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Assessment of how Ride-Hailing services affect individual's travel mode choice in urban transportation

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ABSTRACT

BACKGROUND AND OBJECTIVES: Ride-hailing is a term to describe booking rides and paying for car services through a smartphone app with a Transportation Network Company. As an innovation in the ride-hailing investigation in Iran, this paper is sought to analyze the influence of individual's demographic characteristics on their travel mode choice between ride-hailing, traditional taxi and private car. For this purpose, questionnaires in six different statuses have been designed, and 414 questionnaires have been completed in 22 districts of Tehran metropolitan region.

METHODS: To check the utility of choosing private car and traditional taxi compared to ride-hailing, on short, medium, and, long travel distances with commuting and non-commuting purposes in the peak hours of morning and evening, the six multinomial logit models have been done by considering the ride-hailing option as reference alternative, and the private car and traditional taxi options as the first and second.

FINDINGS: Initially, six logit models were generated, which fitted models are all appropriate. All of the variables used in these models in choosing private car or traditional taxis compared to ride-hailing in different models were statistically significance. But, gender, household dimension, and individuals' educational level didn't affect the individual's choice.

CONCLUSION: The results showed that ride-hailing is more acceptable to younger people, and high-income people attract more to it. Therefore, ride-hailing services can be considered as a wealthy phenomenon and for the young generation. In addition, given the 67% response of individuals incline to use ride-hailing services in a shared way, because of the interest of individuals to use this mode of travel due to its lower cost in some situations, which can be considered as a separate mode of transportation.

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INTRODUCTION

Ride-hailing is one of the most rapidly growing forms of shared-mobility services. These services are also known as on-demand ride services, or Transportation Network Companies (TNCs), such as Uber and Lyft in the international transportation markets (Alemi *et al.,* 2019). These are a type of taxis, which offer personalized vehicle services. Ride-hailing, like traditional taxis, serves passengers to urban trips; but the main difference between them and traditional taxis is in the way that passengers request their travels, which is done through internet-based applications with GPS technology in smartphones. In this regard, ride-hailing services, while simplifying fare payment through online payment within the application, provide passengers with instant travel information, including the travel time within the vehicle and the waiting time for a taxi to arrive (Young and Farber, 2019). These services also have dynamic pricing, so that the price varies depending on the amount of route traffic, weather conditions, the request time, and other similar factors. The dynamic price of the ride-hailing can increase the tendency of people to request a taxi, which sometimes may even be lower than the usual and expected price (Rayle *et al.,* 2016). These applications minimize the chain which links a passenger to a driver by connecting the passengers to a network of available drivers (Contreras and Paz, 2018). Ride-hailing drivers are generally non-professional drivers (drivers who have other main occupations, and ride-hailing in their spare time with these applications as a part-time job) (Alemi *et al.,* 2018). Ride-hailing, like any other mode of transportation, has positive and negative consequences throughout the city. The negative consequences of this system are the competition with public transportation and reduce the use of public transportation, competition with active transportation systems (walking and cycling), increase the single-passenger car travel, and as a result, increase traffic congestion and greenhouse gases emission. But the positive consequences of this system are the replacement of this method instead of a private car in order to reduce the utility of owning a private car and play a complementary role for other modes of urban transportation, especially public transportation by providing these services and filling existing gaps in this area at the times and places where the available public transport services are weaker than required (Habib, 2019). There are a limited number of studies that investigate the behavior of urban passengers in choosing the travel mode in the field of ride-hailing services alongside other modes of urban transportation. (Rayle *et al.,* 2016) compared Uber and Lyft ride-hailing services to the traditional taxi industry but focused more on the features of the users of these services. They regarded ride-hailing as both a competitor and a complement to public transportation. According to them, ride-hailing is a hidden demand in urban transportation, and its users are much younger and more educated and much less inclined to own a private car than traditional taxi users. These findings were also confirmed by (Clewlow and Mishra, 2017), who compared ride-hailing passengers to other people in seven major US cities. The results of this study showed that ride-hailing users are younger, more educated, and have above-average incomes. In addition to traditional taxis, ride-hailing may be an alternative to other modes of transportation; in fact, they may deviate users from more sustainable systems such as public transportation and active transportation systems. This issue has become one of the criticisms of ride-hailing services and has made these services considered harmful to the goals of sustainable urban transportation. For example, the consequences of Uber's entry into urban transportation in major US cities showed a 6% reduction in public transportation use (Clewlow and Mishra, 2017). In addition to the above, there are other factors involved in choosing ride-hailing services as a way for people to travel, among them can be mention to safety and cost as the main reasons for deciding to trip via ride-hailing (Lavieri and Bhat, 2019; Souza Silva *et al.,* 2018). Often, the presence of children or the elderly in the household has a negative impact on the use of ride-hailing (Sikder, 2019). Also, ride-hailing does not have the problems of a private car, such as searching for a parking lot and driving while drunk or tired (Young and Farber, 2019; Rayle *et al.,* 2016). Furthermore, these services often attract people who want fast and affordable transportation and are looking to move directly from one place to another (Tang *et al.,* 2018). According to what was mentioned; in metropolitan regions, choosing a vehicle for traveling has always been one of the challenges facing people. Every day, people face the challenge of choosing the mode of available transportation for trips with different purposes. This step is called the modal split or choose a vehicle for travel. The modal split step is the third step of urban transportation system models, which also called four steps models. The four steps of these models include trip generation, trip distribution, modal split, and network assignments (Goulias, 2002; Hensher *et al.,* 2015). The four-step process is one of the most common methods of demand analysis in transportation planning. The modal split step plays a crucial role in public transport policy-making due to its manageable variables (Ortúzar and Willumsen, 2011). Despite increasing the commercial value of ride-hailing service provider companies and their effective role in urban transportation, limited information still exists about the type of people who use ride-hailing services, likewise, the purposes and distances of the trips made with this new mode of transportation. Besides, its impact on other modes of transportation, including traditional taxis and private cars, remains extensively unknown in many aspects. This issue has been considered as the main gap and the main sentence in this research. In addition, the main question of this research was who used the ride-hailing option compared to traditional taxis and private car for what distances and what purposes, and who did not? In this direction, for the first time in Iran, in this article the alternatives of Ride-hailing (RH), Traditional Taxi (TX; named as *taxi khatti* in Iran) and Private Car (PC) in the existing transportation system in the Tehran metropolitan region have been studied. Eventually, a road map for expressing the article structure presented in Fig. 1. That is the innovation of this study and also, one of the first ride-hailing studies in Iran. The current study has been carried out in Tehran metropolitan area in December 2019.

