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Research paper

Effect of socioeconomic and latent variables in vehicle ownership: A case study of Agartala city, India

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Abstract

On the whole, car ownership is regarded as an imperative variable in travel behavior research. Car and motorcycle ownership are increasing rapidly in developing countries leading to an unsustainable developments. Using a data of 584 respondents from the Agartala city randomly collected, a model has been prepared to understand vehicle ownership for both car and motorized two wheeler mode (MTW). Latent variables along with socioeconomic variables such as monthly income, gender, age were used for modeling vehicle ownership using structural equation modelling. Latent variables used in this study, flexibility (Motorized Two wheeler), Negative public transportation perception and comfort (car) were found to be significant in the model. Our result suggests apart from socioeconomic variables, latent variables also explains vehicle ownership model.

Keywords: *Car ownership, attitude and perception, structural equation modeling.*

1. Introduction

The majority of cities, transportation developers have been spending hard to cope increasing private vehicle (particularly car and two-wheeler) travel requirement. In recent times, there is a greater than before dependency on the car and motorized two wheeler (MTW) can lead to issues such as pollution, congestion, accidents etc. Limiting car ownership and motorized two wheeler and their use will be a difficult task for the majority of the developing economies. In India, the average level of proprietorship of cars, presently 13 per 1,000 populations, and is anticipated to develop exponentially [1]. From the perspective of sustainable transportation design, consideration of the future car and MTW proprietorship and activities of individuals spending private vehicles will be of greater importance in case of developing countries. In recent years, India has undergone fast urbanization on a large measure. The speedy development of vehicle purchase rates has elevated concerns regarding social, economic and ecological sustainability [1]. Growth of vehicle proprietorship represents the aspiration of India's middle-class to lead more relaxed life and engage in more economic and discretionary activities. Relatively low per-capita income in the country also makes car ownership a symbol of luxury and status.

Car ownership is principally used as an exogenous variable, besides spatial and socioeconomic variable to describe travel behavior [2-3]. Some studies also have considered car ownership as exogenous variable and describe it in accordance with numerous spatial and socioeconomic variables [4-5]. In the majority of the smaller Indian cities, with population not more than five hundred thousand, there have been noteworthy transformations in the trip making activities of the individuals. Factors such as growing geographical area, changing socioeconomic and land use patterns, increasing number of motorized personal vehicles, absence of planned public transportation system might be influencing the change in travel behavior observed in these cities. In accordance with a survey of Ministry of Urban Development (MoUD), Govt. of India (2008), in the majority of the small sized Indian cities there will be a considerable upsurge in the modal shares of private transport modes for instance cars and motorized two wheeler (MTW) (57% in 2007 to 72% in 2031). Moreover, the part of the public transport modes (5% in 2007) and non-motorized modes (NMT) (38% in 2007) is decreasing in many of these cities. According to this report, the percentage mode share of public transport for small cities was very low and also predicted it to be much lower in the future (2% in 2031). At this juncture it becomes important to understand the factors related to car ownership and car use.

Organization of the remainder of this paper is given as follows. The subsequent section reviews the relevant literature. Section 3 details the data collection and study area description. Section 4 gives complete details of the methodology, and section 5 provides the relevant results. Section 6 concludes the paper by summarizing the major findings and discussing the policy implications.

2. Literature review

There are substantial amount of investigations and studies related to vehicle ownership [6, 7, 5, 8, 9, 10, 11, 12]. Golob [6] have studied the relationship between the competing influence on mobility on income and car ownership and also analyzed the effect of other mode of transport after controlling for the causal influence of both income and car ownership. He concluded that number of car and car trip were both increasing function of income. The middle income class shows a strong negative effect on public transport trip, the lower income class has a strong positive effect.

