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Ride-hailing, a new mode of commuting? Evidence from Tehran, Iran

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Abstract:

In the last decade, ride-hailing services have spread all over the world. While these technology-enabled services account for a small part of the modal split in many Western cities, the situation is different in the developing world, where many people use ride-hailing on a daily basis. To better understand the role of ride-hailing in the mobility system and to confirm the hypothesis that ride-hailing is a new mode of commuting, we constructed, tested, and administered a questionnaire on travel behavior and ride-hailing practices in Tehran, Iran. 601 questionnaires were completed in February 2019. Descriptive analysis is combined with correlation tests and a frequency model. The findings show substantial adoption of ride-hailing in the population, used by people from all social backgrounds as it is the most versatile and flexible mode of transportation in the metropolitan area. While there is a high rate of adoption, frequency of use is mainly determined by smartphone use and income level. Ride-hailing presents the comfort and speed of the private car to those who can afford this new mode on a daily basis, especially for university students, workers in the formal sector and women. Local authorities might consider ride-hailing as an alternative to the private car, in complement to public and semi-public transportation systems.

Keywords:

ride-hailing, daily travel, travel behavior, survey analysis, Tehran, developing country

Highlights

- Ride-hailing represents 5% of commute trips.
- Frequency of use is strongly influenced by smartphone use and income level.
- Students, workers in the formal sector and women are more likely to use ride-hailing.
- People use ride-hailing because of its comfort and speed

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1. Introduction

In the last decade, ride-hailing services have expanded all over the world. Some providers are internationally known firms such as Uber, Didi, or Lyft, whereas others – such as Snapp or Tap30 in Iran – are local operators. These services connect drivers with passengers via smartphone applications. They affect travel behavior in multiple ways, for example by increasing the number of options available for a trip, reducing uncertainty over travel and parking, or replacing other travel modes. At present, research into the impact of ride-hailing services on travel behavior remains limited (Lavieri and Bhat, 2019), mainly because of the scarcity of data. To our knowledge, most of the research on ride-hailing has focused on the Western world, especially North America (Rayle et al., 2016; Alemi et al., 2018; Young and Farber, 2019; Lavieri and Bhat, 2019). Little is known about the impacts of ride-hailing in other parts of the world, especially developing countries.

The aim of this research is to contribute to filling the gap in data on travel behavior related to ride-hailing in the developing world, where conditions often differ with respect to the growth in private motorization and in transit provision, and the use of taxis and shared taxis. We chose the city of Tehran in Iran as the case study for this research. The capital of Iran is a car-oriented city where a majority of the 8.7 million inhabitants rely on taxis, shared line taxis, and the private car for day-to-day travel (Allen, 2013). Despite improvements over the last two decades, the public transportation system remains inadequate to meet the population's increasing travel needs. Under these circumstances, local ride-hailing services have expanded fast. Our hypothesis is that ride-hailing has become a new mode of travel, used mainly for daily commuting, and that it has been adopted extensively in the population, with high frequency of use. To test the hypothesis, we put together a questionnaire on travel behavior in general and on the use of ride-hailing services in particular. We administered the questionnaire to inhabitants of Tehran in order to find out about their mobility practices, since there is no household travel survey publicly available for Tehran. To do this, we built a correlation test and a frequency model to accompany the descriptive analysis. The findings are discussed in terms of their policy implications.

The remainder of this paper is organized as follows. Section 2 contains a literature review on the users and uses of ride-hailing services. Section 3 introduces the case study and presents the analytical framework of the research. Section 4 sets out the main findings of the research in terms of travel behavior, the profiles of ride-hailing users and the use of the services. Section 5 completes the paper with a discussion of the policy implications and conclusions from the research.

2. Literature review

To use a ride-hailing service, travelers need to download an app to their smartphone. The spread of ride-hailing services depends on a high rate of penetration of smartphone use, and on affordable local Internet access. Smartphone ownership rates and the cost of mobile data vary widely across the world. The literature emphasizes the significant positive impact on ride-

hailing experience of familiarity with and use of information and communication technologies (Alemi et al., 2019; Lavieri and Bhat, 2019).

Besides familiarity and comfort with smartphone use as a main contributory variable in the use of ride-hailing services, socio-demographic variables play a role. In North America, users of ride-hailing services are mainly young urban adults with a college education and medium to high incomes (Clewlow and Mishra, 2017; Dias et al., 2017). They are less likely to be car owners than their non-ride-hailing counterparts (Clewlow and Mishra, 2017). There is also a negative correlation between having children and the use of ride-hailing among low- and middle-income households (Dias et al., 2017). Lower income individuals make more ride-hailing trips for utilitarian purposes, while individuals with higher incomes tend to make more trips to airports and the central business district, and for recreational purposes (Dias et al., 2019). In the developing world, users show a wider diversity in terms of income (Tirachini and Gomez-Lobo, 2018). In some of these countries, such as India, these services remain unaffordable at the lower end of the income scale and are not used by those at the upper end (Lozano Landinez and Shastry, 2018). In China, the factors that influence the use of ride-hailing instead of other travel modes are income-related (Tang et al., 2019).

The main reasons for the use of ride-hailing instead of the private car are shortages of parking space and drunk driving laws (Clewlow and Mishra, 2017), whereas bus passengers use it primarily because it is economical and saves time (Alemi et al., 2019). Sociodemographic variables are a significant determinant of trip frequencies (Dias et al., 2019), and other variables such as land-use mix or density of activities play a role (Alemi et al., 2019). Social and recreational trips largely dominate in North and Latin America (Lavieri and Bhat, 2019; Rayle et al., 2016; Young and Farber, 2019; Tirachini and Gomez-Lobo, 2018). However, frequent ride-hailing users are more likely to use the services for work-related purposes (Lavieri and Bhat, 2019). In China and India (Lozano Landinez and Shastry, 2018; Tang et al., 2019) routine trips, mainly work-related, dominate. This may be due to the lack of availability of private vehicles for daily mobility.

The impacts of ride-hailing services on urban transportation remain unclear and vary according to the characteristics of the built environment and population (Lavieri and Bhat, 2019). Ride-hailing is often a substitute for taxi trips. To a lesser degree, ride-hailing also replaces public transit, active travel modes, and solo driving (Clewlow and Mishra, 2017). In car-dominated urban areas, like Dallas, Texas, ride-hailing mainly replaces trips by private car or taxi. Women, more than men, tend to use ride-hailing to replace active modes or public transit (Lavieri and Bhat, 2019). Induced demand exists but remains small at around 6% to 8% of trips (Rayle et al., 2016; Lavieri and Bhat, 2019). Clewlow and Mishra (2019) reported that 9% of ride-hailing users they surveyed had disposed of a vehicle. However, there is no agreement in the literature that ride-hailing will reduce private car ownership (Jin et al., 2018). What is likely to happen everywhere is that ride-hailing will generate more “solo drive” trips and to a certain extent more traffic. This can result in increases in traffic congestion, energy consumption, and greenhouse gas emissions. More research is needed to shed light on these issues, especially in the context of emerging world cities where private motorization is increasing, and traffic congestion and air pollution are high (Dimitriou and Gakenheimer, 2011).

In the light of these insights from the literature, it is particularly interesting to study a car-centric city in the developing world, such as Tehran, in order to assess whether or not there is a correlation between the impacts of ride-hailing on travel behavior and urban and social conditions. The main aims of the research are to understand (1) the factors that determine travel

behavior relating to ride-hailing and (2) the impact of ride-hailing on the use of other modes of transport.

