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Research Article

Heterogeneity in the Preferences of Potential Users of Automated Transit Network (ATN)

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Many cities in Iran, including the metropolis of Shiraz, are increasingly car-oriented, resulting in traffic congestion and related issues. Considering the current conditions of Iran, an automated transit network (ATN) can be one of the available solutions to this problem. ATN is an advanced type of public transit consisting of automated vehicles moving passengers on a network of dedicated guideways. As a combination of public, personal, and private transport, ATNs may decrease the use of cars and address related problems. In order to design effective policies aimed at achieving the benefits of ATN, it is necessary to have a better understanding of how people accept an ATN system, especially car users. This research aims at advancing future research on the effects of ATNs on travel behavior through identifying the characteristics of users who are likely to accept ATN services, by examining the heterogeneity in the preferences of these people. To achieve this goal, a stated choice survey was conducted and analyzed using multinomial logit (MNL) and mixed logit (ML) models. The results showed that the parameters of trip purpose, owning a hybrid car, and the level of education affect the preferences toward the ATN system. Additionally, from the comparison of the results of the MNL and ML models, it was found that despite the greater ability of the ML model in estimating possible heterogeneities, likely the MNL model can also help to record some heterogeneities more realistically. In the end, the methodological limitations of the study were also acknowledged. Despite the potential hypothesis bias and the status quo bias, the results captured the directionality and relative importance of the attributes of interest.

1. Introduction

Many cities in Iran are facing the problem of their residents being car-oriented [1], and the city of Shiraz is also not an exception and facing increasing traffic congestion [2, 3]. Meanwhile, the car is the most used mode in this city with a 50% share of all travel modes [4]. In addition, the Shiraz Traffic Masterplan in 2001 declared that the rate of car ownership per household for inner, middle, and outer regions was 0.36, 0.45 and 0.53, respectively. According to the latest data collected in the winter of 2016 by the Transport and Traffic Research Center (TTRC) at Shiraz University, the average rate of car ownership per household is 1.59, which shows rapid growth of 24% every year. It should be noted that the inner, middle, and outer regions of Shiraz refer to areas within 0 to 5, 5 to 10, and 10 to 20 km of the central business district (CBD) [5]. 88.5% of the households living in the outer region of Shiraz have a car, and 13.3% of the mentioned households have 3 or more cars, which is higher than households living in the middle and inner regions [5]. The lack of a citywide metro network in Shiraz, and especially the absence of active metro lines in the outer region, the low quality of the bus fleet, and high fares of taxi and ride-sourcing systems for long distances have caused that the residents of the outer region of Shiraz rely on cars more than the residents of other areas of this metropolis. Since many governmental and non-governmental organizations and offices, hospitals and medical centers, universities and educational centers, shops, restaurants, entertainment places, etc. are located in the CBD, many residents of Greater Shiraz must travel to this area for various purposes.

Autonomous vehicles (AVs) can reduce costs related to congestion on the one hand [6], and on the other hand, even the use of shared autonomous vehicles (SAVs) can increase levels of flexibility similar to cars [7] and cause a decrease in car ownership [8]; therefore, it is possible to consider autonomous vehicles as a suitable solution to moderate the car orientation of cities in Iran. It is worth mentioning that autonomous vehicles also require the infrastructure to have certain requirements [9], but Iran and many developing countries are still far from building such infrastructure. Therefore, perhaps automated transit networks (ATNs) and similar systems in countries such as Iran can be a bridge from current city transportation to autonomous vehicles on dedicated networks. By accepting these facts and subsequently creating useful and effective transportation policies, it is necessary to know what characteristics and preferences the potential users have and how and under what conditions they would use the ATN system. Although examining research conducted in different geographical areas indicates the attractiveness of the ATN option for a wide range of people, it is important that heterogeneity in the preferences of potential ATN users be examined in detail and extensively. In this regard and based on the literature reviews as well as to the best of the authors' knowledge, so far no research has extensively investigated the heterogeneity in the preferences of potential users regarding the use of ATN as a travel mode. This study aims to investigate the heterogeneity in the preferences of residents of two towns located in the northwestern region of Shiraz and examines the effect of the ATN system on their travel behavior, using a stated preference survey and analyzing it by discrete choice models.

The structure of this paper is as follows. In Section 2, the definition and nature of the ATN system as well as the research related to passenger acceptance will be investigated. Explanations of the process of designing a questionnaire and collecting data are given in Section 3. Section 4 analyzes the collected data and investigates the findings and possible causes of them. In Section 5, the main findings are reviewed, the policy implications are derived, and finally, the limitations of the research are addressed together with conclusions.

2. Automated Transit Network (ATN)

The idea of ATN dates back to 1950, but the first ATN system reached the operational stage in 1975 at the University of West Virginia in Morgantown, USA. In the following decades, other cities built and operated ATN systems and many of these systems around the world are currently in operation as well as study, design, and experimental stages. ATN is an advanced type of public transit consisting of automated vehicles moving passengers on a network of dedicated guideways. ATN cars can be available at all stations 24/7 on-demand. These cars typically have a carrying capacity of 4 to 6 people [10].

ATN system can provide relatively high service levels compared to more conventional transportation systems, especially as it can also be considered a solution to the first/last mile problem [11, 12]. In addition, the operation of ATN systems, which are inherently on-demand in comparison to conventional guided public transport types, can be cheaper. This fact along with other features such as being highly accessible, user-responsive, and environmentally friendly has made this system a sustainable and economical solution [13].

The ATN system is more flexible than light rail transit (LRT), which, along with passengers' shared use of the system vehicles, has caused the ATN systems to be a combination of public, personal, and private transportation [14] and is thus well received by both public transport and car users. These ATN characteristics result in a reduction in the use of cars [15] and consequently address congestion problems, poor air quality, and social exclusion and complement existing forms of public transport [13]. ATN systems also have weaknesses. For example, since many guideways of ATN systems are constructed elevated, they raise concerns from an aesthetic point of view and affect the face of the city [11].

In recent years, among the research that has examined various aspects of ATN systems [11, 13], some have examined how passengers accept the system. For example, Kim et al. with the help of logistic regression models investigated the characteristics that can determine the travel mode choice for a short-distance trip. Analysis of the survey data showed that the factors of travel purpose and weather conditions, compared to other considered factors, significantly affect the travel mode choice of respondents for the ATN system [16]. In another research aimed at estimating the initial ridership of an ATN system, a questionnaire was set up to answer under what conditions people would use the ATN system. Results showed a wide range of factors including the trip frequency and sensitivity of ATN ridership to fare. For example, it was found that non-working trip-making is sensitive to cost [17]. Findings on the relationship between travelers' sociodemographic characteristics and attitudes toward ATN systems have also been reported. In a study aimed at developing an advanced airport ATN shuttle service connecting parking to the airport terminal, a questionnaire was set up and distributed to discover users' expectations about the services of this system [18].

In the past decade, other research has been conducted to predict changes in the mode choice behavior of respondents by checking their willingness to pay (WTP) [19, 20]. One of the most comprehensive research studies evaluating ATN systems, called Evaluation and Demonstration of Innovative City Transport (EDICT), showed that not only was the concept of ATN welcomed by the public in all the cities that participated in the project, but also people would be willing to pay a fare of two to three times the amount set out in the project survey because this system offered additional benefits compared to conventional public transport modes [13]. Research conducted at the time of the COVID-19 pandemic recorded travel mode choices before, during, and after COVID-19 and showed that more than 50% of people will use an ATN system when the performance is normal, but during emergencies, passengers were willing to pay more fares for safer travel modes [21]. It should be noted that one of the other objectives of this study was to identify a safe and disaster-resilient public transportation system to meet the needs of car users. One factor affecting decisions is the perceived value of time (VoT). For instance, Li et al. showed that the monetary value of waiting time (VoWT) at the ATN station for passengers would be 10 Euros per hour [22]. It should be noted that the extra cost that an individual is ready to pay in order to save time is considered the VoT [23]. Apart from WTP or VoT, some of the features of the ATN system may also have a negative or positive value. For instance, traveling at an altitude of 5 meters above the surface carries a low negative value (−7 cents) or having an ATN station where there is a human operator has a high positive value (0.5 USD) compared to stations that do not have a human operator [24].

Other research has conducted surveys examining how many passengers and trips will be transferred to ATN if implemented [17, 25, 26]. In this regard, Jain et al. investigated the travel demand for an ATN system using the stated preference technique and binary logit models, showing that 36.6% of all trips would shift from the available modes to this system and most of these shifts will belong to the car user group (38.8%) [27]. Another study to determine the share of public transport showed that after providing a citywide ATN network, the share of the ATN mode would be dominant and the share of private transportation including cars and motorcycles will be reduced to below 15% [28]. This research also shows that if there is a citywide ATN system with comparable fares, the share of public transportation will be dominant with a significant increase, and car-oriented trips will be insignificant. In this regard, other research results showed that 25% to 30% of car users are ready to shift to an extended ATN system [29].

In a master's thesis that was published in the winter of 2020, the propensity level of current private car users to shift to the ATN system was studied [30]. In this research, the heterogeneity was investigated only with the help of the multinomial logit (MNL) model. In an article based on the mentioned thesis, no covariates were used and the heterogeneity in the preferences of potential users of ATN was not examined [31].