Srinivasan et al. [7] found that the vehicle ownership to be significantly influencing the sensitivity of the decision maker towards travel time. They have modeled this effect by segmenting the decision makers based on the vehicle ownership and the

vehicle availability for making the trip. He concluded that two-wheeler and car ownership considerably increase with overall household income; and the latter is also certainly disturbed by lagged-income. Using a credit card in an individual's name was controlled for (as an explanatory variable) and it completely disturbed car ownership, most possibly because of the holder's access to loans and additional financing options. The amount of household workers certainly affected MTW ownership, however had no direct effect on car ownership (even though these effects are also picked up through the existence of the income and income-associated variables).

Cao et al. [5] reported that with the increase in income the utility for car increases and that with the presence of a driving license transit utility is reduced. Dissanayake and Morikawa [8], from a study on Bangkok metropolitan area, identified household income, job status, and existence of school children in the households as the key considerations leading to household's resolutions on vehicle proprietorship, mode choice, and trip allocation. Walker et al. [9] from a study carried out on Chengdu, China, reported that car ownership increases the utility of car. Padmini and Dhingra[10] developed a revealed preference car ownership model, revealed preference two-wheeler ownership model, and mode choice model for the city of Pune in India. The variables they finally used for the two-vehicle ownership models were an ordinal variable for income, household size, ownership of residence, type of residence, street and private parking, parking cost, and whether any household member had a driver's license. Banerjee et al. [11] developed an MNL model for the city of Surat, India. However, the study did not consider households without any private vehicles. Income of individual was collected by the survey in the form of an ordinal variable, and it was the primary explanatory variable of the final vehicle ownership model developed. The multinomial model was designed for 18 alternatives about vehicle ownership, each with a different combination of number of cars and motorized two-wheelers. Income and household size were utilized as explanatory variables. They concluded that income is extremely noteworthy than household magnitude in explaining car ownership.

Attitudinal factors also have influence on car proprietorship verdicts among metropolitan young adults in emerging country like India. Verma et al.[12]concluded that the latent car demand among young adults in Bangalore was especially prevalent among those who originate from car holding families and those who have education at or beyond post-graduation level. This investigation recommended that individual does not purchase a car if somebody got job near their home. If public transport and bicycle infrastructure is good and car ownership and other taxes are high then people do not have to buy a car. Car ownership also affected by the factor related to comfort. Fresh grown-ups who have a pro-sustainability attitude are also expected to own a car in future.

3. Methodology

Structural Equation Modeling is a technique which deals with sociology, the biological science, psychology, educational research, marketing research and political science. Increasingly, Structural Equation Modeling has been applied to understand the relationship between socio demographics latent attitudinal factors for understanding car ownership and travel behavior with respect to mode choice. Structural equation modeling consists of two components: Structural model (Path analysis model) and measurement model. Path Models are described using the path diagram, in which the arrow represents the effect of prior on the succeeding variables. There are total three effects on path model; one is direct effect, indirect effect and total effect. When one variable direct influence on other variables is called direct effect. Indirect effect is simply the influence of one variable to the supplementary variables through other mediating variable. Total effect is the amount of direct and indirect effect. The measurement model describes the relationship between a latent variable and its indicators. The measurement models confirm the hypothesized association among the measured variable and latent factor.

Structural Equation Modeling includes quite a lot of steps. Initially, the researchers structures a conceptual model in accordance with the research problem and the hypothesis. The researcher subsequently indicates the model by following pictorial representation that comprises depiction of the hypotheses by means of arrows and other shapes. When the model has been identified, the researcher estimates the identification position of the hypothesized model. The researcher selects suitable estimation scheme for the purpose of estimating the parameters of the hypothetical model. The researcher then continues to assess model fit, and if find satisfactory, he/she reports model findings; if not, re-specifies the model.

