

Travel Behavior of Agartala City, India Using Panel Data



Amitabha Acharjee and Partha Pratim Sarkar

Abstract This study analyzes the change in mobility pattern and their psychological effect on dynamic travel behavior. 3,416 respondents' data have been collected from the Agartala city randomly to understand the travel behavior of two different panels. More specifically, from the data, it can be observed that motorized two wheelers (MTW) ownership, car ownership, and nonmotorized transport were increasing from the last 5 years. The influences of attitudes along with socioeconomic parameters such as monthly cluster income, motorized two wheeler ownerships (MTW), non-motorized ownerships (NMT), employment type were used for modeling. Structural equation modeling has been used to analyze the travel behavior. Results show that the change of travel decision varies with income. From the analysis of latent variables such as comfort, flexibility, reliability, and safety associated with modes such as car, motorized two wheeler, nonmotorized transport was found to be significant with cluster income over the change of time. Also from the data, it can be seen that there was an increase in the use of NMT modes even when infrastructure was not favorable; and with improvement in infrastructure, there is a good probability to increase the mode share of NMT modes across all income level.

Keywords Psychological · Habit · Car ownership · Two wheeler ownership (MTW) · Bicycle ownership (NMT) · Flexibility · Safety · Comfort · Reliability

1 Introduction

Rapid urbanization, shifting behavior of vehicle especially nonmotorized to motorization, and the change of economy are leading to decline urban transportation systems substantial in many developing countries like in South Asia [18]. Because of limited resource, the restricted and imperfect way of implementing system capacity and the inequality between demand and supply is increasing further [19]. As a result,

A. Acharjee (✉) · P. P. Sarkar
Department of Civil Engineering, National Institute of Technology, Agartala, Tripura, India
e-mail: amitabhaacharjee1990@gmail.com

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many cities are facing problems of increased suburbanization and congestion and also decrease the safety of human mobility [19].

Because of these changes, the specific human mobility characteristics need to be studied broadly [14]. For making a good urban planning strategy, it is essential to study the dynamic travel behavior in developing countries. This paper carried out an extensive study of human behavior on mobility characteristics of two panels in Agartala city, India. Mode choice behavior generally consists of individual's attitudes, subjective norms, and perception of travel behavior [4]. Psychological effect on the choice of different modes is an important factor which was considered in this study. A person who uses the bus for work trip may not reflect the habits of bus choice for the very next day. Choice of mode of the past and the present panel of data may not depend on their habits but also on their socioeconomic factors [2, 5, 6]. But it is true that past behavior could contribute to the predictions of present behavior. The hypotheses proposed on social norms [15], anticipated regret [20], and self-identity [7, 8] were found to affect the travel behavior. Some authors [8–10, 12, 13] carried out a longitudinal study to investigate the effect of new bus service among the college students in Germany. They observed that attitude and subjective norms are important factors for the choice of bus mode.

To test the habit and psychological factors, we studied some frequency performance parameters to analyze the variation of travel behavior. The parameters were generally used to identify travel behavior on mode choice based on number of trips per person per day, travel time per trip, travel distance per trip, and passenger kilometers of travel (PKT) [11, 26, 27]. Temporal variabilities of car use and the car ownership were also important factors for understanding the habit process in mode choice [21]. Attitudes and perceptions of different modes were also reported to affect travel behavior [16, 25, 28]. Some of the author [17] adopted Markov models to analyze the changes in the activity and travel patterns over time in the Puget sound transportation panel. One-way analysis of variance ANOVA was carried out to investigate the three different panel data like stayers, dropouts, and refresher. The same panel data were used by Sunkanapalli et al. [26] and carried out a dynamic analysis of traveler's attitudes and perceptions. They found that bus mode was declining more than the automobile mode. This outlined the use of association rules to identify patterns in activity [14].

2 Study Area Description

Data have been collected in Agartala city to understand the effect of dynamic travel behavior. Agartala city is the second largest city based on population and municipality area in northeastern part of India, after Guwahati. Municipality area is divided into 49 wards (Fig. 1).

According to census data 2011, the population of Agartala was 5,22,613 with male population of 2,66,103 and female population of 2,56,864 and having a total municipal area of 76.51 km² [3, 22, 23].

