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IMPACT OF TRANSPORTATION NETWORK COMPANY (TNC) SERVICES ON OTHER MODES: THE CASE OF DHAKA, BANGLADESH

Mostaq Ahmed*[1], Muhaiminul Islam[2]

*1*Corresponding Author: Assistant Professor, Urban and Rural Planning Discipline, Khulna University, Khulna.*
Email: mostaqurp@gmail.coom,
2. Bachelor of Urban and Rural Planning Discipline, Urban and Rural Planning Discipline, Khulna University, Khulna

ABSTRACT

Widespread popularity of TNC services has significantly changed the realm of urban transportation. This study presents an empirical investigation of the impact of TNC services on the other conventional modes in megacity Dhaka, the capital of the developing country Bangladesh. For this study, multinomial logit models have been developed using data collected from household travel survey. The no TNC scenario information has been collected by asking the respondents about their preferred mode for a similar kind of trip in a no TNC scenario when a trip made by TNC has been found. This study has found that TNC services are drawing passengers mostly from the CNGs. The finding is actually similar to several other researchers who concluded that TNCs are actually competing with taxi services in the cities of the first world countries. Considering the nature of these CNG vehicles, they can be compared to the taxi services of the first world countries. This study has also found comparatively higher impact of TNCs on public transit than many other studies.

KEYWORDS: Transportation Network Company, Other Modes of Transport, Dhaka.

1. INTRODUCTION

Popularity of TNC services (Uber, Lyft, etc.) has changed the realm of urban transportation significantly by providing on-demand and flexible mobility options. These Transportation Network Companies (TNCs) use an internet based highly sophisticated 'app' to match the people seeking transportation with the nearby drivers who will offer that service at that moment. These TNCs neither own the vehicles nor are the drivers the employees of them. Impact of TNC services on other modes is of many folds. So far, it is well found that TNCs are direct competitors of Taxi services on the road (Wallsten, 2015). Though, often TNCs regarded as complementary to public transit, evidences show that they have a negative effect on public transit as well (Habib, 2019). The emergence and rapid growth of Uber, Lyft etc. has challenged the existing transportation industry by providing a new option which is cost-effective compared to taxi and comes without the need for parking space compared to private vehicle. However, not much of the type and magnitude of the impact of TNC services on other transportation is known to date (Alemi et al., 2017, Alemi et al., 2018, Habib 2019). It is of importance that transit agencies and planners understand the impact of continued growth of TNCs on other modes so that they can take measures to respond effectively.

2. LITERATURE REVIEW

2.1 What are TNCs?

There is much debate on status of TNCs as transportation provider or technological innovation. TNCs provide transportation services through smartphone based app that can find nearby drivers who are available to offer ride at that moment. Unlike Taxi companies, TNCs don't own the vehicles and the drivers are independent contractors. The drivers are supposed to have vehicles at his/her own expense. TNCs can't have direct/ indirect ownership of transportation business. If the app provider company owns vehicles to be used to provide transportation services, the company can no longer be defined as TNC (Kessler, 2017).

2.2 TNCs in Dhaka

Uber is the most dominant among the TNCs operating in Dhaka. It has launched in Dhaka in November 2016. Chalo and BDcabs had started in 2015. Chalo had failed to maintain a solid customer base, whereas BDcabs remained a limited operation service with its partnership with Toma Taxi. Amarbike and similar motorbike services had popularity for a short period but none of them are doing well at present. Taxiwala was investing a lot for promotion in 2016, but Uber's arrival prohibited them to gain a good market share (Uber And The Next Phase Of Car-hailing In Dhaka, 2016). Because of this, Uber did not have any strong competition in Bangladesh when they have started their journey. In October 2016, the ride-sharing platform Pathao started their operation and introduced motorcycle ridesharing service. Later, Uber also started their motorcycle ridesharing service (Mamun, Meet the minds behind the success of Pathao, 2017). Pathao's ridesharing platform has now become a familiar name alongside Uber. At present there are 11 companies in Dhaka who are providing ridesharing services- Uber, Pathao, SAM, Amar Ride, Chalo, BDCabs, MUV, Bahon, Ezzyr, Trippo and Let's Go (An Updated List Of Ride-hailing Startups In Dhaka, 2017).