A common SEM model can be given as follows:

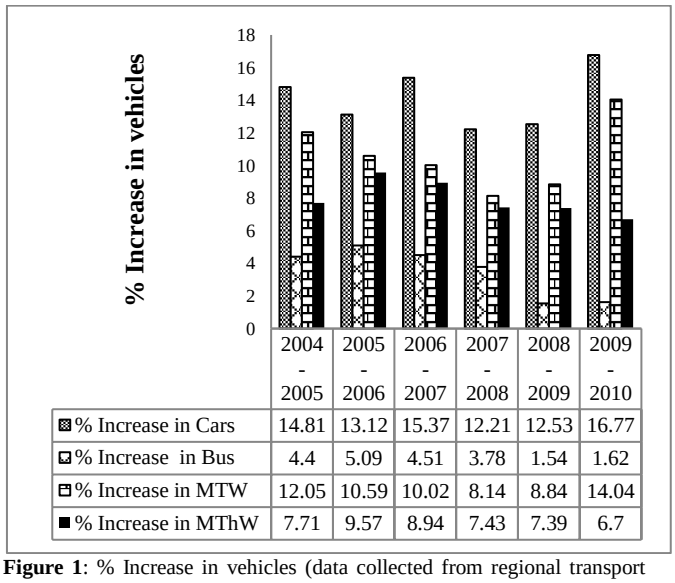
$$Y = \alpha + \beta Y + \Gamma X + \xi \quad (1)$$

In which, 'Y' represents a column vector of dependent variables, 'X' indicates a column vector of independent variables, 'α' represents a column vector of intercept terms; 'β' indicates a square matrix of the direct relation among the dependent variables, 'Γ' indicates a square matrix of coefficients from independent to dependent variables, and 'ξ' represents a column vector of errors.

4. Data collection

4.1. Study area and data collection

In this paper, Agartala, capital of the state of Tripura, situated in north eastern part of India, has been selected as the study zone. Agartala municipality includes 35 municipal wards, divided typically for administrative purposes. This city is the 2nd biggest city in the north-east India, following Guwahati, based on municipal area (58.84 km2). In accordance with the census data 2011, the population of Agartala city was 399688 with a population density of 6793 persons per km2. Recently, there has been high growth in the vehicle ownership, which may be attributed to the recent economic boom seen in the country. Vehicle population growth data in Agartala city presented in Figure 1 shows that there is a significant growth in car and MTW population and a decrease in the growth of number of buses in Agartala city. This sharp increase in the percentage of private vehicle ownership may be one of the reasons behind people shifting to private modes from sustainable modes of transportation. At this juncture it becomes important to understand the factors related to car ownership and car use.



	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
% Increase in Cars	14.81	13.12	15.37	12.21	12.53	16.77
% Increase in Bus	4.4	5.09	4.51	3.78	1.54	1.62
% Increase in MTW	12.05	10.59	10.02	8.14	8.84	14.04
% Increase in MThW	7.71	9.57	8.94	7.43	7.39	6.7

Figure 1: % Increase in vehicles (data collected from regional transport office, agartala)

It must be observed that travel data have been gathered through a household survey conducted in the study area for the period of March-September, 2012, taken randomly from different municipal wards. Information related to the journeys and the travel modes like origin, destination, purpose of the trip, mode of travel, length of the trip have been gathered. Also, the socioeconomic characteristics like age, gender, and years of education, household size, household income, vehicle proprietorship, and the license status of the trip makers have been collected. From the survey carried out 584 data were used in the current study. Statistics of sample data is given in Table 1.

Table 1: Summary of Socioeconomic Data Acquired from the Sample

Socioeconomic characteristic	Value in Percentage
Gender	
Male	73.38
Female	26.62
% of individual in the age category	
Up to 20	3.95
20 -30	17.69
30 – 40	18.53
40 -50	24.08
50 -60	22.77
> 60	12.98
% of household having driving License	
Having	49.5
Not Having	50.5
% of individuals (Years of education)	
0	0.19
1 to 5	4.05
5 to 8	9.13
8-10	20.51
11 to 12	15.62
13-15	33.02
16 to 18	17.31
19-21	0.00
More	0.19
MTW ownership	44.21
Monthly household income (in Indian rupees)	
0-2000	0.03
2001-10000	30.86
10000-20000	25.55
20000-50000	31.37
> 50000	12.15

Responses to the qualitative questions provide valuable insights into the individuals' opinions on travel modes. The trip makers had offered responses to several qualitative questions (Table 2) during the household survey. The defendant had to rate his/her level of agreement on a five-point Likert scale ranging from a total disagreement (response of 1) to a complete agreement (response of 5). Indicator variables were grouped appropriately in accordance with the prior assumptions to build four latent variables specifically, comfort, flexibility, safety, and reliability.