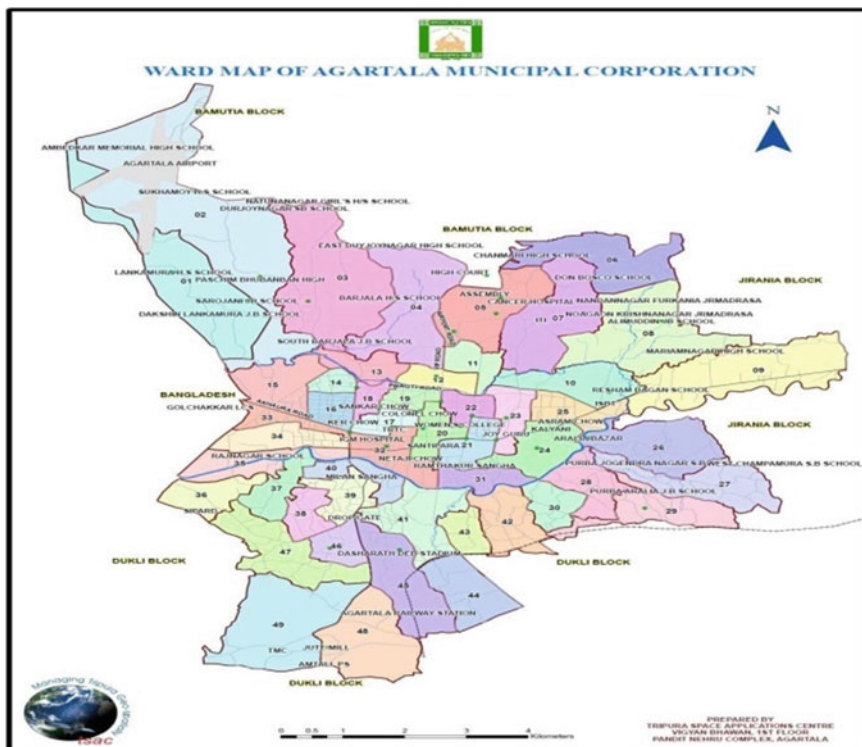


Fig. 1 Location of the study area (Agartala)

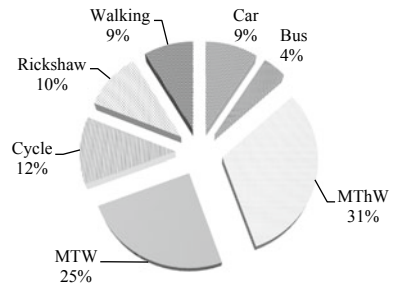
Table 1 shows different percentages of vehicle ownership between two panel data, in which one panel is retrospective in nature. It is observed that motorized vehicle increased very abruptly compared to the nonmotorized vehicle. Data indicate that a number of students slightly reduced in current scenario. Data were categorized into three education qualifications such as graduate, higher secondary level, and secondary school certificate (SSC) level. It is observed that the large percentages of people are educated up to SSC level. In work-related trips, 75% of people traveled between 0 and 1 km at the last end of the panel data in 2012.

People are more interest to walk compared to motorized and nonmotorized vehicle when the travel distance is less. Apart from walking, people use more NMT and motorized three wheeler (MThW) vehicle. Figure 2 shows the mode used for work trips. It can observe that MThW use is 31% and MTW is 25%. Mode shares of buses and car are less commute mode compared to the other modes. The share of bicycle and walking are almost equal.

Table 1 Comparison of two panel data

	At present (value in percentage)	5 years back (value in percentage)
<i>Vehicle ownership</i>		
Car ownership	11	7
Motorized two wheeler	43	28
Nonmotorized mode	20	7
<i>License driver in a family</i>		
Four wheeler vehicle	7	4
Two wheeler vehicle	35	25
Both four and two wheeler vehicles	6	3
No vehicle	56	40
<i>Education qualification</i>		
Up to SSC	79	48
Class 12	8	4
Graduate	50	35
<i>Distance of work trip (km)</i>		
0–1	75	65
2–5	40	30
6–10	30	25
11–20	22	12
Above 20	10	7

Fig. 2 Mode use for work trip



In Table 2, the statistics of socioeconomic characteristics like age, gender, household income, vehicle ownership, and driving license status of commuter are presented. These data are useful in examining the variability of socioeconomic information, which could be useful in the formulation of the Dynamic model.