To the best of our knowledge, no research has extensively studied the heterogeneity in people's preferences toward the ATN system.

3. Methodology

The data were collected using an online survey (see Supplementary Materials (available here)) in August and September 2020, consisting of 408 respondents who were car drivers and living in two towns located in the northwestern region of Shiraz called Golestan and Beheshti (see Figures 1(a) and 1(b)). There were two reasons for considering the residents of the Golestan and Beheshti towns in this study. First, both these towns are located in the outer region of Shiraz. Second, there were some differences between these two towns and the other towns located in the northwestern area of Shiraz. For example, Golestan was the most populated town in the northwest of Shiraz and local investigations showed that the residents of Beheshti town had the highest monthly income in comparison to the residents of other towns located in the same area. Therefore, it was likely that these differences would affect residents' preferences. In addition, the reasons for selecting car users (driver only) for surveying were as follows. (1) Non-car modes were not popular among the residents of these two towns for travel to the CBD. (2) Since the cost of traveling by mass public transportation (such as buses) was insignificant (about 0.04 USD), there was virtually no option to compete with it. (3) The reason for considering only those car users who were drivers was a test survey conducted before the main survey showing that car passengers either did not have any idea about some of the required variables of this research (such as the car travel cost, car access/egress time, and access to free parking) or if they did, their information was insufficient. About the first reason, it is necessary to mention that public transit such as buses is available only in Golestan town and Beheshti town does not have any public transit system. Therefore, it was impossible to consider public transit as one of the options of the choice sets. Furthermore, since these two towns are far from the CBD of Shiraz, very few people use taxis, and that too on special occasions, because the taxi fare will be very high. Therefore, the residents of these two towns cannot use taxis regularly, and for this reason, taxis were not also considered as one of the available options in the choice sets.

To ensure that respondents were aware of the area of the Shiraz CBD, a picture of the area and boundaries of the CBD were shown to each of the respondents before the survey began (see Figure 1(c)). Then, they were asked whether they had traveled from their town to the CBD or vice versa in the last/current week by car, and only if the respondent answered the question positively, the survey was continued. The survey consisted of two parts. In the first part, a questionnaire was distributed to collect personal and socioeconomic information. The second part of the survey consisted of a stated choice experiment, during which respondents were asked if they were willing to use the ATN instead of a car on a recent trip from their town to the CBD or vice versa.

3.1. Personal and Socioeconomic Characteristics. In this study, the personal and socioeconomic characteristics of respondents were collected about gender, age, level of education, job, owner/tenant, area of the house, number of cars in the house, and make and model of each of them. Since many people in Iran do not wish to declare their income, this study tried to estimate respondents' affordability indirectly by asking questions about their house and car(s). It is worth mentioning that using factors of the area of the house and the number of cars in the house and the make and model of

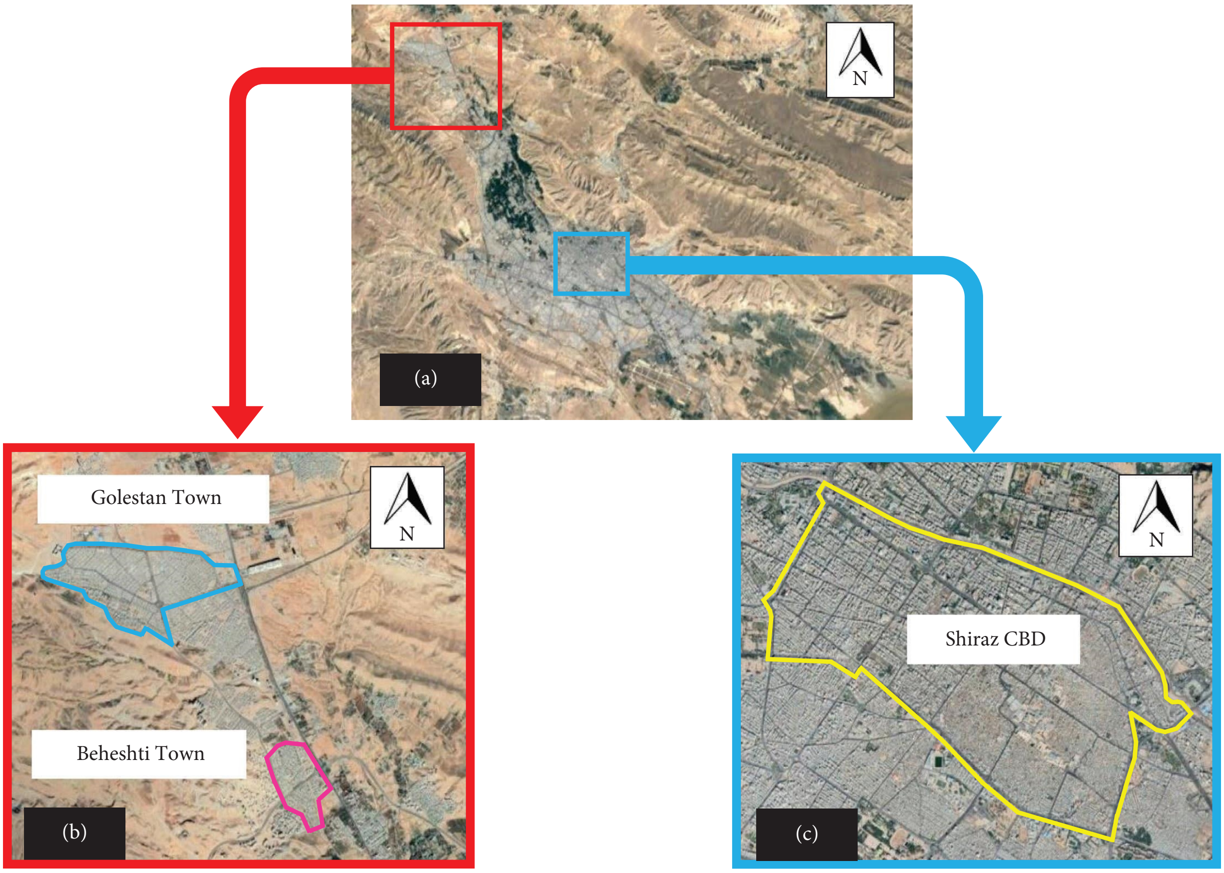

Figure 1: (a) Aerial image of Shiraz and the suburbs. (b) Golestan and Beheshti towns. (c) Shiraz CBD.

each of them is an approach that Iran's government itself sometimes uses to indirectly estimate people's real income and therefore their affordability.

3.2. Stated Choice Experiment. In general, the stated choice experiment had three stages.

3.2.1. Questions of Revealed Preference. This part of the experiment collects information about the trip that respondents had made in the last/current week. This information included the trip purpose, the departure time, the total travel time, the access/egress mode and time, the origin and destination of the trip, the distance traveled by car, the respondents' car being hybrid or not, having access or not to free parking in the CBD, and the cost of the trip. In this research, hybrid cars are meant to be both gasoline and compressed natural gas (CNG). Since hybrid electric vehicles (HEVs) are not yet common in Iran, this type of bi-fuel car is the most common among other hybrid vehicles in the country.

3.2.2. Awareness of ATN. In this stage, to familiarize respondents with the ATN system, a video clip showing how to use the ATN from the moment of buying a ticket and getting into its vehicle until getting out of it was displayed to each respondent. Also in this video clip, the features of the ATN system were emphasized as fully as possible. As an example, it was shown that the ATN vehicles are completely autonomous, can carry 4 to 6 passengers, become available according to passengers' demands, and move on their network of dedicated guideways.

3.2.3. Questions of Stated Preference. In the final stage of the stated choice experiment, each respondent had to respond to 3 choice sets and choose one of the two mobility options. The reason for selecting 3 choice sets per person was that according to the pretests, most respondents either gave up in the middle of answering the fourth and fifth choice sets and refused to continue the survey because they felt tired or admitted that after the third choice set, they were confused and could no longer make the right choice. Therefore, this study determined only three choice sets for each respondent in order to maintain the accuracy and quality of the answers. A sample of these choice sets is shown in Figure 2. The experiment was designed by the fractional factorial method. This design also used orthogonal arrays. In addition to the main effects, two-way interactions are also included. Due to the high number of final discrete choice experiments, blocking has also been done by the software. All stages of the design of the experiment were done by SAS software [32].