Table 2: Observed Mean Perception Rating for Different Modes

attribute	CAR	MTW
Comfortable in journey	4.06	3.72
Always availability of comfortable seats	3.76	3.68
Very easy accessibility	3.69	3.89
Ability to reach destination in time	3.91	3.89
Can exactly calculate travel time prior to trip	3.89	3.91
Safety from accident	3.83	3.22
Safety from theft	3.91	3.68
Safety from weather	3.88	2.20
Ability to make more trips	3.85	3.68
Can travel without changing vehicles	3.94	3.92

Table-2 gives the mean perception evaluation for various modes in Likert scale (1- Strongly disagree, 5 – Strongly agree).From table 2 it can be seen that people have a positive perception towards car related to comfort. Related to perception of MTW, people have negative perception towards safety and have a positive perception towards flexibility offered by the modes.

Figure 2 shows model split of the collected data used in this study. It can be seen that MThW (31%) and MTW (25%) are the predominant modes used for making the work trips. Bus (4%) and car (9%) are less frequently used as the commute modes. Bicycle, rickshaw and walk modes have almost got equal share in the work related trips.

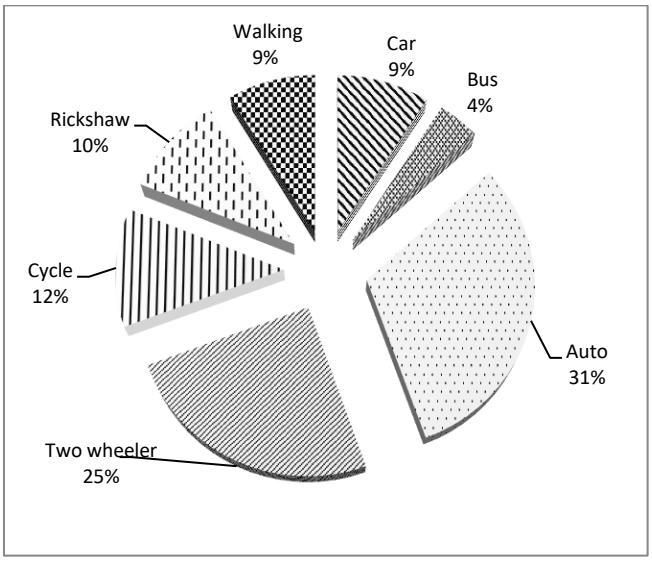


Figure 2: Modal composition for work trips

Table 3 provides shows mean perception rating of the agreement and disagreement statements used in the model for public transport

Table 3: Mean Perception Rating of the Agreement and Disagreement Statements

Perception attribute	Ratings
If I use public transport instead of car or two wheeler I have to cancel some of the activities	3.72
It is hard to take public transport when travelling with children.	3.92
It is hard to take public transport with bags & luggage.	3.97
I need to have more flexibility to make many trips during working hours.	3.72
Bus is chosen when no other option is available.	3.72
Using bus service is cumbersome.	3.57

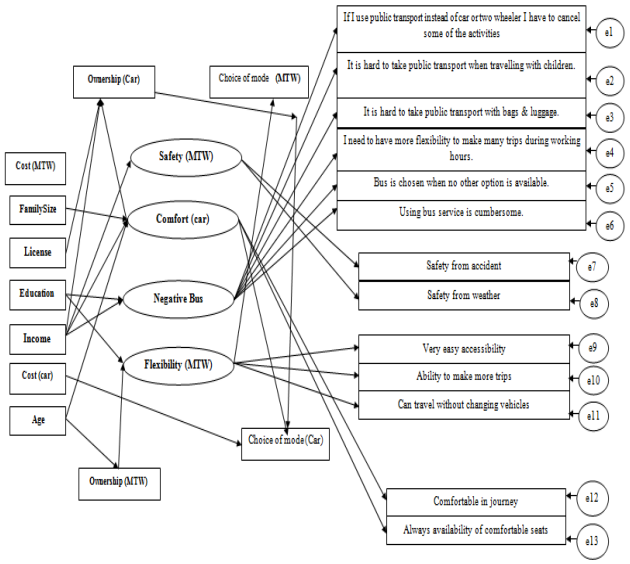


Figure 4: Schematic diagram of SEM model for estimation results of car and MTW travel mode choice and vehicle ownership model