Table 2 Summary of socioeconomic data acquired for the study

Socioeconomic characteristic	Value in percentage
<i>Gender</i>	
Male	73.38
Female	26.62
<i>% of individual age</i>	
Up to 19	3.95
20–29	17.69
30–39	18.53
40–49	24.08
50–59	22.77
>60	12.98
License	49.5
Not having license	50.5
<i>% of individuals (years of education)</i>	
0	0.19
1–5	4.05
5–8	9.13
8–10	20.51
11–12	15.62
16–18	17.31
19–21	0.00
More	0.19
Car ownership	13.83
MTW ownership	44.21
<i>Household income (monthly)</i>	
0–2000	0.03
2001–10,000	30.86
10,000–20,000	25.55
20,000–50,000	31.37
>50,000	12.15

3 Methodology

More precisely, structural equation modeling (SEM) is a general modeling framework that integrated a number of different multivariate techniques into the overall framework. It is a framework which draws on a number of different disciplines. In this study, structural equation modeling has been applied to reveal the causal relationship between sociodemographics and latent attitudinal factors of the two different waves. Confirmatory factor analysis was one of the suitable processes to understand

Table 3 Average perception rating for different modes

Statement of attribute	Car	Bus	MTW	NMT
Comfortable journey	4.06	3.80	3.72	2.48
Comfortable seats	3.76	3.98	3.68	2.6
Very easy accessibility	3.69	2.90	3.89	2.71
Quickly accessible mode	3.91	2.78	3.89	2.49
Travel time prior to trip is known	3.89	3.22	3.91	2.29
Safety (accident)	3.83	4.20	3.22	2.14
Safety (theft)	3.91	3.70	3.68	1.97
Safety (weather)	3.88	4.00	2.2	1.8
Ability to make more trips	3.85	2.90	3.68	3.85
Can travel in a same vehicle	3.94	2.70	3.92	3.95

the travel analysis. Confirmatory factor analysis is a process by which judgment regarding the structure and content of the factors was applied and then the statistical results for these established factors were estimated. Confirmatory factor analysis (CFA) produces many goodness-of-fit measures to evaluate the model. Therefore, CFA using AMOS was carried out in this study area.

A general SEM model can be written as

$$Y = \alpha + \beta y + \Gamma x + \xi \tag{1}$$

where “X” represent the independent variables, “Y” represent the dependent variables, “α” is a intercept term, “β” is a square matrix of the direct relationship between the dependent variables, “Γ” is a square matrix of coefficients from independent to dependent variables, and “ξ” is a column vector of errors.

Table 3 gives the mean perception rating of different modes. From Table 3, it can be seen that people generally prefer car for their comfort as well as safety. In case of flexibility, people experience MTW to be more flexible mode compared to the other modes.

4 Model Formation and Result

The study has verified the hypothesis that perception of individuals influences mode choice with respect to the level of income. The contribution of this study with respect to 5 years back responses about income in the consideration of heterogeneity in individual choice, especially comparing the attributes of individual mode choice characteristic. This study also highlights the reason for shifting of mode for 5 years back to the current scenarios. Table 4 is estimated using all two waves of the panel data carried out in Agartala city. Statistically, significance of latent variable is included in

the model. Structural equation model is used to correlate the 5-year socioeconomic panel along with their cluster income. From the model, it is clearly observed that motorized and nonmotorized transportation mode increased from the last 5 years and also observed the shifting behavior of the mode from last 5 years. Model also suggests that high-income person are likely to use a car, and low-income person are likely to use bicycle (NMT) mode. The reason behind the use of car is comfort, flexible, reliable, and safe. All the three alternative comforts are measured in terms of journey, reliability measured in terms of easy to access, flexibility measured in terms of ability of trip, and safety is measured with accident. The latent factor of MTW ownership such as comfort of MTW, reliability of MTW, safety of MTW, and flexibility of MTW modes are correlated with medium-income person. Flexibility, comfort, and reliability of motorized two wheeler ownerships are positively correlated but the safety of MTW is negatively correlated. It seems that the causes of accident by MTW vehicles are more comparing to other two modes. Similarly, the four latent variables such as flexibility, comfort, reliability, and safety are correlated with NMT with respect to low income. Low-income people are feeling that motorized vehicles have the ability to make more trips in a short time. Estimated results show good model fit. The values of RMSEA and GFI values are 0.015 and 0.97, respectively, which is in the range of good model fit [1] (Fig. 3).