3. Data and analytical framework

3.1 Case study

The city of Tehran has a population of 8.7 million, with 13.3 million living in the Tehran region (Iran Census, 2016). Located in north-central Iran between the slopes of the Alborz mountain range and the central plain, the city is characterized by a dramatic topography with an altitude range of more than 1,000 meters. In the north, the mountains limit urban sprawl, whereas to the south the city opens onto the desert. The city is socio-spatially segregated. Wealthy residents live at higher altitudes where the air is less polluted and cooler. The motorization rate continues to rise (Soltani et al., 2018) and is strongly favored by government policies. Gasoline is still highly subsidized, although the government has recently reduced the subsidies. These car-friendly policies have resulted in major traffic congestion, parking shortages, and air pollution. Transportation is the main source of air pollution in Tehran (Soltani, 2017). The municipal authorities have introduced two downtown traffic zones to restrict automobile use. A restricted traffic zone – which people pay an annual fee to enter – was implemented in 1981 (Allen, 2013). In 2005, an odd-even traffic scheme was introduced around the restricted travel zone (Figure 1). Still in force at the time of survey, the odd-even scheme was replaced by a new air pollution control scheme in June 2019. The geographical boundary is the same. All vehicles can now enter the zone for free for a maximum of 80 days per year, regardless of their license plate.¹

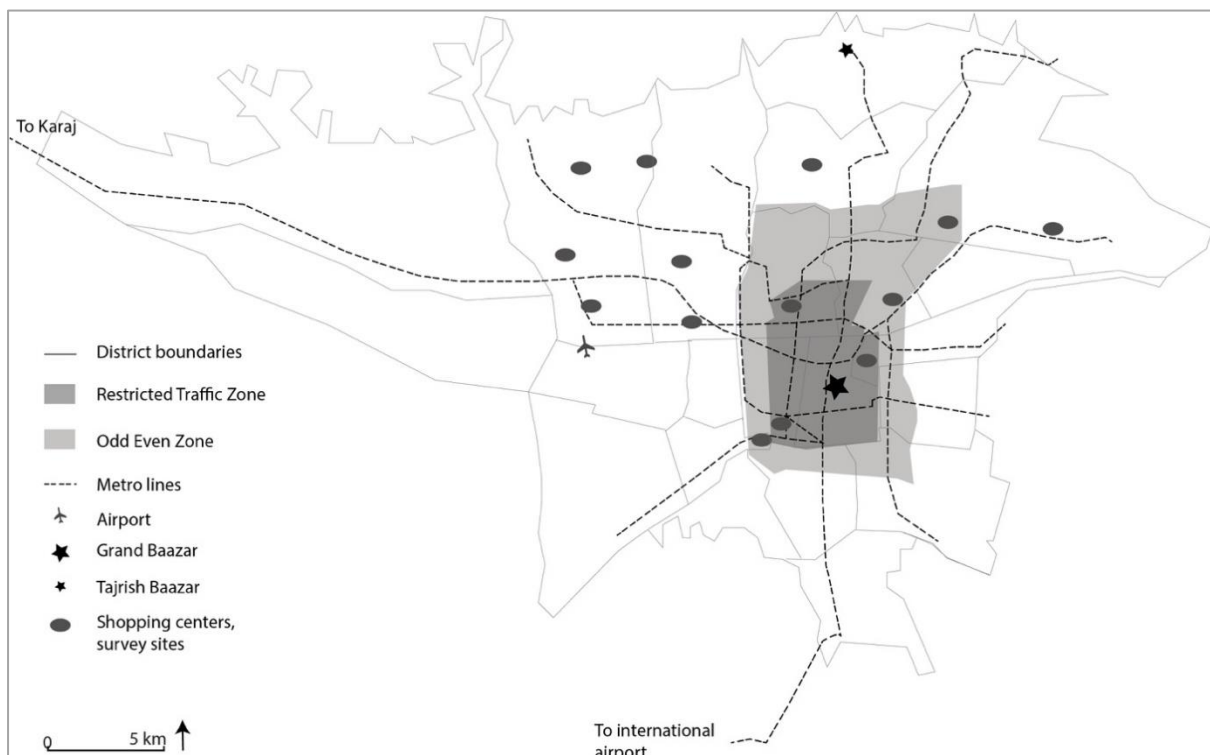


Figure 1- The city of Tehran

¹ Financial Tribune, 2019. Tehran Mulls Modifications to Air Pollution Control Scheme, Article November 19, 2019, <https://financialtribune.com/articles/people/100619/tehran-mulls-modifications-to-air-pollution-control-scheme>

Besides the implementation of traffic schemes, the public transportation network has been improved in the last two decades. The first metro line was launched in 1999 and the first BRT line in 2007 (Allen, 2013). There are now 7 metro lines, 10 BRT lines, plus a large bus network. In addition to mass transit, there are numerous on-demand taxis, company minibuses for employees, and shared line taxis running on specific routes. Metro fares are highly subsidized to allow the poor to travel. The metro mostly operates as a suburban train, with long distances between stations. Many shared line taxis operate as feeder modes for the metro. This situation does not satisfy middle-class and wealthy users, who prefer to use on-demand and line taxis, and increasingly the private car.

To our knowledge, there is no publicly available household travel survey for Tehran city. Table 1 shows estimates of modal shares based on a number of previous independent studies. Motorized travel modes are very dominant. Soltani (2017) estimates that 55% of all the trips made every day are work- and school-related.

| | Hashemi, 2010 cited by Allen, 2013 | Soltani, 2017 | Tehran Municipality, 2015 cited by Nassereddine and Eskandari, 2017 |
|-----------------|------------------------------------|---------------|---|
| Metro | 11% | 12% | 11.8% |
| Bus & BRT | 23% | 11% | 18.3% |
| Taxi & minibus | 36% | 37% | 20.4% |
| Private vehicle | 30% | 40% | 49.5% |

Table 1 - Estimated modal split in Tehran

Favorable conditions for motorized travel, affordable Internet data, and the growing penetration of smartphones are among the main reasons for the success of ride-hailing services in Iran. In Tehran, five ride-hailing services are currently operating. The most popular is Snapp, followed by Tap30, Ding, Maxim, and Carpino. Snapp was launched in 2014 and is present in more than 100 cities across the country. According to the company website, the application has been installed more than 10 million times. As of today, about 500,000 drivers work for Snapp.² Most are ordinary drivers operating with their own vehicles, usually locally manufactured mid-category cars. Taxi drivers can also join the platform. About 1 million rides are requested every day across the country. Available in both Persian and English, the app allows multiple stops on a single ride. At the time the data were collected, the company charged a 13% commission for each ride, though this rate has recently been increased to 15%. Fares are based on proprietary formulae and vary according to traffic conditions (e.g. evening slots are more expensive than afternoon slots) and to the weather (rain increases the fare). The minimum fare is less than a dollar. Despite high inflation, it remains affordable for a large proportion of the population, even though it is on average some ten times more expensive than a bus or metro ticket or a liter of gasoline.³

3.2 Survey

The data used for the analysis were obtained through a face-to-face survey. In order to establish a random sample of inhabitants, we selected ten shopping centers across the city as survey sites (Figure 1). Shopping centers are important social hubs for the Iranian population, with an even mix of gender and income. A pilot questionnaire was tested in January 2019. The questionnaire was then administered in February 2019, at weekdays and weekends. The investigators were recruited from students at the University of Tehran. In total, 601 completed questionnaires were collected.

² These data are retrieved from <https://snapp.ir/about>, April 30, 2019.

³ At the time of the survey (February 2019), gasoline was sold at a subsidized rate of about 10 cents a liter.

