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Who will board urban air taxis? An analysis of advanced air mobility demand and value of travel time for business, airport access, and regional tourism trips in Iran

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ABSTRACT

Recent advancements in the development of a comprehensive urban air mobility ecosystem promise the opportunity for its implementation in the near future. However, the utility of this emerging mode of transportation in comparison to the existing modes varies for different trip purposes and geographical contexts. It is, therefore, imperative to assess its usage potential for various scenarios before moving forward with implementation efforts. This paper presents the findings of three stated preference surveys aimed at characterizing prospective urban air mobility travel demand for weekly business, airport access, and regional tourism trips in Iran. Hybrid multinomial logit and hybrid nested logit models are estimated for each trip purpose. The results indicate that urban air mobility for weekly business trips represents the most viable market segment. Value-of-time estimates for weekly business trips are more than two and a half times higher than those for airport access trips, and tourism trips are valued even less. There is a trend towards delaying the adoption of air taxis to gain trust, and reducing ticket prices is seen as the most effective incentive for increasing the adoption rate. This study pioneers research on urban air mobility in a developing country context, offering valuable insights into market viability for investors and policymakers.

1. Introduction

Low-altitude airspace provides a new layer of intraurban mobility (Sabzekar et al., 2024). The global rise in popularity of urban air mobility (UAM) as an emerging mode of transportation, as well as the technological adequacy of air taxi vehicles and infrastructure, along with the introduction of airspace management regulations, enables cities to adopt this new mode (Al Haddad et al., 2020; Holden and Goel, 2016). Pons-Prats et al. (2022) suggest that four major requirements should be addressed before UAM can be implemented, including technical specifications for the aircraft, certification and regulations, infrastructures, and social acceptance. Raghunatha et al. (2023) argue that while the engineering and technological aspects of this new technology have been the center of focus, adoption prospects have received less attention. Studies from different contexts, such as Yavas and Tez (2023) in Turkey, Park et al. (2022) in the US, Ariza-Montes et al. (2023) in China and the US, Ragbir et al. (2020) and Rice et al. (2022) in the US and India, EASA (2021) and Al Haddad et al. (2020) predominantly in Europe, Kalakou et al. (2023) in Portugal, and Karami et al. (2023) and Karimi et al. (2023) in Iran, all report generally favorable attitudes towards the new mode of transportation, constantly on the rise (Tepylo et al., 2023; Park et al., 2022), even though concerns about its safety (Ahmed et al., 2023; Ilahi et al., 2021; EASA, 2021; Al Haddad et al., 2020), security (Ilahi et al., 2021; EASA, 2021), and noise pollution (EASA, 2021) still need to be addressed. Meanwhile, the rapid technological development of autonomous vehicles has contributed to familiarizing society with delegating control to autonomous systems (Bjørnskau et al., 2023; Garrow et al., 2021).

The idea of an intracity air taxi is not totally new. In fact, several on-demand helicopter-hailing companies worldwide have been providing air taxi services for business or aerial sightseeing purposes in Australia (Microflite, 2023), in Japan (Hiratagakuen, 2023), as well as in São Paulo, Mexico City, and San Francisco Bay Area (Acubed, 2020). However, for widespread use of UAM, people should still be introduced to this technologically advanced mode of transportation (Ilahi et al., 2021). It is a common characteristic of new technologies that the more individuals are aware of their benefits, the more they will trust and use them (Deloitte, 2017).

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Electric passenger drones are expected to start commercial service as early as 2024. For instance, the city of Paris has expressed its intention to provide air taxi services during the 2024 Olympic Games (Hader et al., 2020). However, the actual success of this mode relies on the involvement of state and local governments, along with other stakeholders who will invest in the infrastructure development (PwC, 2023; Wisk Aero, 2023). Meanwhile, it is prudent to focus on targeted markets where the implementation of UAM is deemed viable. As Straubinger et al. (2020) pointed out, it is not realistic to consider UAM as a mass transit service. This assertion is especially relevant to developing country contexts where widespread adoption of an expensive mode of transportation is not yet a tenable assumption. Nevertheless, niche segments can be identified where a successful implementation may be quite within reach.

This paper aims to characterize the prospective demand for UAM in Iran. It contributes to the emerging literature by suggesting that UAM should not be viewed as a comprehensive solution to the problem of congestion or a way to achieve sustainable urban transportation but rather as an option to curb chronic urban congestion for specifically targeted demand segments. It aims to address the fundamental question of whether passengers would utilize air taxis (Straubinger and Rothfeld, 2018), assuming that they are available along with the existing modes (Fu et al., 2019). In this perspective, we consider three niche markets of weekly business trips, airport access trips, and tourism trips, and propose to characterize the corresponding demand in the developing country context of Iran by conducting three independent stated preference surveys.

The rest of the paper is organized in the following manner. Section 2 presents a review of the literature on UAM. Section 3 discusses the research methodology and the survey design. Case studies are introduced in Section 4, and statistical analyses and modeling results are presented in Section 5. Section 6 discusses the main findings, and Section 7 highlights implications, limitations of the study, and directions for future research.

2. Literature review

Ilahi et al. (2021) used data from a combined revealed and stated preferences survey in Greater Jakarta that included UAM as an emerging mode in the choice set. They concluded that UAM is potentially suitable for affluent residents over long-distance trips and suggested that it may find practical use for accessing satellite cities or the airport within the Greater Jakarta metropolitan area as a means to curb congestion. Ahmed et al. (2021) found that the willingness to hire and pay for flying taxi services is significantly influenced by socio-demographic factors such as age, gender, ethnicity, education, and income levels. They pointed out that older respondents are generally unwilling to pay more than current Uber/Lyft rates for an air taxi trip and women are more likely to use human-operated flying taxis. Rajendran and Srinivas (2020) highlighted the importance of public perception factors such as safety and long-distance commuting preferences for demand estimation. Long et al. (2023) suggested that air shuttle services, operating on regular routes, are more feasible than air taxi services, operating on a point-to-point network, at least in the short run. They also highlighted the importance of integrating UAM with the existing transportation system, as providing service with short delays depends highly on fast and reliable ground-based transportation (Ale-Ahmad and Mahmassani, 2022). Reiche et al. (2018) compared stated preferences regarding vertiport ground access mode choice in several American cities, showing substantial discrepancy among them: while in New York City, public transport is the preferred ground access mode by a wide margin, driving has the overwhelming majority in Los Angles, and other cities, which correlates with the current modal shares in these cities. According to Straubinger et al. (2020), the fewer vertiports there are, the more heavily dependent the UAM becomes on the ground transportation system.

Fu et al. (2019) presented results from a stated preferences survey for regular commuting and non-commuting purposes in Munich. They estimated the air taxi value of time equal to €44.7 per hour, nearly 60% more than the private car and 40% more than the autonomous ground taxi, and indicated that UAM is more relevant to occasional trips rather than daily commutes primarily due to its high fares. This viewpoint is also shared by Reiche et al. (2018) who showed that UAM users prefer to share autonomous vehicles for long-distance recreational trips and airport access and concluded that lowering the cost is the most effective incentive for increasing UAM use. Ahmed et al. (2023) argued that the viability of UAM services is closely tied to keeping operational costs competitive with conventional transportation options. Kalakou et al. (2023) identified six classes of respondents, labeled from “first movers” for the most enthusiastic about UAM, down to “deniers” for the least enthusiastic. They concluded that, regardless of the differences in opinions, all classes have a positive view of the utility of UAM for healthcare trips. Haan et al. (2021) studied the prospective UAM demand in American cities and showed that major metropolitan areas have the potential to support profitable UAM markets early on. Rimjha et al. (2021b) emphasized the detrimental effect of delay on potential demand, estimating that a 10-min delay can cut demand by more than half. Sun et al. (2018) found that, in the presence of fast and comfortable railway services, UAM cannot acquire a competitive advantage in interurban travel time, while its competitiveness highly depends on the region as well.

While there is a trend in the literature to draw parallels between UAM and autonomous ground vehicles due to their similarities from an emerging technology standpoint, there are also significant differences that should be considered. Al Haddad et al. (2020) highlighted that socio-demographic characteristics, safety concerns, data and ethical concerns, and the value of time play important roles in UAM adoption, while Merat et al. (2017) found that reliability and safety are the main factors influencing the use of shared autonomous vehicles, followed by availability, performance in weather conditions, and ease of access. One should note that safety and autonomy manifest themselves in completely different ways in the UAM and autonomous vehicle contexts. For instance, Deloitte (2017) observed that German drivers overwhelmingly prefer to be able to intervene and take control of their autonomous ground vehicle at any time, a provision that cannot be afforded at all in the UAM context.

UAM is found to be more attractive to high-income households (Straubinger et al., 2021b; Ilahi et al., 2021; Binder et al., 2018), at least in the short run. Ahmed et al. (2021) found that high-income households exhibit a higher willingness to pay a premium for flying taxis and individuals with a college degree are also more likely to use these services. Cohen et al. (2021) enumerated four major challenges to UAM acceptance, including (1) noise, visual pollution, and privacy for flights over residential land uses, (2) social equity as UAM is a costly mode of transport, (3) personal safety, and (4) operational safety and security. In particular, social equity plays an important role in the community acceptance of UAM, as low-income individuals are almost unable to use this mode of transport. Uber estimated a kickoff price of about $5 per passenger mile, which they predicted will decrease tenfold in the long run (Binder et al., 2018) as a result of achieving economies of scale (Reiche et al., 2018). This is compatible with the willingness to pay reported by Kreimeier et al. (2018) in Germany, ranging from €0.5 to €0.8 per kilometer. Rimjha et al. (2021a) studied the demand for UAM as a mode of access to the Dallas-Fort Worth International Airport and Dallas Love Field Airport, distinguishing between business and non-business trips made by visiting and resident travelers. In the case of the business trips by visitors and residents, they estimated the value of time equal to $57.5 per hour and $56.5 per hour, respectively, while the estimates were significantly lower at $36.4 per hour and $32.5 per hour, respectively, for non-business trips. Using data from Dallas and Los Angeles, Song et al. (2019) examined several model specifications yielding different value-of-time estimates approximating $26.0, $20.7, and $34.5 per hour for access, flight, and egress portions of an air taxi trip. Meanwhile, using data from New York and Los Angeles, Haan et al.