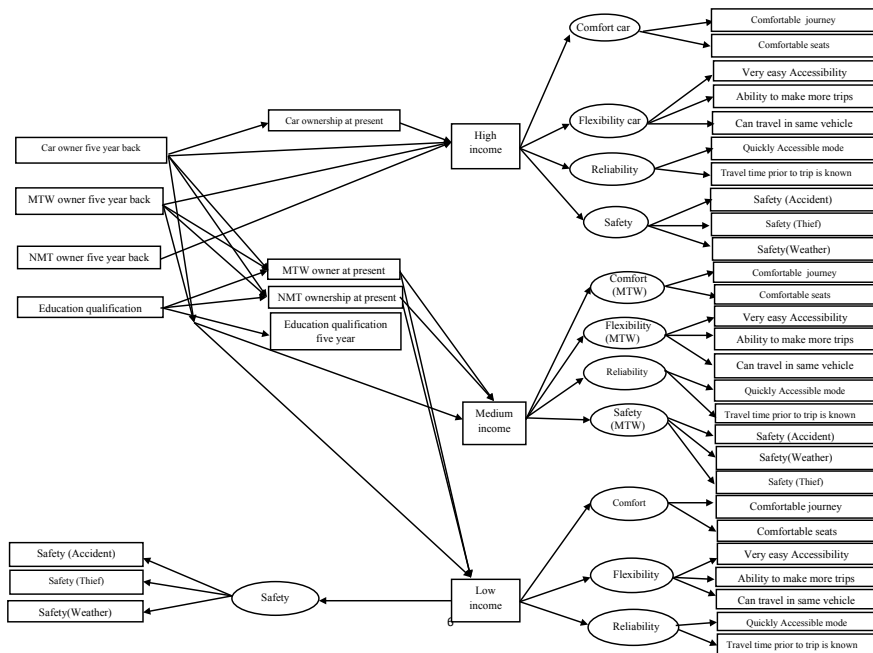


Fig. 3 Schematic diagram

Table 4 Results of two panels of car, MTW, and NMT travel mode

Latent construct	Path		Estimate	P-value
Education qualification	←	Education qualification five	1.192	0.001
NMT ownership	←	NMT 5 years	1.776	0.001
Car ownership	←	Car ownership 5 years	1.14	0.002
MTW ownership	←	MTW 5 years back	1.49	0.01
NMT ownership	←	MTW 5 years back	2.054	0.01
NMT ownership	←	Car ownership 5 years	1.102	0.01
MTW ownership	←	Car ownership 5 years	2.193	0.01
NMT ownership	←	Education qualification	-1.3	0.003
Car ownership	←	Education qualification	2.002	0.05
MTW ownership	←	Education qualification	2.02	0.01
High income	←	Car ownership	1.97	0.03
Low income	←	MTW ownership	-1.18	0.04
Medium income	←	MTW ownership	2.639	0.05
High income	←	MTW ownership	2.009	0.02
Medium income	←	NMT ownership	-1.15	0.01
Low income	←	Car ownership 5 years	-1.05	0.01
High income	←	Car ownership 5 years	1.002	0.01
Medium income	←	Car ownership 5 years	-1.27	0.03
Low income	←	MTW 5 years back	-3.086	0.04
Medium income	←	MTW 5 years back	3.05	0.01
High income	←	MTW 5 years back	2.01	0.00
Low income	←	NMT 5 years	1.172	0.01
Medium income	←	NMT 5 years	2.069	0.01
High income	←	NMT 5 years	-1.07	0.00
High income	←	NMT ownership	-3.08	0.002
Medium income	←	Car ownership	1.51	0.06
Low income	←	NMT ownership	1.13	0.07
License 5 years	←	Car ownership	1.248	0.05
Comfort (MTW)	←	MTW 5 years back	-1.03	0.02
Comfort (NMT)	←	Low income	2.383	0.04
Reliability (NMT)	←	Low income	1.184	0.03
Flexibility (NMT)	←	Low income	2.214	0.05
Safety (NMT)	←	Low income	1.002	0.02
Safety (MTW)	←	Medium income	-2.14	0.02
Comfort (MTW)	←	Medium income	1.319	0.03
Reliability (NMT)	←	Medium income	2.066	0.01
Flexibility (MTW)	←	Medium income	1.124	0.02
Flexibility (NMT)	←	High income	-2.24	0.01