The investigators presented the survey as a 10-minute questionnaire on mobility practices in Tehran. The questionnaire was divided into two parts. The first part was general. It started with questions on sociodemographic characteristics, followed by questions about attitudes to smartphone use, home and work location, travel practices (car ownership, parking, and access to work by public transportation). It then continued with questions on daily travel behavior, with a focus on commuting trips. Respondents were asked to indicate what mode they generally used for commuting trips, their usual time of departure from home and their usual time of arrival at work or school. Car drivers were asked a specific question on parking at destination. Then all the respondents reported how often they used the different modes of transportation available in their area in the course of a month, starting with the private car, then public transportation (metro, BRT, or bus), following by line taxi, on-demand taxi, and ride-hailing. The second part of the questionnaire was dedicated to the adoption and use of ride-hailing services. Respondents who reported no use of ride-hailing services or using them less than once a month answered questions on their reasons for not using these services and on what would persuade them to adopt them. Respondents who reported using ride-hailing services once a month or more were asked to recall the details of their last ride-hailing trip. They gave information on the purpose of travel, the time of day, the length of trip, the service used, the fare paid, the mode replaced, and the reason for choosing ride-hailing. The survey ended with questions on living standards and income.

3.3 Analytical framework

A two-step approach was adopted for this research. First, we analyzed general travel practices in Tehran. Then we studied ride-hailing practices in terms of frequency of use. We distinguished between individuals who used a ride-hailing service at least once a month, defined as “users”, and those who never or very infrequently used ride-hailing, defined as “non-users”, to test our hypothesis about ride-hailing as a new mode of commuting. Figure 2 presents the framework.

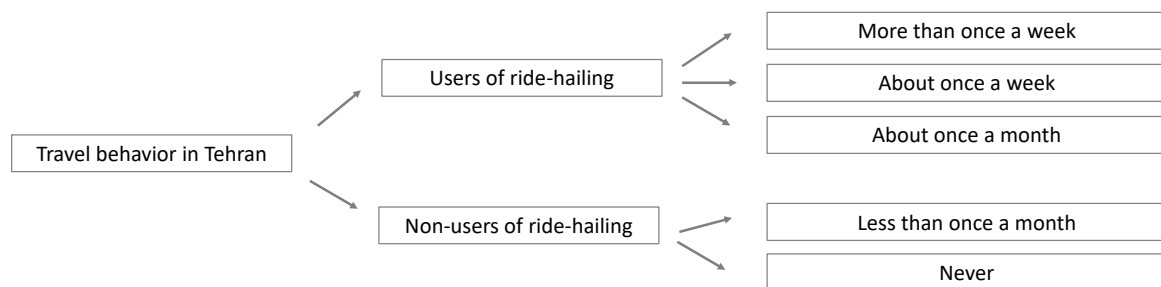


Figure 2 – Analytical framework based on the frequency of ride-hailing use

We then pursued a two-step methodology: (1) First, we used descriptive statistics to establish the socioeconomic characteristics of ride-hailing users and Chi-square tests to evaluate the dependence/independence of ride-hailing frequencies on demographic characteristics in the case of individuals considered as users. All statistical analyses were conducted using R 3.3.1, employing a variety of packages (R Core Team, 2019). (2) Then, we implemented an ordered logit model to evaluate the contribution of different parameters in explaining the propensity to use ride-hailing services. The findings are the factors to be considered in policy making. The PandasBiogeme package (Bierlaire, 2018) is used for estimating the ordered logit model.

3.4 Sample description

In this section we describe the sample in terms of sociodemographic characteristics, smartphone use, and car ownership. Table 2 presents a comparison of the sample with the

population of the Tehran region, as characterized by the 2016 National Population and Housing Census. The comparison shows consistency in terms of gender distribution, with men being slightly more numerous than women in both cases (50.6% of males in the survey compared to 50.3% in the Census data). The age breakdown in the survey is more consistent with the census data for the four intermediate age groups, although it is still more skewed towards the 18 to 24 age bracket. The reasons may be related to the choice of survey location, as the young and elderly may frequent shopping centers less often. The effect of this inconsistency on the results of the study is not expected to be significant, since the two underrepresented age groups have a lower rate of smartphone ownership and are much less likely to use ride-hailing on their own.

| | | Sample | <i>Tehran region (2016 Census)</i> | |
|------------|--------------|--------|------------------------------------|-------|
| Population | | 601 | 13,267,637 | |
| Gender | Male | 50.6% | <i>Male</i> | 50.3% |
| | Female | 49.4% | <i>Female</i> | 49.7% |
| Age | Under 18 | 4.7% | <i>Under 15</i> | 20.2% |
| | 18-24 | 25.5% | <i>15-24</i> | 13.4% |
| | 25-34 | 26.6% | <i>25-34</i> | 21.7% |
| | 35-49 | 23.8% | <i>35-49</i> | 23.7% |
| | 50-64 | 19.0% | <i>50-64</i> | 14.1% |
| | 65 and above | 0.5% | <i>65 and above</i> | 6.8% |

Table 2 - Comparing gender and age distribution of the sample with the 2016 census

Table 3 presents the distribution of the sample. The sample consists of 49% female and 51% male respondents. With respect to age, 76% of the respondents are between 18 and 50 years old, with a uniform distribution across three age ranges. Nearly 30% of the sample have a high-school diploma, about 45% a bachelor's degree, 21% a master's degree, and around 5% a PhD or medical degree.

| Variable | Count (out of 601) | % Total | Count in ride-hailing users (out of 456) | % in ride-hailing users |
|--------------------------------|-----------------------|---------|---|----------------------------|
| <i>Gender</i> | | | | |
| Female | 297 | 49.4 | 229 | 50.2 |
| Male | 304 | 50.6 | 227 | 49.8 |
| <i>Age</i> | | | | |
| Under 18 | 28 | 4.7 | 21 | 4.6 |
| 18-24 | 153 | 25.5 | 127 | 27.9 |
| 25-34 | 160 | 26.6 | 124 | 27.2 |
| 35-49 | 143 | 23.8 | 108 | 23.7 |
| 50-64 | 114 | 19.0 | 74 | 16.2 |
| 65 and above | 3 | 0.5 | 2 | 0.4 |
| <i>Occupation</i> | | | | |
| Business owner | 116 | 19.3 | 79 | 17.3 |
| Private sector employee | 124 | 20.6 | 97 | 21.3 |
| Public sector employee | 71 | 11.8 | 55 | 12.1 |
| High-school student | 34 | 5.7 | 27 | 5.9 |
| University student | 118 | 19.6 | 111 | 24.3 |
| Informal sector | 19 | 3.2 | 8 | 1.8 |
| Retired | 41 | 6.8 | 29 | 6.4 |
| Housewife | 62 | 10.3 | 37 | 8.1 |
| Unemployed | 16 | 2.7 | 13 | 2.9 |
| <i>Education level</i> | | | | |
| Completed high school | 176 | 29.3 | 105 | 23.0 |
| Completed undergraduate degree | 268 | 44.6 | 221 | 48.5 |
| Completed graduate degree | 126 | 21.0 | 107 | 23.5 |

| | | | | |
|---|-----|------|-----|------|
| Completed medical degree | 18 | 3.0 | 13 | 2.9 |
| Completed PhD | 13 | 2.2 | 10 | 2.2 |
| <i>Smartphone use</i> | | | | |
| Very active | 102 | 17.0 | 83 | 18.2 |
| Active | 212 | 35.3 | 177 | 38.8 |
| Common | 186 | 30.9 | 145 | 31.8 |
| Basic | 62 | 10.3 | 41 | 9.0 |
| No use | 25 | 4.2 | 8 | 1.8 |
| No smartphone | 14 | 2.3 | 6 | 0.4 |
| <i>Household Composition</i> | | | | |
| Single | 124 | 20.6 | 92 | 20.2 |
| Couple with no children | 89 | 14.8 | 67 | 14.7 |
| Couple with one child | 105 | 17.5 | 81 | 17.8 |
| Couple with more than one child | 223 | 37.1 | 174 | 38.2 |
| Single parent with one child | 0 | 0 | 0 | 0 |
| Single parent with more than one child | 0 | 0 | 0 | 0 |
| Other (e.g. living with grandparents) | 60 | 10.0 | 42 | 9.2 |
| <i>Household car ownership</i> | | | | |
| 0 | 95 | 15.8 | 73 | 16.0 |
| 1 | 313 | 52.1 | 224 | 49.1 |
| 2 or more | 193 | 32.1 | 159 | 34.9 |
| <i>Access to a reserved parking place at work/school</i> | | | | |
| Yes | 220 | 36.6 | 177 | 38.8 |
| No | 220 | 36.6 | 169 | 37.1 |
| N/A | 161 | 26.8 | 110 | 24.1 |
| <i>Household monthly income (in million tomans⁴)</i> | | | | |
| Less than 1.5 | 29 | 4.8 | 21 | 4.6 |
| 1.5 – 2.5 | 87 | 14.5 | 55 | 12.1 |
| 2.5 – 4 | 162 | 27.0 | 122 | 26.8 |
| 4 – 6 | 158 | 26.3 | 122 | 26.8 |
| 6 – 8 | 88 | 14.6 | 72 | 15.8 |
| 8 and above | 77 | 12.8 | 64 | 14.0 |