(1) Alternatives. In each choice set, respondents were faced with two alternatives and had to choose one of them: (1)

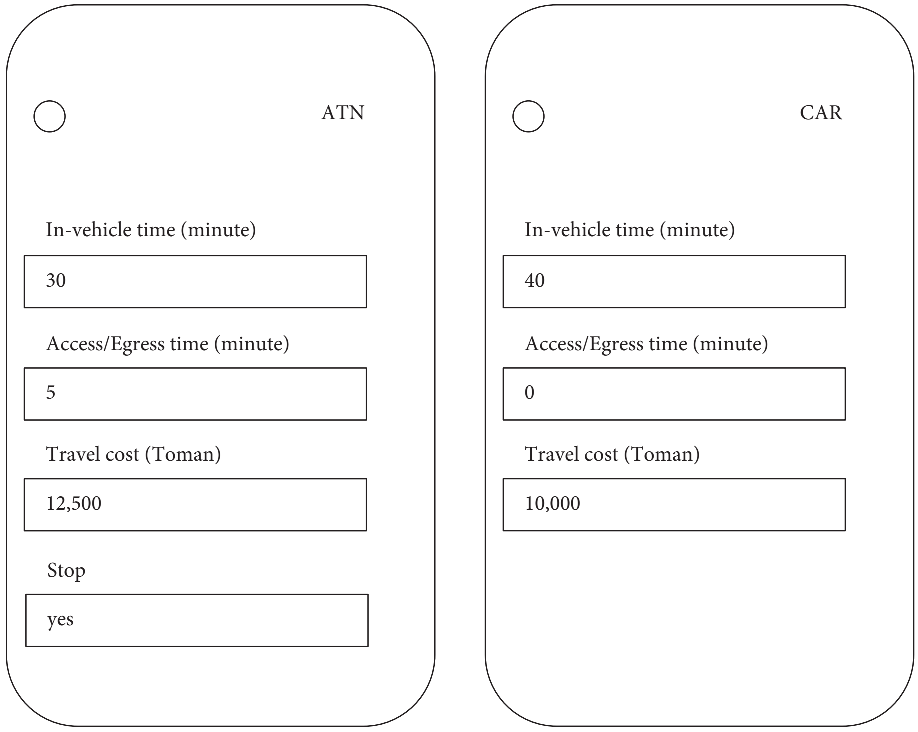

Figure 2: Format of the choice sets.

ATN—obviously, this option was hypothetical and did not exist and respondents were made clear that in this option, passengers will share the vehicle with others; (2) car—that is, the same vehicle that the respondents had previously completed their trip with.

(2) Attributes of the Alternatives and the Attribute Levels. At first, a total of five attributes were considered to define the alternatives. These attributes were in-vehicle time, access/egress time, waiting time, and stop and travel cost. The in-vehicle time was defined as when passengers are inside the vehicle and not including waiting time and access/egress time. The access/egress time was the time that passengers, both in their place of residence and in the CBD, had to walk to get to the vehicle or final destination they wanted. Waiting time was defined as the time when the passengers were waiting at the station. This attribute was meaningless for the car on the one hand, and on the other hand, the waiting time of the ATN system is very short and usually in the range of 1 to 3 minutes; hence, the respondents in the experimental surveys did not consider this attribute as an impactful one that could influence their decision to choose the alternatives. Therefore, the waiting time attribute was removed from the choice sets. The stop attribute indicated that the vehicle was stopping during the trip to pick up or drop off passenger(s). It should be noted that this attribute was defined only for the ATN system and the reason for studying the effect of this attribute on people's preferences is that the performance of the ATN system will be more optimized when the vehicles stop en route to pick up or drop off passenger(s) [33]. The cost of the trip represented the fare that a person had to pay for using a particular vehicle to carry out their desired trip.

The attribute levels for the car option in all choice sets were constant and equal to the information that the respondents had previously stated about their trip, but these levels were changeable for the ATN option during different choice sets. In order to estimate the ATN in-vehicle time, first of all, the distance traveled by the ATN vehicle for each respondent in particular according to the origin and destination of his/her trip and based on the ATN network (designed by the PRTsim software) was calculated. Assuming a speed of 45 km/h and depending on whether the ATN vehicle stops en route or not and after multiplying in one of the three levels of 0.75, 1, and 1.25, ATN in-vehicle time was estimated for each respondent and displayed automatically to him/her. ATN access/egress time levels were selected so that they could be considered as the result of the sum of access time at the origin and egress time at the destination to prevent respondents from encountering a multiplicity of attributes and thus complex scenarios. The mentioned levels were 5, 10, and 15 minutes. It should be noted that the cumulative issue of access time at the origin and the egress time at the destination was notified to the respondents.

Although there are different scenarios for ATN vehicles to stop [33], this study aimed to prevent respondents from facing complex scenarios and defined only two levels of Yes and No for the stop attribute. While the level of the stop attribute was Yes, this meant that the ATN vehicle will stop at least 1 time and up to 2 times for passenger(s) to board or disembark. In this case, the respondent's in-vehicle time, in addition to multiplying in one of its three levels that were previously stated, was also multiplied by 1.2. The reason for this was the prolongation of the travel time due to the possible deviation from the direct path to the destination of the respondent, as well as stopping to pick up or drop off passenger(s). Therefore, besides the fact that the stop attribute with the help of its levels could naturally influence the decision of the respondents, it also affected the in-vehicle time attribute. It should be noted that the issue of the number of stops and longer in-vehicle time due to possible redirection as well as stopping to pick up or drop off other passengers was informed to the respondents in the questionnaire.

The cost attribute for the ATN option had three levels of 7500, 10,000, and 12,500 Tomans (0.33, 0.43, and 0.54 USD, respectively). For the car option, if the respondents had an estimate of the monetary cost of their trip, their estimate would be placed in the choice sets, but if the respondents were unable to estimate the cost of their trip, since car owners often do not know the real cost of driving, the research used the costs in an index called total cost of ownership (TCO) to obtain an accurate estimate of the car travel cost per kilometer.

The total cost of ownership means estimating and calculating all direct and indirect costs associated with the use of an asset during its life cycle [34]. To achieve this goal, the costs applied by Gilmore and Lave [35] in estimating the total cost of ownership index were used. These costs were capital cost for a new vehicle, maintenance cost, repair cost, insurance and driving license costs, technical examination cost of a vehicle, tax cost, and fuel cost. Since the sample of this study was made up of car users, it was assumed that all people constituting the sample had cars and driving licenses at the time of the survey and they did not need to spend money to get a car and a driving license (for the first time). As a result, the capital cost for a new car and the cost of obtaining a driving license for the first time were excluded from other costs.

To estimate the car travel cost per kilometer, three cars named Pride (Saipa 131), Peugeot 206 (1.4 liters and 1.6 liters), and Peugeot 405 (XU7) were considered. Each of these three cars was the basic model of its group. The reason for considering these cars was that all of them were among the most frequent cars in Iran. The mentioned costs were calculated for each of the three cars per kilometer, and the cost of each vehicle per kilometer was estimated by algebraic sum. Then, the average of the three numbers obtained was calculated and considered as the travel cost of a car per kilometer. The car travel cost per kilometer in each gasoline and hybrid sector was 569 and 435 Tomans (or 0.03 and 0.02 USD), respectively. It should be noted that to estimate the fuel cost of the hybrid sector, it was assumed that each person puts his car in 70% of the route in CNG-burning mode and the remaining 30% in gasoline mode.

4. Data Analysis and Discussion

4.1. Sample Composition. During the survey process, 408 questionnaires were collected from the residents of the two mentioned towns. Some information related to the personal and socioeconomic characteristics of respondents is reported in Table 1. The questionnaire of this research was online. To ensure the quality of the data, answering all questions were required to submit the questionnaire and if all questions were not answered, the respondent was not able to submit the questionnaire. Due to adopting this approach, this research did not face any missing respondents. According to the total population of the age groups considered in this research, the population frequencies of people in the age groups of 20–29, 30–49, 50–64, 65–74, and ≥75 were 24%, 43%, 24%, 7%, and 2%, respectively. For the sample, 49% of the respondents were females and 51% were males. Furthermore, 81% of the respondents were owners and 19 were tenants. All the respondents held a driving license and they regularly had access to a car as a driver. Moreover, 43%, 41%, 11%, and 5% of the respondents had 1, 2, 3, and ≥4 car(s) in their houses, respectively.

Table 1: Sample frequencies of personal and socioeconomic variables.

%Variable	Distribution (%)
Gender (female, male)	(49, 51)
Age (years) (18–29, 30–49, 50–64, 65–74, ≥75)	(33, 42, 13, 11, 1)
Level of education (≤high school diploma, high school diploma, associate degree, bachelor's degree, master's degree, PhD degree)	(5, 25, 18, 30, 18, 4)
Position in residence (owner, tenant)	(81, 19)
Number of cars (1, 2, 3, ≥4)	(43, 41, 11, 5)

4.2. Reference Trip Specification. A summary of the respondents' reference trip specifications is shown in Table 2. The access/egress mode of all respondents was walking. The average car access/egress time of the respondents was 6.2 minutes. Six different trip purposes were identified, with the absolute and relative frequency of each of them shown in Table 3. The work purpose with 65% had the highest share among other trip purposes. 43% of respondents had completed their trip by hybrid car and 57% of them by gasoline car.

4.3. Stated Choice Analysis. According to each of the 408 respondents encountering 3 choice sets, finally, 1224 valid observations were stored in the database. Each of the car and ATN options was selected 579 and 645 times, respectively. The data obtained from the stated choice experiment were analyzed using MNL and mixed logit (ML) models.

4.3.1. Model Formulation and Modeling Procedure. Discrete choice models describe the choice of decision makers from all available options. The basic assumption of discrete choice models is that when the decision maker is faced with a choice, his/her individual preference for each option can be expressed by a utility or attractiveness criterion [23]. The utility function of the jth option for person q is expressed as $U_{jq} = V_{jq} + \varepsilon_{jq}$. According to the $j \in C_q$ if $U_{jq} > U_{mq} \forall m \neq j$ relationship, the decision maker chooses the option in the choice set C_q that has the

Table 2: Reference trip characteristics.