MATERIALS AND METHODS

Discrete choice method

The principal hypothesis of discrete choice models is that in the encounter with the situation of choosing, individual preferences for each option can be described by measuring the utility associated with each option. This tool is a function of the characteristics of the options and the decision-maker. It is assumed that the decision-maker chooses the option from which he receives the highest utility. However, the degree of utility is not directly observable or measurable. The discrete choice theory also assumes that the decision-maker

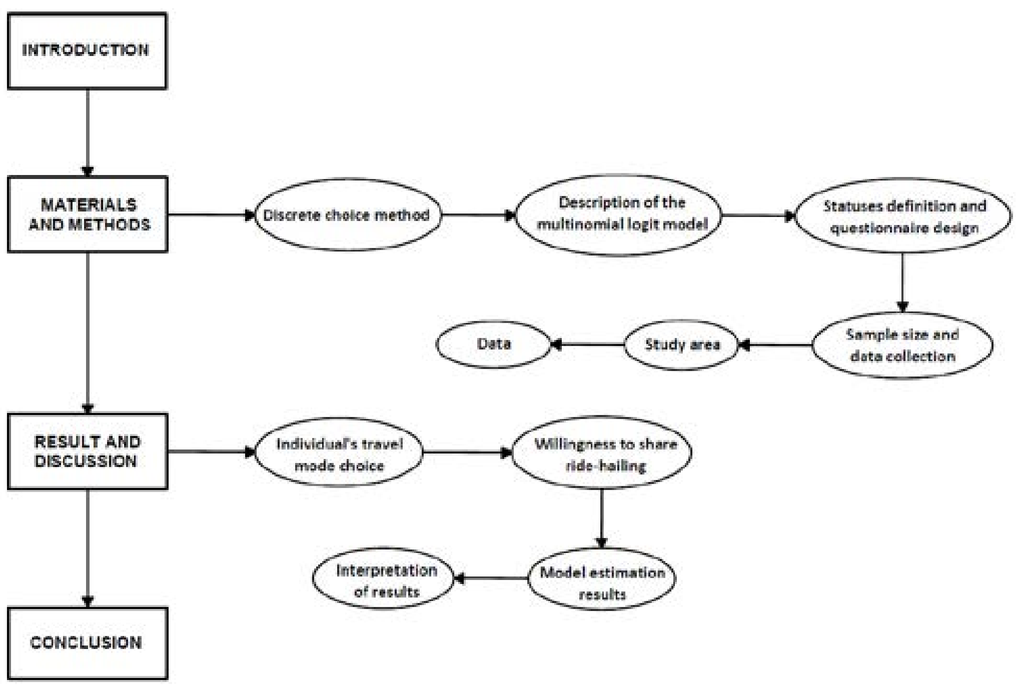

Fig. 1: Road map of paper

is faced with a set of options that he can choose only one of them, not some of each. Ultimately, the utilities are modeled stochastically, meaning that the selected models can only offer the probability of choosing options and cannot pick them directly (Ben-Akiva and Lerman, 1985; Sheffi, 1985; Antolín, 2018).

Description of the multinomial logit model

The choice of transport mode is probably one of the most important classic models for modal split in transport planning. This is because of the key role played by types of transport modes in policy making. (Ortúzar and Willumsen, 2011). Hence, a multinomial logit model (MNL) has been used to study who choose each of the mentioned modes in each status and figure out the mode share in this research. The multinomial logit models (MNL) are used when the dependent variable is nominal (a set of classes that cannot be meaningfully ranked). The existence of these three hypotheses together leads to the development of a well-known structure called the multinomial logit model (Ben-Akiva and Lerman, 1985):

1. The error components in the logit model have a Gumbel distribution.
2. The error components are distributed independently and uniformly in all alternatives.
3. The error components are evenly and independently distributed to all individuals or observations.

In discrete choice modeling, the utility function defined for decision-maker n is represented as Eq. 1. To select option i from the set of available choices. In this approach, stochastic modeling of each option for each individual has two components, a definite component and a random component. A variable is random, in which (Train, 2009; Tutz, 2002):

$$U_{in} = V_{in} + \varepsilon_{in} \tag{1}$$

In the above Equation, U_{in} is the perceived stochastic utility of option i for the n th individual, V_{in} is the measurable and predictable (systematic) utility of option i for the n th individual, and $å_{in}$ is the random component of error for option i and n th individual. According to logit models, by obtaining the utility function of each option (alternative), the probability of selection for each option is calculated according to Eq. 2 (Train, 2009; Tutz, 2002):

$$P_{in} = \frac{e^{U_{in}}}{\sum_{j=1}^{k} e^{U_{jn}}} \tag{2}$$

In the above Equation, P_{in} is the probability of choosing the i th option (alternative) by the n th individual, U_{in} is the utility of the option (alternative) i for the nth individual, and U_{jn} is the utility of other options (alternatives) for the n th individual. The multinomial logit model is a generalization of the simple logit model (binary) with the difference that in the simple logit model, the dependent variable takes one of the two values 0 or 1, but the dependent variable in the multinomial logit model can have more than two values. For example, suppose the variable $Y \epsilon \{1,2,\ldots,k\}$ is a dependent variable of the model that takes one of the numbers $1,2,\ldots,k$ for each set which has k member. For example, if the variable Y is the vehicle choosed for travel by one of the modes of a private car, traditional taxi, and ride-hailing the value of k is equal to 3. By considering the k th option (alternative) as the reference option (alternative), Eq. 3 is expressed as follows (Train, 2009; Tutz, 2002):

$$U_{in} = log\left(\frac{P(Y=i)}{P(Y=k)}\right) = \beta_{0i} + \beta_{1i}x_1 + \cdots + \beta_{qi}x_q + \varepsilon \quad , \quad i = 1,2,\ldots,k- \tag{3}$$

