World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Effects of Transportation Development on Travel Behaviour in Rural Areas

Biswarup Das[a]* and Bhargab Maitra[b]

[a] Former Student, Department of Civil Engineering, Indian Institute of Technology Kharagpur, West Bengal, India
[b] Professor, Department of Civil Engineering, Indian Institute of Technology Kharagpur, West Bengal, India
*Corresponding Author:biswarupdas10@gmail.com

Abstract

The main aim of this paper is to observe the effects of different transportation development on the travel behaviour of rural commuters by modelling the purpose wise trip rates as a function of socioeconomic characteristics and hypothetical scenarios such as road infrastructure improvements, improvements of feeder service (in term of average waiting time), different fare structure of feeder service. Structural Equation Model (SEM) is used to observe the relationships between the different variables which affect trip making behaviour of rural people in India. Two types of trip rates (i.e. revenue and household) of rural commuters are modelled. It was found that vehicle ownership and household category takes the major part in affecting the revenue trips. For the household trip, the effects of income and vehicle ownership are higher than the other factors. The trip rates of rural commuters are observed through different stages of transport developments and the findings suggest that there is an increase in number of trips with every stage of progressive development. Further, the results indicate that people are very sensitive to change in fare rate as well as the average waiting time of feeder vehicle for both revenue and household trips.

Keywords: Travel Behaviour, Structural Equation Modelling, SEM, Rural Area, Transportation Development, Feeder Service, Trip Rates

1. Introduction

In India, rural population contributes 68.84 % of the total population (Census of India, 2011) and it is essential to develop rural areas for the overall growth of the country. Improvements of transportation facilities in rural areas could play an important role in this growth. Many rural areas have low road connectivity and lack basic transport services for the movement of people and goods. Therefore, people in rural areas have less access to centre markets, employment opportunities, education and other important facilities. Additionally, car ownership is low in rural India and many rural roads are not served by buses. Hence, feeder vehicles such as 'trekker' and 'tempo' became the main modes of transportation in these areas for accessing the bus stops (Das et al, 2012; Dandapat and Maitra, 2015; Maitra et al, 2013). Accordingly, improvements of road connectivity and planning for feeder services to bus stops are expected to be a great deal in developing the rural areas. However, it is also expected that the transportation improvements could also affect travel behaviour of rural people. Therefore, it is substantive to investigate the changes in travel behaviour with respect to the transportation developments along with socio-economic characteristics in rural India. Several research works had attempted to predict travel behaviour using the various types of factors. The impacts of attitude, residential neighbourhood types and life style on travel behaviour were observed in many studies in the past (Dobson, et al.1978; Golob 2001; Golob and Hensher, 1998; Bagley and Mokhtarian 2002). Some research studies investigated the effects of other factors such as telecommunication and the internet on travel

behaviour (Choo and Mokhtarian 2007; Ren and Kwan 2009). The complex relationship between socio-demographics, activities and travel behaviour was studied before to understand travel patterns (Lu and Pas 1999). Other factors such as car ownership and built environment factors may affect the individual travel patterns. Van Acker and Witlox (2010) observed the effects of car ownership (as a mediating variable) and built environment factors on car travel behaviour. It could be very challenging to forecast the travel pattern as there are many uncertainties associated with future developments. Therefore, it may be important to develop scenarios which may help to predict possible future events and produce much superior forecasting results (Masser et al, 1992; Zegras et al, 2004). For travel related forecasting, hypothetical scenarios could help to understand the possible impacts on travel behaviour as it was shown by Fujii and Kitamura (2000). But the majority of the research works on travel behaviour were carried out in context of urban areas in developed countries. There is lack of research on travel behaviour of rural people in developing countries. Further, the changes in travel behaviour with respect to the changes in transportation developments have not been investigated adequately. Therefore, in this paper, an attempt is made to observe the effects different scenarios of transportation developments along with socioeconomic characteristic on travel behaviour in rural areas in India.