Statistics	Travel distance by private car (km)	Travel cost (Toman)	In-vehicle time (min)	Access/egress time (min)
1st quartile	18.18	9500	39	5
Median	20.35	10000	41	5
Mean	20.20	10424	42	6
3rd quartile	22.10	11500	45	10
Std. dev.	2.58	1495	6	4

Table 3: Trip purpose frequencies.

Trip purpose	Absolute frequency	Relative frequency (%)
Office work	51	4
Educational	150	12
Leisure	30	3
Shopping	84	7
Medical	90	7
Work	798	65
Return home	21	2
Total	1224	100

most utility over other options. In these relationships, U_{jq} represents the utility of choosing the jth option by person q, V_{jq} is a fixed term of the utility of choosing the jth option by person q, and ε_{jq} is the random term of the utility of choosing the jth option by person q. The probability of person q choosing jth option is $P_{\mathrm{jq}} = P(U_{jq} \geq U_{\mathrm{mq}})$ $\forall_m \neq j \in C_q$ and therefore equals $P_{\mathrm{jq}} = P(\varepsilon_{\mathrm{mq}} - \varepsilon_{jq} \leq V_{\mathrm{jq}} - V_{\mathrm{mq}}) \forall m \neq j \in C_q$. The MNL model is the simplest, most basic, and most widely used discrete choice and specifically generalized extreme value (GEV) model [36]. Assuming an independent and identical distribution (IID) or Gumbel distribution in all options for the random part of the utility function, the MNL model is defined as

$$P_{\mathrm{jq}} = \frac{e^{V_{\mathrm{jq}}}}{\sum_{m \neq j \subset C_q} e^{V_{\mathrm{mq}}}}, \quad (1)$$

in which P_{jq} is the probability of choosing the jth option by person q. MNL models can capture taste variations, but only with limitations. In particular, tastes that change systematically according to the observed variables can be included in MNL models, while tastes that change with unobserved or completely random variables cannot be examined. However, MNL may be able to discover average tastes well even when tastes are random, as the MNL formula seems to be relatively robust against misspecifications. Ultimately it has been suggested that the ML model can be used instead of the MNL model to incorporate the random taste variation appropriately and thoroughly [23]. The ML model is one of the most flexible discrete choice models that with its help, almost any other structure in random utility models can be estimated [37]. The probability function of the ML model is an integral of the choice probability function of the MNL model on a density function of parameters [23]. In general, this probability function has a definition of the form

$$P_{\mathrm{jq}} = \int L_{\mathrm{jq}}(\beta) f(\beta) d\beta, \quad (2)$$

in which P_{jq} is the probability of choosing the jth option by person q and $L_{\mathrm{jq}}(\beta)$ is the probability of choosing the jth option by person q in the logit model which is a function of β parameter and is expressed as

$$L_{\mathrm{jq}}(\beta) = \frac{e^{V_{\mathrm{jq}}(\beta)}}{\sum_{m \neq j \subset C_q} e^{V_{\mathrm{mq}}(\beta)}}. \quad (3)$$

In this relationship, $f(\beta)$ is the density function of β parameter and $V_{\mathrm{jq}}(\beta)$ is the observed term of the utility function of choosing the jth option by person q, which depends on β parameter. Finally, the choice probability function of the ML model is written as

$$P_{\mathrm{jq}} = \int \left(\frac{e^{V_{\mathrm{jq}}(\beta)}}{\sum_{m \neq j \subset C_q} e^{V_{\mathrm{mq}}(\beta)}} \right) f(\beta) d\beta. \quad (4)$$

Layering the selected random parameters in the ML model can have several predefined functional forms or distributions [38]. In this study, the normal distribution, which is one of the most widely used distributions in ML models, was used to estimate the random parameters. The density function in this distribution is expressed as

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\left((x-\mu)^2/2\sigma^2\right)\times -1}, \quad x \in (-\infty, +\infty). \quad (5)$$

It should be noted that to ensure the actuality of the positive sign of the heterogeneity value in estimating the mean parameters of ATN in-vehicle time × the work trip purpose and ATN access/egress time × the work trip purpose, normal distribution of the in-vehicle time parameter was replaced with the proposed distributions by Hess et al. [39] i.e. bounded distributions such as Triangular and Johnson's S_{B}, and the ML model was executed for each of these two distributions as well. It is worth mentioning that in the two mentioned distributions, bounds are estimated from the data used. However, the use of these distributions did not change the sign of the mean values of the mentioned parameters, and therefore, the normal distribution was used again for the in-vehicle time parameter. In this research and its ML model, the variables of cost, in-vehicle time, and access/egress time for both car and ATN are considered random parameters. In contrast, the stop variable is considered a non-random parameter. In addition, all parameters were considered alternative-specific to investigate the effect of variables according to the type of respondents' vehicles.

There are two approaches for investigating the heterogeneity of respondents' preferences through the MNL model. In the first approach, the representative variable of each group is used as a dummy variable in utility functions. The sign and coefficient value of this variable can indicate how the relevant group behaves in choosing the travel mode. In this approach, it is assumed that different groups have the same effect from other variables. But such a hypothesis is a little far from reality and interaction between variables is used to get closer to reality. In this case, the effect of each variable is seen separately on the target group. To determine the possible sources of any possible heterogeneity through the ML model, the interaction of any random parameter with other characteristics or variables that a person suspects that is likely to be the heterogeneity sources of preferences is investigated [38]. In other words, introducing an interaction between estimating the random parameter mean and a covariate is equal to revealing the presence or absence of heterogeneity around the mean parameter estimation. If this interaction is not statistically significant, it can be concluded that based on the observed covariates, there is no heterogeneity around the mean, but that does not mean that really there is no heterogeneity around the mean but only shows that we have not been successful in revealing its presence [40]. In this regard, in the utility function of $U_{\text{in}} = \beta_n' x_{\text{in}} + \varepsilon_{\text{in}}$ in which β_n is the coefficient matrix, x_{in} is the vector of the explanatory variable, and ε_{in} is the error, the result of the first two parameters, i.e., $\beta_n' x_{\text{in}}$, is the deterministic part of the utility function and the random parameter of β_n is not constant and changes between individuals to detect heterogeneity. Therefore, when the random parameter β_n in the mentioned utility function expands to $\beta_n = \beta + \gamma' z_n + \delta_n$, where β is mean and γ is the standard deviation of the random parameter of β_n, z_n vector consists of heterogeneity and has a mean and standard deviation of 0 and 1, respectively, and δ_n is the β error term [41].

4.3.2. Results and Discussion. Table 4 shows the results of the MNL and ML models. The overall MNL model is statistically significant (chi-square value of 767.1115 with 17 degrees of freedom), and the overall model fit for this model obtained from the pseudo-R^2 is 0.452 which is statistically acceptable for this class of model. In this model, the mean of all random parameters, i.e., in-vehicle time, access/egress time, and travel cost for both car and ATN options at the 1% level, was statistically significant. However, the non-random parameter of stop (which is only specific to ATN) is not statistically significant. The sign of the mean value of all random parameters is in accordance with expectations and negative.

The variables of access/egress time and in-vehicle time in the MNL model show that by increasing the amount of each of them, the utility and probability of choosing and using the relevant travel mode will decrease. In addition, increasing the ATN access/egress time compared to increasing the car access/egress time has a more negative effect on the utility and probability of using that travel mode. In other words, car users in the CBD are more willing to walk to their final destination from the car park or back compared to when they want to walk from the ATN station to their final destination or back. According to the data about the walking time of people to access/egress car and ATN, one of the main reasons for this propensity can be the shorter walking time of people to access/egress their car compared to ATN. In addition, people's willingness to drive can also be considered as another possible reason for their greater desire to access/egress cars compared to ATN. This tendency is rooted in topics such as emotions evoked while driving [42, 43] such as the feeling of pleasure [44] and symbolic functions of a car as a means of the expression of the self and social status [45, 46]. Of course, given that ATN vehicles were shared in this research and the passengers shared their trip and the vehicle with others, perhaps topics such as independency and privacy of cars [5, 47] can be considered as another reason for this.

However, the effect of variables of ATN and car in-vehicle times is not so different, indicating that the increase in in-vehicle time, both in the ATN and in the car, from the respondents' point of view will have almost the same effect on the utility and probability of using that mode. Although a lot of research assumes that the in-vehicle time, regardless of the travel mode, will be equally valued [48, 49], a review of other research shows otherwise. For example, Wardman showed that for car users, the value of car in-vehicle time is more than the value of public transport in-vehicle time [50]. In this research, based on the coefficients of in-vehicle time and travel cost, VoT estimates for ATN in-vehicle time and car in-vehicle time are 3936 and 5515 Tomans per minute (or 0.17 and 0.24 USD), respectively. Probably, the proximity of the attributes and characteristics of the ATN system to the car has led car users in the sample of this study not to put much different value on the in-vehicle time of the car and ATN, and hence the increase in this time, both in ATN and in the car, has the same effect on the probability of choosing them by the respondents. In general, both ATN in-vehicle VoT and car in-vehicle VoT are very low which may be due to low VoT in Iran according to the poor economy. This means that people tend to sacrifice a lot of time to save just a little bit on costs.