(2021) estimated the value of both in-vehicle and out-of-vehicle travel time to be $25.7 and $15.2 per hour, respectively. Finally, Karimi et al. (2023) estimated an air taxi value of time of $26.4 per hour in Tehran.

3. Methodology

Air taxi services are expected to become operational in the near future, however, they are not currently available. Therefore, stated preferences surveys are the main tools for acquiring insight into the behavior of the individuals regarding air taxi use. In this study, three stated preferences surveys corresponding to the three aforementioned weekly business, airport access, and tourism trip purposes are designed and conducted independently. Each survey incorporates a number of existing modes of transportation, and the air taxi as the emerging mode. Descriptive statistics and discrete choice modeling are employed to infer the relevant preferences of the respondents.

3.1. Questionnaire design

Three separate questionnaires were designed to capture preferences for air taxi use across three different trip purposes, including weekly business, airport access, and tourism. Each questionnaire was structured in four sections. The questions were similar among the three questionnaires except for the mode choice scenarios, which were appropriated for the corresponding trip purposes. The first section inquired about sociodemographic characteristics such as age, education, employment, gender, income, and the number of available cars in the household, as well as respondents' regular habits, such as their common mode of transportation and the time they usually spent on social networks. In the second section, Likert-type statements were included to inquire about respondents' opinions regarding environmental concerns, use of private vehicles, availability of a car parking area, practice of trip sharing, and use of driving assistance systems.

In the third section, air taxis were introduced as shared mobility services operated by automated electrically-powered vertical take-off and landing aircraft with the capacity for four passengers traveling at a speed of 150–200 km per hour in the urban low-altitude airspace. They were advertised as less noisy and more comfortable than regular helicopters. An illustration was also provided to help visualize a trip on board an air taxi. Following the brief introduction, a series of six scenarios specific to each trip purpose was presented to the respondents, who were asked to choose their preferred mode for the questionnaire's corresponding trip purpose. For weekly business and airport access trip purposes, four modes of transportation, including private cars, public transport, air taxis, and ride-hailing taxis, were considered. For tourism trips, public transport was excluded. Each mode of transport was characterized by three attributes, including travel time, total travel cost, and waiting/walking time, chosen from the values provided in Table 1. Respondents who did not choose an air taxi in any of the six scenarios were asked an extra question inquiring about the most effective incentive that would persuade them to use air taxis.

In the last section of the questionnaire, Likert-type statements were included to inquire about respondents' concerns about safety, the use of new "unproven" technology, and privacy.

It should be noted that the three surveys were conducted independently, and the respondents participating in each survey were random individuals who were not necessarily aware of the other surveys. Each respondent was presented with a contextual introductory statement explaining what an Urban Air Taxi is and what the scenarios are. Then, they were asked to choose their preferred mode in each scenario. Participants were not required to be currently engaged in tourism, airport access, or weekly commute activities to participate in the survey. They were simply requested to have prior experience with these types of trips, ensuring their familiarity with the subject matter.

Table 1
Attributes used in scenarios for different trip purposes and modes of transport.

	Mode of transport	Travel time (min)	Total travel cost (thousand tomans[a])	Waiting/ Walking time (min)
Weekly Business	Private Car	50, 75, 90	30, 50, 70	0, 2, 4
	Taxi	70, 90	100, 120, 150	5, 10
	Air Taxi	15, 20	400, 600	5, 7, 10
	Public Transport	70, 85, 105	5, 10, 15	15, 25
Airport Access	Private Car	60, 75, 100	70, 95, 130	5, 7, 10
	Taxi	70, 110	95, 120, 150	5, 10
	Air Taxi	15, 20	300, 400, 600	5, 7, 10
	Public Transport	85, 110, 120	15, 20	20, 30
Regional Tourism	Private Car	65, 80, 115	60, 85, 100	0, 5, 10
	Taxi	70, 110	90, 110, 140	5, 10
	Air Taxi	15, 20	400, 600	5, 7, 10

[a] At the time of the survey, 1 USD was equal to 28,000 tomans.

3.2. Model specification

Two model specifications are considered. The multinomial logit model, with the assumption of independence among alternatives, provides the baseline. However, since urban air taxi is a new mode with which people do not have real-world experience, following Bierlaire et al. (2001), we suggest testing a similarity structure among existing modes, reflecting respondents' familiarity with them as opposed to the future mode. To do so, a nested logit model specification depicted in Fig. 1 is used.

A nesting parameter that deviates significantly from unity indicates a correlation between existing modes, suggesting that respondents perceive them as somewhat similar. While this does not rule out the possibility of other meaningful nesting structures, our focus is on identifying correlations resulting from respondents' familiarity with the existing modes.

Moreover, we employed an indirect measurement approach to capture respondents' latent behavioral constructs. This involved utilizing attitudinal Likert-type questions as indicators. Latent constructs are integrated into the choice models, resulting in hybrid multinomial logit and hybrid nested logit models.

3.3. Factor analysis and latent constructs

A series of five-point Likert-type statements were asked to inquire respondents' opinions. These questions were compiled from expert suggestions collected through interviews conducted for this study. These questions are summarized in Table 2, presenting the mean and standard deviation for each statement, with responses ranging from one (strongly disagree) to five (strongly agree). Exploratory factor analysis is employed to identify three distinct factors, each with a minimum loading threshold of 0.4. These factors were labeled as "Tech Guy," "Safe

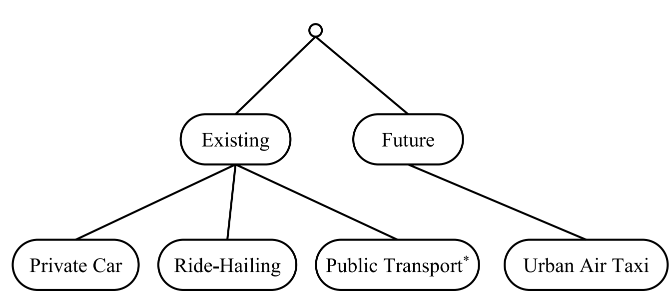

Fig. 1. Nested logit model structure (*Public transport is not available for tourism trips).

Table 2
Factor analysis and item loading on three latent constructs.

Item	Weekly Business					Airport Access					Tourism				
	Mean	S.D.	Factor Loadings			Mean	S.D.	Factor Loadings			Mean	S.D.	Factor Loadings		
			Tech Guy	Safe Guy	Non-Car Guy			Tech Guy	Safe Guy	Non-Car Guy			Tech Guy	Safe Guy	Non-Car Guy
1 I trust autonomous driving systems	3.44	0.88	0.487			3.32	1.14	0.623			3.40	0.89	0.459		
2 I use satellite navigation apps such as Waze or Google Maps	4.28	0.86	0.600			4.38	0.88	0.462			4.27	0.88	0.409		
3 I use apps such as Google Assistant or Siri	3.67	1.05	0.560			3.70	1.10	0.680			3.72	1.02	0.476		
4 I trust ADAS such as cruise control or collision avoidance	3.79	0.92	0.570		0.449	3.67	1.01	0.710			3.82	0.85	0.448		0.487
5 I prefer to use electric cars	3.79	0.97			0.526	3.81	1.11	0.577			3.92	0.91			0.474
6 I prefer to use hybrid cars	3.94	0.94				3.86	1.11	0.577			3.95	0.93	0.518		
7 I prefer that air taxis use the same app as ground ride-sourcing services	4.02	0.99				4.08	0.98	0.498			4.02	0.97			
8 Multitasking while sitting in a car is a priority for me	3.80	0.92	0.516			3.79	1.08	0.411			3.84	0.86	0.486		
9 I feel safer if air taxis are equipped with security cameras	4.10	1.03				4.27	0.88		0.596		4.18	0.95			
10 I feel safer if a ground operator can take over control of the air taxi	3.63	1.15		0.560		3.67	1.24		0.444		3.70	1.20		0.506	
11 I feel safer if I can contact a ground operator at will when on board an air taxi	3.87	1.02		0.404		3.95	1.06		0.670		3.95	0.95		0.410	
12 I prefer air taxis and ground taxis integrated within a single platform	3.83	0.95		0.583		3.81	1.12		0.506		3.92	0.92		0.631	
13 My cellphone is indispensable to me	4.31	0.83		0.482		4.40	0.81		0.431		4.31	0.93		0.505	
14 I am concerned that excessive use of tech may compromise my privacy	3.24	1.29		0.564		3.20	1.35				3.43	1.24		0.567	
15 I feel satisfied with my financial situation	2.58	1.19		0.505		2.51	1.25				2.59	1.25		0.523	
16 My commute trips are always plagued with congestion	3.88	1.02	0.420	0.425		3.59	1.23				3.83	1.06		0.442	
17 Using ride-hailing taxi is more comfortable than driving	3.43	1.16			0.625	3.59	1.12			0.444	3.49	1.10			0.602
18 I prefer that someone else does the driving	2.97	1.30			0.420	3.31	1.25			0.424	3.13	1.26			0.490
19 I prefer public transport over driving whenever possible	3.51	1.25			0.509	3.49	1.33			0.485	3.50	1.32			0.561
20 I usually need my car while I am working	3.16	1.23			0.436	3.18	1.29				3.29	1.18			
21 I prefer walking over driving whenever possible	3.62	1.22			0.421	3.72	1.25				3.65	1.18			

Guy," and "Non-Car Guy." The detailed results of the factor analysis are presented in Table 2. Subsequently, measurement equations for each latent variable are estimated using ordered probit models as functions of the sociodemographic characteristics of the respondents. The outcomes of these analyses are included in Table 3.

