11	Usage Intention	0.932	0.795	0.875	0.921	0.910	0.947	0.885	0.166	0.791	0.932	**0.954**

Note. bolded numbers: square root of AVE.

Table 4
Estimation results of structural model.

Hypothesis and Number		Path coefficient			Total effect		
		β	P-Value	Conclusion	β	P-Value	Conclusion
Attitude → Usage intention	H1	0.588	0.000	Accepted	0.588	0.000	Accepted
Perceived usefulness → Usage intention	H2	0.198	0.001	Accepted	0.367	0.000	Accepted
Perceived usefulness → Attitude	H3	0.287	0.000	Accepted	0.287	0.000	Accepted
Subjective norm → Trust	H4	0.740	0.000	Accepted	0.740	0.000	Accepted
Subjective norm → Usage intention	H5	0.142	0.039	Accepted	0.430	0.000	Accepted
Ecological awareness → Perceived usefulness	H6	0.130	0.000	Accepted	0.130	0.000	Accepted
Trust → Attitude	H7	0.323	0.000	Accepted	0.478	0.000	Accepted
Trust → Perceived usefulness	H8	0.542	0.000	Accepted	0.542	0.000	Accepted
Personal innovativeness → Perceived usefulness	H9	0.303	0.000	Accepted	0.303	0.002	Accepted
Compatibility → Usage intention	H10	0.065	0.346	Rejected	0.065	0.346	Rejected
Enjoyment → Attitude	H11	0.312	0.000	Accepted	0.312	0.000	Accepted
Price evaluation → Attitude	H12	0.080	0.001	Accepted	0.080	0.001	Accepted
Safety → Attitude	H13	−0.021	0.073[a]	Accepted	−0.021	0.073	Accepted
Safety → Usage intention	H14	0.027	0.055	Rejected	0.015	0.317	Rejected
Ecological awareness → Usage intention	-	-	-	-	0.048	0.000	Accepted
Enjoyment → Usage intention	-	-	-	-	0.183	0.000	Accepted
Personal innovativeness → Usage intention	-	-	-	-	0.111	0.001	Accepted
Price evaluation → Usage intention	-	-	-	-	0.047	0.002	Accepted
Subjective norm → Attitude	-	-	-	-	0.354	0.000	Accepted
Personal innovativeness → Attitude	-	-	-	-	0.087	0.000	Accepted
Subjective norm → Perceived usefulness	-	-	-	-	0.401	0.000	Accepted
Trust → Usage intention	-	-	-	-	0.388	0.000	Accepted

[a] Despite its 90% confidence level, including this parameter in our model aligns with the literature.

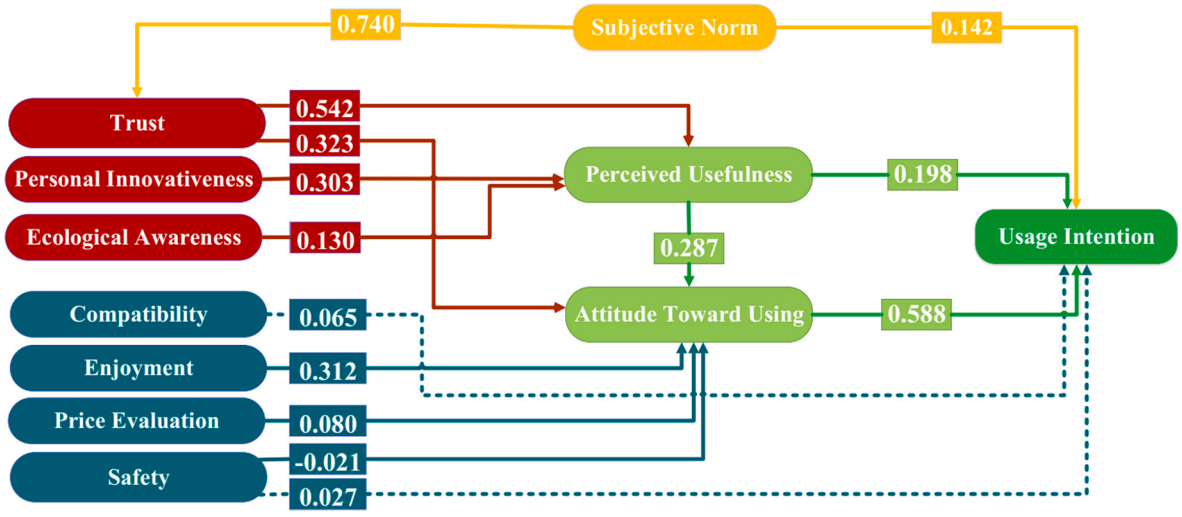

Fig. 3. Estimation of path coefficients in structural model (Note: The dashed path indicates the insignificance of estimated coefficients).

order indirectly. However, no significant indirect effect was found between safety and usage intention.