Increasing the cost of travel in accordance with expectations has a negative effect on the utility of both options, and this effect on ATN is more than the car. This finding is in line with the results of research about AVs, in which the cost of traveling by AVs is more negatively valued than the cost of traveling by car [51]. Regarding the present research, one explanation may be that many respondents who mentioned that they are capable of estimating their car travel cost underestimated their true cost of driving. Furthermore, it is also likely that paying for travel in the form of ATN fares, compared to paying the operating costs of the car, is more tangible for individuals and therefore has a more mental impact on them. As a result, the increase in the travel cost has a more negative effect on choosing the ATN option by individuals.

The statistically insignificant stop parameter shows that the stopping of ATN vehicles en route to pick up or drop off passenger(s) does not affect the utility of this system and, as a result, the probability of people using it. Perhaps one of the

Table 4: Results of MNL and ML models.

Attribute	Alternative	MNL			ML		
		Value	t ratio	p value	Value	t ratio	p value
Random parameter mean							
In-vehicle time (minute)	Car	−4.5	−3.24	0.00118	−0.1225	−0.78	0.4381
	ATN	−4.33	−3.05	0.00227	−0.02903	−3.46	0.001
Access/egress time (minute)	Car	−0.195	−7.6	0.001	−0.18659	−6.29	0.001
	ATN	−0.357	−7.61	0.001	−0.19007	−4.22	0.001
Travel cost (1000 Tomans)	Car	−0.816	−10.9	0.001	−0.00070	−8.38	0.001
	ATN	−1.1	−13.2	0.001	−0.00016	−5.09	0.001
Random parameter spread							
In-vehicle time (minute)	Car	—	—		0.00195	0.23	0.8174
	ATN				0.02903	3.46	0.001
Access/egress time (minute)	Car	—	—		0.00597	0.08	0.9387
	ATN				0.19007	4.22	0.001
Travel cost (1000 Tomans)	Car	—	—		0.00012	0.25	0.8051
	ATN				0.00016	5.09	0.001
Non-random parameters							
Constant	ATN	3.35	3.93	0.001	3.90992	3.78	0.001
Stop	ATN	−0.184	−1.07	0.287	−0.55337	−1.53	0.1261
Heterogeneity in random parameters							
In-vehicle time | work purpose	ATN	−0.32	−0.214	0.83	0.05306	3.03	0.0024
In-vehicle time | owning a hybrid car	ATN	1.8	1.24	0.217	0.06297	3.30	0.001
In-vehicle time | having a high school diploma	ATN	1.3	0.755	0.45	0.01416	0.63	0.5279
Access/egress time | work purpose	ATN	−0.0488	−1.08	0.28	−0.14520	−2.58	0.01
Access/egress time | owning a hybrid car	ATN	0.0312	0.721	0.471	0.02652	0.42	0.6719
Access/egress time | having a high school diploma	ATN	0.073	1.38	0.168	0.08662	1.19	0.2360
Travel cost | work purpose	ATN	0.0287	0.528	0.597	−0.00018	−2.92	0.0035
Travel cost | owning a hybrid car	ATN	−0.088	−1.67	0.0941	−0.00030	−4.28	0.001
Travel cost | having a high school diploma	ATN	−0.113	−1.84	0.066	−0.00011	−1.37	0.1710
LL (0)		−848.4121			−848.41215		
LL (β)		−464.8564			−560.42380		
Chi-square		767.1115			575.97670		
Pseudo-R^2		0.452			0.3394439 (McFadden pseudo-R^2)		
Observations		1224			1224		

most likely reasons why the stop parameter is not important for respondents is the shared taxi system in Iran that people are used to. This means a system in which each taxi does not only pick up a passenger or a group of passengers with the same origin and destination but may stop many times on the way to pick up or drop off passenger(s).

Examining the interaction between the random parameters of ATN in-vehicle time, ATN access/egress time, and the ATN travel cost and covariates of the trip purpose, owning a hybrid car and the level of education by the MNL model show that the multiplication of each of the dummy variables of having a high school diploma and owning a hybrid car in ATN travel cost variable is statistically significant at 10% level.

For those respondents whose highest educational qualification was a high school diploma (low literacy), the increase in ATN travel cost has a more negative effect, by 10.27%, compared to others, on the utility of the ATN option. A possible reason that made travel cost more important for these people compared to other respondents [52] is their lower income as a result of their lower education level [53]. In addition, since people with only a high school diploma are less literate than others, the benefits of sustainable transportation systems (such as ATN) are not so important for them compared to other people [54]. Therefore, they are willing to pay less for environmentally friendly options [55, 56], and thus this has likely caused the ATN travel cost to have a more negative impact on them than other groups. In addition, some studies such as the research conducted by Vij et al. have shown that the level of education of individuals has a direct relationship with the probability of using on-demand transportation systems [57], so people with higher education levels are more likely to frequently use on-demand transportation.

In addition, for people whose car is hybrid, the increase in ATN travel cost will have a higher negative effect on choosing the ATN option compared to those whose car is gasoline by 8%. Since some research conducted both in developed and developing countries indicated that one of the reasons people use hybrid cars is their lower fuel costs compared to gasoline cars and not environmental concerns [58–60], and these people are likely more sensitive to the cost compared to gasoline car owners. As a result, this sensitivity has caused the increase in the ATN travel cost to have a more negative effect on them than the owners of gasoline cars. It is worth mentioning that this result may be somewhat interesting, as some other research has shown that one of the reasons people buy hybrid cars is their environmental concerns [61] and these concerns indirectly increase people's WTP for renewable energy even in a developing country [62]. Therefore, based on this logic, it was perhaps expected that these people, due to their environmental beliefs, would accept the increase in the ATN travel cost, which is a clean and sustainable transportation system, and this increase would have less negative effect on them.

The lack of statistically significant interaction between other random parameters and covariates indicates that these interactions, based on the MNL model estimation, will not affect the utility of ATN and the probability of people using this system.

The overall ML model is also statistically significant (chi-square value of 575.97670 with 20 degrees of freedom). The overall model fit for this model obtained from the McFadden pseudo-R^2 is 0.3394439 which is statistically acceptable for this class of model. In this model, the mean of all random parameters except the car in-vehicle time was statistically significant at the level of 1%, and similar to the MNL model, the stop variable has not been statistically significant again. The sign of the mean value of all random parameters is in accordance with expectations and negative.

The results of this model show that by the increase in the amount of access/egress time variable, the utility and probability of using both ATN and car options will be reduced almost equally. This indicates that for individuals, walking to access a car or ATN or to egress these two vehicles has not much different negative effect on their decision to choose either of these two options. Research has shown that while the value of walk time is higher for car users than for public transport users [63], this time is equally valued by users of the metro and train which are both rail systems [50]. Therefore, similar to the in-vehicle time parameter in the MNL model, here it is again likely that the proximity of attributes and characteristics of the ATN system to the car has caused the increase in access/egress time for both of these options to have the same effect on their utility.

Additionally, the increase in the ATN in-vehicle time will have a negative effect on the utility of this option and reduce the probability of using it, which is obvious, because people usually choose the transportation mode that has the shortest in-vehicle time [64, 65].

Similar to the results of the MNL model in this model as well, the effect of the travel cost variable on the utility of both options is negative, but here the amount of this effect for the car option is more than ATN. Perhaps one of the main reasons is that considering the similarity of many car attributes and characteristics with the ATN system as well as considering the advantages of ATN as a sustainable transport compared to the car by respondents has caused the travel cost to have a more negative impact on the utility of the car option compared to ATN. For instance, regarding AVs, the cost will become less significant as the perceived benefits of travel time in an automated vehicle increase [66].

The statistically insignificant stop parameter, as in the MNL model, indicates that the stopping of ATN vehicles en route to pick up or drop off passenger(s) will not affect the utility of this system and, as a result, the possibility of people choosing it as a mode of travel.

The random parameters of the ATN in-vehicle time, ATN access/egress time, and ATN travel cost have statistically significant dispersion and spread, which indicate the existence of heterogeneity. According to this result, it is obvious that we see statistically significant results of interaction of these random parameters with the covariates of travel purpose, owning a hybrid car, and education level.