The connectivity in rural India is mainly based upon national highway, states highway, major district roads and these major roads are predominately served by bus services. However, some rural areas which are not served by buses due to the unavailability of proper roads connectivity and feeder services to bus stops even though there are some significant improvements in connectivity through the construction of new roads have been observed in past few years (Sikdar, 2002; Das et al, 2009). Some research works had been reported about the bus transportation system and feeder service to bus stops in rural India (Satishkumar et al, 2018; Phanikumar and Maitra, 2010; Phanikumar and Maitra, 2007; Ramanayya et al. 2007). However, attempt to understand the travel behaviour under the effects of transportation developments such as improvements of feeder services to bus stop in terms of average waiting time and fares rates, construction of new all weather bituminous roads along with socio-economic characteristics were seldom made.

For the present study, structural equation modelling was used to understand the effects on travel behaviour. The applications of SEM in travel behaviour were initially observed in early 1980's. For example, a model of vehicle ownership and distance travelled was developed and estimated simultaneously (Den Boon, 1980). Thereafter, another model of attitudes and modal choice was formulated to understand the relationships (Lyon, 1981a and 1981b). Earlier, simultaneous equation models of travel behaviour and attitudes were developed (Tardiff, 1976 and Dobson et al, 1978) and effectiveness of tool like SEM is noticed in travel demand modelling (CRA, 1978 and Allaman et al, 1982).

2. Study Area

Some of the catchments areas around a stretch of rural road, representing the typical rural characteristics of West Midnapur district, West Bengal, India was selected as the study area. All these areas were not served by bus transportation. However, few feeder vehicles were operational within the study area at the time of the study. Main travel modes were either bicycle or motorcycle in order to have access to the different activities. The areas include several villages (or Para) which are located both sides of the road segment of almost 20 km length between Paradiha and Kultigiri.

3. Methodology

Structural Equation Modelling (SEM) was made used as a tool to observe the relationship between different variables including the hypothetical scenarios, socio-economic attributes and trip rates for the present study. SEM has been largely applied in transportation

related studies and continuously growing because of its effectiveness in handling huge number of variables, simultaneous estimation of multi equations, accounting missing data, and capabilities to include latent or unobserved variables (Golob, T. F. 2003). The general formulation of structural equation model is as follows (Hayduk, 1987; Oud and Folmer, 2008):

$$y = By + \Gamma x + \xi, \quad (1)$$

Where, y = (p x 1) vector of endogenous variables, B = (p x p) matrix of coefficients associated with the right-hand-side endogenous variables, x = (m x 1) vector of exogenous variables, Γ = (p x m) matrix of coefficients associated with the exogenous variables, and $=$ (p x 1) vector of error terms associated with the endogenous variables.

Latent variables are introduced by expanding model (equation 1) into a system involving two sub models:

$$y = \Lambda\eta + \varepsilon, \quad (2a)$$

$$\eta = B\eta + \Gamma x + \xi, \quad (2b)$$

Where, η = *(q x 1)* column vector of latent variable constructs, Λ = *(q x p)* matrix of coefficients in the measurement model relating the latent variable constructs and the observed endogenous variables, ε = *(q x 1)* vector of measurement errors.

The step wise whole methodological framework along with the four steps of Structural Equation Modelling is shown in fig. 1 and Maximum Likelihood Estimation (MLE) was used to estimate the parameters of SEM which requires a sufficient sample size, particularly when non-normal data are involved. It was being observed that at least 200 samples are required for MLE (Boomsma and Hoogland, 2001).