Table 4: Estimation Results of Car and MTW Travel Mode Choice and Vehicle Ownership Model

Latent Construct	Path	coefficient	t-value
If I use public transport instead of car or two wheeler I have to cancel some of the activities	←Negative bus	1.000	
It is hard to take public transport when travelling with children.	←Negative bus	1.948	7.628
It is hard to take public transport with bags & luggage.	←Negative bus	1.929	7.507
I need to have more flexibility to make many trips during working hours.	←Negative bus	.776	5.380
Bus is chosen when no other option is available.	←Negative bus	.924	5.132
Using bus service is cumbersome.	←Negative bus	.723	4.401
Very easy accessibility	←Flexibility(MTW)	1.000	
Ability to make more trips	←Flexibility(MTW)	1.584	6.699
Can travel without changing vehicles	←Flexibility(MTW)	1.612	6.764
Safety from accident	←Safety (MTW)	1.033	2.862
Safety from weather	←Safety (MTW)	1.000	
Comfortable in journey	←Comfort (car)	1.000	
Always availability of comfortable seats	←Comfort (car)	1.459	4.280
Structural Model			
Negative bus	←Income	0.018	2.921
Negative bus	← Education	0.008	1.969
Comfort(car)	← Age	0.004	2.235
Comfort(car)	← Income	0.037	3.724
Comfort(car)	← Family size	-0.017	-1.678
Flexibility(MTW)	← Age	-0.005	-3.919
Flexibility(MTW)	←Availability(MTW)	0.175	5.070
Flexibility(MTW)	← Education	0.023	5.000
Safety (MTW)	← Income	-0.057	-3.812
Availability(Car)	←Income	0..043	6.832
Availability(Car)	← Comfort (car)	0.289	3.424
Availability(Car)	←License	0.073	2.746
Availability(MTW)	←License	0.570	17.850
Choice of mode (MTW)	←License	0.185	7.313
Choice of mode (MTW)	← Availability(MTW)	0.637	22.651
Choice of mode (MTW)	←Cost (MTW)	-0.009	-6.162
Choice of mode (MTW)	Flexibility(MTW)	0.238	4.026
Choice of mode (MTW)	← Safety(MTW)	0.125	1.915
Choice of mode (Car)	←cost(car)	-0.001	-3.090
Choice of mode (Car)	←Comfort (car)	0.180	2.102
Choice of mode (Car)	←Income	0.024	2.253
Choice of mode (Car)	←Availability(Car)	0.337	1.452
		RMSEA	0.099
		CFI	0.606

5. Conclusion

Parameters effecting vehicle ownership and choosing private vehicles is presented here. From the SEM model, two wheeler vehicle ownership depends upon driving license and flexibility of the mode, Ownership of car is explained by parameter like having driving license and comfort parameter of the mode. Cost of car, comfort parameter of car, income and car ownership affects mode choice of car. Cost parameter is negatively related and comfort, income and car ownership is positively related. From the model, mode choice of two wheeler depends upon vehicle ownership, travel cost and safety. Overall it can be concluded that apart from socioeconomic variables, perception and attitudes towards modes effect vehicle ownership and mode choice in developing cities of India. Policies towards reduction of two wheeler mode may be

implemented by increasing the travel cost of the trips. Planners may consider making transit mode more lucrative by making more accessible and reliable. Similarly for car mode also, increases in travel cost, which may be implemented by some taxation/parking or penalization may also reduce the mode of travel by car. Planning of future transport planning systems may also need to consider these aspects.

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