Travel mode choice of young people with differentiated E-hailing ride services: A case study in Nanjing China

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Keywords: E-hailing ride service (ERS), Mode choice, Nested logit model, Demand elasticity, On-road vehicular emissions

Introduction

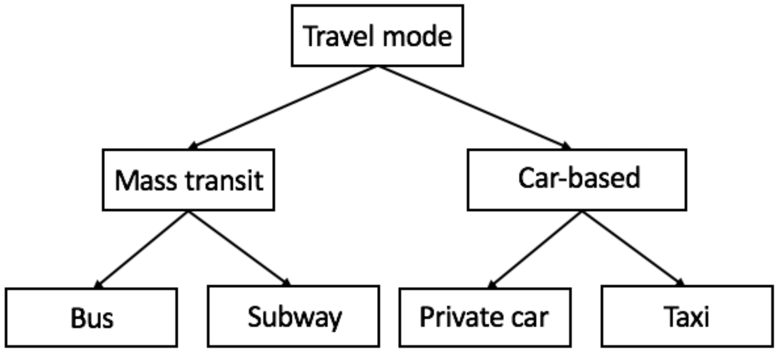
E-hailing ride service (ERS), also known as ride-hailing, on-demand ride service, ridesourcing, and transportation network companies (TNC), has blossomed in recent years, such as Uber, Lyft, Grab, DiDi Chuxing etc.. The leadership in Chinese market is DiDi Chuxing, which provides various services, DiDi Taxi (D-Taxi), DiDi Express (D-Express), DiDi Premier (D-Premier), DiDi Hitch (D-Hitch), and so on (Jiang and Zhang, 2018).

From the perspective of transportation planning, existing research roughly falls into two categories: (1) investigating traveler willingness to use ERS (Taylor et al., 2016; Alemi et al., 2018a; Alemi et al., 2018b; Circella et al., 2018); and (2) understanding how ERS changes people's travel behavior including mode choice and its environmental implications (Castrodale, 2016; Smith, 2016; Nie, 2017; Hall et al., 2018). However, the perception among young people of differentiated ERS modes in competition with conventional modes has not been studied in the literature. To fill this gap, this paper focuses on young people's mode choice behavior with coexistence of multiple ERS (D-Taxi, D-Express, and D-Premier) and conventional modes (bus, subway, private car, and taxi). The used data is collected by stated preference (SP) survey, and the defined young people is between 18 and 45 (Rayle et al., 2016).

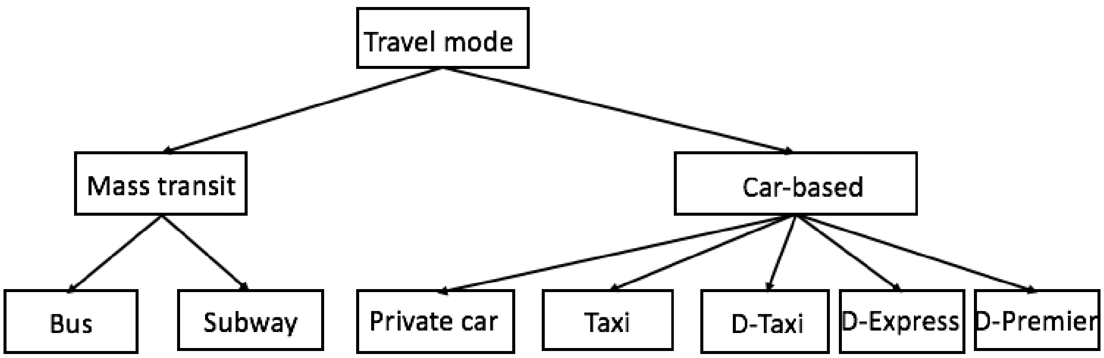
According to the survey data, when ERS is absent, subway is the most preferred mode among young respondents. When ERS is introduced, over 50% of respondents would choose ERS modes. Young respondents are naturally drawn to the ERS regardless of the performance of the conventional modes. The propensity to choose ERS increases when the trip takes place during peak periods. Besides, ERS demand is generally elastic to its own trip attributes, such as waiting time, in-vehicle travel time, and parking cost, and mostly to travel cost. Among the ERS modes, D-Premier is more sensitive than the other two. Finally, ERS will inevitably increase the overall vehicle kilometers traveled (VKT) and on-road vehicle emissions.