6. Discussion

6.1. Theoretical implications

Detailed results of standard estimation and the significance of construct direct effects on hypotheses testing are shown in Table 4. A total effect column is also included in Table 4, which represents the sum of all direct and indirect effects that are associated with Usage Intention. Moreover, the significance of each relationship is assessed by the p-values of all total effects. Variables indirectly affect each other when they are mediated by a third variable called mediator (Carrión et al., 2017). By taking advantage of the indirect effect, we can gain a better understanding of the relationship between the two latent variables. Therefore, to prioritize the most relevant factors of UAM usage intention, both indirect and direct effects need to be evaluated simultaneously.

As it can be seen, attitude ($\beta = 0.588$) is the strongest factor in explaining the UAM usage intention. In accordance with Eiβfeldt et al. (2020) and Rohlik and Stasch (2019), attitude is a significant parameter to predict an intention to use UAM. A number of factors were positively correlated with attitudes toward UAM use, including trust, enjoyment, perceived usefulness, and price evaluation, whereas safety was negatively correlated. Moreover, attitude is strongly influenced by trust and subjective norm which is in line with Rohlik and Stasch (2019). The positive attitude has previously been associated with usage intentions and, as a result, actual use (Davis, 1989; Ajzen, 1991). Accordingly, aside from the importance of building trust in UAM performance, the environment influence is critical in attitude toward UAM.

The second strongest factors associated with UAM usage intention is subjective norm ($\beta = 0.430$). Both direct and indirect effects are significant. Trust, perceived usefulness and attitude mediated the effect of subjective norm on usage intention. Inexperienced individuals' acceptance is likely to be influenced by third-party opinions, according to Venkatesh and Davis (2000). Hence, the results highlighted the positive impact of environment and social influence on usage intention of UAM which has been confirmed by Rohlik and Stasch (2019).

Trust ($\beta = 0.388$) ranked third in terms of contributed factors in usage intention of UAM. Perceived usefulness and attitude mediate the relationship between trust and usage intention. In accordance with Al Haddad et al. (2020) trust is a positive factor in explaining the UAM usage intention and it is positively correlated with transparency, which includes being able to understand and predict the functionality of UAM.

Among the significant factors of UAM usage intention, perceived usefulness ($\beta = 0.367$) is the fourth and in line with Rohlik and Stasch (2019) it is positively associated with intention to use UAM. It can also be seen that attitude is a significant mediator of the relationship between perceived usefulness and usage intention.

The issue of whether or not people will use a UAM depends on how they perceive its usefulness in fulfilling their mobility needs. Accessibility, traffic avoidance, and time and money savings are some effective positive concepts that determine UAM usefulness.

Enjoyment ($\beta = 0.183$) is the fifth factor which is only associated with UAM usage intention indirectly by the mediation effect of attitude. No direct relationship has been considered in the proposed framework between enjoyment and usage intention. UAM will be more appealing and user-friendly if they are perceived as a fun activity. In previous studies, enjoyment has not been considered before but it has been considered in other contexts such as E-scooter and autonomous vehicle (Javadinasr et al., 2022), highlighting the positive impact of enjoyment on usage intention.

Personal innovativeness ($\beta = 0.111$) is the sixth factor associated with usage intention. In this study, personal innovativeness and usage intention did not have a direct relationship. However, attitude and perceived usefulness mediate the relationship between personal innovativeness and UAM usage intention. Based on Rohlik and Stasch (2019), personal innovativeness is a critical construct affecting the behavioral intention to use air taxis. Positive perceptions and views of UAM are more likely to form in people who are motivated by new modes and like to experiment with novel technologies.