In the above Equation, U_{in} is the utility of the i th option (alternative) compared to the kth option (alternative) for the n th individual, $x_1,\ldots,x_q$ are independent variables from 1 to q, β_{0i} is the constant coefficient of the i th option, $\beta_{1i},\ldots,\beta_{qi}$ are coefficients of the independent variables from 1 to q for i th option (alternative), and ε is the random component of error.

Also, after fitting the logit model, an index called $McFadden's\ R^2 (Pseudo-R2)$ can be used to measure the goodness of fit of the model; the value of this index varies between zero and one. The closer this index is to one, the more the model matches the reality and the higher goodness of fit; conversely, the closer this index is to zero, the lower the goodness of fit. In the logit model, $McFadden's\ R^2$ statistic is obtained from Eq. 4:

$$McFadden\ R^2 = \rho^2 = 1 - \frac{LL(\beta)}{LL(0)} \quad (4)$$

In the above Equation, $LL(0)$ is the log-likelihood of the reduced model and $LL(\beta)$ is the log-likelihood of the full model. In other words, $LL(\beta)$ represents the maximum log-likelihood function calculated by Eq. 5:

$$LL(\beta) = log\big(L(\beta)\big) = \sum_{\forall\ n}^{N} \sum_{\forall\ j}^{J} \left[\delta_{jn} \times ln\left(P_{jn}(\beta)\right)\right] \quad (5)$$

In the above Equation, $L(\beta)$ is the maximum likelihood function, P_{jn} is the choice probability of the j th option (alternative) by the nth individual and δ_{jn} is also an index that if the n th individual chooses the j th alternative is equal to one, otherwise, it is zero. Moreover, in the interpretation of the goodness of fit of the logit model, according to Eq. 4, (McFadden, 1974) states that, for example, if $McFadden's\ R^2$ is between 0.2 and 0.4, it is entirely appropriate. Many empirical studies have also found that values greater than 0.1 are appropriate (Cohen *et al.,* 2002; Hu *et al.,* 2006).

Statuses definition and questionnaire design

For conducting this research, statistical modeling has been used. For this purpose, the *nnet package* has been used for modeling in the *R Studio* programming environment, and the multinomial logit model has been used with the maximum likelihood method in 6 statuses; In these 6 statuses, short, medium, and long-distance trips with commuting (work and study) purposes in the morning peak hours and non-commuting purposes (recreation, shopping, social, etc.) in evening peak hours, are separated from each other. The criteria for classifying travel distances and determining the peak time in the morning and evening are also presented in the following. In this study, trips less than 5 km are considered as short-distance trips, trips between 5 to 15 km are considered as medium-distance trips and trips longer than 15 km are considered as long-distance trips in urban trips (Agyemeang, 2017). Finally, the route from Sanat Square to Vanak Square as a short-distance route (5 km), Sanat Square to Seyed Khandan Bridge as a medium-distance route (12 km), and Sanat Square to Resalat Square as a long-distance route (18 km), are considered. Besides, according to Col. Abedi, Deputy Chief of the Greater Tehran Traffic Police, in an interview with ISNA News Agency: "Urban traffic reaches its peak between 7 and 8 a.m., in the morning. Also, in the evening, between 6 and 8 p.m., we see a high volume of traffic on city routes." As a result, in this article, the morning peak time is considered between 7 to 8 a.m. and the evening peak time between 6 and 8 p.m. Finally, by preparing the relevant surveys, according to the appendix at the end of the article in which 6 statuses of the article, the identification of way that individuals choose from the alternatives (ride-hailing, traditional taxi, and private car) according to the travel time and travel cost of each of the mentioned transportation systems, has been discussed in each of the six statuses. Whereas many private car and ride-hailing drivers use navigation applications such as Waze and Google Map to determine the optimal route with the least traffic and travel time, the travel time variable (within the vehicle) for private car and ride-hailing options is obtained according to the estimated time for the optimal route between the known origin and destination by Google Map application, and for the traditional taxi option, is obtained according to field research on the intended path in the morning and evening peak hours. The variable of travel cost for a private car has been calculated by considering the current annual expenses according to the prices in 2019 for a Pride car due to its multiplicity and prevalence. These costs include parking costs, fuel consumption based on distance traveled, insurance, car maintenance during the year according to the prices in 2019. This variable for a traditional taxi has been the same price approved by the Taxi Organization of Tehran in each of the known lines so that for Sanat Square to Vanak Square has been $0.31 for Vanak Square to Seyed Khandan Bridge has been $0.37 and for Seyed Khandan Bridge to Resalat Square has been $0.21 (in general approximately, 1 US Dollars is equal to 100,000 Iranian Rials in November and December 2019). For ride-hailing on the mentioned routes, both in the morning peak hour (7 to 8 a.m.) and the evening peak hours (6 to 8 p.m.), the prices in the Snapp application have been calculated every 10 minutes for a week on November 2019. The mean of them is considered as the price of ride-hailing for that route at that time (commuting trips in the morning peak hours and non-commuting trips in the evening peak hours).