Heterogeneity in estimating the mean parameter of the ATN in-vehicle time × the work trip purpose at the 1% level is statistically significant and it has a positive sign which is against expectations. This finding is in line with the results of some research conducted in developed countries. For instance, Jain and Lyons indicated that since travel time is perceived in many different ways and is context-dependent, it is difficult to reduce it to a monetary value. According to this fact, travel time can in some cases be seen and experienced as a gift rather than a burden, at least for the passenger [67]. Furthermore, they found out that travel time is an ideal time for a lot of individuals in many cases and is an opportunity for them to deal with their daily activities and job-related responsibilities. For instance, some people consider the time spent traveling to work as a chance to think and plan out the upcoming activities, but they consider the time spent traveling back as a time for relaxing and letting go of the day's stresses in order to avoid bringing bad moods home and to create a clear gap between each day. Moreover, passengers generally would accept longer travel times if there is a chance for work during the trip or they would choose the slower travel mode if this mode has better conditions for working [67, 68]. Similarly, some other researchers discovered that people do not always try to have a shorter commute time and might rather seek to experience a longer trip if the trip duration is less than a desired minimum [69, 70]. This shows that traveling may have a role other than just moving from point A to point B and that people might truly enjoy it or use it for a specific reason [53]. In this regard, research conducted in the past on travel time has examined zero elasticity in Singapore [71] or positive elasticity in the USA [72] and there are interesting statements from the public about this issue. For example, some people believe that in the morning, their travel time allows them to do what they are supposed to do on the day or they have stated that they would rather take more than an hour to travel than have a 5-minute commute or have even said that their travel time is an opportunity for decompression [73]. Some other studies have examined a situation in which travel is not considered a byproduct of activity but rather itself constitutes that activity and thus argue that it is likely that this issue explains the evidence of excess travel, i.e., trips with more than the absolute necessary travel time, which can be seen even in the context of a mandatory journey [69]. In general, there are two possible reasons for excess travel. The first reason is the presence of unobserved objective factors, i.e., the case in which the negative marginal utility of the travel time increase is compensated by the utility of the activities performed simultaneously. The second reason is the presence of unobserved subjective factors, for example, the feeling of pleasure when driving a car, coupled with a positive social perception of having and using it, may justify the presence of additional trips [74]. According to this issue, the new and innovative ATN system for residents of a developing country such as Iran can be considered as one of the unobserved mental factors that by creating a feeling of pleasure and positive social perception in these people will justify additional trips.

Moreover, heterogeneity in estimating the mean parameter for the ATN in-vehicle time × owning a hybrid car at the level of 1% is statistically significant and its sign is positive. In this regard, it can also be said that since it is often not possible to clearly determine the impact of conjoint activities or travel experience factors, there is a significant risk of a biased estimate of the travel time coefficient. In such circumstances, model makers must acknowledge the potential impact of unobservable items on their estimates and accept the limitations of their model [39].

Based on the ML model, the marginal utilities and, as a result, the sensitivity of people with only a high school diploma (low literacy) to the increase in the ATN in-vehicle time are not different compared to other people.

The ATN access/egress time × work trip purpose which has a negative sign and is statistically significant at the 1% level indicates that people with work trip purpose, regarding their access/egress time, are different in terms of marginal utility compared to others. In other words, an increase in this time creates more sensitivity in these people and negatively affects their decision to use the ATN system. This finding is in line with the results of research on public transportation in both developing and developed countries that has investigated the effect of passengers' travel purpose on their sensitivity to the increase in the time to access the station [75–77]. Since both in developing and developed countries the VoT for work trips is higher compared to the VoT in trips with other purposes [63, 78], it is obvious that the increase in walking time to access/egress ATN will create more sensitivity for people who travel with the purpose of work. This finding again reinforces the possibility of correctness that the reason for the positive sign of heterogeneity in estimating the mean parameter for the ATN in-vehicle time × work trip purpose is not because of this issue that respondents do not value their time in work trips but instead, it is due to the presence of unobserved objective and subjective factors.

On the contrary, the marginal utilities and sensitivity of people whose educational qualification is a high school diploma or owning a hybrid car to the increase in ATN access/egress time are not different compared to others.

The heterogeneities in the mean parameters for the ATN travel cost × the work trip purpose and the ATN travel cost × owning a hybrid car have negative signs and are statistically significant at the 1% level. This shows that people with a work trip purpose or a hybrid car tend to have individual specific estimates for ATN travel cost parameter that are closer to zero. This means that these people are less sensitive to the increase in the ATN travel cost because people who travel for other purposes or whose car is not a hybrid tend to have a marginal utility greater than zero. This finding about the less sensitivity of work trips to the increase in ATN travel cost is in line with the results of research conducted by Matas et al. about public transportation [79] and the findings of other research in Iran that showed workers are less sensitive to travel cost than non-workers [80]. Furthermore, research conducted on the ATN system by Adler et al. also showed that users whose trips are non-working are sensitive to cost [17]. Perhaps more VoT in work trips can be considered as the likely reason for people's less sensitivity to travel cost. However, the finding of the ML model that people with hybrid cars are less sensitive to the ATN travel cost is exactly the opposite of the finding of the MNL model. Based on the ML model result, one possible explanation is that since ATN is among the environmentally friendly and sustainable transportation systems and people's environmental concerns are one of the reasons for buying hybrid cars and environmental concerns indirectly increase people's WTP for renewable energy, these individuals will incur an increase in the ATN travel cost and be less sensitive to this cost increase. Since people in low-income countries (such as Iran) have fewer environmental concerns compared to high-income countries [81] and also in recent years, the purchasing power of Iranians due to bad economic conditions has decreased a lot, the result of the MNL model seems more realistic in this field. It should be noted that the sensitivity of low-educated people to the increase in the ATN travel cost is not different compared to others.

From the comparison of the above two models, the ML model is more capable of capturing heterogeneity (i.e., differences in people's behavior that can be attributed to differences in their tastes and decision-making process in the population) than the MNL model, and this result is in line with the findings of other researchers such as Train [23]. In general, when the tastes associated with the observed variables change systematically in the population, this variation can be included in the MNL models; if the variety of tastes is at least partially random, MNL is a misspecification. However, it is also not a must and approximately MNL may be able to achieve average tastes even when tastes are also random, as the MNL formula is fairly robust against misspecification. Therefore, researchers may use MNL for simplicity, even when they know that tastes have a random term. Although researchers finally consider the ML model as the superior model for investigating and capturing heterogeneity compared to the MNL model, as the present study showed about heterogeneity in the mean parameter for ATN travel cost × owning a hybrid car, it is likely that the MNL model can in some cases contribute to more realistically capturing some heterogeneity.

5. Conclusions

The majority of Iranian cities, including Shiraz, are becoming more and more car-oriented, which causes traffic congestion and other related problems. An ATN system would be a viable option to address this issue given the current conditions in Iran, since ATNs may decrease the car-oriented rate and handle related issues by combining public, personal, and private transport. A deeper knowledge of how people, particularly car users, accept an ATN system is required in order to develop effective policies aimed at taking advantage of the benefits of ATN. The main goal of this study is to advance future research on the effects of ATNs on people's travel behavior through identifying the users' characteristics who probably accept the ATN system, by studying the heterogeneity in the preferences of these potential ATN users. Therefore, the results of the present study help to expand the existing literature about how people accept ATN systems.

For this purpose, a stated choice survey was conducted in which respondents were asked whether they were willing to use ATN instead of a car on a recent trip from the town where they live to the Shiraz CBD or vice versa. Additionally, various kinds of information about the mentioned recent trip and respondents' personal and socioeconomic characteristics were also collected. During the survey process, 408 questionnaires were collected from the residents of the Golestan and Beheshti towns. The survey then was analyzed using MNL and ML models.

The findings showed that for people with only a high school diploma or a hybrid car, the increase in the ATN travel cost had a more negative effect on utility and therefore on choosing the ATN option, compared to other people. In addition, the increase in ATN access/egress time creates more sensitivity in people who travel for work purposes than others and negatively affects their decision to use the ATN system and people with a work trip purpose are less sensitive to the increase in ATN travel cost. Moreover, by comparing the results of MNL and ML models, it was found that despite the greater ability of the ML model to estimate possible heterogeneity, it is likely that the MNL model can in some cases help to more realistically capture heterogeneity.

From this research, several policy implications can be derived. The findings show that the use of the ATN system is different among different demographic groups. Additionally, individuals' travel characteristics as well as their personal and socioeconomic characteristics affect the decision to use this mobility mode. Since there are not many job opportunities in a majority of towns and cities around the metropolises of Iran, they are just being used as dormitories for the workforce. Therefore, it is necessary to pay attention to the priorities and needs of commuters who travel for work purposes. In addition, due to the poor economic conditions of the people in Iran and the results of this study, it is necessary to be careful in determining the affordable travel fare for the ATN system.

Due to the hypothetical nature of the stated choice experiment, there may be a hypothetical bias in the data, i.e., the results obtained in this study may have limited value in the real environment. In this regard, although the results may not exactly reflect the preferences of decision makers, they can be useful in identifying people's directionality toward their attributes of interest and the relative importance of these attributes for them. The results of this study may have been exposed to a status quo bias. This is due to not only the hypothetical but also the futuristic nature of the ATN system for residents of a developing country such as Iran. Therefore, it is possible that the preferences elicited from respondents to the stated choice survey may not accurately reflect users' preferences when the ATN system is implemented and put into operation. Therefore, although the results now show the directionality and relative importance of different attributes of interest, it is necessary to refine the stated choice methods by considering hypothetical and status quo biases to predict the effects of ATN on people's travel behavior in a more precise manner.