Table 3 - Sociodemographic distribution of the sample

The three dominant occupations are private sector employees, business owners, and university students, each accounting for about 20% of the sample. They are followed by public sector employees (12%) and housewives (10%). The rate of household vehicle ownership is significantly higher among business owners, where more than 90% of households have at least one vehicle. The ownership rate drops to 85% for private sector employees and around 80% for public sector employees. Students have a relatively high rate of ownership, probably because they come from middle-aged families with sufficient resources to own a car. The lowest ownership rate, at just under 75%, is among respondents working in the informal sector. Having access to a reserved parking place at work or school is not an option for all respondents. In fact, for a quarter of them it is not applicable. About half of the remaining sample of respondents have access to a parking space at their destination, whether the whole sample or only ride-hailing users are considered. However, some differences can be observed in terms of occupation. The proportion of private sector employees and university students with no access to parking at their destination is greater among ride-hailing users than in the sample as a whole. Breakdown tables for these statistics are not provided for the sake of brevity.

Interestingly, more than half of the respondents consider themselves to be very active smartphone users, which correlates well with the youth of the population. Moreover, 31% use smartphones on a day-to-day basis and 10% find them difficult to use. Only about 7% do not

⁴ One million tomans at the time of the survey (Feb. 2019) was roughly equal to 75 to 80 USD.

use smartphones at all. A breakdown of smartphone use by age reveals that people tend to use smartphones more moderately as they grow older. Also, a breakdown by gender shows that men tend to use smartphones slightly less than women (Table 4).

| Smartphone use | Very active | Active | Common | Basic | No use | No smartphone | Total |
|----------------|----------------|----------------|----------------|---------------|---------------|---------------|----------------|
| <i>Gender</i> | | | | | | | |
| Male | 48 (26.5%) | 105 (58%) | 106 (58.6%) | 30 (16.6%) | 10 (5.5%) | 5 (2.8%) | 304 (50.6%) |
| Female | 54 (29.8%) | 107 (59.1%) | 80 (44.2%) | 32 (17.7%) | 15 (8.3%) | 9 (5%) | 297 (49.4%) |
| <i>Age</i> | | | | | | | |
| Under 18 | 11 (39.3%) | 12 (42.9%) | 3 (10.7%) | 1 (3.6%) | 0 (0%) | 1 (3.6%) | 28 (4.7%) |
| 18-23 | 47 (30.7%) | 67 (43.8%) | 33 (21.6%) | 6 (3.9%) | 0 (0%) | 0 (0%) | 153 (25.5%) |
| 25-34 | 33 (20.6%) | 77 (48.1%) | 41 (25.6%) | 7 (4.4%) | 1 (0.6%) | 1 (0.6%) | 160 (26.6%) |
| 35-49 | 8 (5.6%) | 42 (29.4%) | 71 (49.7%) | 18 (12.6%) | 4 (2.8%) | 0 (0%) | 143 (23.8%) |
| 50 and above | 3 (2.6%) | 14 (12%) | 38 (32.5%) | 30 (25.6%) | 20 (17.1%) | 12 (10.3%) | 117 (19.5%) |
| Total | 102 (17.0%) | 212 (35.3%) | 186 (30.9%) | 62 (10.3%) | 25 (4.2%) | 14 (2.3%) | 601 |

Table 4 - Smartphone use by gender and age

4. Results

This section first presents the findings on general travel behavior in Tehran, based on the survey data. It then goes on to analyze the profile of ride-hailing users and the characteristics of ride-hailing trips.

4.1 Mobility and travel behavior in Tehran

Figure 3 shows the number of trips per day made on a typical weekday, based on the survey data. The average for women is 2.86 trips per day (standard deviation of 1.17) and for men 2.97 trips (standard deviation of 1.22). About 51.7% of the respondents make only two trips per day, 13.3% make three trips per day, and 19.6% make four. The higher percentage of four daily trips compared with three daily trips indicates that people are less inclined to chain their third trip in a tour and prefer to make a round trip. Nearly 94% of the sample make no more than six trips per day.

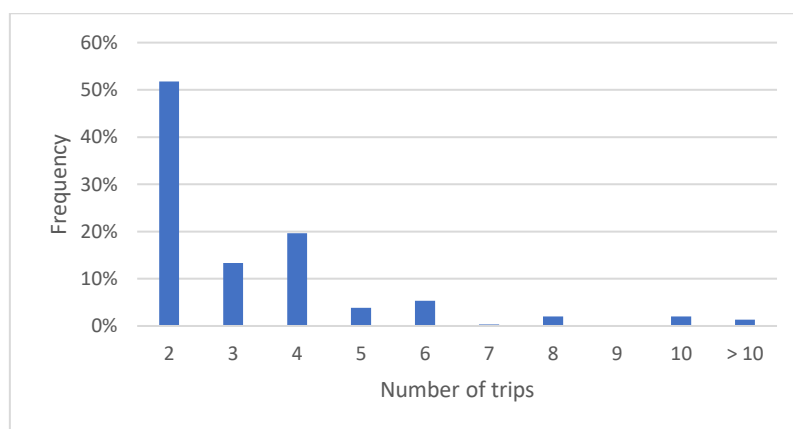


Figure 3 - Distribution of trip numbers per day

We now consider modal splits for commuting trips. Respondents who declared an occupation other than 'housewife', 'retired', and 'unemployed' were asked what mode of transportation

they used for their commute trips. The subsample size was 482 out of the total number of 601. Respondents were allowed to declare up to two modes for their commute trips, and for those who declared two modes instead of one, a weight of one-half was assigned to each of the modes. Private motorized modes dominate, as 28.7% are car drivers and 9.3% car passengers (Figure 4). Next follows public transportation, with 16.8% for the metro, 7.6% for BRT and 7.9% for the bus, totalling 32.3%. For line taxis, the modal share is 11.0%, while ride-hailing services account for 9.1%, which is markedly higher than the 0.8% for on-demand taxis. The modal share for motorcycles is 1.7%, while active modes (walking and cycling) account for 6.7% and 0.3% respectively.