Sample size and data collection

According to the statistics published in 2017, among 700,000 trips made every day and night in Iran, which was made by the Snapp service, 420,000 trips were made by the residents of Tehran metropolitan region (Etminani-Ghasrodashti and Hamidi, 2019). The minimum size of the statistical population according to these statistics, and by using Cochran's formula based on knowing the statistical population volume (Cochran, 1963), the number of 384 samples were obtained. In this study, 414 questionnaires were completed and collected. Data were collected from people living in Tehran on December 2019, in the form of face-to-face polls in collaboration with a questioning statistical team within the geographic location of studied routes. That is around the Sanat Square, Vanak Square, Seyed Khandan Bridge, and Resalat Square. So that initially, the person was asked whether he lives in Tehran or not, and if the answer was yes, he/she has been questioned.

Study area

This article seeks to investigate the effect of individual's demographic characteristics on their travel mode choice in 22 districts of Tehran. The study area and the geographic location of intended routes in this research is shown in Fig. 2.

Data

In order to modelling the choice of travel mode, the statistical data of the questionnaires were used, which are described in Table 1 and lists all the cases related to the demographic characteristics of the respondents in the survey as the independent variables used in the model. As can be seen, the variables of gender, marriage, having a child in the household, having a driver's license, and owning private car are defined in the form of binary variable, which success (variable equal to one) and failure (variable equal to zero). The variables of the number of household members, number of households employed members, and the number of cars in the household are defined continuous and integer. Also, other variables are defined dummy in the modeling process in which the first or last category is considered as the base category and is not included in the model. Furthermore, the dependent variables in this article are options of the private car, traditional taxi, and ride-hailing.

Fig. 2: Study area and geographic location of intended routes

Table 1: Descriptive statistics and definition of variables

Independent variables	Definition	Abbreviation in models	Count	Percentage
Gender	Male (Gender=1)	Gender	250	60.4%
	Female (Gender=0)		164	39.6%
Marital status	Married (Marital=1)	Marital	194	46.9%
	Single (Marital=0)		220	53.1%
Age	Age between 18-29 years	Age 18-29	203	49%
	Age between 30-39 years	Age 30-39	98	23.7%
	Age between 40-49 years	Age 40-49	73	17.6%
	Age between 50-59 years	Age 50-59	27	6.5%
	Age more than 60 years	-	13	3.2%
Job	Student	Student	98	23.7%
	Government employee or companies	Employee	158	38.2%
	Self-employment or businessman	Self-employee	114	27.5%
	Unemployed or retired	No job or retired	18	4.3%
	Other	-	26	63%
Monthly income ($1 is equal to 100,000 Iranian RIALS in December 2019)	Less than $200	-	18	4.3%
	Between $200 to $300	$200-$300	53	12.8%
	Between $300 to $400	$300-$400	61	14.7%
	Between $400 to $500	$400-$500	92	22.2%
	Between $500 to $600	$500-$600	52	12.6%
	Between $600 to $800	$600-$800	63	15.2%
	More than $800	More than $800	75	18.1%
Educational Level	Diploma & lower	Diploma	96	23.2%
	Post-diploma & bachelor's degree	Bachelor	169	40.8%
	Master's degree	Master	132	31.9%
	PHD	-	17	4.1%
Number of household members (household dimension)	One person	HHD	18	4.3%
	Two persons		67	16.2%
	Three persons		111	26.8%
	Four persons		142	34.3%
	Five persons or more		76	18.4%
Number of households employed members	No employed	HHEN	3	0.7%
	One person		183	44.2%
	Two persons		164	39.6%
	Three persons		45	10.9%
	Four persons or more		19	4.6%
Number of cars in the household	No car	HHCN	49	11.8%
	One car		238	57.5%
	Two cars		97	23.5%
	Three cars		23	5.5%
	Four cars or more		7	1.7%
Having child in the household	Yes (Have household child=1)	HHCh	115	27.8%
	No (Have household child=0)		229	72.2%
Having driver's license	Yes (Have driving license =1)	DL	343	82.9%
	No (Have driving license =0)		71	17.1%
Owning private car	Yes (Car ownership =1)	CO	190	45.9%
	No (Car ownership =0)		224	54.1%
Duration of residence in Tehran	Less than 1 year	-	20	4.8%
	Between 1 to 5 years	TRT 1-5Y	51	12.3%
	More than 5 years	TRT more than 5Y	343	83.9%
Residential area in Tehran	Northern areas	N residential	97	23.4%
	Western areas	W residential	61	14.7%
	Eastern areas	E residential	137	33.1%
	Southern areas	S residential	38	9.2%
	Central areas	-	81	19.6%

RESULTS AND DISCUSSION

Individual’s travel mode choice

Diagrams of the choice of each travel modes by the respondents between the alternatives of the private car, traditional taxi, and ride-hailing (modal split) according to the six statuses for short, medium and long-distance travel in each of the trips with commuting purposes (work and study) in the morning peak hours and with non-commuting purposes (recreation, shopping, social, etc.) in the evening peak hours are shown in Fig. 3a and 3b, respectively. According to these figures, it can be seen that the