To further improve our knowledge about people's preferences toward the ATN system in developing countries, this study recommends conducting attitudinal research in these regions. These attitudinal studies can cover topics related to the inherent attributes of ATN such as its comfort, safety, security, and visual barriers. In addition, to strengthen the body of literature related to how the ATN system is accepted by people in developing countries, similar research can be conducted among other developing nations. It should be noted that all available transport modes that can compete with the ATN system should be considered in the survey in order to prevent biased results.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Supplementary Materials

This section includes a sample of the online questionnaire used in this research. (*Supplementary Materials*)

References

[1] M. H. Abdi, "What the newcomers to transit-oriented development are confronted with? Evidence from Iranian policy and planning," *Journal of Transport Geography*, vol. 92, Article ID 103005, 2021.

[2] R. Etminani-Ghasrodashti, M. Paydar, and S. Hamidi, "University-related travel behavior: young adults' decision-making in Iran," *Sustainable Cities and Society*, vol. 43, pp. 495–508, 2018.

[3] A. Shaer, M. Rezaei, B. Moghani Rahimi, and F. Shaer, "Examining the associations between perceived built environment and active travel, before and after the COVID-19 outbreak in Shiraz city, Iran," *Cities*, vol. 115, Article ID 103255, 2021.

[4] A. Soltani, D. Pojani, S. Askari, and H. E. Masoumi, "Socio-demographic and built environment determinants of car use among older adults in Iran," *Journal of Transport Geography*, vol. 68, pp. 109–117, 2018.

[5] A. Soltani, "Social and urban form determinants of vehicle ownership; evidence from a developing country," *Transportation Research Part A: Policy and Practice*, vol. 96, pp. 90–100, 2017.

[6] J. M. Anderson, N. Kalra, K. D. Stanley, P. Sorensen, C. Samaras, and T. A. Oluwatola, "Autonomous Vehicle Technology," *A Guide for Policymakers*, vol. 23, 2016.

[7] R. Krueger, T. H. Rashidi, and J. M. Rose, "Preferences for shared autonomous vehicles," *Transportation Research Part C: Emerging Technologies*, vol. 69, pp. 343–355, 2016.

[8] D. Fagnant, K. Kockelman, and P. Bansal, "Operations of shared autonomous vehicle fleet for austin, Texas, market," *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2563, no. 1, pp. 98–106, 2016.

[9] Y. Liu, M. Tight, Q. Sun, and R. Kang, "A systematic review: road infrastructure requirement for Connected and Autonomous Vehicles (CAVs)," *Journal of Physics: Conference Series*, vol. 1187, no. 4, Article ID 042073, 2019.

[10] D. Jeffery, "Guidelines for implementers of personal rapid transit," 2010, https://www.rupprecht-consult.eu/fileadmin/user_upload/NICHES_1/NICHES_WG4.2_PRT.pdf.

[11] B. Furman, L. Fabian, S. Ellis, P. Muller, and R. Swenson, "Automated transit networks (ATN): a review of the state of the industry and prospects for the future," 2014, https://trid.trb.org/view/1323833.

[12] K. Mueller and S. Sgouridis, "Simulation-based analysis of personal rapid transit systems: service and energy performance assessment of the Masdar City PRT case," *Journal of Advanced Transportation*, vol. 45, no. 4, pp. 252–270, 2011.

[13] European Commission, "Evaluation and demonstration of innovative city transport (EDICT) [final report]," 2004, https://issuu.com/simplylovelife/docs/edict_final_report.

[14] M. Parent, "New technologies for sustainable urban transportation in europe," *Transportation Research Record*, vol. 1986, no. 1, pp. 78–80, 2006.

[15] H. Muir, D. Jeffery, A. D. May, A. Tripodi, S. Shepherd, and T. Vaa, "Assessing the contribution and the feasibility of a citywide personal rapid transit system," *Transportation Research Record*, vol. 2110, no. 1, pp. 163–170, 2009.

[16] H. Kim, H. Seok, S. Iris You, and C. Lee, "An empirical analysis for mode choice in a short-distance trip with personal rapid transit," *Journal of Advanced Transportation*, vol. 2020, Article ID 7436710, 13 pages, 2020.

[17] T. J. Adler, L. L. Rimmer, C. Szeto, R. A. North, and R. A. Shimizu, "Ridership estimation for a suburban prt system," in *Proceedings of the 4th National Conference on Transportation Planning Methods Applications*, Federal Transit Administration McTrans Center University of Florida, Gainesville, Florida, September 1993.

[18] K. Mobolaji, D. Földes, and C. Csiszár, "Concept of advanced personal rapid transit at airports," *Periodica Polytechnica: Civil Engineering*, vol. 65, no. 1, pp. 320–334, 2020.

[19] J. W. Yu and J. Y. Choi, "Diversion rate estimation model for unexperienced transportation mode by considering maximum willingness-to-pay: a case study of personal rapid transit," *Journal of Korean Society of Transportation*, vol. 31, no. 3, pp. 33–44, 2013.

[20] J.-W. Yu, S.-K. Shin, and J.-Y. Choi, "An approach to capture travelers' choice behaviour in response to unexperienced transportation modes: a case study of Personal Rapid Transit," in *Proceedings of the KSR Conference*, pp. 1730–1738, South Korea, May 2011.

[21] A. Thombre and A. Agarwal, "A paradigm shift in urban mobility: policy insights from travel before and after COVID-19 to seize the opportunity," *Transport Policy*, vol. 110, pp. 335–353, 2021.

[22] J. Li, Y. S. Chen, H. Li, I. Andreasson, and H. Zuylen, "Optimizing the fleet size of a Personal Rapid Transit system: a case study in port of Rotterdam," in *Proceedings of the 13th International IEEE Conference on Intelligent Transportation Systems*, pp. 301–305, Indianapolis, IN, USA, June 2010.

[23] K. E. Train, *Discrete Choice Methods with Simulation*, Cambridge University Press, Cambridge, UK, 2 edition, 2009.

[24] G. Tegner, "Personal rapid transit in stockholm market demand and economic appraisal," 2000, https://www.semanticscholar.org/paper/PERSONAL-RAPID-TRANSIT-IN-STOCKHOLM-MARKET-DEMAND-Tegner/38313f1082182ec14822be2ad5489ce5f79dc53f.

[25] H. Li, Y. Chen, J. Li, H. J. Zuylen, and B. Arem, "Demand modeling of innovative transport system PRT at the Rotterdam port area," in *Proceedings of the 13th International IEEE Conference on Intelligent Transportation Systems*, pp. 137–142, Macau, China, September 2010.

[26] M. Minderhoud and H. Zuylen, *Willingness-to-Pay for Personal Rapid Transit in the City of Almelo*, University of kansas, Lawrence, Kansaa, 2005.

[27] U. Jain, P. Sarkar, A. Vibhuti, and D. Arora, "Demand estimation of Personal Rapid Transit (PRT) using stated preference technique and binary logit models," *Journal of Transport Literature*, vol. 10, no. 2, pp. 5–9, 2016.

[28] J. Schweizer and J. Meggs, *PRT Mode Share Estimations Using a Direct Demand Stated Preference Method*, University of kansas, Lawrence, Kansaa, 2013.

[29] M. Lowson, "New approach to effective and sustainable urban transport," *Transportation Research Record*, vol. 1838, no. 1, pp. 42–49, 2003.

[30] A. Kohandel Shirazi, *Study of Propensity Level of Potential Users to Use Personal Rapid Transit (PRT) System: Case Study of Northwest Shiraz Towns, Iran, Master's Thesis*, Islamic Azad University Estahban Branch, Estahban, Iran, 2020.

[31] A. Kohandel Shirazi and H. R. Mokhtarian, "Investigating the willingness of potential users to use the personal rapid transit system (PRT): a case study of northwestern towns of Shiraz, Iran," *Quarterly Journal of Transportation Engineering*, vol. 14, no. 1, pp. 2301–2326, 2022.

[32] W. F. Kuhfeld, *Marketing Research Methods in SAS*, SAS Institute Incorporated, Cary, CA, USA, 2003.

[33] I. Andréasson, "Operational strategies from personal to mass transit," in *Proceedings of the 15th International Conference on Automated People Movers and Automated Transit Systems*, pp. 288–297, Toronto, Ontario, Canada, April 2016.

[34] New Zealand Ministry of Business, *Total Cost of Ownership: An Introduction to Whole-Of-Life Costing*, Government Procurement Branch Ministry of Business Innovation & Employment, New Zealand, 2013.

[35] E. A. Gilmore and L. B. Lave, "Comparing resale prices and total cost of ownership for gasoline, hybrid and diesel passenger cars and trucks," *Transport Policy*, vol. 27, pp. 200–208, 2013.

[36] S. Hess, *Advanced Discrete Choice Models with Applications to Transport Demand*, Ph.D. thesis, University of London, London, 2005.

[37] D. McFadden and K. Train, "Mixed MNL models for discrete response," *Journal of Applied Econometrics*, vol. 15, no. 5, pp. 447–470, 2000.

[38] D. A. Hensher, J. M. Rose, and W. H. Greene, *Applied Choice Analysis: A Primer*, Cambridge University Press, Cambridge, UK, 2005.

[39] S. Hess, M. Bierlaire, and J. W. Polak, "Estimation of value of travel-time savings using mixed logit models," *Transportation Research Part A: Policy and Practice*, vol. 39, no. 2-3, pp. 221–236, 2005.

[40] D. A. Hensher and W. H. Greene, "The Mixed Logit model: the state of practice," *Transportation*, vol. 30, no. 2, pp. 133–176, 2003.