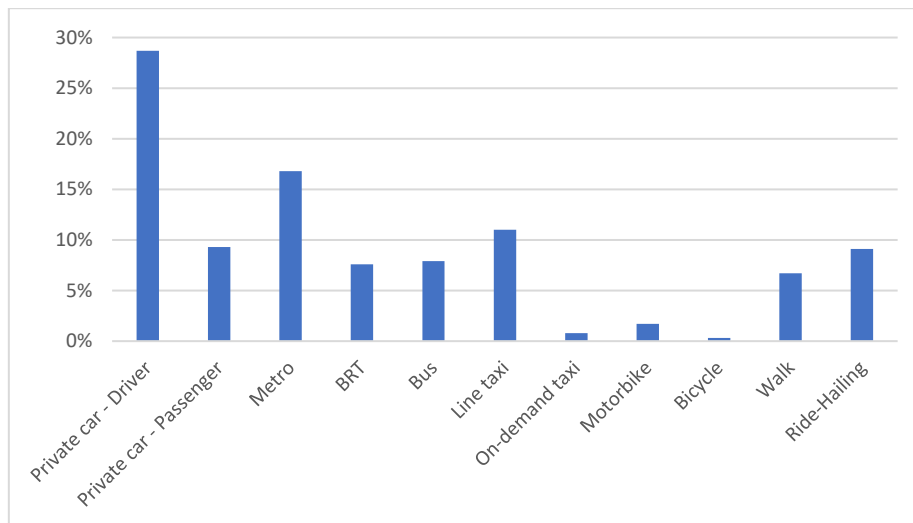


Figure 4 – Modal shares for commute trips

The decision to assign a half weight might lead to distortion, since people do not necessarily use their first and second declared modes of transportation equally. In order to assess the robustness of the estimated shares, another breakdown is obtained by taking into account only the more conventional mode. For instance, if both the private car and ride-hailing are declared, the conventional mode is deemed to be the private car and ride-hailing is ignored. The second breakdown shows clear substitution between the private car and ride-hailing, with the result that the frequency of use of ride-hailing falls to 5.2%, representing people who have declared ride-hailing as their only commuting mode.

The travel time for commuting trips was calculated for each respondent as the difference between the declared time of departure from home and the declared time of arrival at work or school. On average, the commute time is 43.5 min with a standard deviation of 23.9 min. Departure times are spread between 6:30 am and 8 am. Arrivals, on the other hand, are more concentrated between 7:30 am and 8:00 am, after which their numbers decrease significantly. It is as if people adjust their departure time so that they can arrive at their destination at the administratively required time.

All respondents were asked how often they used four main modes – the private car as a driver, public transportation, shared line taxi, and ride-hailing. Figure 5 shows the results: 44.3% of the respondents reported driving a car more than once a week, while 33.4% never used the car. The disparities in the use of other modes are less marked: 47.4% use public transportation more than once a week, as compared with 37.4% for line taxis and 28.3% for ride-hailing. Interestingly, however, ride-hailing is used at least once a month by about 76% of the respondents, which is

higher than other modes. In fact, ride-hailing shows the least disparities of all the four modes, as it provides the most versatile and flexible service.

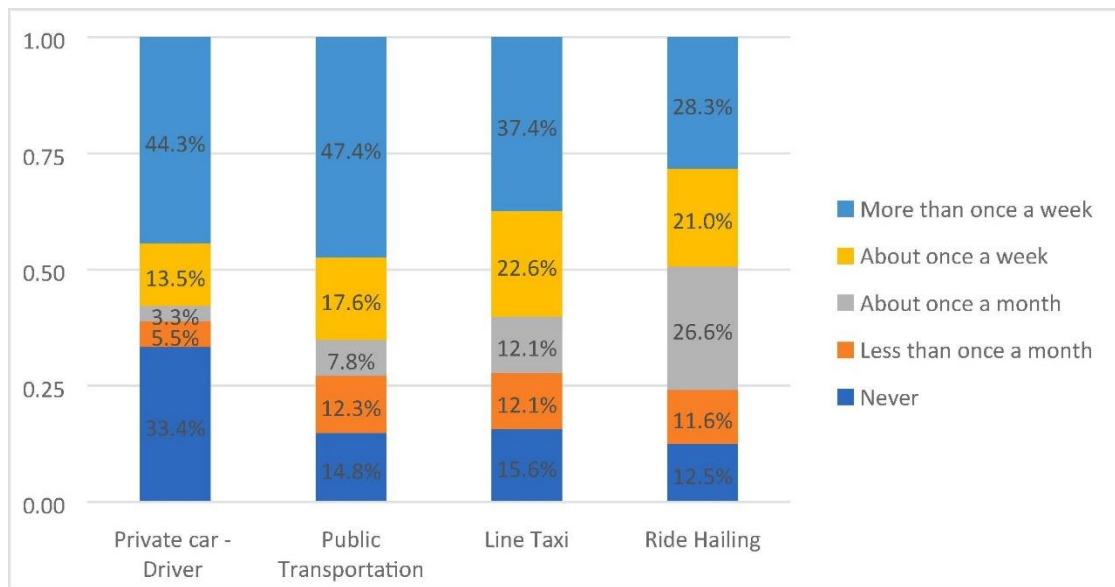


Figure 5 – Frequency of use of the main travel modes for all trip purposes

12.5% of the sample never use ride-hailing apps and 11.6% use them less than once a month. It is interesting to note that the number of people who report never using the private car (33.4%) or public transportation (14.8%) is actually greater.

4.2 Ride-hailing users – adoption and frequency

Respondents who reported using ride-hailing either never or less than once a month were not considered to be ride-hailing users. Presented with different possible reasons for not using such services, 29% stated that they had never felt obliged to consider them because they had access to other modes, 15.2% that they are too expensive, and 20.7% that, while ride-hailing services are affordable, they prefer their own vehicle for reasons of comfort. Moreover, 36.6% of people in this category said that they would see lower prices as a good incentive to use ride-hailing more often, while 35.2% stated that they would never consider using it, regardless of the incentives.

Respondents who reported using ride-hailing once a month or more were more or less split into three equal tiers according to frequency, together accounting for three-quarters of the sample. On the day on which they had used a ride-hailing service, they made an average of 1.52 trips using this mode, with 55.5% making only one ride-hailing trip on that day, and 36.2% making two.

Figure 6 shows the breakdown of ride-hailing usage by income bracket. Excluding the first income bracket, the figure suggests a correlation between higher income and more frequent use of ride-hailing.

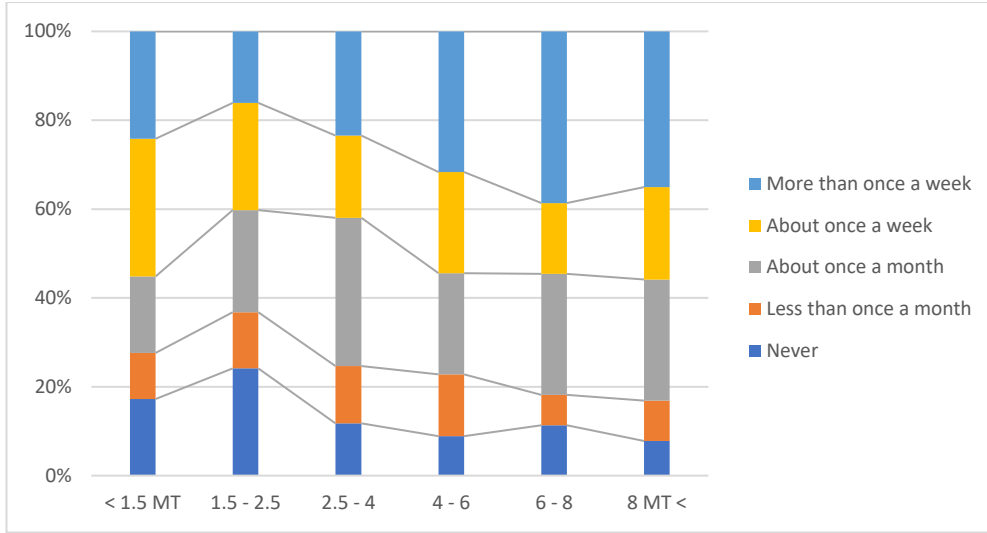


Figure 6 – Frequency of ride-hailing use by income (1 MT = 1 million tomans)

Chi-squared tests for categorical data were carried out between the rate of ride-hailing use and socio-demographic attributes to assess the null hypothesis of independence between the variables. Table 5 presents p-values and significance levels for different attributes. According to these results, the null hypothesis – that use of ride-hailing is independent of occupation, education, smartphone use, and number of trips – can be rejected at a significance level of 0.001, suggesting a correlation between use of ride-hailing and these attributes. A similar conclusion can be reached for age at a significance level of 0.001, and gender at a significance level of 0.01, which is expected since younger people tend to use ride-hailing more than older people, and female respondents are more likely to use ride-hailing than their male counterparts. Income is not independent of ride-hailing use at a significance level of 0.1, whereas the independence of car ownership and household composition – at a significance level of 0.1 – cannot be rejected.