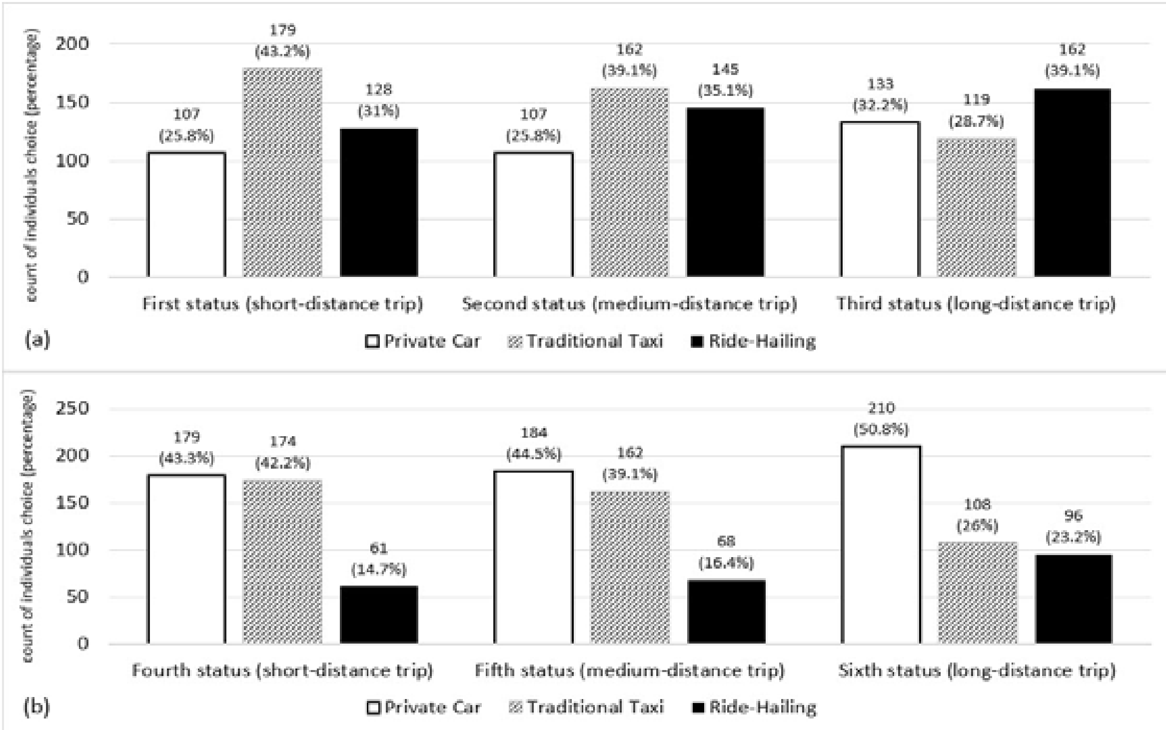

Fig. 3: Frequency distribution chart of individuals' chosen travel modes for: (a) commuting trips in the morning peak hours, (b) non-commuting trips in the evening peak hours

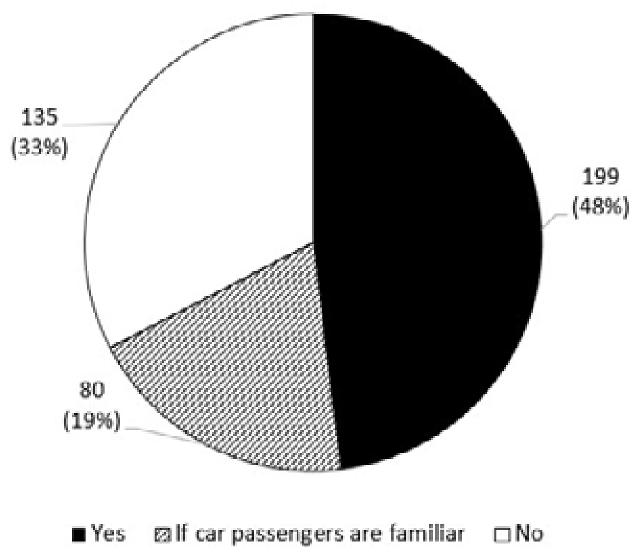

Fig. 4: Frequency distribution chart of individuals' willingness to share ride-hailing

demand of individuals to choose the option of ride-hailing for commuting trips in the morning peak hours is clearly higher than non-commuting trips in the evening peak hours, and vice versa for private car. Also, in general, the demand for traditional taxis is higher than the other two modes; however, with increasing travel distance, this demand decreases.

Willingness to share ride-hailing

According to previous studies result, other flexible and collective transports such as the emerging ridesharing and shared ride-hailing services might be, in some situations, more convenient means of transport (Gilibert *et al.,* 2020). In this section, the degree of respondents' willingness to the shared use of ride-hailing services if the travel destinations of passengers are close to each other is presented in Fig. 4. As can be seen, the highest relative frequency with 48% is related to people who agree with the shared use of ride-hailing regardless of other car passengers and by taking into account the other 19% for whom passenger familiarity is important, the 67% of people can be considered willing to use these services:

Model estimation results

In this article, in order to analyze the data and inference about the choice of individuals' travel mode in each of the six statuses, it has been investigated what variables are identified to be significant and have an influence on the choice of individuals' travel mode in the proposed statuses. In this modeling, the ride-hailing option is considered as a reference alternative, and the private car and traditional taxi options are considered as the first and second alternatives. In the modeling process for each status, a multinomial logit model is fitted to choose the Private Car as the first alternative compared to the Ride-Hailing as the reference alternative (PC/RH) and the Traditional Taxi as the second alternative compared to the Ride-Hailing as the reference alternative (TX/RH) for short, medium and long-distance travel in the form of commuting trips at the peak hours of the morning and non-commuting trips at the peak hours of the evening. Thus, the variables that have become significant at the 95% confidence level in the models, which means that the variables for which the P-value is less than 0.05 and according to this the t-statistic is out of the critical range (-1.96 and +1.96) is presented in Tables. 2, 3, 4, 5, 6 and 7:

According to above tables, the utility functions for each status in choosing Private Car and Traditional Taxi compared to Ride-Hailing (PC/RH and TX/RH) is expressed in Eqs. 6, 7, 8, 9, 10, 11, 12, 13 14, 15, 16 and 17 as follows:

Table 2: Result of multinomial logit model for 1st status

1st status	Variables	Coefficient	P-value (t-statistic)
	HHCh	0.885	0.028 (2.210)
PC/RH	DL	1.131	0.050 (1.968)
	CO	0.879	0.031 (2.164)
	Marital	-0.845	0.021 (-2.317)
TX/RH	Age 30-39	-1.995	0.033 (-2.140)
	More than $800	-1.637	0.042 (-2.039)

Table 3: Result of multinomial logit model for 2nd status

2nd status	Variables	Coefficient	P-value (t-statistic)
PC/RH	DL	1.670	0.004 (2.917)
	Student	1.310	0.040 (2.062)
	No job or retired	1.915	0.027 (2.226)
	$200-$300	-1.672	0.028 (-2.204)
	More than $800	-2.182	0.005 (-2.769)
TX/RH	HHCN	-0.648	0.003 (-3.025)
	DL	1.154	0.002 (3.117)
	E residential	0.957	0.012 (2.525)
	N residential	0.898	0.034 (2.121)
	W residential	1.011	0.021 (2.323)

Table 4: Result of multinomial logit model for 3rd status

3rd status	Variables	Coefficient	P-value (t-statistic)
PC/RH	HHCh	0.811	0.029 (2.185)
	DL	1.258	0.016 (2.423)
	CO	0.923	0.011 (2.549)
TX/RH	Age 18-29	-2.852	0.005 (-2.827)
	Age 30-39	-3.199	0.002 (-3.136)
	Age 40-49	-2.582	0.011 (-2.546)
	More than $800	-1.608	0.030 (-2.171)

Table 5: Result of multinomial logit model for 4th status

4th status	Variables	Coefficient	P-value (t-statistic)
PC/RH	Age 50-59	-2.224	0.045 (-1.999)
	HHCN	0.905	0.002 (3.133)
TX/RH	Constant	3.294	0.050 (1.977)

Table 6: Result of multinomial logit model for 5th status

5th status	Variables	Coefficient	P-value (t-statistic)
PC/RH	Age 50-59	-2.458	0.036 (-2.097)
	HHCN	0.991	0.005 (3.522)
TX/RH	Constant	5.624	0.005 (2.835)
	Marital	-1.217	0.015 (-2.450)
	$200-$300	2.394	0.044 (-2.021)
	More than $800	-3.135	0.011 (-2.565)
	HHEN	-0.538	0.030 (-2.176)
	E residential	1.240	0.008 (2.662)

Table 7: Result of multinomial logit model for 6th status

6th status	Variables	Coefficient	P-value (t-statistic)
PC/RH	Marital	-1.215	0.007 (-2.716)
	HHCN	0.945	0.001 (3.555)
	DL	1.124	0.011 (-2.564)
	CO	1.121	0.007 (2.727)
	TRT 1-5Y	2.062	0.008 (2.691)
	TRT more than 5Y	0.954	0.050 (1.966)
TX/RH	Constant	3.536	0.031 (2.161)
	Marital	-1.355	0.002 (-3.179)
	$200-$300	-1.716	0.015 (-2.451)
	$400-$500	-1.952	0.023 (-2.285)
	More than $800	-2.380	0.007 (-2.747)
	HHCN	-0.548	0.025 (-2.242)
	CO	-1.021	0.008 (-2.687)

Table 8: Final results of goodness of fit and validation of models in six statuses

	1st status	2nd status	3rd status	4th status	5th status	6th status
Maximum log-likelihood	-122.197	-140.796	-142.691	-154.460	-218.917	-194.230
McFadden's R^2	0.137	0.157	0.158	0.185	0.258	0.227
P-value in Hosmer-Lemeshow test	0.219	0.212	0.296	0.086	0.183	0.211

$$U_{1^{st}\ status,\ PC/RH} = \log\left(\frac{P(Y = private\,car\,in\,1^{st}\ status)}{P(Y = ride-hailing\,in\,1^{st}\ status)}\right) = 0.885 \times HHCh + 1.131 \times DL + 0.879 \times CO \quad (6)$$

$$U_{1^{st}\ status,\ TX/RH} = \log\left(\frac{P(Y = traditional\,taxi\,in\,1^{st}\ status)}{P(Y = ride-hailing\,in\,1^{st}\ status)}\right) = -0.845 \times Marital - 1.995 \times Age\,30-39 - 1.637 \times More\,than\ \$800 \quad (7)$$

$$U_{2^{nd}\ status,\ PC/RH} = \log\left(\frac{P(Y = private\,car\,in\,2^{nd}\ status)}{P(Y = ride-hailing\,in\,2^{nd}\ status)}\right) = 1.670 \times DL \quad (8)$$

$$U_{2^{nd}\ status,\ TX/RH} = \log\left(\frac{P(Y = traditional\,taxi\,in\,2^{nd}\ status)}{P(Y = ride-hailing\,in\,2^{nd}\ status)}\right) = 1.310 \times Student + 1.915 \times No\ job\,or\,retired - 1.672 \times \$200-\$300 - 2.182 \times More\,than\ \$800 - 0.648 \times HHCN + 1.154 \times DL + 0.957 \times E\,residential + 0.898 \times N\,residential + 1.011 \times W\,residential \quad (9)$$

$$U_{3^{rd}\ status,\ PC/RH} = \log\left(\frac{P(Y = private\,car\,in\,3^{rd}\ status)}{P(Y = ride-hailing\,in\,3^{rd}\ status)}\right) = 0.811 \times HHCh + 1.258 \times DL + 0.923 \times CO \quad (10)$$

$$U_{3^{rd}\ status,\ TX/RH} = \log\left(\frac{P(Y = traditional\,taxi\,in\,3^{rd}\ status)}{P(Y = ride-hailing\,in\,3^{rd}\ status)}\right) = -2.852 \times Age\,18-29 - 3.199 \times Age\,30-39 - 2.582 \times Age\,40-49 - 1.608 \times More\,than\ \$800 \quad (11)$$