[41] W. H. Greene, D. A. Hensher, and J. Rose, "Accounting for heterogeneity in the variance of unobserved effects in mixed logit models," *Transportation Research Part B: Methodological*, vol. 40, no. 1, pp. 75–92, 2006.

[42] J. Anable and B. Gatersleben, "All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes," *Transportation Research Part A: Policy and Practice*, vol. 39, no. 2-3, pp. 163–181, 2005.

[43] D. Lois and M. López-Sáez, "The relationship between instrumental, symbolic and affective factors as predictors of car use: a structural equation modeling approach," *Transportation Research Part A: Policy and Practice*, vol. 43, no. 9-10, pp. 790–799, 2009.

[44] G. Schuitema, J. Anable, S. Skippon, and N. Kinnear, "The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles," *Transportation Research Part A: Policy and Practice*, vol. 48, pp. 39–49, 2013.

[45] H. Dittmar, *The Social Psychology of Material Possessions: To Have Is to Be*, Martin's Press Harvester Wheatsheaf, Springfield, Missouri, 1992.

[46] L. Steg, "Car use: lust and must. Instrumental, symbolic and affective motives for car use," *Transportation Research Part A: Policy and Practice*, vol. 39, no. 2-3, pp. 147–162, 2005.

[47] A. Ellaway, S. Macintyre, R. Hiscock, and A. Kearns, "In the driving seat: psychosocial benefits from private motor vehicle transport compared to public transport," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 6, no. 3, pp. 217–231, 2003.

[48] F. J. Amador, R. M. González, and J. de Dios Ortúzar, "On confounding preference heterogeneity and income effect in discrete choice models," *Networks and Spatial Economics*, vol. 8, no. 2-3, pp. 97–108, 2008.

[49] M. J. I. Gaudry, S. R. Jara-Diaz, and J. D. D. Ortuzar, "Value of time sensitivity to model specification," *Transportation Research Part B: Methodological*, vol. 23, no. 2, pp. 151–158, 1989.

[50] M. Wardman, "Public transport values of time," *Transport Policy*, vol. 11, no. 4, pp. 363–377, 2004.

[51] M. D. Yap, G. Correia, and B. van Arem, "Preferences of travellers for using automated vehicles as last mile public transport of multimodal train trips," *Transportation Research Part A: Policy and Practice*, vol. 94, pp. 1–16, Dec. 2016.

[52] D. Ettema and L. Verschuren, "Multitasking and value of travel time savings," *Transportation Research Record*, vol. 2010, no. 1, pp. 19–25, 2007.

[53] I. Lavrinovicha, O. Lavrinenko, and J. Teivans-Treinovskis, "Influence of education on unemployment rate and incomes of residents," *Procedia Social and Behavioral Sciences*, vol. 174, pp. 3824–3831, 2015.

[54] D. Göddeke, K. Krauss, and T. Gnann, "What is the role of carsharing toward a more sustainable transport behavior? Analysis of data from 80 major German cities," *International Journal of Sustainable Transportation*, vol. 16, no. 9, pp. 861–873, 2021.

[55] A. W. Agrawal, J. Dill, and H. Nixon, "Green transportation taxes and fees: a survey of public preferences in California," *Transportation Research Part D: Transport and Environment*, vol. 15, no. 4, pp. 189–196, 2010.

[56] M. Mehedi Masud, A. Q. Al-Amin, R. Akhtar et al., "Valuing climate protection by offsetting carbon emissions: rethinking environmental governance," *Journal of Cleaner Production*, vol. 89, pp. 41–49, 2015.

[57] A. Vij, S. Ryan, S. Sampson, and S. Harris, "Consumer preferences for on-demand transport in Australia," *Transportation Research Part A: Policy and Practice*, vol. 132, pp. 823–839, 2020.

[58] B. A. Abbanat, "(CNG) vehicles in California households," *Alternative Fuel Vehicles: The Case of Compressed Natural Gas*, Master's Thesis, University of California, Davis, CA, USA, 2001.

[59] M. Shaterabadi, M. A. Jirdehi, and N. Amiri, "Impact of fuel price increasing policies on fuel smuggling and acceptance of green cars: a case study of Iran," *Journal of Engineering*, vol. 2022, no. 12, pp. 1239–1248, 2022.

[60] M. I. Khan and T. Yasmin, "Development of natural gas as a vehicular fuel in Pakistan: issues and prospects," *Journal of Natural Gas Science and Engineering*, vol. 17, pp. 99–109, 2014.

[61] J. J. Soto, V. Cantillo, and J. Arellana, "Incentivizing alternative fuel vehicles: the influence of transport policies,

attitudes and perceptions," *Transportation*, vol. 45, no. 6, pp. 1721–1753, 2018.

[62] C.-Y. Lin and D. Syrgabayeva, "Mechanism of environmental concern on intention to pay more for renewable energy: application to a developing country," *Asia Pacific Management Review*, vol. 21, no. 3, pp. 125–134, 2016.

[63] P. A. L. Abrantes and M. R. Wardman, "Meta-analysis of UK values of travel time: an update," *Transportation Research Part A: Policy and Practice*, vol. 45, no. 1, pp. 1–17, 2011.

[64] M. Chandra and R. S. Chalumuri Ch, "Commuter's sensitivity in mode choice: an empirical study of New Delhi," *Journal of Transport Geography*, vol. 57, pp. 207–217, 2016.

[65] B. Maitra, S. Dandapat, and P. Chintakayala, "Differences between the perceptions of captive and choice riders toward bus service attributes and the need for segmentation of bus services in urban India," *Journal of Urban Planning and Development*, vol. 141, no. 2, Article ID 04014018, 2015.

[66] J. J. LaMondia, D. J. Fagnant, H. Qu, J. Barrett, and K. Kockelman, "Shifts in long-distance travel mode due to automated vehicles: statewide mode-shift simulation experiment and travel survey analysis," *Transportation Research Record*, vol. 2566, no. 1, pp. 1–11, 2016.

[67] J. Jain and G. Lyons, "The gift of travel time," *Journal of Transport Geography*, vol. 16, no. 2, pp. 81–89, 2008.

[68] V. Kaufmann, "Temps et pratiques modales. Le plus court est-il le mieux," *Recherche Transports Sécurité*, vol. 75, pp. 131–143, 2002.

[69] P. L. Mokhtarian and I. Salomon, "How derived is the demand for travel? Some conceptual and measurement considerations," *Transportation Research Part A: Policy and Practice*, vol. 35, no. 8, pp. 695–719, 2001.

[70] S. Handy, L. Weston, and P. L. Mokhtarian, "Driving by choice or necessity?" *Transportation Research Part A: Policy and Practice*, vol. 39, no. 2-3, pp. 183–203, 2005.

[71] A. J. Richardson, "Some evidence of travelers with zero value of time," *Transportation Research Record*, vol. 1854, no. 1, pp. 107–113, 2003.

[72] L. Redmond and P. Mokhtarian, "The positive utility of the commute: modeling ideal commute time and relative desired commute amount," *Transportation*, vol. 28, no. 2, pp. 179–205, 2001.

[73] A. Sipress, *Not All Commuters Driven Crazy*, Washington Post, Washington, DC, USA, 1999.

[74] I. Salomon and P. L. Mokhtarian, "What happens when mobility-inclined market segments face accessibility-enhancing policies?" *Transportation Research Part D: Transport and Environment*, vol. 3, no. 3, pp. 129–140, 1998.

[75] S. Sadhukhan, U. K. Banerjee, and B. Maitra, "Commuters' willingness-to-pay for improvement of transfer facilities in and around metro stations a case study in Kolkata," *Transportation Research Part A: Policy and Practice*, vol. 92, pp. 43–58, 2016.

[76] S. Park, J. Kang, and K. Choi, "Finding determinants of transit users' walking and biking access trips to the station: a pilot case study," *KSCE Journal of Civil Engineering*, vol. 18, no. 2, pp. 651–658, 2014.

[77] S. Park, K. Choi, and J. S. Lee, "To walk or not to walk: testing the effect of path walkability on transit users' access mode choices to the station," *International Journal of Sustainable Transportation*, vol. 9, no. 8, pp. 529–541, 2015.

[78] Z. N. J. W. Van and M. Raza, "Search of the value of time: from South Africa to India," in *Travel Survey Methods*, P. Stopher and C. Stecher, Eds., Emerald Group Publishing Limited, Bingley, United Kingdom, 2006.

[79] A. Matas, J.-L. Raymond, and A. Ruiz, "Economic and distributional effects of different fare schemes: evidence from the Metropolitan Region of Barcelona," *Transportation Research Part A: Policy and Practice*, vol. 138, pp. 1–14, 2020.

[80] K. A. Azari, S. Arintono, H. Hamid, and S. R. Davoodi, "Evaluation of demand for different trip purposes under various congestion pricing scenarios," *Journal of Transport Geography*, vol. 29, pp. 43–51, 2013.

[81] A. Franzen and R. Meyer, "Environmental attitudes in cross-national perspective: a multilevel analysis of the ISSP 1993 and 2000," *European Sociological Review*, vol. 26, no. 2, pp. 219–234, 2010.