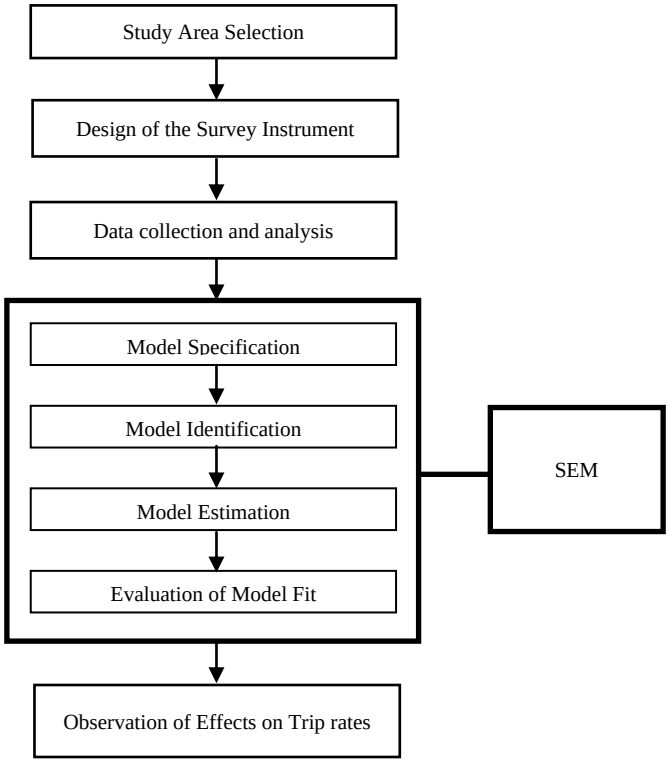


Figure 1: Methodological Framework along with Steps in SEM

3.1. Design of Survey Instrument & Data Collection

A suitable survey instrument was designed and thereafter several rounds of pilot surveys were carried out to train survey team members. The pilot survey also helped to check the presence of any demerit in the survey instrument before taking up main survey. During the main surveys, data was collected through interviewing respondents face to face for this study. It was also necessary to collect preferences of people in the form of either Revealed preference (RP) or Stated Preference (SP) data or both together. RP data may not be suitable for future trip rates predictions as it cannot consider hypothetical scenarios. Therefore, SP data which can include hypothetical scenarios (Louviere 1988b) could be used for this purpose. Different questions were prepared based on literature review and local conditions. The survey instrument was designed to have three main sections which includes household characteristic, travel information and stated preference responses. Household characteristic was represented by five attributes such as household size, household income, household category, vehicle ownership and age of the respondents. Travel information included trip information of the respondents regarding the past and present time, travel modes during these times, distance from the village to bus stop and type of roads. The last section was about the stated preferences responses concerning purpose wise number of trips to be made per week by the respondents under the scenario of average waiting time and fare rates of feeder services to bus stops. Average waiting times of 10, 20 and 30 minutes along with fare rates of Rs. 0.50, 1.00 and 1.50 per kilometre for feeder services were included in the scenario to collect the stated preference responses. The trip purpose was divided into two major parts which are revenue and household trips for the present study.

The data was collected from the 500 households among which 80.6% refined observations were used to prepare the finale database for the purpose of model development after excluding the incomplete observations. A summary of the database regarding the socio demographic characteristics and travel information of the respondents is given in Table 1.

Table 1: Summary of the Database

Attributes	Category	%
Age of Respondent	18-25	4.23%
	25-35	25.62%
	35-40	19.90%
	40-45	24.13%
	> 45	26.12%
Household Size	1	0%
	2	2.48%
	3	17.62%
	4	38.46%
	5	17.87%
	> 5	23.57%
Household Type	Business & Service Household	33.99%
	Cultivator Household	41.69%
	Daily Labour Household	24.32%
Household Income	< 2000	1.74%
	2000-4000	25.81%
	4000-6000	31.01%
	6000-8000	14.14%
	8000-10000	9.93%
	> 10000	17.37%
Vehicle Ownership	Only Bicycle	79.70%
	Motorcycle + Bicycle	20.30%

Travel Mode	Walk Bicycle Motorcycle Feeder Vehicle (Trekker)
Trip Purpose	Revenue Trip Household Trip
Road Type	PMGSY Road

3.2. Model Development

Before developing a model, it was essential to prepare a well-organized the database and code it properly. There are several coding styles that are available to decide how levels of attributes may be entered into the models. Quantitative attributes like household size were entered into the model in cardinal linear form whereas the qualitative attributes like household categories were entered into the model in effect codes (1, 0, -1). However, household income was initially entered into the model in cardinal linear form by taking the mean value of the income ranges that were considered but later discarded due to statistically insignificant results. It was then coded using dummy coding (0, 1) with '0' being the low-income group and '1' being the high-income group. Household income which is Rs. 6000 or below was considered as the low-income group and more than Rs. 6000 was considered as the high-income group for the present study based on the statistically significant results.