$$U_{4^{th}\ status,\ PC/RH} = \log\left(\frac{P(Y = private\,car\,in\,4^{th}\ status)}{P(Y = ride-hailing\,in\,4^{th}\ status)}\right) = -2.224 \times Age\,50-59 + 0.905 \times HHCN \quad (12)$$

$$U_{4^{th}\ status,\ TX/RH} = \log\left(\frac{P(Y = traditional\,taxi\,in\,4^{th}\ status)}{P(Y = ride-hailing\,in\,4^{th}\ status)}\right) = 3.294 \quad (13)$$

$$U_{5^{th}\ status,\ PC/RH} = \log\left(\frac{P(Y = private\,car\,in\,5^{th}\ status)}{P(Y = ride-hailing\,in\,5^{th}\ status)}\right) = -2.458 \times Age\,50-59 + 0.991 \times HHCN \quad (14)$$

$$U_{5^{th}\ status,\ TX/RH} = \log\left(\frac{P(Y = traditional\,taxi\,in\,5^{th}\ status)}{P(Y = ride-hailing\,in\,5^{th}\ status)}\right) = 5.624 - 1.217 \times Marital - 2.394 \times \$200-\$300 - 3.135 \times More\,than\ \$800 - 0.538\,HHEN + 1.240 \times E\,residential \quad (15)$$

$$U_{6^{th}\ status,\ PC/RH} = \log\left(\frac{P(Y = private\,car\,in\,6^{th}\ status)}{P(Y = ride-hailing\,in\,6^{th}\ status)}\right) = -1.215 \times Marital + 0.945 \times HHCN + 1.124 \times DL + 1.121 \times CO + 2.062 \times TRT\,1-5Y + 0.954 \times TRT\ more\,than\,5Y \quad (16)$$

$$U_{6^{th}\ status\ ,\ TX/RH} = \log\left(\frac{P\left(Y = traditional\ taxi\ in\ 6^{th}\ status\right)}{P\left(Y = ride-hailing\ in\ 6^{th}\ status\right)}\right) = 3.536 - 1.355\times Marital - 1.716\times \$200 - \$300 - 1.952\times \$400 - \$500 - 2.380\times More\ than\ \$800 - 0.548\times HHCN - 1.021\times CO \tag{17}$$

Furthermore, the information about the goodness of fit and validation of the models is provided in Table 8, which includes the value of the maximum likelihood function and the $McFadden's\ R^2$ index to evaluate the goodness of fit of each of the fitted models in each of the six statuses; According to the (McFadden, 1974; Cohen *et al.,* 2002; Hu *et al.,* 2006), the accuracy of the fitted models is appropriate. Moreover, Hosmer–Lemeshow test was used to models' validation. Given that the P-value in the Hosmer–Lemeshow test for these models is higher than 0.05 (Hosmer and Lemeshow, 2004), the test shows that the fitted models are all appropriate.

Interpretation of results

According to the created models, variables of gender, educational level, and household dimension were not significant at the 95% confidence level. In other words, these variables in the above models do not affect the choice of travel mode of individuals. Unlike some studies in Western countries (Young and Farber, 2019; Rayle *et al.,* 2016; Tirachini and Río, 2019), in Iran, this article does not confirm the effect of gender, education, and the household dimension of individuals. The variable of individuals' age in the first status in the category of 30 to 39 years, and in the third status in the categories of 18 to 29 years, 30 to 39 years and 40 to 49 years, have become significant with negative coefficients in the utility of choosing a traditional taxi compared to ride-hailing. In other words, in this article, younger people increase the utility of choosing ride-hailing services compared to traditional taxis. Besides, this variable in the fourth and fifth statuses in the category of 50 to 59 years, have become significant with negative coefficients in the utility of choosing a private car compared to ride-hailing. This choice by the elderly can be due to inability, avoidance of driving, or lack of driver's license. Individuals' monthly income variable in the first and third statuses in the category more than \$800, in the second and fifth statuses in the categories between \$200 to \$300 and more than \$800 and in the sixth status in the categories between \$200 to \$300, \$400 to \$500 and more than \$800 were all have become significant with negative coefficients in the utility of choosing a traditional taxi compared to ride-hailing. Significance of the income range more than \$800 per month in all statuses except the fourth status indicates that with increasing income, people tend to use ride-hailing compared to traditional taxis. Therefore, individuals' income factor can be named as one of the motivating factors for people to use ride-hailing services. Besides, in this study, the individual's income amount does not affect the utility of choosing a private car compared to ride-hailing. The job variable of individuals in the second status in the categories of students and unemployed or retired have become significant with positive coefficients in the utility of choosing a traditional taxi compared to ride-railing; The results of this variable indicate that people who do not have a permanent job (student or unemployed) are likely, for economic reasons, to be less inclined to use ride-railing and prefer the traditional taxi option. The variables of having child in the household and owning private car in the first and third statuses, as well as having driver's license in the first, second and third statuses in the utility of choosing a private car compared to ride-railing were all have become significant with positive coefficients. Therefore, it can be concluded that these three variables can be used as a deterrent factor to the use of ride-hailing services, especially on commuting trips in the morning peak-hours. The variable of the number of cars in the household in the fourth, fifth, and sixth statuses in the utility of choosing a private car compared to ride-hailing have also become significant with a positive sign. This result indicates that the increase in the number of cars in the citizens' household directly affects their use of private cars compared to ride-hailing, especially on non-commuting trips during the peak hours of the evening. Therefore, the variable of the number of cars in the household is also one of the deterrent factors in the use of ride-hailing. Also, the variable of residency time between one to five years and more than five years in the Tehran metropolitan regions in the sixth status has become significant with a positive sign in the utility of using a private car compared to ride-hailing. From this factor, it can be concluded that Tehran citizens who have lived in Tehran for a long time, especially on their non-commuting long-distance travel, prefer to use their private cars.