| Variable tested against ride-hailing usage | p-value | Significance |
|---|---------|--------------|
| Gender | 0.008 | (**) |
| Age | 0.000 | (***) |
| Occupation | 0.000 | (***) |
| Education level | 0.000 | (***) |
| Smartphone use | 0.000 | (***) |
| Household composition | 0.150 | |
| Household car ownership | 0.127 | |
| Access to a reserved parking place at destination | 0.020 | (*) |
| Number of typical daily trips | 0.001 | (***) |
| Household income | 0.063 | (*) |

Table 5 - Chi-square test of the relationship between ride-hailing use and the respondents' sociodemographic characteristics – significance levels (‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1)

In terms of categorical analysis, an ordered logit model was estimated in which the alternatives are the five levels of ride-hailing usage described in Figure 2. In an ordered logit model with J choice alternatives, the probability of individual n choosing the i th alternative is given by,

$$P_n(i) = \frac{1}{1 + \exp(\tau_{i-1} - V_n)} - \frac{1}{1 + \exp(\tau_i - V_n)}$$

where, τ_i are constants and $\tau_i > \tau_{i-1}$. Moreover, $V_n = \sum_k \beta_k x_k$ is a systematic utility function, where β_k represent tastes, and x_k are binary dummy variables representing socio-demographic attributes. A model with J ordered alternatives includes $J + 1$ constants τ_0 to τ_J and the model

is normalized by setting $\tau_0 = -\infty$ and $\tau_J = +\infty$. Consequently $J - 1$ variables τ_1 to τ_{J-1} are added to the model as alternative specific constants, to be estimated along with β_k parameters. Here, there are five ordered choice alternatives, $i \in \{1 \dots 5\}$ corresponding to five levels of ride-hailing use.

A preliminary model including all socio-demographic variables is estimated to serve as a base for analysis. Many of the coefficients estimated in the preliminary model are statistically insignificant and need to be eliminated. Through the sequential removal of insignificant parameters, the final model is obtained, as presented in Table 6.

| Parameter | Initial Model Estimation | | | Final Model Estimation | | |
|--|--------------------------|--------|--------------|------------------------|--------|--------------|
| | Value | t-test | Significance | Value | t-test | Significance |
| Constants | | | | | | |
| τ_1 | -1.754 | -1.323 | | -0.873 | -2.354 | (*) |
| $\delta_2 = \tau_2 - \tau_1$ | 0.969 | 8.728 | (***) | 0.951 | 8.733 | (***) |
| $\delta_3 = \tau_3 - \tau_2$ | 1.404 | 13.797 | (***) | 1.388 | 13.821 | (***) |
| $\delta_4 = \tau_4 - \tau_3$ | 1.039 | 12.186 | (***) | 1.025 | 12.202 | (***) |
| Gender (Base: female) | | | | | | |
| Male | -0.364 | -2.116 | (*) | -0.339 | -2.206 | (*) |
| Age (Base: 65 and above) | | | | | | |
| Under 18 | -2.592 | -1.846 | (.) | | | |
| 18-24 | -1.646 | -1.443 | | | | |
| 25-34 | -1.528 | -1.363 | | | | |
| 35-49 | -1.378 | -1.239 | | | | |
| 50-64 | -1.256 | -1.131 | | | | |
| Occupation (Base: Unemployed) | | | | | | |
| Business Owner | 0.347 | 0.712 | | | | |
| Private sector employee | 0.426 | 0.888 | | | | |
| Public sector employee | 0.228 | 0.451 | | | | |
| High-school student | 2.329 | 2.528 | (*) | 0.889 | 2.482 | (*) |
| University student | 1.099 | 2.183 | (*) | 0.559 | 2.730 | (**) |
| Informal sector | -0.875 | -1.360 | | -1.102 | -2.399 | (*) |
| Retired | 0.386 | 0.666 | | | | |
| Housewife | 0.201 | 0.365 | | | | |
| Education level (Base: High-school) | | | | | | |
| Completed undergraduate degree | 0.608 | 2.571 | (*) | 0.530 | 2.709 | (**) |
| Completed graduate degree | 0.614 | 2.161 | (*) | 0.536 | 2.289 | (*) |
| Completed medical degree | 0.590 | 1.131 | | | | |
| Completed PhD | 0.294 | 0.533 | | | | |
| Smartphone use (Base: No possession) | | | | | | |
| Very active | 2.183 | 3.275 | (**) | 1.642 | 4.039 | (***) |
| Active | 2.124 | 3.311 | (***) | 1.560 | 4.173 | (***) |
| Common | 2.051 | 3.233 | (**) | 1.507 | 4.082 | (***) |
| Basic | 1.612 | 2.511 | (*) | 1.135 | 2.785 | (**) |
| No use | 0.704 | 1.016 | | | | |
| Household car ownership (Base: 2 cars or more) | | | | | | |
| No car | 0.101 | 0.382 | | | | |
| One car | -0.336 | -1.767 | (.) | -0.328 | -2.122 | (*) |
| Access to a reserved parking place at destination (Base: Yes) | | | | | | |
| No | 0.389 | 2.290 | (*) | 0.377 | 2.346 | (*) |
| Number of trips (Base: 7 trips or more) | | | | | | |
| 2 | -0.757 | -2.148 | (*) | -0.385 | -2.266 | (*) |
| 3 | 0.269 | 0.679 | | 0.603 | 2.425 | (*) |
| 4 | -0.282 | -0.760 | | | | |
| 5 | -0.993 | -1.946 | (.) | | | |
| 6 | -0.195 | -0.430 | | | | |
| Household income class (million tomans) (Base: 8 and above) | | | | | | |
| Less than 1.5 | -0.474 | -1.076 | | | | |
| 1.5 – 2.5 | -0.745 | -2.294 | (*) | -0.772 | -3.395 | (***) |
| 2.5 – 4 | -0.317 | -1.123 | | -0.292 | -1.662 | (.) |
| 4 – 6 | 0.000 | 0.000 | | | | |

| | | |
|-------|--------|--------|
| 6 – 8 | -0.059 | -0.194 |
|-------|--------|--------|

Table 6 - Initial and final ordered logit model - significance levels (**** 0.001 *** 0.01 ** 0.05 * 0.1)

According to the final model estimation, the coefficient for gender shows that being a male decreases the propensity to use ride-hailing. Being a high-school student or a university student increases the utility of more frequent ride-hailing use, whereas working in the informal sector decreases the propensity to use ride-hailing. Not having access to a reserved parking space at destination increases ride-hailing use, although the effect is small. Car ownership has the opposite effect, since individuals in car-owning households show less propensity to frequent use of ride-hailing. Notably, the parameter with the highest level of significance in favor of ride-hailing is smartphone use. Households in a lower income class are less prone to use ride-hailing. Age category does not contribute directly to explaining ride-hailing use, but being aged under 18, or between 18 and 24, is highly correlated with being respectively a high-school student or a university student. Finally, individuals behave differently according to the number of trips they make each day. Individuals who make two trips a day are associated with reduced propensities towards frequent use of ride-hailing when compared to individuals who make four trips or more a day. However, individuals who make three trips a day tend to use ride-hailing more frequently.