Methodology

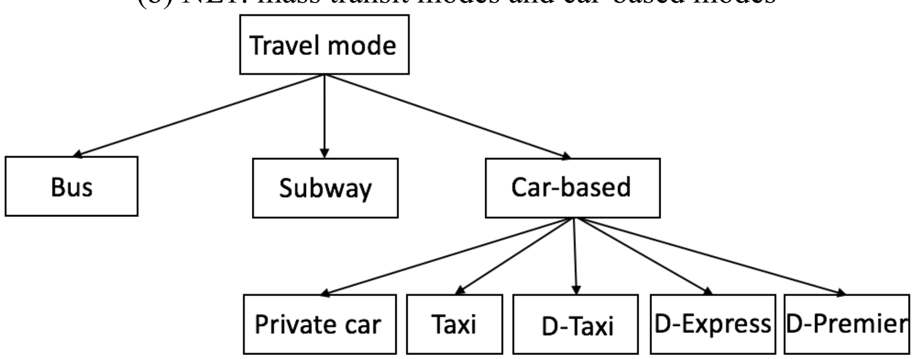
Nested Logit (NL) model is estimated to study young people's mode choice behavior. The choice set after introducing ERS includes bus, subway, taxi, private car, D-Taxi, D-Express, and D-Premier. Before introducing ERS, the nesting structure (NL0) (Figure 1(a)) is estimated. After ERS, three possible nesting structures (NL1, NL2, and NL3) (Figure 1(b)-(d)) are explored.



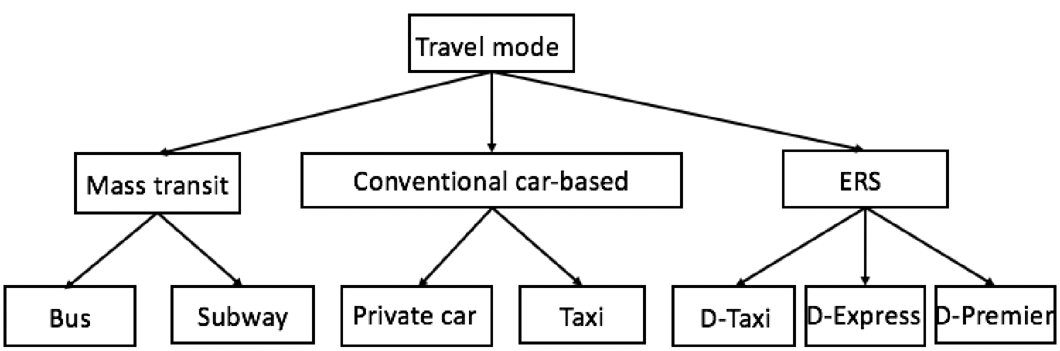
(a) NL0: mass transit modes and car-based modes



(b) NL1: mass transit modes and car-based modes



(c) NL2: modes by vehicle type and travel speed



(d) NL3: modes by mass transit, conventional car-based, and ERS modes

Figure 1 Nesting structures without (NL0) and with (NL1, NL2, NL3) ERS

The considered explanatory variables fall into three categories: (I) personal social demographic characteristics including gender, age, income, occupation, and education level; (II) trip related characteristics including trip purpose, distance, weather condition, and time-of-day of travel; and (III) mode specific characteristics including waiting time, in-vehicle travel time, travel cost, and parking cost.

Results

Young people's mode choice behavior analysis

Figure 2 describes the aggregate mode choice preference with and without ERS. When ERS is absent, subway is the most preferred mode. When ERS is introduced, over 50% of respondents prefer ERS modes. Among the three nesting structures, NL3 has the best goodness-of-fit measure, and is used to analyze further. Before introducing ERS, age, associate degree, managerial and self-employed occupation, car ownership, trip purpose, weather, waiting time, in-vehicle travel time, parking cost, bus and subway convenience are important variables affecting mode choice. After introducing ERS, except for variables above, education, income, and time-of-day of travel are also significant. However, age is no longer a significant indicator. D-Express is slightly preferred over D-Taxi and D-Premier is less preferred over D-Taxi possibly due to its higher service charge.