(continued)

Table 4 (continued)

Latent construct	Path		Estimate	P-value
Comfort car ownership	←	High income	1.046	0.04
Safety car ownership	←	High income	1.071	0.04
Reliability car ownership	←	High income	2.061	0.01
Comfortable in journey (MTW)	←	Comfort (MTW)	1	
Very easy accessibility (MTW)	←	Reliability (MTW)	1	
Can exactly travel time prior to trip is known (MTW)	←	Reliability (MTW)	1.986	0.05
Very easy accessibility (MTW)	←	Flexibility (MTW)	1	
Can travel in a same vehicle (MTW)	←	Flexibility (MTW)	2.844	0.04
Ability to make more trips (MTW)	←	Flexibility (MTW)	3.499	0.01
Safety (weather) (MTW)	←	Safety (MTW)	1	
Safety (theft) (MTW)	←	Safety (MTW)	2.381	0.03
Safety (accident) (MTW)	←	Safety (MTW)	1.855	0.08
Comfortable seats (car)	←	Comfort (car)	1	
Comfortable in journey (car)	←	Comfort (car)	1.699	0.01
Can exactly travel time prior to trip is known (car)	←	Reliability (car)	1	
Very easy accessibility (car)	←	Reliability (car)	2.225	0.00
Very easy accessibility (car)	←	Flexibility (car)	1	
Can travel in a same vehicle (car)	←	Flexibility (car)	-1.06	0.04
Ability to make more trips (car)	←	Flexibility (car)	-1.29	0.05
Safety (weather) (car)	←	Safety (car)	1	
Safety (theft) (car)	←	Safety (car)	-1.54	0.04
Safety (accident) (car)	←	Safety (car)	1.73	0.09
Comfortable seats (NMT)	←	Comfort (NMT)	1	
Comfortable in journey (NMT)	←	Comfort (NMT)	1.676	0.03
Can exactly travel time prior to trip is known (NMT)	←	Reliability (NMT)	1	
Very easy accessibility (NMT)	←	Reliability (NMT)	1.86	0.05
Very easy accessibility (NMT)	←	Flexibility (NMT)	1	
Can travel in the same vehicle (NMT)	←	Flexibility (NMT)	-1.64	0.03
Ability to make more trips (NMT)	←	Flexibility (NMT)	-1.87	0.06
Safety (weather) (NMT)	←	Safety (NMT)	1	
Safety (accident) (NMT)	←	Safety (NMT)	2.637	0.03
Goodness of model fit		RMSEA	0.015	
		GFI	0.97	

5 Conclusion

In this paper, we have explored several latent variables related to the physiological parameter along with the socioeconomic and demographic parameters of two panel waves. From the analysis of latent variables such as comfort, flexibility, reliability, and safety associated with modes such as car, MTW and NMT are significant with income. It is observed that higher income people are choosing a car as it provides comfort, safety, reliability, and flexibility. In case of medium income, people are choosing MTW for comfort, reliability, and flexibility but not as a safe mode. If we talk about the NMT mode, lower income persons are choosing NMT mode as a comfortable, reliable, and safe mode but not as a flexible mode. It is observed from the two waves (2007 and 2012) of the similar household data that Agartala city with its thousands of nonmotorized users has a huge potential to become a state with major share of nonmotorized user in India. From the structural equation model, ownership of a car and motorized vehicle also increased from the last 5 years. It is noteworthy that uses of the nonmotorized vehicle are also increased despite the poor presence of any nonmotorized friendly infrastructure and policies. We have to encourage more NMT mode by implementing some of the policies like educational campaigns, allocation of the fund to create more bicycle-oriented infrastructures. Apart from all the policies, the crucial point is to change the current mindset of all kind people in the society to promote NMT mode.

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