Based on the exploratory factor analysis results, being a "Tech Guy" is associated with an increased interest in emerging technologies, such as autonomous, electric, or hybrid vehicles. Individuals conforming to this profile prefer utilizing technologies like cruise control and navigation apps while driving, and multitasking in the vehicle is important to them. The measurement equation estimation results suggest that age inversely affects the likelihood of an individual aligning with this construct. Furthermore, individuals who own a single vehicle and have a monthly income within the range of 20–30 million tomans are more likely to fit the "Tech Guy" profile. Being retired or employed in the private sector appears to negatively influence the manifestation of the "Tech Guy" construct. "Tech Guys" also tend to use ride-hailing services at least once a week. However, phone usage showed no significant effect, which probably is due to the ubiquitous nature of smartphone usage, rendering its impact negligible in the context of the "Tech Guy" construct.

The "Safe Guy" construct represents individuals who prioritize safety measures in air taxi services, including the connection to ground controllers or integration with trusted taxi services. These individuals also place a high emphasis on security and are financially satisfied. Our estimation of this latent construct suggests that men, particularly those of middle age, are less likely to align with this construct, except on regional tourism trips where men are more concerned about safety,

Table 3
Measurement equations modeling for latent variables – significance levels ('***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1).

Weekly Business	Tech Guy		Safe Guy		Non-Car Guy	
	Value	t-Statistic	Value	t-Statistic	Value	t-Statistic
Gender						
Female	Base		Base		Base	
Male	–		−0.413	−3.98 (***)	−0.192	−1.78 (.)
Age						
Under 18	Base		Base		Base	
18–24	–		0.203	1.65 (.)	–	
25–34	−0.166	−1.91 (.)	–		–	
35–44	–		0.394	2.64 (**)	–	
45–54	−0.278	−1.82 (.)	–		−0.319	−1.71 (.)
55–64	–		–		–	
Over 65	–		–		–	
Education						
Completed high school	–		Base		−0.377	−2.86 (**)
Bachelor's degree	–		−0.348	−2.84 (**)	–	
Master's degree	–		−0.472	−3.05 (**)	–	
Equal or above PhD	Base		−0.673	−2.77 (**)	Base	
Occupation						
Business owner	–		–		–	
Private sector employee	−0.203	−1.68 (.)	–		0.270	1.86 (.)
Public sector employee	–		–		–	
Student	−0.173	−1.78 (.)	–		0.336	2.46 (*)
Informal sector	–		–		–	
Housewife	–		–		–	
Retired	−0.203	−1.74 (.)	–		–	
Unemployed	Base		Base		Base	
Household car ownership						
0	–		–		0.894	3.9 (***)
1	0.127	1.72 (.)	–		0.532	4.5 (***)
2	–		–			
3 or more	Base		Base		Base	
Smartphone use						
Less than 2 hr	–		−0.321	−2.55 (*)	–	
Between 2 and 4 hr	–		–		–	
Between 4 and 6 hr	–		–		–	
More than 6 hr	Base		Base		Base	
Place of work and residency						
Lives in Tehran	−0.215	−1.85 (.)	−0.413	−3.82 (***)	−0.233	−1.87 (.)
Works in Tehran	–		–		–	
Ride-hailing use frequency						
Never	Base		Base		Base	
Less than once a month	–		–		−0.638	−4.04 (***)
Once a month	–		–		–	
Once a week	–		–		–	
More than once a week	–		−0.194	−2.06 (*)	0.536	3.8 (***)
Airport Access	**Tech Guy**		**Safe Guy**		**Non-Car Guy**	
	Value	t-Statistic	Value	t-Statistic	Value	t-Statistic
Gender						
Female	Base		Base		Base	
Male	–		−0.232	−3.02 (**)	–	
Age						
Under 18	Base		Base		Base	
18–24	–		–		–	
25–34	–		–		–	
35–44	–		–		–	
45–54	–		–		0.444	2.8 (**)
55–64	–		–		–	
Over 65	–		–		–	
Education						
Completed high school	–		–		–	
Bachelor's degree	–		–		–	
Master's degree	–		−0.142	−2.23 (*)	–	
Equal or above PhD	Base		Base		Base	
Occupation						
Business owner	–		–		–	
Private sector employee	−0.109	−1.79 (.)	–		–	
Public sector employee	0.172	2.32 (*)	0.238	2.68 (**)	–	
Student	–		–		−0.414	−4.19 (***)
Informal sector	−0.598	−2.68 (**)	−0.723	−2.65 (**)	–	
Housewife	–		–		–	
Retired	–		–		0.274	1.5
Unemployed	Base		Base		Base	

(*continued on next page*)

Table 3 (*continued*)

Airport Access	Tech Guy		Safe Guy		Non-Car Guy	
	Value	t-Statistic	Value	t-Statistic	Value	t-Statistic
Household monthly income (million tomans)						
Less than 3.5	Base		Base		Base	
3.5–6	–		0.288	2.88 (**)	0.256	2.02 (*)
6–9	0.158	2.21 (*)	–		0.271	2.66 (**)
9–14	–		–		–	
14–20	0.091	1.5	0.103	1.4	–	
20–30	0.336	3.23 (**)	–		–	
30 and above	–		–		–	
Household car ownership						
0	–		−0.17	−1.6	–	
1	0.223	3.29 (***)	–		–	
2	–		−0.215	−2.82 (**)	−0.261	−2.97 (**)
3 or more	Base		Base		Base	
Smartphone use						
Less than 2 hr	–		−0.342	−3.01 (**)	–	
Between 2 and 4 hr	–		–		–	
Between 4 and 6 hr	–		−0.108	−1.71 (.)	−0.141	−1.75 (.)
More than 6 hr	Base		Base		Base	
Place of work and residency						
Lives in Tehran	−0.169	−2.77 (**)	–		−0.131	−1.66 (.)
Works in Tehran	–		–		–	
Ride-hailing use frequency						
Never	Base		Base		Base	
Less than once a month	–		–		−0.376	−3.33 (***)
Once a month	–		−0.167	−2.31 (*)	–	
Once a week	0.288	3.27 (**)	0.234	2.78 (**)	0.251	2.29 (*)
More than once a week	0.261	3.21 (**)	–		–	

Regional Tourism	Tech Guy		Safe Guy		Non-Car Guy	
	Value	t-Statistic	Value	t-Statistic	Value	t-Statistic
Gender						
Female	Base		Base		–	
Male	–		0.222	2.81 (**)	–	
Age						
Under 18	Base		Base		–	
18–24	–		–		–	
25–34	–		–		–	
35–44	0.146	1.67 (.)	–		–	
45–54	−0.105	−1.45	–		–	
55–64	–		–		–	
Over 65	–		–		–	
Education						
Completed high school	–		−0.121	−1.77 (.)	–	
Bachelor’s degree	0.103	1.42	–		–	
Master’s degree	–		–		–	
Equal or above PhD	Base		Base		–	
Occupation						
Business owner	–		–		–	
Private sector employee	−0.117	−1.43	0.293	3.09 (**)	–	
Public sector employee	–		0.119	1.38	–	
Student	–		–		–	
Informal sector	–		–		–	
Housewife	–		–		–	
Retired	−0.14	−1.37	–		–	
Unemployed	Base		Base		–	
Household monthly income (million tomans)						
Less than 3.5	–		–		–	
3.5–6	–		–		–	
6–9	–		–		–	
9–14	–		−0.117	−1.43	–	
14–20	–		–		–	
20–30	–		–		–	
30 and above	Base		Base		–	
Household car ownership						
0	–		−0.528	−2.89 (**)	–	
1	–		−0.156	−2.16 (*)	–	
2	–		–		–	
3 or more	Base		Base		–	
Smartphone use						
Less than 2 hr	–		0.219	2.25 (*)	–	
Between 2 and 4 hr	–		–		–	
Between 4 and 6 hr	–		–		–	
More than 6 hr	Base		Base		–	

(*continued on next page*)

Table 3 (*continued*)

Regional Tourism	Tech Guy		Safe Guy		Non-Car Guy	
	Value	t-Statistic	Value	t-Statistic	Value	t-Statistic
Place of work and residency						
Lives in Tehran	–		0.35	3.37 (***)	–	
Works in Tehran	–		–		–	

probably due to their sense of being traditionally protective of their family members. Higher education and employment in either the private or public sector positively correlate with being a "Safe Guy".

As for the "Non-Car Guy" construct, these individuals prefer public transport and are less inclined to drive. For them, using ride-hailing services is also more comfortable than driving. According to our results, women and older individuals are more likely to identify with the "Non-Car Guy" profile. The number of cars owned by an individual's household is highly correlated with this construct, suggesting that fewer car ownership aligns with being a 'Non-Car Guy'. Additionally, individuals with lower income levels also fit this profile. Interestingly, frequent use of ride-hailing services was also found to be correlated with the '"Non-Car Guy" construct. It is worth mentioning that the "Non-Car Guy" did not emerge as statistically significant for the regional tourism case study. This was expected, as public transport is not a convenient option for tourists anyway.