A basic model was first specified considering all the socioeconomic characteristics and trip characteristics of the respondents under hypothetical scenarios which include different fare rates, average waiting time of feeder services to bus stop and no feeder service in the presence of bituminous road. For the all different levels of fare rates (i.e. Rs. 0.50, 1.00 and 1.50 per kilometre) of feeder service, household and revenue trips were modelled and the specifications of the models were kept same as the basic model. The SP responses for trip rates were divided into three different groups according to the fare rates of feeder services and trip rate models were developed for each group. The first trip rate model was developed for fare rate of Rs. 0.5/km for feeder service and next two trip rate models were formulated for fare rates of Rs. 1.00 and 1.50 per kilometre for feeder service respectively. Each of these three trip rate models was further divided into two sub-groups for different purpose of trips that were revenue and household trips per week respectively. The main purpose of the multi-group analysis was to find out the extent to which groups differ. The first model which was developed was the least significance and discarded. New model was developed and thereafter checked for the level of significance. This procedure was repeated until final model was developed with statistical significance. The schematic path diagram of the final model is shown in Figure 2 below.

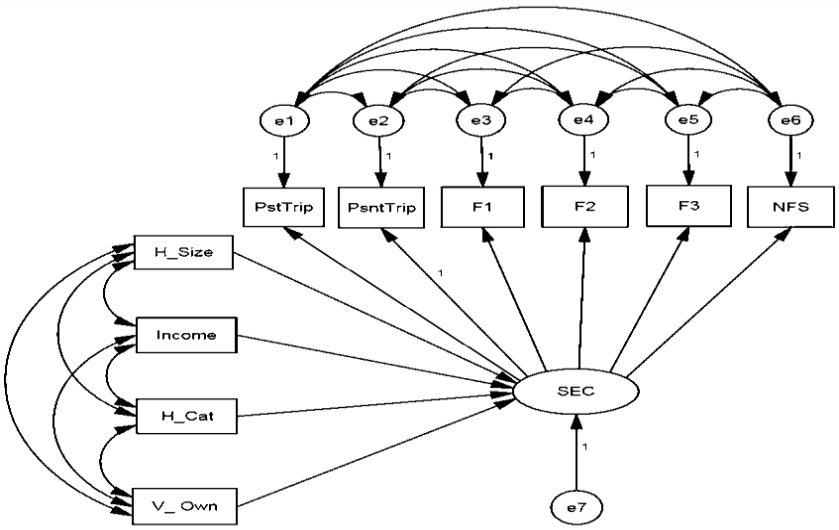


Figure 2: Path Diagram of Structural Equation Model for Trip Rates

The descriptions for all the variables that were used in the model are shown below in the Table 2.

Table 2: Descriptions of variables in model

Variables	Description
H_Size	Household Size
Income	Household Income
H_Cat	Household Category
V_Own	Vehicle Ownership
SEC	Socio-economic Characteristics (latent variable) with an error term e7
PstTrip	Past Trip Rates when no road, no feeder service were present (with an error term e1)
PsntTrip	Present Trip Rates when bituminous road and few feeder service are present (with an error term e2)
F1	Trip Rates at average waiting time of 10 min for feeder vehicles (with an error term e3)
F2	Trip Rates at average waiting time of 20 min for feeder vehicles (with an error term e4)
F3	Trip Rates at average waiting time of 30 min for feeder vehicles with an error term e5
NFS	Trip Rates when no feeder service but bituminous road was present in the study area(with an error term e6)

4. Results and Discussions

The models were found to be statistically significant as the goodness of fit values are within acceptable range. The degree of fit of the model is in terms of various fitness indices and the accepted values as per conventional criteria (Hu and Bentler, 1999; Fan et al., 1999) are shown in Table 3.