Ecological awareness ($\beta = 0.048$) is the seventh factor associated with intention to use UAM. the effect of ecological awareness on UAM usage intention is mediated through perceived usefulness and attitude even though no significant direct relation was found between them. These factors have not been considered in UAM usage intention studies before however in other innovative mobility technology contexts, such as electric motorcycles (Guerra, 2019) or electric scooter sharing systems (Samadzad et al., 2023; Rejali et al., 2021; Kopplin et al., 2021; Eccarius and Lu, 2020), it has been confirmed that ecological awareness is positively associated with usage intention.

Lastly, the eighth factor which is positively associated with usage intention is price evaluation ($\beta = 0.047$). There is only an indirect relationship between price evaluation and usage intention which is mediated by attitude. There is a lack of studies which have considered the effect of price evaluation of UAM. However, some studies highlighted the importance of the UAM's travel cost (Fu et al., 2019; Rohlik and Stasch, 2019; Goyal et al., 2018).

6.2. Practical implications

Identifying the factors that will encourage individuals to make use of a new system and lessen their resistance to change is crucial to ensuring the successful introduction of an innovative technology. According to the proposed model, for determining the determinants behind the UAM usage intention, eight constructs significantly affect the intention to use UAM including, attitude, subjective norm, trust, perceived usefulness, enjoyment, personal innovativeness, ecological awareness, and price evaluation.

Attitude is the most critical factor that affects the usage intention of prospective UAM users. It is positively influenced by trust, subjective norm, enjoyment, perceived usefulness, personal innovativeness, price evaluation, and ecological awareness, while it is negatively associated with perceived safety. By lowering the cost and spotlighting the advantages of environmentally friendly mobility systems, such as decreased noise and air pollution, policymakers can enhance people's attitude toward UAM and increase their intention to use them. Concerning the direct and indirect effect of trust on attitude, it is important for authorities to build trust with users, which can be accomplished in a variety of ways, such as ensuring that UAM systems are safe and accessible. Some safety measures could decrease the safety concerns and build trust in UAM such as real-time control of UAM while flying, continuous checks to prevent any probable malfunction, and presence of in-vehicle cameras and operators (Goyal et al., 2018; Al Haddad et al., 2020). Subjective norms as the second most important factor affecting the usage intention towards UAM, highlights the effect of an individual's social setting on his/her decision to use UAM. It is therefore viable to encourage the use of UAM by advertising in every possible media channel, such as social media to highlight UAM's benefits including lower travel time and air and noise pollution (EASA, 2021).

Perceived usefulness as another factor affecting usage intention, highlights the improvement in fulfilling individuals' transportation needs (Rohlik and Stasch, 2019; Goyal et al., 2018). Perceived usefulness is influenced by trust, subjective norms, personal innovativeness and ecological awareness, respectively. It is therefore necessary for authorities to use the above factors to identify gaps in the use of UAM by individuals and to improve their perceived usefulness. Moreover, it is recommended that policymakers present the benefits and advantages of UAM to citizens to increase the usage intention. A similar point is that UAM advertisements need to emphasize that a UAM can be fun and cool so as to enhance the desire for enjoyment, a critical factor that

determines whether or not individuals intend to use them. Hence, enjoyment can increase the use of UAM by different individuals and good design of UAM could attract more potential users who are looking for more fun. Personal innovativeness is also another factor that could increase the usage intention towards UAM. Policymakers could promote policies to attract more and more innovative individuals to UAM such as proposing free trials for early adopters.

7. Conclusion

Challenges of traffic congestion include longer travel times, air pollution, noise pollution, and unreliable public transport, emphasizing the need for sustainable and efficient transportation systems (Abbasi et al., 2020; Abbasi and Hadji Hosseinlou, 2022; Macioszek et al., 2022). This paper analyzed 828 respondents' stated intentions regarding urban air mobility by conducting a face-to-face survey in Tehran, a capital city of the developing world, which encounters serious congestion and pollution issues. In the survey, hypotheses were uncovered regarding urban air mobility, and an extended technology acceptance model was validated for this emerging mobility service, using a wide range of factors from individual differences and system characteristics to social influence which were extracted from the literature on technology adoption. Structural equation modeling estimation results highlight the importance of attitude, subjective norms, trust, and perceived usefulness in increasing respondents' usage intention towards UAM. However, perceived safety was negatively associated with attitude toward UAM. Therefore, as a policy guideline, it is essential to address the public perception of UAM and ensure that these parameters are thoroughly regarded in policies pertaining to future urban transportation.