4. Case studies

Hader et al. (2020) suggest three main use areas for the UAM functioning as city taxis, as airport shuttles, or as intercity taxis. Straubinger et al. (2021a) identify five groups of potential UAM users, including inner-city citizens, outside commuters/suburban dwellers, airport passengers, tourists, and companies. Based on a simulation approach, Ploetner et al. (2020) estimate the UAM market share in Germany, ranging from 0.5 percent over distances shorter than 10 km up to 3 to 4 percent over distances longer than 30 km. Al Haddad et al. (2020) emphasize that UAM is not competitive in terms of travel time saving over short-range trips. In the same context, Pukhova et al. (2021) conclude that UAM will not save much travel time over short distances, especially when one takes into account the access/egress trips to/from vertiports, implying that UAM is more competitive over medium to long ranges. Similarly, Rothfeld et al. (2021) conclude that UAM provides time savings beyond respective distances of a 50 to 55 min car ride. As for the number of passenger seats in an air taxi, Reiche et al. (2018) observe that high-passenger-capacity aircraft are systematically preferred to low-capacity ones, probably due to their lower per capita operational costs.

Based on the above discussion, trip purpose, range, and vehicle capacity are the trifecta of criteria that are considered in the design of our case studies. We considered three trip purposes, including weekly business, airport access, and regional tourism. These trip purposes were selected based on their relevance to operations along regular routes (Long et al., 2023) over long-distance (Ilahi et al., 2021) in the 30-to-50-km range corresponding to regional routes. Moreover, we focused on occasional trips and placed a strong emphasis on fare as the primary determinant of UAM usage, which is in line with previous studies (Reiche et al., 2018; Fu et al., 2019). The vehicle type was introduced as a four-seater eVTOL, guaranteeing aviation-grade safety level.

4.1. *Case study 1: A typical weekly business trip*

Karaj, a city of 1.6 million residents, is the main satellite city of Tehran. Fig. 2 shows the relative location of Karaj and Tehran, as well as a typical aerial route between the two city centers. Approximately one-third of Karaj's population commutes daily between the two cities, utilizing three highways and one urban train line, which collectively link the two cities. Although it is not reasonable to assume that people will use an air taxi for their daily commute due to its high cost, an air taxi can offer tangible gains in travel time and convenience for occasional business trips (Fu et al., 2019). Therefore, in the first case study, we offer six scenarios with four modes of transportation, including private car, public transport, and ride-hailing taxi, as the three existing modes and air taxi as the new mode.

4.2. *Case study 2: A typical access trip to the international airport*

As many airports are located outside cities and mostly in rural areas all over the world, they usually face long access times for passengers (Straubinger et al., 2021a). Tehran has two major airports, one dedicated entirely to domestic flights within the city borders, and the other only operating international flights, located some 30 km to the city's southwest. Ground access to the IKA international airport is provided by road and an urban train line, which operates as an extension of the Tehran metro. Fig. 3 shows the relative location of Tehran and the IKA international airport, along with a typical aerial route between a well-known international hotel in the northern part of the city and the international airport. Avoiding crossing the congested city network is a reasonable incentive for passengers to choose air taxis for their access trips, to save time and reduce mental fatigue (Brunelli et al., 2023; Rimjha et al., 2021a). Therefore, in the second case study, we offer six scenarios with four modes of transportation, including private car, public transport, and ride-hailing taxi, as the three existing modes and air taxi as the new mode.

4.3. *Case 3: A typical regional tourism trip*

Ploetner et al. (2020) emphasize the UAM market potential for tourism and leisure, and Tez et al. (2022) indicate generally favorable attitudes towards the use of UAM technology among tourists, who view it as a fast, comfortable, and in general "fashionable" mode of transport. According to Lee (2023), there is an urge from the South Korean UAM group to establish collaboration for the development of air tourism on the country's southern coast and its marine tourism resources such as Hallyeohaesang National Park and many islands and beaches. Paris is planning to establish a tourist UAM route to Versailles in 2024 (Goldstein, 2023), and Brisbane is working to provide UAM services for the 2032 Olympics (Wisk Aero, 2023).

Shiraz, a city of 1.6 million residents in the Iranian mid-south, is one of the country's major metropolitan areas and a prime tourist and pilgrimage destination. Persepolis, the world-renowned capital of the ancient Persia, which is the main tourism attraction of the region, is located some 50 km to the northeast of Shiraz. Fig. 4 shows the relative location of Shiraz and Persepolis and a typical direct aerial route between the two. Currently, the only way to access the site from Shiraz is by road, which involves an approximately 90 min drive. It is, therefore, a reasonable destination for operating an air taxi shuttle for tourists who would consider the service as an occasional timesaving and leisurely opportunity, justifying the high cost.

Notably, the choice of the Shiraz-Persepolis route was influenced by both the prominence and recognition of the Persepolis site, and the logistical and technological sufficiency of Shiraz as a major city and a regional hub. It should be mentioned that Iran boasts numerous other tourist routes with similar appeal, including many southern islands in the Persian Gulf.

Fig. 2. A schematic flight path for a typical weekly business trip between the central business districts of Tehran and its main satellite city of Karaj.

In this case study, we offer six scenarios with three modes of transportation, including private car and ride-hailing taxi, as the two existing modes and air taxi as the new mode. Tables A1–A3summarizes the scenarios in the three case studies.

5. Results

The online stated preference surveys were conducted during June and July 2022. Questionnaires were collected separately through social networks for each trip purpose. In total, 214 valid questionnaires were collected for weekly business trips, 323 valid questionnaires for airport access trips, and 239 valid questionnaires for regional tourism trips.

5.1. Description of the samples

Table 4 presents a comparison between the gender and age distribution in the three samples with that of the 2016 national census of Iran. The samples show an overrepresentation of the 18 to 24 year old age group, which can be explained by the observation that younger people are more likely to participate in online surveys (Dillman, 2022).

Table 5 summarizes the main sociodemographic characteristics of respondents for each trip purpose. As the three samples were collected randomly, no significant discrepancy is expected among them.

As mentioned previously, a number of five-point Likert-type statements about respondents' opinions were also inquired and presented in Table 1. Statements related to air taxi safety received consistently high scores, with particular emphasis on two aspects: the ability to establish

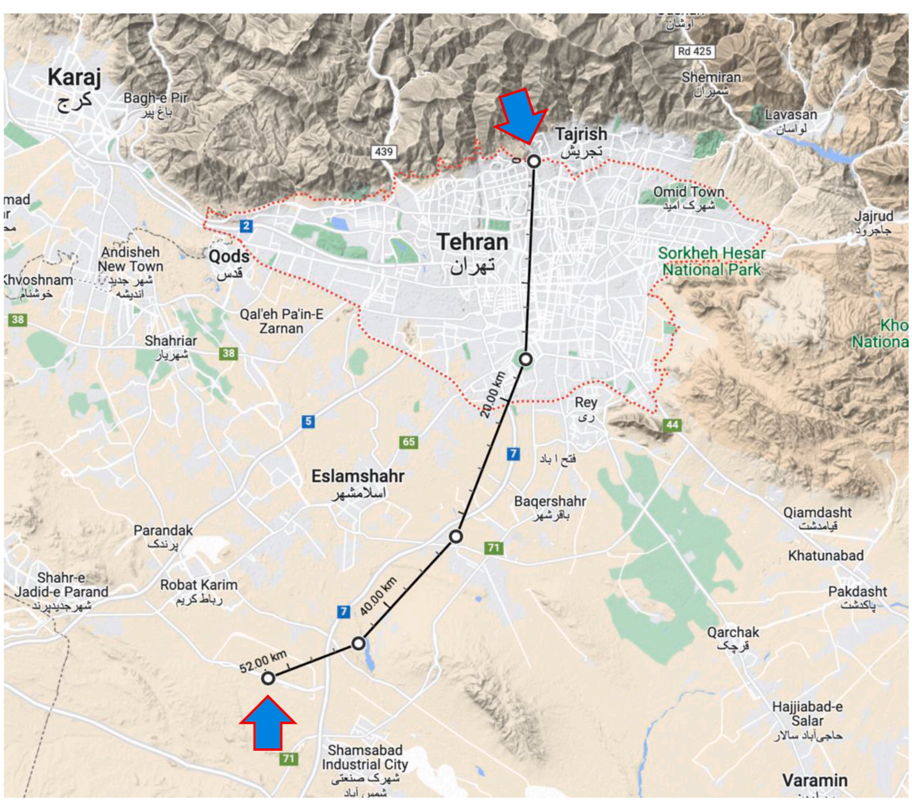

Fig. 3. A schematic flight path for a typical access trip from an international hotel to the IKA international airport of Tehran.