Table 3: Goodness of fit values

Fitness Indices	Value	Accepted value
Chi-square	29.526	
Degrees of freedom	16	
GFI	0.986	$\geq$ 0.90

AGFI	0.951	≥ 0.90
CFI	0.996	≥ 0.90
NFI	0.99	≥ 0.90
RMR	0.01	≤ 0.05
RMSEA	0.046	≤ 0.05

The model has chi-square value amounting to 29.526 with 16 degrees of freedom, which was significant as the ratio between chi-square and the degree of freedom gives a value reaching 1.845 which is within the accepted value of 5. The GFI of the model shows a good fit as the value is 0.986 which is higher than 0.900. The AGFI, CFI and NFI of the model are 0.951, 0.996 and 0.99 respectively which are more than the accepted value of 0.900. The RMR and RMSEA of this model are 0.010 and 0.046 respectively which are lower than the limit of 0.05 (Steiger, 1990; Browne and Cudeck, 1992) for a good fit. Hence it seems that the structural model has a fairly good fit and statically significant from the observed values given in Table 3.

The results of the three cases and their sub-cases of the model as defined earlier are as follows:

4.1. First Trip Rate Model

This model accommodates the different trip rates as given in path diagram which is shown in Figure 2 at a fare rate of Rs. 0.5/km for feeder service. The model is further divided into parts for purpose wise trip rates which are revenue and household trip rates.

4.1.1. Results for Revenue Trip Rates

The casual relationships between variables are given below in Table 4. In this case, the revenue trips are affected more by vehicle ownership and household category. However, the total positive effects of vehicle ownership on trips are decreasing as the average waiting time for feeder vehicles are increasing and it is lowest at past condition when there was no bituminous road as observed from Table 5. It was found that for those who owned motor vehicles, revenue trips per week vary from 3.5 to 8 and those who don't own any motor vehicle, trips varies from 2 to 5.5 for different average waiting time at a fare rate of Rs. 0.5/km. For revenue trips, the effects of income are not so significant compared to the other attributes. However, the effects of household categories are significant on the revenue trips and past trips are least affected by this.

Table 4: Regression weights for the revenue trips in the first case

			Estimate	S.E.	C.R.
SEC	<---	H_Size	.316	.062	5.096
SEC	<---	V_ Own	.822	.195	4.224
SEC	<---	Income	.021	.184	.116
SEC	<---	H_Cat	.698	.102	6.810
PstTrip	<---	SEC	.570	.042	13.463
PsntTrip	<---	SEC	1.000		
F1	<---	SEC	1.264	.033	38.347
F2	<---	SEC	1.179	.030	38.828
F3	<---	SEC	1.092	.030	36.490

			Estimate	S.E.	C.R.
NFS	<---	SEC	.798	.035	22.572

Table 5: Total Effects on the revenue trips in the first case

	H_Cat	Income	V_ Own	H_Size	SEC
SEC	.698	.021	.822	.316	.000
NFS	.557	.017	.656	.252	.798
F3	.762	.023	.897	.345	1.092
F2	.823	.025	.969	.372	1.179
F1	.882	.027	1.039	.399	1.264
PsntTrip	.698	.021	.822	.316	1.000
PstTrip	.398	.012	.469	.180	.570

4.1.2. Results for Household Trip Rates

The regression weights of different attributes including socio-economic characteristics for the household trips are given below in Table 6. From the Table 7, it is observed that the household trips are positively and significantly affected by household income and vehicle ownership. It was also found that for those who are in high-income group, the household trips per week varies from 2 to 4 and for the low-income group, the trips vary from 1.5 to 3 for the different average waiting time at a fare rate of Rs. 0.5/km. Based on this observation, it can be stated that if the income is higher and people owned vehicle then it is most likely that more household trips are expected to be made.

Table 6: Regression weights for the household trip in the first case

			Estimate	S.E.	C.R.
SEC	<---	H_Size	.085	.023	3.698
SEC	<---	V_ Own	.228	.071	3.185
SEC	<---	Income	.230	.068	3.364
SEC	<---	H_Cat	.099	.037	2.695
PstTrip	<---	SEC	.704	.080	8.853
PsntTrip	<---	SEC	1.000		
F1	<---	SEC	1.257	.077	16.319
F2	<---	SEC	1.197	.069	17.248
F3	<---	SEC	1.071	.070	15.228
NFS	<---	SEC	.918	.073	12.579