Ridesharing services have gained tremendous popularity in Dhaka and, on an average, Uber, Pathao and Bahon altogether log in 10,000 rides a day (Islam, 2017). Motorcycle ridesharing services have made Dhaka's TNC services unique compared to the TNC services in the U.S. and Europe. It is easy to understand that motorbikes unlike auto-rickshaws and taxis are not only fast but also easy to avoid traffic jams, making them an ideal alternative to navigate through Dhaka's traffic-choked streets.

2.3 TNCs as supplement and complement of Public Transit

TNCs can act as supplement of public transit by providing transportation service while there is a deficiency. This role of TNCs as a supplement has both temporal and spatial aspects. From temporal aspect, TNCs can provide services in that part of the hours when public transit does not offer their services. For example, public transit authority doesn't provide services during late hours at night and early hours of the morning. TNCs can offer their services during these hours and act as a supplement to public transit. From spatial aspect, TNCs can provide transportation services in the areas where public transit doesn't provide their services at all. In the areas of low demand, TNCs can even be a low-cost option if the transit agency subsidizes TNC services to provide transportation services to the people of those areas (Kessler, 2017).

TNCs can complement public transit by solving the first and last mile problem. Researchers have argued in favor of TNCs role as a compliment to public transit (Davidson et al., 2016; Kessler, 2017). Pinellas Suncoast Transit Authority (PSTA) operates a service called DirectConnect for which they have made an agreement with Uber. Through this agreement, trip makers can use Uber at a subsidized fare to be transferred to a bus stop to ride a PSTA bus. Transit agency can also partner with TNCs to serve transportation demand in case of special events in a city. San Diego Metropolitan Transit System (MTS) partnered with Uber to provide transportation services when there were two major exhibitions at once- a baseball game event and a convention. MTS used Uber's assistance to manage the projected surge ofdemand during the anticipated timeframe. Uber offered a onetime discount of five dollars for UberPOOL under this agreement (Kessler, 2017).

2.4 Competition between public transit and TNC

In their study, Davidson et al. (2016) used descriptive analysis to study the competition between public transit and Uber in New York. For this study, they used data from 'Transit', a smartphone-based app which provides updates on modes (public transit, Uber, carsharing and bikesharing) fused with publicly released data of Uber trips in New York. They concluded that there is no direct competition between Uber and public transit in New York and Uber actually acts as complemented of public transit in the city.

Contreras and Paz (2018) aggregated trip data of taxi, Uber and public transit ridership data in Las Vegas and developed regression model to study competition among the modes. They inferred that Uber directly competes with taxi services and Both Uber and taxi actually work as compliment to public transit in Las Vegas.

Rayle et al. (2016) used exploratory analysis to investigate competition among Uber/Lyft, taxi and public transit and used an intercept survey to collect data about trip characteristics of the modes. They concluded that there is significant competition between TNCs and public transit in San Francisco, and TNCs draw riders equally from taxis and public transit.

Mahmoudifard et al. (2017) estimated nested logit model to investigate the competition between TNCs and other modes. In their study, they collected data by a web-survey of Uber riders in Chicago. The respondents were asked about their second-best choice of mode if Uber were not available. They concluded that high-income person would choose private car or taxi, but low-income person would choose public transit if Uber were not available. They also inferred that personal characteristics of trip makers, e.g., age, gender, income etc. play an important role in choosing a mode alternative to Uber.

Alemi et al. (2019) also concluded that choice of Uber as a travel mode is mostly influenced by income, trip distance, trip purpose, and transit accessibility. The developed discrete choice model by using information collected through an online survey about the use of TNCs in California.

3. DATA AND METHODS

3.1. Study area and data collection

Ridesharing service was introduced in October 2016 in Dhaka city. The study area in this research is Dhaka city, the capital and the largest city in Bangladesh. The population of Dhaka is 14.3 million (BBS, 2011). Dhaka city is divided into two City Corporation. One is Dhaka North City Corporation (DNCC) and the other is Dhaka South City Corporation (DSCC). There are 41 Thana's in Dhaka city. From those 41 Thana's, 6 Thana's were selected based on two online surveys on two Facebook pages named "Pathao Users of Bangladesh" and "Uber Users of Bangladesh". These Thanas are the places where the use of ridesharing services is the most frequent, according to Facebook polls.