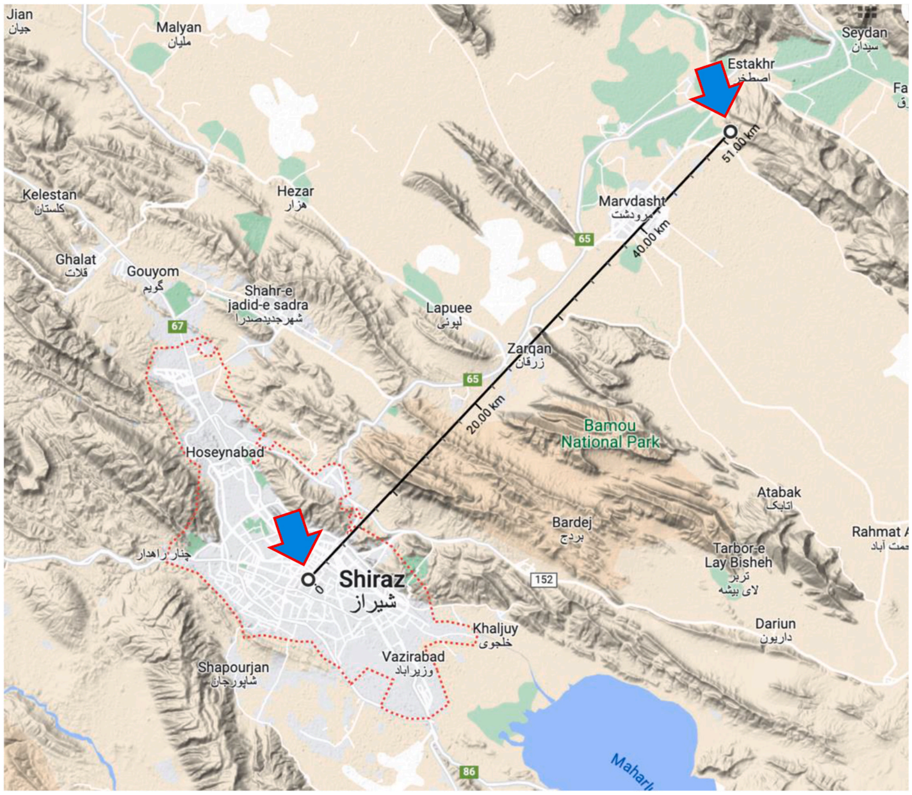

Fig. 4. A schematic flight path for a typical tourism trip from the Shiraz city center, a major touristic city, and Persepolis, a world heritage site, 50 km to its northeast.

communication with a ground operator at will, and the installation of a security camera in the vehicle. Respondents expressed their preference for postponing the use of air taxis, which agrees with Al Haddad et al. (2020), who found that early adopters make up less than a third of their sample. Respondents exhibited a strong consensus, either agreeing or strongly agreeing, on several points. For instance, they expressed the indispensability of their smartphones in their daily lives. The utilization of satellite navigation apps was also a common practice among respondents. Moreover, a prevalent preference emerged for an integrated platform that seamlessly combines air taxi services with ground-based ride-sourcing options.

5.2. Hybrid model estimation

For each trip purpose, hybrid multinomial logit and hybrid nested logit models are estimated. The hybrid multinomial logit model serves as the baseline, and the hybrid nested logit model tests for the similarity among the existing alternatives in contrast to the new emerging mode. The PandasBiogeme software package (Bierlaire, 2023) was used for the estimation of the models. Tables 6–8 summarize the estimation results for the multinomial logit and the nested logit models.

5.2.1. Case 1: A typical weekly business trip

The sample includes 214 valid questionnaires with 1284 choice tasks. The stated modal shares are 47% for private car, 13% for ride-hailing taxi, 11% for air taxi, and 29% for public transport. Table 6 summarizes coefficient estimates and t-statistics of the final model specification for the hybrid multinomial and hybrid nested logit models. Only estimates that are statistically significant at a 0.1 level or better are included.

For weekly business trips, the air taxi value of time is estimated at 1,340,000 tomans per hour ($47.9 per hour) based on the hybrid multinomial logit model. Also, the public transport value of time is estimated to be 8500 toman ($0.30 per hour). On the other hand, using

Table 4
Gender and age breakdown in the samples and the 2016 national census of Iran.

	Samples						2016 National Census (Tehran province)	
	Weekly Business		Airport Access		Regional Tourism			
	Count (out of 214)	% Total	Count (out of 323)	% Total	Count (out of 239)	% Total		
Gender								
Female	99	46.3%	180	55.7%	127	53.1%	Female	49.7%
Male	115	53.7%	143	44.3%	112	46.9%	Male	50.3%
Age								
Under 18	26	12.1%	45	13.9%	33	13.8%	Under 15	20.2%
18–24	56	26.2%	67	20.7%	62	25.9%	15–24	13.4%
25–34	52	24.3%	103	31.9%	64	26.8%	25–34	21.7%
35–44	46	21.5%	73	22.6%	46	19.2%	35–49	23.7%
45–54	24	11.2%	25	7.7%	30	12.6%	50–64	14.1%
55–64	6	2.8%	7	2.2%	2	0.8%	65 and above	6.8%
65 and above	4	1.9%	3	0.9%	2	0.8%		

the hybrid nested logit model results, the value of time for air taxi and public transport is estimated at 1,324,000 tomans per hour ($47.3 per hour) and 9000 tomans per hour ($0.32 per hour), respectively.

Being male and being in the middle-income tier of 9 to 14 million tomans increases the propensity towards using air taxis for weekly business trips compared to ride-hailing. It is worth mentioning that higher income tiers have similar effects of increasing the utility of air taxis, albeit at weaker that 0.1 significance levels. This is probably due to the modest size of the sample. The “Tech Guy” construct positively influences the utility of the air taxi mode, while the “Safe Guy” construct has a negative effect. The “Non-Car Guy” variable positively impacts both ride-hailing and public transport modes.

Table 5
Main demographic characteristics of respondents.

	Weekly Business		Airport Access		Regional Tourism	
	Count (out of 214)	% Total	Count (out of 323)	% Total	Count (out of 239)	% Total
Education						
Completed high school	72	33.6%	87	26.9%	83	34.7%
Bachelor’s degree	62	29.0%	112	34.7%	74	31.0%
Master’s degree	68	31.8%	96	29.7%	69	28.9%
Equal or above PhD	12	5.6%	28	8.7%	13	5.4%
Occupation						
Business owner	35	16.4%	47	14.6%	39	16.3%
Private sector employee	48	22.4%	71	22.0%	53	22.2%
Public sector employee	22	10.3%	49	15.2%	24	10.0%
Student	77	36.0%	100	31.0%	97	40.6%
Informal sector	12	5.6%	15	4.6%	11	4.6%
Housewife	8	3.7%	22	6.8%	8	3.3%
Retired	0	0.0%	5	1.5%	0	0.0%
Unemployed	12	5.6%	14	4.3%	7	2.9%
Household monthly income (million tomans)						
Less than 3.5	14	6.5%	17	5.3%	20	8.4%
3.5–6	16	7.5%	32	9.9%	21	8.8%
6–9	34	15.9%	61	18.9%	37	15.5%
9–14	53	24.8%	81	25.1%	51	21.3%
14–20	48	22.4%	57	17.6%	51	21.3%
20–30	19	8.9%	38	11.8%	25	10.5%
30 and above	30	14.0%	37	11.5%	34	14.2%
Household car ownership						
0	17	7.9%	25	7.7%	20	8.4%
1	91	42.5%	178	55.1%	99	41.1%
2	70	32.7%	90	27.9%	73	30.5%
3 or more	36	16.8%	30	9.3%	47	19.7%
Household size						
1 person	14	6.5%	33	10.2%	12	5.0%
2 people	42	19.6%	85	26.3%	49	20.5%
3 people	54	25.2%	72	22.3%	74	31.0%
4 people	69	32.2%	91	28.2%	66	27.6%
5 or more	35	16.3%	42	13.0%	38	15.9%
Smartphone use						
Less than 2 hr	32	15.0%	40	12.4%	27	11.3%
Between 2 and 4 hr	63	29.4%	114	35.3%	69	28.9%
Between 4 and 6 hr	74	34.6%	107	33.1%	83	34.7%
More than 6 hr	45	21.0%	62	19.2%	60	25.1%
Commute mode						
Private car as a driver	73	34.1%	115	35.6%	78	32.6%
Private car as a passenger	24	11.2%	37	11.5%	27	11.3%
Public transport	40	18.7%	76	23.5%	41	17.2%
Ride-hailing	24	11.2%	39	12.1%	33	13.8%
Motorcycle	12	5.6%	9	2.8%	17	7.1%
Bicycle	2	0.9%	4	1.2%	4	1.7%
Walk	34	15.9%	26	8.0%	31	13.0%
Telework full time	0	0%	10	3.1%	0	0%
Telework part time	2	0.9%	2	0.6%	1	0.4%
Others	3	1.4%	5	1.5%	7	2.9%

5.2.2. Case 2: A typical access trip to Tehran’s international airport

A total of 323 valid questionnaires were collected for an airport access trip from Tehran’s IKA international airport to an international hotel in the northern district of Tehran. Each questionnaire includes six choice scenarios leading to 1938 choice tasks. The stated modal shares are 43% for private car, 18% for ride-hailing taxi, 19% for air taxi, and 20% for public transport. Table 7 presents coefficient estimates and t-statistics of the final model specification for the hybrid multinomial and hybrid nested logit models.

For airport access trips, the common private car and ride-hailing value of time was estimated at approximately 71,100 tomans per hour ($2.53 per hour) using the hybrid multinomial logit model. The air taxi value of time was estimated at 532,000 tomans per hour ($19.0 per hour) using the same model, which represents approximately 40% of the air taxi value of time for weekly business trips. The nested logit model produced slightly different results, with the common private car and ride-hailing value of time estimated at around 98,600 tomans per hour ($3.52 per hour) and the air taxi value of time estimated at 482,000 tomans per hour ($17.2 per hour).

The “Safe Guy” construct negatively influences the utility of the air taxi mode compared to private car, signifying that safety concerns are indeed valid when choosing air taxis over other modes (Karami et al., 2023). As for ride-hailing, the “Safe Guy” construct also has a negative impact, while the “Tech Guy” construct positively affects its utility.