Table 7 summarizes the results of the model estimation. The final model shows a statistically significant improvement over the initial model in terms of the Akaike and Bayesian information criterion statistics, with half as many parameters. The final model contains 20 parameters which are all statistically significant.

| | Initial Model | Final Model |
|--|---------------|-------------|
| Number of parameters | 40 | 20 |
| Sample size | 601 | 601 |
| Initial Log-likelihood, $\mathcal{L}(0)$ | -967.3 | -967.3 |
| Constant Log-likelihood, $\mathcal{L}(c)$ | -929.9 | -929.9 |
| Final Log-likelihood, $\mathcal{L}(\beta)$ | -854.9 | -861.9 |
| Likelihood ratio test | 224.8 | 210.7 |
| Rho square | 0.116 | 0.109 |
| Rho bar square | 0.075 | 0.088 |
| Akaike Information Criterion (AIC) | 1789.7 | 1763.9 |
| Bayesian Information Criterion (BIC) | 1965.7 | 1851.9 |

Table 7 - Ordered logit model estimation summary

4.3 Characterization of ride-hailing trips

In order to characterize trips using ride-hailing services, we look at the purposes of these trips, the times of departure and arrival, the reasons for choosing ride-hailing services, and substitute modes.

Figure 7 shows the breakdown by trip purpose at origin (blue) and destination (orange). 46.7% of ride-hailing trips originate at home, 20.6% at work. Education, personal business, visits, and leisure come next, each accounting for around 6% of purposes at origin. With regard to destinations, home is the destination in the case of 21.3% of trips and work for 17.3% of trips. Behind these as reasons for travel come visits, leisure, personal business, and education. Healthcare and administrative procedures are also significant reasons for travel.

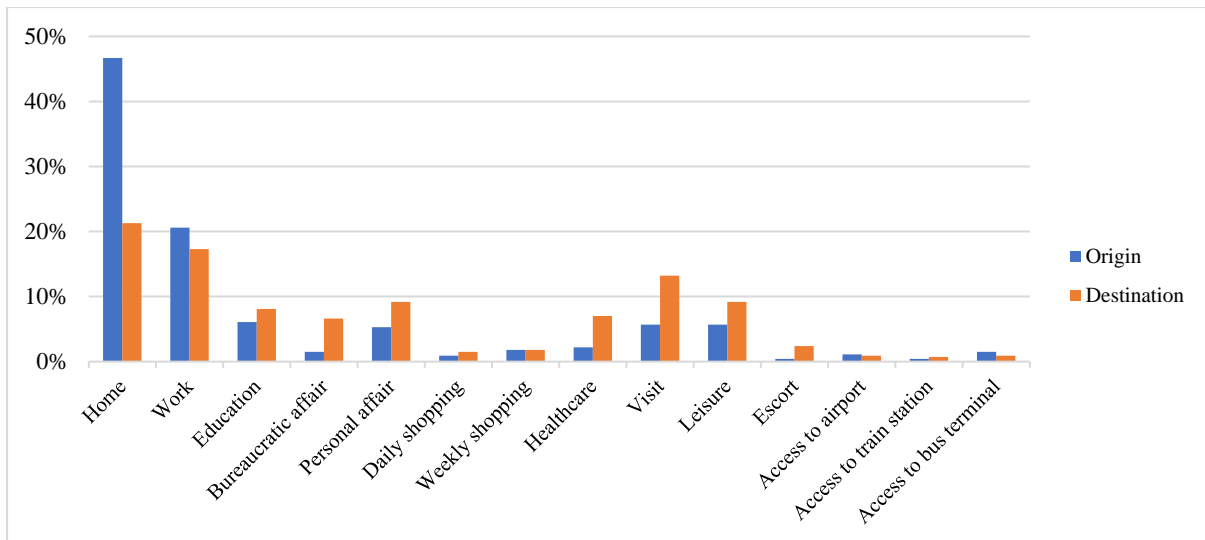


Figure 7 – Breakdown of purposes of ride-hailing trip at origin and destination.

Figure 8 shows the histogram of the departure times of ride-hailing trips for the eight frequent purposes of travel. Trips where the purpose is to return home are more frequent towards evening, while trips where the purposes are work and education span the morning hours. Administrative procedures are concentrated around midday, personal business and healthcare more frequent around midday and in the afternoon, and visits and leisure mostly in the afternoon and early evening.

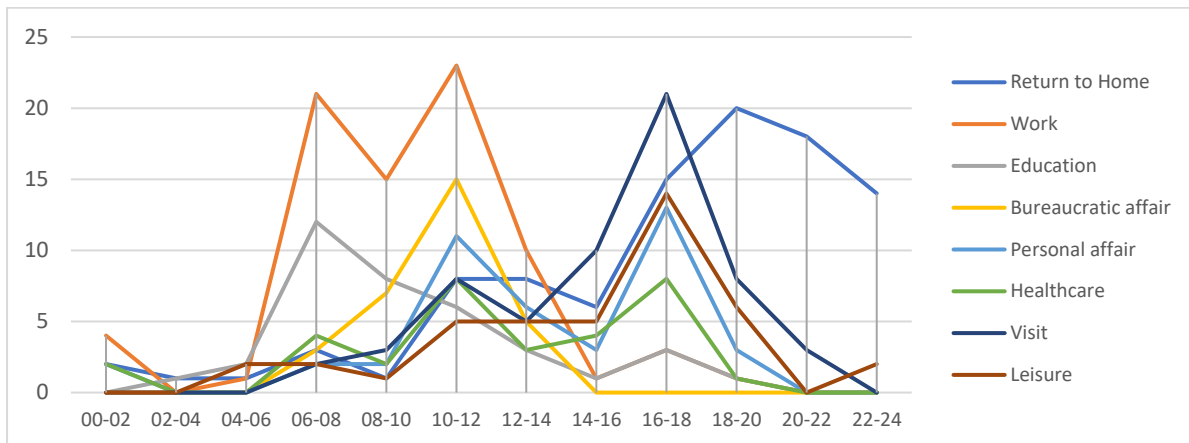


Figure 8 – Departure time of ride-hailing trips for common trip purposes

Ride-hailing users were asked to state whether their trip was planned in advance and whether they already knew the mode of transport they would use. Most of them (57.9%) stated that they planned their trip and mode in advance, on the assumption that the service would be available. 15.8% of users had planned their trip beforehand, but without considering the availability of ride-hailing when planning the trip. Finally, 26.3% of users stated having made their trip spontaneously (i.e., unplanned trip and mode).

Respondents were asked to explain why they chose ride-hailing services over all other modes for their most recent trip, and what mode they would have chosen (if any) if ride-hailing had not been available. Respondents were given eleven reasons to choose from, the results of which are presented in Table 8. Interestingly, the most frequent reasons given were that “ride-hailing is more comfortable” and that “it is faster than public transportation and line taxi”, which is consistent with the fact that ride-hailing users are more affluent. The next notable reasons given

were that “ride-hailing is cheaper than line taxi or the private car”, “destination was located inside restricted traffic zones”, and that “ride-hailing is flexible in departure time relieving me of parking limitation constraints”.

| Reason for preferring ride-hailing | Proportion (%) |
|---|-----------------------|
| It is cheaper than line taxi or the private car | 12.7 |
| It is faster than public transportation or line taxi | 24.1 |
| Trip destination was located inside restricted traffic zones | 9.4 |
| It is flexible and allows me to chain more trips in a tour | 2.1 |
| It is flexible in departure time relieving me of parking limitation constraints | 6.6 |
| It is flexible in departure time relieving me of peak hour congestion | 1.3 |
| It is more comfortable than other available alternative modes | 28.2 |
| It is safer than other available alternative modes | 3.0 |
| It is more convenient as it relieves me of driving burden | 4.8 |
| I was carrying luggage (groceries, ...) therefore public transportation was not an option | 5.8 |
| I had someone in my care (handicap, infant, elderly, ...) (not an escort trip) | 2.0 |

Table 8 – Stated reasons for preferring ride-hailing.