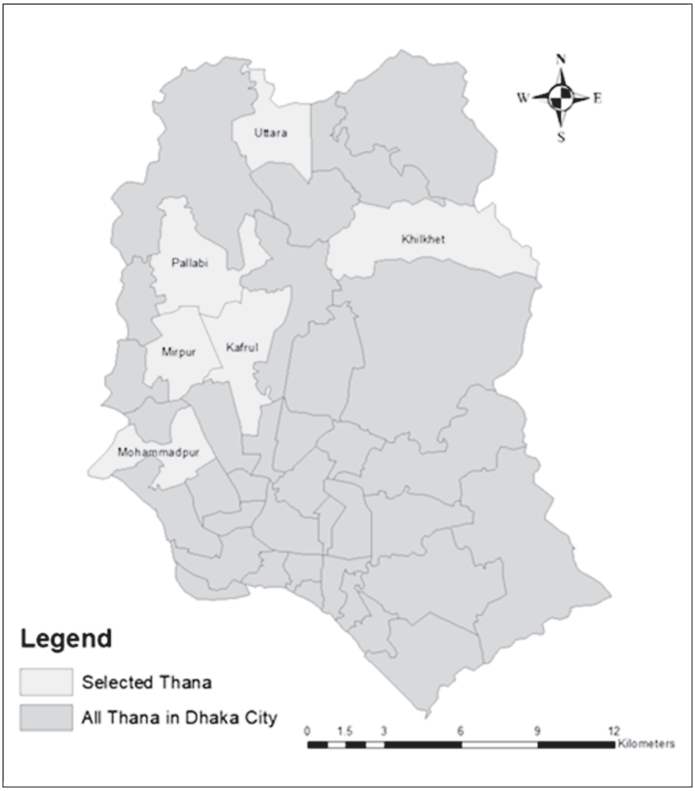

Figure 1: Map of Selected six Thanas in Dhaka

Data collection has been done by household travel survey using travel diaries. The household travel surveys involved contacting respondents in their home and collecting information regarding their household characteristics, their personal characteristics and the travel decisions made in the recent past. In case of a trip which has been made by TNCs the respondents were asked about their preferred mode for that kind of trip when TNC services were not available.

3.2. Discrete choice modeling framework

Discrete choice modeling is a disaggregated approach to modeling mode choice in a transportation system. Disaggregated models have huge advantages over aggregated models in understanding why individuals are making those choices and experimenting the impact of various policy measures on the mode choice patterns. Discrete choice model explains why an individual make his/her choice from different alternative modes with different attributes given his/her socio-economic characteristics and therefore, better able to predict the changes of mode choices because of changes in the trip makers conditions or the changes of attributes of modes. Aggregated modeling primarily relies on statistical association among variables at a coarser level other than individual decision maker which makes it difficult to provide reliable and accurate information about the impact of changes of characteristics of the individuals or of the modes on mode choice pattern (Koppelman & Bhat, 2006; Ortúzar & Willumsen, 2002). In a discrete choice framework, an individual first sees the alternative modes, then evaluate different attributes of those alternatives under some given criteria (led by his socio-economic characteristics) and use a decision rule to select most suitable alternative for him from the modes (Koppelman & Bhat, 2006). An individual always tries to maximize his/her utility when selecting the mode for his trips. Trip maker evaluate the derived the utilities of the modes from attributes like trip cost, trip time, safety, comfort, etc. and choose the mode with highest utility (Ben-Akiva & Lerman, 1994). This is called utility maximization when making choices.

A utility function of a mode "m" can be expressed mathematically as,

$$U_{mi} = \beta_1 X_{mi1} + \beta_2 X_{mi2} + \ldots\ldots\ldots\ldots\ldots + \beta_k X_{mik} \qquad (2.1)$$

Where,

U_{mi} is the net utility function for a mode 'm' for individual 'i';

X_{mi1} , …, X_{mik} are k number of attributes of a mode m for individual i; and

β_1 , ………, β_k are k number of coefficients (or weights attached to each attribute) which need to be inferred from the survey data.