5.2.3. Case 3: A typical regional tourism trip

The regional tourism trip sample consists of 239 individuals, each responding to six scenarios, amounting to 1434 stated choice tasks. In total, private car is chosen in 64% of the cases, ride-hailing in 23%, and air taxi in 13% of the cases. Table 8 shows model estimation results for regional tourism trips.

The private car value of time for tourism trips was found to be 24,800 tomans per hour ($0.88 per hour) using the hybrid multinomial logit model and 28,200 tomans per hour ($1.01 per hour) using the nested logit model. Gender and age do not turn out to be significant factors in this trip purpose. Interestingly, being a member of a relatively high-income household increases the utility of using a private car over an air taxi. Being a ride-hailing user decreases the utility of using a private car. The “Safe Guy” variable has a negative influence on the overall utility of ride-hailing services compared to the base mode, which is the private car. Our models were unable to estimate the value of time for the air taxi mode. This may be attributed to the nature of tourism as a family activity, where purchasing tickets for multiple individuals may not be feasible for a household. Hybrid multinomial logit and hybrid nested logit model estimates are consistent over the board, but the nested logit structure allows to account for a significant correlation of $\rho = 0.72$ among the two existing alternatives compared to the emerging air taxi mode.

6. Discussion

Three stated preference surveys were conducted, aiming to characterize the prospective demand for urban air taxis for weekly business, airport access, and regional tourism trips in Iran. The value of time estimates varied appreciably among the three trip purposes, as summarized in Table 9. The airport access value-of-time was estimated at $19.0 per hour based on the hybrid multinomial logit model, which is nearly 40% of the weekly business trip value-of-time of $47.9 per hour.

Table 6
Coefficient estimates and t-statistics for the weekly business trip purpose – significance levels ('***' 0.001 '**' 0.01 '*' 0.05 'none' 0.1).

Parameter	Hybrid Multinomial Logit				Hybrid Nested Logit			
	Auto	Ride-hailing	Air taxi	Public transport	Auto	Ride-hailing	Air taxi	Public transport
Constants	−49.0 (−2.6**)	−57.8 (−2.7**)	Base	−46.6 (−2.37*)	−23.0 (−2.64**)	−27.1 (−2.62**)	Base	−21.5 (−2.58**)
Travel cost ([$10^3 \times$ tomans]$^{-1}$)	–	–	−0.064 (−2.67**)	−0.317 (−2.33*)	–	–	−0.0295 (−2.68**)	−0.141 (−1.92*)
Travel time ([min]$^{-1}$)	−0.1 (−2.7**)	–	−1.43 (−2.65**)	−0.0452 (−2.34*)	−0.047 (−2.29*)	–	−0.658 (−2.60**)	−0.0212 (−1.6)
Gender (Base: Female)								
Male	–	−1.32 (−3.28**)	Base	–	–	−0.648 (−1.96*)	Base	–
Age								
25–34	Base	–	−5.00 (−2.19*)	–	Base	–	−2.26 (−2.38*)	–
35–44	Base	–	−3.17 (−1.84)	–	Base	–	−1.23 (−1.89)	–
45–54	Base	–	–	−3.92 (−2.8**)	Base	–	–	−1.93 (−1.98*)
Household monthly income								
9 - 14 million tomans	–	Base	1.97 (1.71)	–	–	Base	0.946 (1.89)	–
Household Size								
More than three	–	–	Base	1.27 (2.32*)	–	–	Base	0.599 (1.67)
Main mode of transportation								
Auto	Base	−1.77 (−3.16**)	–	–	Base	−0.893 (−2.03*)	–	–
Bike	–	Base	–	3.07 (3.00**)	–	Base	–	1.46 (1.92)
Ride-hailing	–	−2.46 (−3.28**)	Base	–	–	−1.24 (−2.07*)	Base	–
Walk	Base	–	5.74 (2.25*)	–	Base	–	2.56 (2.37*)	–
Alternative mode of transportation								
Public transport	4.22 (2.72**)	Base	–	–	2.09 (2.15*)	Base	–	–
Occupation								
Employee private sector	Base	2.34 (3.7***)	–	–	Base	1.17 (2.08*)	–	–
Employee public sector	Base	1.13 (1.89)	–	–	Base	0.554 (1.39)	–	–
Business owner	Base	1.46 (2.46*)	–	–	Base	0.648 (1.59)	–	–
Retired	−3.59 (−2.64**)	Base	–	–	−1.69 (−2.06*)	Base	–	–
Student	−1.18 (−2.02*)	Base	–	–	−0.57 (−1.81)	Base	–	–
Ride-hailing frequency of use								
Once a month	–	–	Base	−1.51 (−2.47*)	–	–	–	−0.706 (−1.59)
Once a week	3.16 (3.1**)	Base	–	–	1.57 (2.32*)	Base	–	–
More than once a week	–	–	Base	−3.47 (−3.47***)	–	–	Base	−1.54 (−1.94)
Latent variables								
Tech Guy	Base	–	11.8 (2.22*)	−7.61 (−2.54*)	Base	–	4.54 (2.00*)	−4.23 (−2.02*)
Safe Guy	Base	–	−3.39 (−1.74)	–	Base	–	−1.39 (−1.71)	–
Non-Car Guy	Base	0.991 (2.31*)	–	1.58 (2.63**)	Base	0.451 (1.87)	–	0.703 (1.85)
Nesting parameter ($\mu_{bottom}/\mu_{top} \geq 1$)					Mu			1.96 (1.84)
Intra-group correlation among existing modes					ρ			0.74
Number of estimated parameters				35				36
Sample size				1284				1284
Init log-likelihood				−1780.0				−1780.0
Final log-likelihood				−1311.8				−1310.6
Rho-square for the null model				0.263				0.264
Rho-square-bar for the null model				0.243				0.243

Moreover, for airport access trips, the air taxi value of time is about seven times greater than that of the private car and ride-hailing, portraying a totally different picture compared to other contexts. This is mostly due to the fact that car trips in Iran benefit from a heavily subsidized gasoline price, which is provided at less than ¢10 a liter, making car-based modes, including auto and ride-hailing, more affordable compared to other contexts (Lesteven and Samadzad, 2021). The weekly business trip value-of-time is also significantly greater than the value estimated by (Karimi et al., 2023), which can be attributed to the long-distance interurban character of the weekly business trip explored here, allowing to appreciate the travel time savings offered by the air taxi more. As for the estimation of the value of time for public transport in the case of weekly business, the value is notably low. This can be attributed to the subsidized ticket prices for mass transit. In fact, the estimated value of time is roughly equivalent to a round-trip ticket price for this specific case.

We could not estimate the tourism air taxi value of time from our data. However, by comparing the private car value of time estimates for

Table 7
Coefficient estimates and t-statistics for the airport access trip purpose – significance levels ('***' 0.001 '**' 0.01 '*' 0.05 'none' 0.1).

Parameter	Hybrid Multinomial Logit				Hybrid Nested Logit			
	Auto	Ride-hailing	Air taxi	Public transport	Auto	Ride-hailing	Air taxi	Public transport
Constants	1.69 (1.8)	Base	5.97 (3.82***)	5.14 (3.42***)	1.29 (1.78)	Base	4.78 (3.9***)	2.42 (1.7)
Travel cost ([1000 × tomans]$^{-1}$)	−0.0156 (−4.29***)		−0.00714 (−7.93***)	–	−0.00955 (−3.7***)		−0.00728 (−9.57***)	–
Travel time ([min]$^{-1}$)	−0.0185 (−4.2***)		−0.0633 (−2.22*)	−0.0404 (−6.52***)	−0.0157 (−4.17***)		−0.0585 (−2.16*)	−0.0198 (−2.57*)
Age								
18–24	Base	–	–	–	Base	–	−0.346 (−2.02*)	–
Number of days with out of home mandatory activity participation								
Once or twice per week	0.999 (3.45***)	0.869 (1.86)	Base	–	0.511 (2.42*)	–	Base	–
Smartphone usage								
2–4 hr per day	Base	1.09 (3.4***)	–	–	Base	0.812 (3.11**)	–	–
4–6 hr per day	–	1.06 (3.48***)	Base	–	–	0.813 (3.15**)	Base	–
Walking time to the nearest public transport station								
Less than 15 min	0.674 (3.83***)	Base	–	–	0.417 (2.97**)	–	–	–
15 min–30 min	0.533 (2.78**)	–	Base	–	0.346 (2.43*)	–	Base	–
Car ownership								
None	–	0.966 (1.68)	Base	–	–	0.616 (1.81)	Base	–
One	–	1.04 (2.1*)	Base	−0.318 (−2.26*)	–	0.645 (1.87)	Base	−0.175 (−1.86)
Two or more	–	1.16 (2.31*)	–	Base	–	0.681 (1.95)	–	Base
Occupation								
Employee of the private sector	–	0.893 (3.16**)	–	Base	–	0.643 (2.87**)	–	Base
Employee of the public sector	–	0.88 (2.71**)	0.635 (2.87**)	Base	–	0.546 (2.32*)	0.415 (2.34*)	Base
Student	0.475 (3.56***)	–	–	Base	0.278 (2.71**)	–	–	Base
IKA flight frequency								
0 to 3 flights per year	0.265 (1.79)	0.712 (2.64**)	–	Base	0.172 (1.85)	0.484 (2.28*)	–	Base
Main mode of transportation								
Auto	1.34 (8.01***)	–	Base	–	0.898 (4.72***)	–	Base	–
Public transport	0.535 (2.62**)	–	Base	–	0.349 (2.24*)	–	Base	–
Ride-hailing	0.621 (3.22**)	Base	–	0.565 (2.97**)	0.462 (2.96**)	Base	–	0.401 (2.62**)
Alternative mode of transportation								
Auto	Base	–	–	−0.592 (−2.46*)	Base	–	–	−0.37 (−2.21*)
Ride-hailing	Base	–	0.364 (2.17*)	–	Base	–	0.348 (2.26*)	–
Which item best describes your use of ride-hailing								
Going to/Returning from airport	−0.396 (−2.59**)	Base	–	−0.325 (−1.84)	−0.308 (−2.61**)	Base	–	−0.26 (−2.02*)
Commuting regularly	1.28 (8.5***)	Base	–	–	0.845 (4.7***)	Base	–	–
Returning home after a night out	–	Base	–	−0.324 (−1.97*)	–	Base	–	−0.216 (−1.93)
Other occasional reason	–	−0.58 (−2.24*)	Base	–	–	−0.396 (−1.99*)	Base	–
Ride-hailing frequency of use								
Less than once a month	–	Base	−0.771 (−2.48*)	–	–	Base	−0.711 (2.49*)	–
Once a month	–	Base	−0.694 (−2.15*)	–	–	Base	−0.558 (−1.92)	–
Once a week	–	Base	−0.556 (−1.73)	–	–	Base	−0.609 (−2.07*)	–
More than once a week	–	Base	−0.595 (−1.89)	–	–	Base	−0.501 (−1.73)	–
Typical commute time								
30–60 min	–	–	Base	−0.422 (−2.79**)	–	–	Base	−0.24 (−2.16*)
Latent Variables								
Tech Guy	Base	1.16 (2.18*)	–	–	Base	0.784 (2.16*)	–	–
Safe Guy	Base	−0.904 (−2.22*)	−0.551 (−1.89)	–	Base	−0.568 (−1.94)	–	–
Nesting parameter ($\mu_{bottom}/\mu_{top} \geq 1$)					Mu			1.66 (4.48***)
Intra-group correlation among existing modes					ρ			0.64
Number of estimated parameters				45				45
Sample size				1938				1938
Init log-likelihood				−2686.6				−2686.6
Final log-likelihood				−2133.8				−2133.4
Rho-square for the null model				0.206				0.206
Rho-square-bar for the null model				0.189				0.189