Respondents were asked if they would still have made the trip if ride-hailing services had not been available and, if so, how they would have traveled. 94.7% said that they would still have made the trip, with only 5.3% saying that would have canceled. The remaining respondents declared they would have rescheduled the trip to another time or day. At first glance, induced demand is low as 87.5% of the respondents stated that they would have made the same trip using another mode, including their own car (19.7%), public transportation (23.2%), line taxi (18.9%), or on-demand taxi (35.7%), showing that on-demand taxis are the most likely substitute for ride-hailing. One can notice a considerable difference between the actual modal share of on-demand taxi (cf. Figure 4) and the percentage of people who declared on-demand taxi as their preferred mode of substitution for ride-hailing. Such a difference can be attributed to a number of factors. Firstly, one can deduce that people consider on-demand taxi as an easy and obvious substitute to ride-hailing as it offers as much comfort and speed as ride-hailing without the constraints of the private car in terms of driving burden, access to a parking space or access to tolled traffic zones. Secondly, and this is partially inferred by the first point, the response can be biased due to a clear framing effect suggesting that induced demand is actually higher. The uncertainty is mainly due to a lack of publicly available references indicating modal share of on-demand taxi prior to the onset of ride-hailing in Tehran.

5. Discussion and conclusion

5.1 Towards more car-oriented mobility

The city of Tehran is characterized by its car-oriented mobility system. The modal share of active modes (walking and cycling) for commute trips is less than 10%, which is not much for a city in the emerging world. In Table 1, we collated the modal shares given by different authors. According to these data, the modal share of private vehicles ranges from 30% to 50% of motorized trips. As there is no publicly available household travel survey to serve as a benchmark, we used these data for comparison. Although the comparison is not one-to-one – since we consider only commuting trips – data from the survey are consistent with these figures. Our findings show that 41% of motorized trips are made by private car, as driver or passenger. The metro’s share is slightly greater (18%) than in Table 1, but equivalent to that of bus and BRT. The remainder is split between shared line taxis and ride-hailing, showing a large decline in the modal share of line taxis compared with the data quoted in Table 1. Our results confirm the importance of individual motorized modes in Tehran. At this stage, it is not possible to say whether ride-hailing has had an impact on reducing private car use. It

encourages more individual use of motorized travel. The fact that ride-hailing services are faster and more comfortable than public transportation and line taxis is the main reason why respondents reported using ride-hailing and confirms a trend also noted by Etminani-Ghasrodashti and Hamidi (2019).

5.2% of commuting trips are made with ride-hailing services only and the figure rises to 9.1% when considering commuters that use two modes of transport alternatively. It differs from observations in Western countries. Young and Faber (2019), for example, find a 1% modal share for ride-hailing as a mode of travel on commuter trips in Toronto, Canada. As in Western countries (Clewlow and Mishra, 2017), ride-hailing services in Tehran are taking market share from public transportation. In Tehran, however, ride-hailing is also a substitute for on-demand and line taxis. Ride-hailing represents a modernization of taxi services, which are important components of the local mobility system. However, and by contrast with the situation in other cities (Clewlow and Mishra, 2017), it replaces almost no walking trips. As in other cities, and because it partly replaces public transportation and line taxis, ride-hailing is likely to contribute to a rise in the number of vehicle kilometers traveled. The net effect is still unclear and more data are needed to confirm this increase. From a planner's perspective, this growth may contribute to higher greenhouse gas emissions, especially when one considers the kinds of cars used in ride-hailing services, which are usually old and polluting vehicles.

Ride-hailing has been widely adopted by the inhabitants of Tehran. Only 12.5% of the sample had never used a ride-hailing app, i.e. fewer than the percentage of people who never use the private car (33.4%) or public transportation (14.8%). Adoption levels are higher among the inhabitants of Tehran than can be found in the literature on Western countries. In the US, 70% of the population never use ride-hailing services (Clewlow and Mishra, 2017). However, these differences need to be qualified. The American survey was conducted five years before the Iranian survey, and the penetration rate has probably increased over that time. Ride-hailing is a well-known and widely used mode of transport in Tehran. People of all incomes, all ages, and all education levels use the services. As shown in the model, however, frequency of use is strongly influenced by income and smartphone use. These results are consistent with the literature, which notes that smartphone use has a significant positive impact on ride-hailing practices (Alemi et al., 2019; Lavieri and Bhat, 2019) and that frequency of use is linked with income (Clewlow and Mishra, 2017). However, the final modal estimates highlight some major differences. Women working in the formal sector and belonging to car-owning households are more likely to use ride-hailing. Men from the same social background would be more likely to drive their own car to work. University students are also prone to use ride-hailing, especially when they have no reserved parking at their destination. Conversely, working in the informal sector reduces the propensity to use ride-hailing. The same trend is observed for individuals who make two trips a day. The success of ride-hailing in Tehran is mainly owing to its comfort, and its higher speed compared to public transportation and line taxi modes. In some respects, ride-hailing might be a first step towards private motorization, since it offers the privacy, speed and comfort of the car for non-car owners. This concerns in particular university students, workers in the formal sector and women who can afford ride-hailing trips on a daily basis.

5.2 Conclusion

This study analyzed the role and impacts of ride-hailing in the urban context of Tehran. The capital of Iran is a large city in the developing world, characterized by car-oriented development and suffering from serious congestion and air pollution. In the last decade, the public transportation network has been improved but remains inadequate to meet the population's travel needs. In these conditions, local ride-hailing services have expanded fast.

Our research hypothesis was that ride-hailing has become a new mode of travel, extensively used for daily commuting. In order to validate the hypothesis, we put together a two-part questionnaire and administered it to residents of Tehran. The first part was designed to collect data on day-to-day mobility in Tehran, as no household travel survey was available. The second part focused on the users and uses of ride-hailing services.

Our findings help to provide a better understanding of the global phenomenon of ride-hailing and its use in contexts other than North America and Europe, which have been extensively studied in the literature. In Tehran, ride-hailing is a significant mode for day-to-day travel. People from all social backgrounds use ride-hailing, as it is the most versatile and flexible mode of transportation in the metropolitan area. While the level of adoption is significant, frequency of use is mainly determined by smartphone use and income. Women working in the formal sector and students are more prone to use these services. Shortage of parking space at destination also plays a role. Ride-hailing replaces on-demand and shared line taxis and public transportation, mainly because it is faster and more comfortable.

There are limitations in the current study that need to be highlighted and potentially addressed in future research. To the best of our knowledge, this is the first survey on ride-hailing in Iran, and there are insufficient data on travel behaviors in Tehran to provide a benchmark for our findings. Our sample remains modest. However, it indicates trends and emphasis on important factors. It would be useful to continue this kind of survey on an annual basis. The government recently put quotas on gasoline, introducing a monthly limit for consumption, then increased subsidized gasoline price by 50% for a consumption within the limit, and by 200% beyond the limit. The gasoline consumption is capped at 60 liters per month for private cars and at 400 liters per month for line taxis. Compensation procedures are also put in place to reimburse ride-hailing taxis based on their weekly traveled distance. These measures will impact the availability of cars and hinder ride-hailing use to some extent.

Ride-hailing impacts the mobility system, as it strengthens the position of motorized travel in an already congested and polluted city. Further analysis is needed to characterize the spatial spread of ride-hailing within the metropolitan area. Current data is not sufficient for a fine-grained analysis of the relationship between the propensity to ride-hailing and characteristics of the urban fabric such as the level of public transportation service or land use. Ride-hailing presents the comfort and speed of the private car to those who can afford ride-hailing trips on a daily basis, especially for university students, workers in the formal sector and women. Local authorities might consider ride-hailing as an alternative to the private car, in complement to public and semi-public transportation systems. As ride-hailing is likely to contribute to increase the number of kilometers traveled in the city, an option is to promote shared ride-hailing trips and to tax solo ride-hailing trips, since the most frequent users are the most affluent. However, strong constraints on the use of ride-hailing could also have a social impact, as driving is a way out of an unemployment for many people. The strict gasoline quota policy that has recently been applied could contribute to containing the growth of ride-hailing.

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