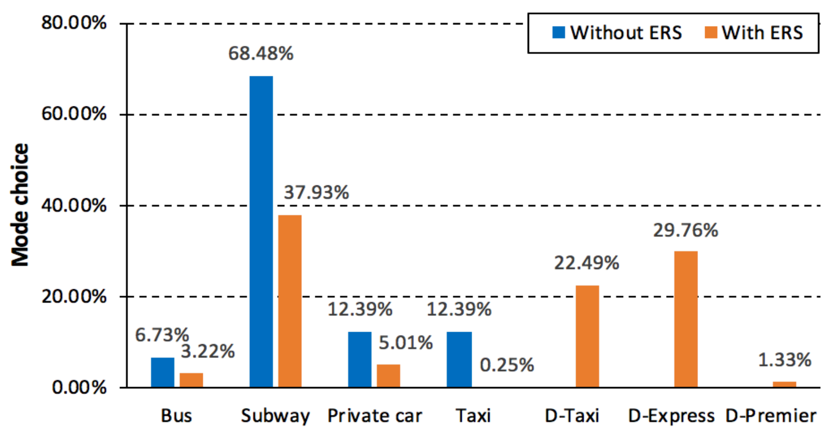


Figure 2 Mode choice preference among the survey respondents, with and without ERS

ERS modes exhibit elastic demand to its in-vehicle travel time and waiting time, and strongly elastic demand to travel cost. In particular, D-Premier is the most elastic. Among the conventional modes, subway has the most inelastic demand to its own attributes, bus demand is elastic to its waiting time, private car and taxi demands are somewhat inelastic to those attributes.

Emission analysis

Assuming that private cars, taxis, and ERS vehicles all use gasoline with the same emission factors, and buses use diesel. Total vehicular emissions are estimated by multiplying the total vehicle kilometers traveled (VKT) with the corresponding emission factors. The results find the total emissions would increase after ERS, because of the mode shift from mass transit to ERS modes, and such a mode shift (particularly from subway trips) would increase the VKT by ERS, which is echoed in prior studies (Dias et al., 2017; Henao, 2017; Wenzel et al., 2019).

Besides, Yu et al. (2017) and Xue et al. (2018) encourage ridesharing to reduce the vehicle emissions. Therefore, a first-order estimation of the threshold rider occupancy for ERS is performed. The estimation shows that a 2-3 occupancy in an ERS vehicle would counteract the overall emission increase.

Conclusion

This paper presents an econometric analysis on mode choice of young people (age between 18 and 45) with presence of differentiated ERS modes (D-Taxi, D-Express, and D-Premier) and conventional modes in Nanjing, China. The analysis is built upon an SP survey using the orthogonal experimental design.

This paper finds young respondents are naturally drawn to the ERS regardless of the conventional modes. In addition, the propensity to choose ERS increases when the trip takes place during peak periods. From post-estimation analysis, ERS demand is generally elastic to its own trip attributes including waiting time, in-vehicle travel time, and parking cost, and mostly to travel cost. D-Premier is more sensitive than the other two ERS modes. From the system perspective, the mode shift from transit to ERS will inevitably increase the overall VKT and on-road vehicle emissions. In order to counteract the increased emissions, 2–3 shared ERS occupancy is needed.

Three contributions are made in the paper. First, considering the dissimilarities among different ERS services, we treat D-Taxi, D-Express, and D-Premier separately. Second, the demand elasticities of ERS with respect to their own service attributes as well as the service attributes of non-ERS modes are estimated which help understand key factors affecting ERS demand. Third, the changes in VKT and emissions after introducing ERS are investigated, and the shared ERS vehicle occupancy is estimated to counteract the increased emissions.

However, there are some limitations. First, the current survey could be extended to cover a larger population sample possibly with more diverse age groups. Second, the survey questions could be extended to seek opinions of young travelers facing electric, autonomous, and shared mobility. Third, the complementary potentials of ERS to other modes was not explored in the survey and should be added in the future survey questionnaire. Lastly, information about induced trips could be collected and used to estimate added travels due to ERS in addition to mode shift.

Disclaimer

This work has recently been published with Transportation Research Part D: Transportation and Environment, a special issue on Young People's Travel Behavior.

Shen, H., Zou, B., Lin, J., Liu, P. (2020) Modeling Travel Mode Choice of Young People with Differentiated E-Hailing Ride Service in Nanjing China, *Transport Research Part D*, online first, https://doi.org/10.1016/j.trd.2019.102216.

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