Table 8
Coefficient estimates and t-statistics for the regional tourism trip purpose – significance levels ('***' 0.001 '**' 0.01 '*' 0.05 'none' 0.1).

Parameter	Hybrid Multinomial Logit			Hybrid Nested Logit		
	Auto	Ride-hailing	Air taxi	Auto	Ride-hailing	Air taxi
Constants	Base	−1.77 (−2.54*)	−3.00 (−3.51***)	Base	−1.1 (−2.03*)	−1.68 (−1.8)
Travel cost ([1000 × tomans]$^{-1}$)	−0.0443 (−6.37***)	−0.0379 (−5.38***)	−0.00755 (−6.99***)	−0.0307 (−4.04***)	−0.0293 (−4.11***)	−0.00749 (−7.59***)
Travel time ([min]$^{-1}$)	−0.0183 (−4.86***)	–	–	−0.0146 (−4.03***)	–	–
Alternative mode of transportation						
Ride-hailing	−0.371 (−2.36*)	Base	–	−0.308 (−2.48*)	Base	–
Household monthly income						
20–30 million tomans	0.656 (2.77**)	–	Base	0.479 (2.38*)	–	Base
Occupation						
Employee of the private sector	–	−0.697 (−2.12*)	Base	–	−0.499 (−1.98*)	Base
Employee of the public sector	–	−1.19 (−2.89**)	Base	–	−0.828 (−2.54*)	Base
Business owner	–	−1.66 (−3.82***)	Base	–	−1.16 (−3.12**)	Base
Retired	–	−1.54 (−2.83**)	Base	–	−1.1 (−2.6**)	Base
Student	–	−1.01 (−3.11**)	Base	–	−0.669 (−2.52*)	Base
Ride-hailing frequency of use						
Once a month	–	Base	0.452 (2.14*)	–	Base	0.452 (2.16*)
Once a week	Base	0.472 (2.09*)	–	Base	0.305 (1.8)	–
More than once a week	Base	0.712 (3.5***)	0.771 (3.72***)	Base	0.489 (2.92**)	0.699 (3.45***)
Number of international flights per *year*						
3 or less	Base	−0.408 (−2.36*)	−0.782 (−4.41***)	Base	−0.295 (−2.26*)	−0.738 (−4.28***)
Latent Variables						
Safe Guy	Base	−0.524 (−1.62)	–	Base	−0.342 (−1.42)	–
Nesting parameter ($\mu_{bottom}/\mu_{top} \geq 1$)				Mu		1.9 (3.19**)
Intra-group correlation among existing modes				ρ		0.72
Number of estimated parameters			21			22
Sample size			1434			1434
Initial log-likelihood			−1575.4			−1575.4
Final log-likelihood			−1078.0			−1073.4
Rho-square			0.316			0.319
Rho-square-bar			0.302			0.305

the two trip purposes, it is safe to assume that its value is significantly lower than the airport access trip, meaning that people would be willing to pay much less for air taxi transportation for tourism. The presence of family members during a tourism trip contributes to amplifying the perceived cost of an air taxi trip, as the household head is usually responsible for covering expenses for all companions. Interestingly, while higher income increases the utility of air taxis for weekly business trips, the effect is completly inverse for regional tourism trips where higher income tiers favor the private car.

Unlike the two other trip purposes, gender impacts the selection of the mode of transport for weekly business trips. Men are less likely to use ride-hailing taxis. Individuals aged between 25 and 44 are less likely to use air taxis, and those between 45 and 54 are less likely to use public transport. Individuals aligning with a "Tech Guy" profile are more likely to use air taxis, while aligning with a "Safe Guy" profile has a negative effect on the utility of choosing air taxis.

For an access trip, respondents' current travel pattern has a similar impact as that of a tourism trip, meaning that people who use ride-hailing taxis regularly are more likely to use air taxis. Individuals who are identified as "Safe Guy" are also less likely to choose air taxis.

We explicitly asked respondents about incentives that would convince them to adopt urban air mobility. Based on the answers depicted in Fig. 5, decreasing travel costs turns out to be by far the most effective, followed by providing adequate time to gain trust. Although safety is the least stated concern, it is rather due to the fact that in the brief presentation of UAM in the questionnaires, the respondents were reassured that air taxis would provide, at a minimum, what was called the aviation-level safety standard.

While higher income was found to increase the utility of the air taxi for weekly business trips, the effect was entirely inverse for regional tourism trips where individuals in higher income tiers favored the private car. This is a significant finding which suggests that people traveling for weekly business and regional tourism purposes follow completely different behavioral frameworks. Contrary to Brunelli et al. (2023), income did not emerge to be significant for airport access trips. According to the 2022 Statistical Yearbook of the Iranian Ministry of Cooperatives, Labor, and Social Welfare, households earned an average monthly income of 14 million tomans (500 USD/month), which is equivalent to an average hourly wage of about 80,000 tomans per month (2.86 USD/hour) given 176 mandatory working hours per month, and spent about 11.4 million tomans per month (400 USD/month). Moreover, households in the top 10% income bracket had an average monthly income of 35 million tomans (1250 USD/month) and spent an average of 25 million tomans per month (890 USD/month) (MCLS, 2022). These figures corroborate observations such as Fu et al. (2019) that air taxi is actually a mode for the most affluent as the average resident, who is

Table 9
Summary of the value of time estimates (per hour).

Trip purpose	Air taxi		Ride-hailing		Private car		Public transport	
	MNL	NL	MNL	NL	MNL	NL	MNL	NL
Weekly Business	$47.9	$47.3	n.a.	n.a.	n.a.	n.a.	$0.3	$0.32
Airport Access	$19.0	$17.2	$2.53	$3.52	$2.53	$3.52	n.a.	n.a.
Regional Tourism	n.a.	n.a.	n.a.	n.a.	$0.88	$1.01	n.a.	n.a.

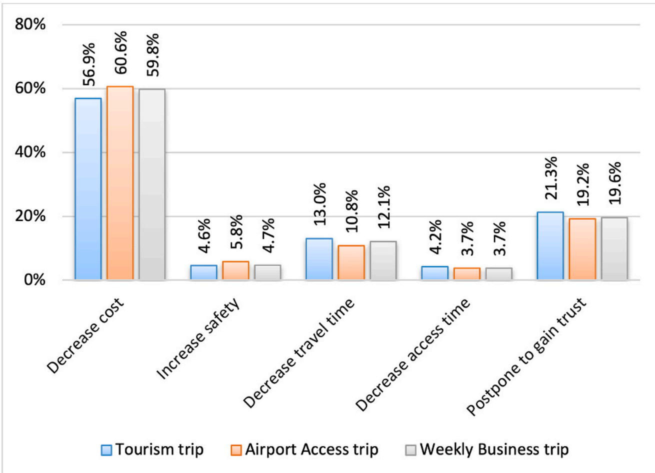

Fig. 5. Incentives to increase individuals' willingness to use air taxis.

enthusiastic about the emerging mode (Karami et al., 2023), spends nearly all their income on the amenities and has little to venture with.