The study makes a valuable contribution to the existing body of literature on the usage intention of UAM by addressing previous gaps. However, as for all scientific studies, it is crucial to acknowledge certain limitations associated with the nature and subject matter of the research. Firstly, this study utilized face-to-face surveys to collect data, which, despite their advantages such as higher response rate (Christensen et al., 2014) and higher data quality compared to online surveys (Goldenbeld and de Craen, 2013; Heerwegh and Loosveldt, 2008), have drawbacks such as sampling bias and interviewer effect causing social desirability bias (Fink, 2003; Owens, 2002). To mitigate these challenges, our study employed random sampling and trained data collectors to minimize the impact of interviewer effects. However, it is possible that our sample may not precisely represent the target population, and participants' responses could still be influenced by the presence of interviewers. Secondly, this study was conducted in Tehran, Iran, as a congested and polluted city in a developing country. Therefore, due to differences in travel behavior, culture, and other context-related diversities, the generalization of findings is difficult. Furthermore, respondents' lack of personal experience with UAM may affect the accuracy of their responses, as previous studies (Brandts and Charness, 2000; Jones et al., 2011) have shown that hypothetical intentions and actions do not always align with actual intentions and actions. To address this limitation, our survey assistants used strategies such as detailed explanations through a simple language and first-person scenarios (Ludwig, 2007). However, the inability to provide a realistic simulation is a limitation of our study, and caution should be exercised when interpreting and generalizing the results. Finally, the results generated are based on the best available efforts at this juncture. Therefore, it is important to note that the perception of future generations towards UAM may evolve and change as they would be exposed to actual UAM operations and other forthcoming transportation modes.

This study aimed to propose an extension of the TAM framework to examine factors related to usage intention towards UAM in terms of individual differences, system characteristics, and environment. Future studies could enhance this research by Investigating the effects of socioeconomic and demographic variables along with the proposed variable in this research. Additionally, the current enriched TAM model does not include emotional constructs such as fear, moods, threats, and similar factors. Therefore, it is recommended to assess the impact of a full range of emotions on individuals' usage intention towards UAM in future studies. What is more, comparing other technology adoption models, such as UTAUT (Unified Theory of Acceptance and Use of Technology) and TCT (Technology Continuance Theory), with the extended TAM could yield valuable outcomes. Lastly, exploring preferences among emerging transportation modes, such as autonomous vehicles and autonomous trains, in a hypothetical scenario can provide insightful conclusions, particularly for future investors.

Finally, it should be noted that the integration of urban air mobility into the transportation systems of economically developing cities in the global south is expected to face challenges due to its high cost and technological complexity (Ahmed et al., 2023). Therefore, achieving widespread adoption of UAM may be unlikely in the near future. However, there are specific areas, such as tourism, medical emergencies, and airport access that hold promise for early adoption and targeted implementation. Indeed, the persistent issue of chronic congestion in a city like Tehran may serve as a catalyst, making such UAM niche markets economically viable.

Authorship statement

Category 1.
Conception and design of study: H. Karami, Samadzad
Acquisition of data: H. Karami, A. Karami
Analysis and/or interpretation of data: Abbasi, H. Karami, Samadzad.
Category 2.
Drafting the manuscript: H. Karami, Abbasi, Samadzad
Revising the manuscript critically for important intellectual content: A. Karami, Samadzad, H. Karami.
Category 3.
Approval of the version of the manuscript to be published (the names of all authors must be listed): H. Karami, Abbasi, Samadzad, A. Karami.

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Declaration of competing interest

The authors have no conflict of interest to report.

Data availability

Data will be made available on request.

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Appendix 1

"Urban air mobility (UAM) is a new mode of transportation that offers fast passenger movement in urban and suburban areas, addressing the prevalent traffic issues in cities. These systems primarily utilize electric vertical take-off and landing vehicles, ensuring high levels of safety and compliance with flight regulations. To facilitate the use of UAM, the establishment of vertiports at strategic locations throughout the city can serve as hubs for passenger transportation."

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