CONCLUSION

Ride-hailing services as a newfound mode of transportation have grown significantly and are expected to continue to evolve. However, while it becomes stable in the urban transportation market, the impact of passenger behavior on the choice of this travel mode, both in short and long-distance urban trips, remains unknown. This article seeks to spread the existing studies by understanding trip behavior and demographic characteristics of individuals to use ride-hailing on trips with different distances, and commuting and non-commuting purposes. The various results of this article are as follows: As shown in the Fig. 3a and 3b, demand for ride-hailing option for commuting trips in the morning peak hours is clearly higher than non-commuting trips in the evening peak hours. This choice may be due to the fact that the passenger goes to work or study in the early-morning hours and spends several hours until the afternoon at work and study place, and during these hours, there is practically no need to trip and reuse the private car. As a result, instead of using a private car, which sometimes has problems such as parking and traffic restrictions at the location of the destination, the passenger prefers to use the best second option (Mahmoudifard *et al.,* 2017) after a private car, which is the ride-hailing. It does not have the problems of a private car and provides more comfort and less travel time than other modes of transportation, including public transportation and traditional taxis. It should be noted that for non-commuting trips in the peak hours of the evening, the predominant demand of people has been to use a private car. This choice may be due to the fact that these trips may be multi-destination, which can last until the last hours of the night. At this time, despite security concerns, in order to return home, other modes of transportation will not be readily available, in which case a private car is the best option in terms of comfort and safety in the late hours of the night. It is also observed that with increasing travel distance, the individuals' tendency to choose a private car and ride-hailing increases, and the choice of traditional taxi mode decreases. But in general, the demand for traditional taxis is higher than private cars and ride-hailing, although this high demand for traditional taxis seems to originate from its lower travel cost than the other two modes. The demand for this mode of transportation also decreases in a long-distance trip, which can be due to a significant increase in travel time compared to the other two methods. In addition to the direct relationship between the number of cars in the household and the choice of the private car instead of ride-hailing, especially in non-commuting trips during the peak hours of the evening and according to the analysis of descriptive statistics, it indicates the higher choice of the private car in these trips; In order to reduce the utility and multiplicity of private car ownership in the household and thus minimize the use of private cars, the government and responsible organizations by adding public transport stations and terminals and traditional taxis in areas where public transportation modes are less available, as well as increasing public transportation service in areas where there is insufficient service; Besides, disposal policies in this regard, such as parking and fuel pricing, can have a negative impact on the use of private cars. As another result in evaluating the models, considering the significance of the three variables of having a child in the household, having a driver's license and owning a private car in all statuses of the commuting trip in the morning peak hours, indicates that people with a driver's license, owning a private car and also having a child (under 12 years old) in the household, prefer to use the option of the private car instead of the ride-hailing for commuting trip (for example, trips for their work or education of their children). In this field, the Transport and Traffic Organization of Tehran Municipality, with the necessary policies, including restricting the movement of private cars in the peak hours of the morning in the central core of the city and districts with high population density and traffic, should reduce the desirability of owning a private car for such trips. Also, the significance of both private car ownership and the presence of a child in the household for the utility of choosing a private car on these trips show the safety and security concerns of parents about sending their children to school and, also, the lack of alternative and safe transportation mode. To this end, ride-hailing companies can attract a large share of trips by adding services for transporting children. Thus, many people who prefer a private car for their commuting trips in the morning peak hours, gradually turn to this mode of travel due to the convenience and many similarities that it has to travel by the private car. According to the modeling performed and the non-significance of the gender variable can be concluded that there was no gender sensitivity in choosing this mode of travel in this study. As a result, while there are public concerns of some women for safety and social security in the city, this can be considered as a sign of high safety and security of this mode of travel in public opinion, and it is necessary for the companies providing these services to maintain the safety of passengers, especially women. According to the results presented on the age and income of individuals similar to most studies conducted in Western countries (Rayle *et al.,* 2016; Dias *et al.,* 2016; Conway *et al.,* 2018), ride-hailing services can be considered a wealthy phenomenon and for the young generation. Therefore, in order for this travel mode to become widespread, the government must use the media to direct public opinion towards the use of the internet and technology for all segments of society, including the elderly, and thus to encourage citizens to choose this new mode of transportation for urban travel. Also, companies providing these services can adopt policies to reduce travel fares and offer special discounts and tariffs, to be successful in attracting and encouraging people with lower than average incomes, including young people and students, who are generally unemployed and do not have much income. As future studies, walking and public transportation modes (bus rapid transit and subway) can be considered in urban transportation, because many respondents in the survey process stated that they use public transportation to a great extent. Therefore, comparing ride-hailing and public transportation in metropolitan regions is also one of the important issues. Moreover, investigating the willingness of people to use ride-hailing at a lower price but sharing the ride with other people if their travel destinations are close to each other, given the 67% response of individuals incline to use ride-hailing services in a shared way, which is presented in Fig. 4., it is one of the most important and thought-provoking issues in this regard, which can be considered as a separate mode of transportation.

AUTHOR CONTRIBUTIONS

A. Edrisi conceived and defined the idea of research. H. Rezaei performed the literature review and conducted the field research, questionnaires, and sampling with the statistical team of the survey. E. Edrisi and H. Rezaei modeled and analyzed the data. H. Rezaei wrote the article. A. Edrisi revised the draft manuscript and finalized and approved the manuscript.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATION

CO	Car Ownership
DL	Driving License
HHCh	Household Child
HHCN	Household Car Number
HHD	Household Dimension
HHEN	Household Employee Number
MNL	Multinomial Logit
PC	Private Car
RH	Ride-Hailing
TNC	Transportation Network Company
TRT	Tehran Residence Time
TX	Traditional Taxi
Y	Years

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