7. Conclusion

This research analyzed the prospective air taxi demand and investigated the factors affecting the adoption of UAM. There has been a tendency in the literature to suggest that UAM will offer a solution to the problem of congestion in cities (Wang et al., 2023; Lowry, 2018). However, it is not realistic to assume that people will leave an already established and, in the case of a developing country, much cheaper surface transportation mode only to move to the sky above. One should eventually be prudent not to suggest trading one congested mobility layer with another far more challenging technologically and economically over the foreseeable future, no matter how intriguing such an idea may sound, as some of the best estimates do not predict over five percent market share (Rimjha et al., 2021b; Ploetner et al., 2020). While in the Californian context, Rimjha et al. (2021b) raised concerns about the possibility of UAM congestion during peak hours, in Iran as well as other developing countries, the aim should be to identify niche markets in which a UAM ecosystem can be implemented viably, allowing for further integration.

Our study suggests that the market for regularly operated interurban air metro for weekly business travelers between Tehran and its main satellite city of Karaj, is quite within reach. This result aligns with similar findings by Ilahi et al. (2021) in the context of Jakarta. Moreover, access to the international airport of Tehran is also valued at approximately half the figures estimated by Rimjha et al. (2021a) in a North American context for non-Business cases. In fact, the Iranian government does not subsidize international flights; therefore, contrary to the car-based modes that benefit from inexpensive gasoline, Iranian international flyers view the price of an air taxi trip in relation to their international flight ticket price. Tourism seems to be a less viable market for air taxis, at least among the nationals. Further research is needed to determine the viability of a market for foreign tourists and travelers.

There are limitations to the current study. Firstly, respondents do not have any firsthand experience with air taxis; therefore, their understanding of the attributes of air taxis is, at best, unsubstantiated. This is a general limitation of any study that relies on stated preferences to draw conclusions, as it is based on hypothetical scenarios. As suggested by Shaheen et al. (2018), one way to address this issue is to include virtual reality experiments that allow respondents to experience an immersive simulation of flying on board an air taxi, thereby increasing the authenticity of their responses. Secondly, the study's data collection approach was based on self-reported answers, which could be subject to biases such as social desirability and recall bias. This may have an impact on the precision of the study's results. Finally, the sample sizes were relatively modest. It is expected that larger sample sizes will contribute to more statistically significant estimations.

Future research can place greater emphasis on scenario design, tailoring scenarios to each respondent based on their specific characteristics and the context of the case studies. Personalizing these scenarios will enhance the relevance and accuracy of the findings. As previously mentioned, the use of immersive technologies, such as virtual reality, can significantly improve the authenticity of respondent experiences, addressing the limitations inherent in stated preference studies. Additionally, the high cost associated with air taxi travel presents a unique challenge for household decision-making. Future studies should explore considerations involved in choosing air taxis for shared family travel. This approach will provide a more comprehensive understanding of the factors influencing air taxi adoption at the household level, which is a deciding factor differentiating tourism trips in contrast to business or airport access trips.

CRediT authorship contribution statement

Mahdi Samadzad: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Fatemeh Ansari:** Writing – original draft, Visualization, Software, Formal analysis, Data curation. **Mohammad Amin Afshari Moez:** Data curation, Formal analysis, Investigation, Software, Writing – review & editing.

Data availability

Data will be made available on request.

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Appendix A

Table A1
Summary of the six scenarios offered to the respondents for a tournism trip.

Mode	Scenarios		
	Scenario 1	**Scenario 2**	**Scenario 3**
	60 thousand tomans **cost** 80 min **travel time** 5 min **access time**	100 thousand tomans **cost** 80 min **travel time** 0 min **access time**	85 thousand tomans **cost** 65 min **travel time** 5 min **access time**

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Table A1 (*continued*)

Mode	Scenarios		
	110 thousand tomans **cost** 70 min **in-vehicle travel time** 5 min **access time**	90 thousand tomans **cost** 70 min **in-vehicle travel time** 10 min **access time**	110 thousand tomans **cost** 70 min **in-vehicle travel time** 10 min **access time**
	600 thousand tomans **cost** 20 min **in-vehicle travel time** 10 min **access time**	400 thousand tomans **cost** 20 min **in-vehicle travel time** 10 min **access time**	400 thousand tomans **cost** 20 min **in-vehicle travel time** 5 min **access time**
	Scenario 4	**Scenario 5**	**Scenario 6**
	85 thousand tomans **cost** 115 min **travel time** 10 min **access time**	60 thousand tomans **cost** 65 min **travel time** 0 min **access time**	85 thousand tomans **cost** 115 min **travel time** 10 min **access time**
	90 thousand tomans **cost** 110 min **in-vehicle travel time** 10 min **access time**	90 thousand tomans **cost** 70 min **in-vehicle travel time** 5 min **access time**	140 thousand tomans **cost** 110 min **in-vehicle travel time** 10 min **access time**
	600 thousand tomans **cost** 20 min **in-vehicle travel time** 5 min **access time**	600 thousand tomans **cost** 15 min **in-vehicle travel time** 7 min **access time**	600 thousand tomans **cost** 15 min **in-vehicle travel time** 7 min **access time**

Table A2
Summary of the six scenarios offered to the respondents for an airport access trip.

Mode	Scenarios		
	Scenario 1	**Scenario 2**	**Scenario 3**
	70 thousand tomans **cost** 85min **travel time** 7 min **access time**	130 thousand tomans **cost** 75 min **travel time** 5 min **access time**	95 thousand tomans **cost** 60 min **travel time** 5 min **access time**
	120 thousand tomans **cost** 70 min **in-vehicle travel time** 5 min **access time**	95 thousand tomans **cost** 70 min **in-vehicle travel time** 10 min **access time**	120 thousand tomans **cost** 70 min **in-vehicle travel time** 10 min **access time**
	600 thousand tomans **cost** 20 min **in-vehicle travel time** 10 min **access time**	300 thousand tomans **cost** 20 min **in-vehicle travel time** 10 min **access time**	400 thousand tomans **cost** 20 min **in-vehicle travel time** 5 min **access time**
	20 thousand tomans **cost** 110 min **in-vehicle travel time** 20 min **access time**	15 thousand tomans **cost** 120 min **in-vehicle travel time** 30 min **access time**	20 thousand tomans **cost** 110 min **in-vehicle travel time** 30 min **access time**
	Scenario 4	**Scenario 5**	**Scenario 6**
	95 thousand tomans **cost** 100 min **travel time** 10 min **access time**	60 thousand tomans **cost** 70 min **travel time** 5 min **access time**	95 thousand tomans **cost** 100 min **travel time** 15 min **access time**
	95 thousand tomans **cost** 110 min **in-vehicle travel time** 10 min **access time**	95 thousand tomans **cost** 70 min **in-vehicle travel time** 5 min **access time**	150 thousand tomans **cost** 110 min **in-vehicle travel time** 10 min **access time**
	600 thousand tomans **cost** 15 min **in-vehicle travel time** 5 min **access time**	600 thousand tomans **cost** 15 min **in-vehicle travel time** 7 min **access time**	600 thousand tomans **cost** 15 min **in-vehicle travel time** 7 min **access time**
	15 thousand tomans **cost** 85 min **in-vehicle travel time** 30 min **access time**	15 thousand tomans **cost** 120 min **in-vehicle travel time** 30 min **access time**	10 thousand tomans **cost** 85 min **in-vehicle travel time** 20 min **access time**

Table A3
Summary of the six scenarios offered to the respondents for a weekly business trip.

Mode	Scenarios		
	Scenario 1	**Scenario 2**	**Scenario 3**
	30 thousand tomans **cost** 75min **travel time** 2 min **access time**	70 thousand tomans **cost** 75 min **travel time** 0 min **access time**	50 thousand tomans **cost** 50 min **travel time** 2 min **access time**

(*continued on next page*)

Table A3 (*continued*)

Mode	Scenarios		
	120 thousand tomans **cost** 70 min **in-vehicle travel time** 5 min **access time**	100 thousand tomans **cost** 70 min **in-vehicle travel time** 10 min **access time**	120 thousand tomans **cost** 70 min **in-vehicle travel time** 10 min **access time**
	400 thousand tomans **cost** 20 min **in-vehicle travel time** 10 min **access time**	400 thousand tomans **cost** 20 min **in-vehicle travel time** 10 min **access time**	400 thousand tomans **cost** 20 min **in-vehicle travel time** 5 min **access time**
	15 thousand tomans **cost** 85 min **in-vehicle travel time** 15 min **access time**	10 thousand tomans **cost** 105 min **in-vehicle travel time** 25 min **access time**	15 thousand tomans **cost** 85 min **in-vehicle travel time** 25 min **access time**
	Scenario 4	**Scenario 5**	**Scenario 6**
	50 thousand tomans **cost** 90 min **travel time** 4 min **access time**	30 thousand tomans **cost** 50 min **travel time** 0 min **access time**	50 thousand tomans **cost** 90 min **travel time** 4 min **access time**
	100 thousand tomans **cost** 90 min **in-vehicle travel time** 10 min **access time**	100 thousand tomans **cost** 70 min **in-vehicle travel time** 5 min **access time**	150 thousand tomans **cost** 90 min **in-vehicle travel time** 10 min **access time**
	600 thousand tomans **cost** 20 min **in-vehicle travel time** 5 min **access time**	600 thousand tomans **cost** 15 min **in-vehicle travel time** 7 min **access time**	600 thousand tomans **cost** 15 min **in-vehicle travel time** 7 min **access time**
	10 thousand tomans **cost** 70 min **in-vehicle travel time** 25 min **access time**	10 thousand tomans **cost** 105 min **in-vehicle travel time** 25 min **access time**	15 thousand tomans **cost** 70 min **in-vehicle travel time** 15 min **access time**

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