Thus, a utility function of a specific mode linearly combines various explanatory variables along with an alternative specific constant term which reflects a relative preference for that alternative. In a three-mode hypothetical situation where TNC, auto and BUS compete, utility functions of the modes can be written as,

Utility TNC = ASC TNC + (β1* IVTT TNC) + (β2 * OVTT TNC) + (β3* Cost TNC) + ………… (1)

Utility auto = ASC auto + (β1* IVTT auto) + (β2 * OVTT auto) + (β3* Cost auto) +………… (2)

Utility BUS = ASC BUS + (β1* IVTT BUS) + (β2 * OVTT BUS) + (β3* Cost BUS) +…………. (3)

Where,

IVTT = In-Vehicle Travel Time

OVTT = Out-of-Vehicle Travel Time

In this situation multinomial logit model establishes the basis for discrete choice framework and, using random utility model as decision rule, calculates the probability of selecting a particular mode evaluating its utility against the utility of all other available alternatives. This can be expressed mathematically as:

$$P_i = \frac{e^{U_i}}{\sum_{j=1}^{j} e^{U_j}}$$

Where,
i and j are alternatives in a choice set,
P_(i)is the probability of choosing Mode i,
J is the set of all alternatives available to the individual (including modes i and j),
U is the utility associated with a given mode
For example, using the three mode example illustrated above, the probability of using TNC over other modes can be calculated as,

$$P_{TNC} = \frac{e^{U_{TNC}}}{e^{U_{TNC}} + e^{U_{auto}} + e^{U_{BUS}}}$$

Thus discrete choice framework is suitable for investigating the impact of TNC services on other modes since it allows examining the role of each variable in individuals' choice making and allows checking the impact of various changes on the choice patterns of individuals.

3.3 Factors affecting mode choice in a discrete choice framework

McFadden (1978) had studied the factors influencing the choice of mode in a discrete choice framework and they are variables with critical explanatory power -travel cost, on vehicle time, walk time, transfer wait time, transit initial headway, and number of persons in household; variables with important explanatory power -numbers of transfers, respondent's relation to household head, employment density at work location, suburban or urban, family composition; variables with ambiguous explanatory power -household income, residential population density, CBD location regarding residence, number of workers in household, age of household head, reliability of transportation mode, perception of comfort, safety, convenience; variables with low explanatory power-CBD work location, sex of respondent, age of respondent, work status of household head, general attitudes toward privacy, and delay. Papacostas & Prevedouros (2015) had categorized the variables related to mode choice behavior of trip makers in three categories -the characteristics of the modes, the socioeconomic status of the trip maker and the characteristics of the trip.

4. ANALYSIS AND FINDINGS

4.1 Model Estimation

Two multinomial logit models have been estimated for this study. One is for the recent time when TNC service is available and other one is for the pastime when TNC service was not available. This data for past have been developed from the responses about respondents' preferred mode for that kind of trip when TNC were not available. The odds ratio for each mode has been observed. The impact of Ridesharing service on other modes can be identified from the difference between odds ratios of those two models.

Table 1: Multinomial logit model when TNC service was not available

Variable name	Notation	Coefficient	t-stat
Bicycle	ASC_BCL	-12.3	-0.12
CNG	ASC_CNG	-3.07	-9.43
Private motorbike	ASC_PM	-0.21	-0.61
Public Transport	ASC_PT	-0.86	-2.93
Rickshaw	ASC_RCKSW	-0.79	-3.41
Walk	ASC_WALK	-0.74	-2.71
Cost of the trip	B_Cost	0.00687	2.24
Duration of the trip	B_Time	-0.00284	-0.41
Distance of the trip	B_Dst	-5.26E-11	0
Age of the respondent	B_Age	-2.98E-11	0
Occupation of the respondent	B_Ocp	-1.99E-11	0
Trip Purpose of the respondent	B_TPrps	3.87E-12	0
Household income of the respondent	B_HI	-2.44E-11	0
Likelihood Ratio Test		178.004	
Rho-square		0.163	

In table 1, we have the coefficients of each variable, correspondent t-statistics, log likelihood of the model and rho-square value of the model. The variables which have 0 in the field t-stat can be excluded from the model because including those variables does not matter much to the model.

Now the utility equations are-
PC = 1 - 0.00284 * CNG_TT + 0.00687 * CNG_TC
BCL = -12.3 - 0.00284 * BCL_TT + 0.00687 * BCL_TC
CNG = -3.07 - 0.00284 * PC_TT + 0.00687 * PC_TC
PM = -0.214 - 0.00284 * PM_TT + 0.00687 * PM_TC
PT = -0.857 - 0.00284 * PT_TT + 0.00687 * PT_TC
RCKSW = -0.795 - 0.00284 * RCKSW_TT + 0.00687 * RCKSW_TC
WALK = -0.74 - 0.00284 * WALK_TT + 0.00687 * WALK_TC
Here,
CNG means Utility of CNG;
BCL means Utility of Bicycle;
PC means Utility of Private Car;
PM means Utility of Private Motorbike;
PT means Utility of Public Transport;
RCKSW means Utility of Rickshaw;
WALK means Utility of Walk;
CNG_TT, BCL_TT, PC_TT, PM_TT, PT_TT, RCKSW_TT and WALK_TT are the travel time for each mode;

CNG_TC, BCL_TC, PC_TC, PM_TC, PT_TC, RCKSW_TC and WALK_TC are the travel cost for each mode.

Table 2:Odds Ratios for alternatives when TNC was not available

Other Modes	Odds Ratio	1 / Odds Ratio	Reference Mode
CNG	0.046	21.54	Private Car
Bicycle	0.0000046	219695.99	
Private motorbike	0.807	1.24	
Public Transport	0.424	2.36	
Rickshaw	0.452	2.21	
Walk	0.477	2.10	

From table 2, we can observe the odds ratio for each mode in this model. Private Car was selected as reference mode in this model. This model shows that odds of Private Car are 21.5 times higher to be chosen as the mode than CNG . Bicycle is also less likely to be chosen compared to private car. Other choices of modes can also be explained just like that. In this model, the probability of choosing private car is the highest and the probability of choosing bicycle is the lowest when all seven modes are available to choose. If a private car were not available, the mode which has the highest value of odds ratio among modes, in this case, Private motorbike, would be more likely to be chosen.

Table 3: Multinomial logit model when TNC service is available

Variable name	Notation	Coefficient	t-stat
Bicycle	ASC_BCL	-11.9	-0.2
CNG	ASC_CNG	-3.55	-10.73
Private motorbike	ASC_PM	-0.68	-1.97
Public Transport	ASC_PT	-1.11	-3.87
Rickshaw	ASC_RCKSW	-1.02	-4.44
Walk	ASC_WALK	-0.97	-3.63
Ridesharing Car	ASC_ RSC	-3.18	-6.56
Ridesharing motorbike	ASC_RSM	-3.27	-10.46
Cost of the trip	B_Cost	-0.00236	-0.9
Duration of the trip	B_Time	-0.0228	-3.76
Distance of the trip	B_Dst	2.6E-12	0
Age of the respondent	B_Age	5.76E-12	0
Occupation of the respondent	B_Ocp	-1.16E-11	0
Trip Purpose of the respondent	B_TPrps	-7.28E-13	0
Household income of the respondent	B_HI	-1.76E-11	0
Likelihood Ratio Test		344.134	
Rho-square		0.226	

In table 3, we can find out the coefficients of each variable, correspondent t-statistics, log likelihood of the model and rho-square value of the model. The variables which have 0 in the field t-stat can be excluded from the model because including those variables does not matter much to the model.
Now the utility equations for the alternative modes when TNC service is available-

PC = 1 - 0.0228 * CNG_TT - 0.00236 * CNG_TC
CNG = -3.55 - 0.0228 * PC_TT - 0.00236 * PC_TC
PM = -0.68 - 0.0228 * PM_TT - 0.00236 * PM_TC
PT = -1.11 - 0.0228 * PT_TT - 0.00236 * PT_TC
BCL = -11.9 - 0.0228 * BCL_TT - 0.00236 * BCL_TC
RCKSW = -1.02 - 0.0228 * RCKSW_TT - 0.00236 * RCKSW_TC
WALK = -0.969 - 0.0228 * WALK_TT - 0.00236 * WALK_TC
RSC = -3.18 - 0.0228 * RSC_TT - 0.00236 * RSC_TC
RSM = -3.27 - 0.0228 * RSM_TT - 0.00236 * RSM_TC

Here,
RSC means Utility of Ridesharing service (TNC) Car;
RSM means Utility of Ridesharing service (TNC) Motorbike;
CNG_TT, BCL_TT, PC_TT, PM_TT, PT_TT, RSC_TT, RSM_TT, RCKSW_TT and WALK_TT are the travel time for each mode;
CNG_TC, BCL_TC, PC_TC, PM_TC, PT_TC, RSC_TC, RSM_TC, RCKSW_TC and WALK_TC are the travel cost for each mode.

Table 4: Odds Ratios for alternatives when TNC is available

Other Modes	Odds Ratio	1 / Odds Ratio	Reference Mode
CNG	0.029	34.81	Private Car
Bicycle	0.0000068	147266.63	
Private motorbike	0.507	1.97	
Public Transport	0.330	3.03	
Rickshaw	0.361	2.77	
Walk	0.379	2.64	
Ridesharing Car	0.042	24.05	
Ridesharing motorbike	0.038	26.31	

From table 4, we can observe the odds ratio for each mode in this model. Private Car was selected as reference mode in this model. This model shows that odds of Private Car are 34.81 times higher to be chosen as the choice of mode than CNG. Bicycle is also less likely to be chosen as the choice of mode than Private Car if both are available. Other choices of modes can also be explained just like that. In this model, the probability of choosing Private Car is highest and the probability of choosing bicycle is lowest when all seven modes are available to choose.

If a private car were not available, the mode which has the highest value of odds ratio among modes, in this case, Private motorbike, would be more likely to be chosen. The probability of choosing Ridesharing service is lower than Private Car, Private Motorbike, Public Transport, Rickshaw and Walk.

4.2 Impact of Ridesharing services on other modes

The difference v¬between the odds ratio of the above two models can explain the impact of TNC services on other modes. One model is for the past situation when TNC service was not available and another model is for the recent situation when TNC service is available. It has been assumed that people who own private vehicles make a negligible number of trips by TNCs and hence we can use that as a reference to compare these two situations.

Table 5: Impact of Ridesharing services on other modes

Other Modes	Odds Ratio when TNC was not Available	Odds Ratio when TNC is Available	Difference	
CNG	21.54	34.81	13.27	38.1 %
Private motorbike	1.24	1.97	0.74	37.2 %
Public Transport	2.36	3.03	0.68	22.4 %
Walk	2.10	2.64	0.54	20.5 %
Rickshaw	2.21	2.77	0.56	20.1 %
Bicycle	219695.99	147266.63	72429.36	32.9 %

From table 5, we can see that the odds ratio of every mode except Bicycle has been decreased on the model with TNC services. The probability of choosing Bicycle has been increased about 33 percent after introducing TNC service. CNG has the highest decreasing value of 38.1 percent. That means the probability of choosing CNG has been decreased more than any other modes after introducing TNC services. The second-most impact on private motorbike and the probability of choosing a private motorbike has decreased by 37.2 percent. After Private Motorbike, public transport is affected by introduction of TNC services with 22.4 percent decrease of odds ratio. Walking, Rickshaw and Private Car are the least affected modes after introducing TNC services.

The difference between the two odds ratios can explain which mode has faced most impact and which has faced less impact. The modes that have more difference in values have less impact and the modes that have a less difference in values have more impact. After CNG, Private motorbike has the most impact on the choice of modes, then Public transport, then Rickshaw, then Walking and finally, Private car has the least impact on mode choice for introducing Ridesharing services.

From the analysis, we can observe that the use of public transport has been decreased significantly after introducing TNC services in Dhaka. Traffic congestion could be the main reason behind this result. Public transport in Dhaka city takes much more time to go to the destination than any other modes. On the traffic choked roads of Dhaka motorbike can travel quick. Considering the cost of using a motorbike ridesharing services, it is more likely that shared motorbikes are drawing passengers from public transit. Since ridesharing motorbike is fast and affordable, people who do not have private car or bike, use ridesharing (motorbike) service instead of public transit.

5. CONCLUSION

This study offers an empirical investigation of the impact of introduction of TNC services in Dhaka on other conventional modes of travel. This study has used revealed preference data of mode choices from household travel survey in selected thanas of Dhaka, Bangladesh. It has been found that TNC services are drawing passengers mostly from the CNGs. The finding is actually similar to several other researchers who concluded that TNCs are actually competing with taxi services in the cities of the first world countries (Conteraz & Paz, 2018; Davidson et al., 2016). Considering these CNG vehicles, they can be compared to the taxi services of the first world countries. This study has also found comparatively higher impact of TNCs on public transit than many other studies (Mahmoudifard et al., 2017; Rayle et al., 2016). This may be attributed to the unique nature of ridesharing services of Dhaka. Ridesharing motorbike may be the factor for higher impact on public transit. Further study with more sophisticated discrete choice model can be useful to investigate this matter.

A notable limitation of this study is that it has used a small sample size of the households of Dhaka. To strengthen conclusion, data from a large-scale survey will help. However, this is a primary step towards understanding the impact of TNC services on other conventional modes of Dhaka. Further investigation with a bigger sample size and more sophisticated models will help to understand this matter.

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