Table 7: Total Effects on the household trips in the first case

	H_Cat	Income	V_ Own	H_Size	SEC
SEC	.099	.230	.228	.085	.000
NFS	.091	.212	.209	.078	.918
F3	.106	.247	.244	.091	1.071
F2	.118	.276	.272	.102	1.197

	H_Cat	Income	V_ Own	H_Size	SEC
F1	.124	.290	.286	.107	1.257
PsntTrip	.099	.230	.228	.085	1.000
PstTrip	.070	.162	.160	.060	.704

4.2. Second Trip Rate Model

Similar to first Model, this model comprises the different trip rates but at a fare rate of Rs. 1.0/km for feeder service. The model is also divided into parts for revenue and household trip rates.

4.2.1. Results for Revenue Trip Rates

The regression weights for the relationships between different variables for the revenue trips rates in this case are given below in the Table 8. The effect of vehicle ownership is found to be positive and very significant and on the other hand, the effect of household categories is significant on influencing the revenue trips as observed from Table 9. However, it is also observed that the effects of all the attributes are slightly reduced compared to the first case due to the increase in fare rates of the feeder vehicles which is the one of the major travel mode in the study area.

Table 8: Regression weights for the revenue trip in the second case

			Estimate	S.E.	C.R.
SEC	<---	H_Size	.248	.059	4.174
SEC	<---	V_ Own	.897	.188	4.768
SEC	<---	Income	.084	.177	.476
SEC	<---	H_Cat	.680	.099	6.851
PstTrip	<---	SEC	.578	.042	13.604
PsntTrip	<---	SEC	1.000		
F1	<---	SEC	1.187	.037	32.407
F2	<---	SEC	1.150	.030	38.209
F3	<---	SEC	1.069	.015	69.962
NFS	<---	SEC	.824	.035	23.264

Table 9: Total Effects on the revenue trips in the second case

	H_Cat	Income	V_ Own	H_Size	SEC
SEC	0.68	0.084	0.897	0.248	0.000
NFS	0.560	0.069	0.739	0.204	0.824
F3	0.727	0.090	0.959	0.265	1.069
F2	0.782	0.097	1.032	0.285	1.15
F1	0.807	0.100	1.065	0.294	1.187
PsntTrip	0.680	0.084	0.897	0.248	1.000
PstTrip	0.393	0.049	0.518	0.143	0.578

4.2.2. Results for Household Trip Rates

For this case, different attributes and regression weights are given below in Table 10. Further observation from Table 11 suggests that income and vehicle ownership play positive and significant role on household trips but it decreases slightly with increase in fare rates of feeder vehicles. Similar to the first model, it is observed that household size has less significance on household trips compared to other attributes but can have important role on influencing this type of trip if the household size is more.

Table 10: Regression weights for the household trip in the second case

			Estimate	S.E.	C.R.
SEC	<---	H_Size	.065	.024	2.783
SEC	<---	V_ Own	.233	.075	3.114
SEC	<---	Income	.265	.072	3.660
SEC	<---	H_Cat	.101	.038	2.625
PstTrip	<---	SEC	.712	.078	9.083
PsntTrip	<---	SEC	1.000		
F1	<---	SEC	1.177	.081	14.583
F2	<---	SEC	1.150	.074	15.464
F3	<---	SEC	1.117	.051	21.931
NFS	<---	SEC	.960	.075	12.753

Table 11: Total Effects on the household trips in the second case

	H_Cat	Income	V_ Own	H_Size	SEC
SEC	.101	.265	.233	.065	.000
NFS	.097	.254	.223	.063	.960
F3	.113	.295	.260	.073	1.117
F2	.116	.304	.268	.075	1.150
F1	.119	.311	.274	.077	1.177
PsntTrip	.101	.265	.233	.065	1.000
PstTrip	.072	.188	.166	.047	.712

4.3. Third Trip Rate Model

Same as first two models, this model includes the different trip rates except the fare rate which is Rs. 1.5/km for feeder vehicles. The model is too divided into parts alike the first and the second model, i.e. models for revenue and household trips rate.

4.3.1. Model Results for Revenue Trip Rates

The strength of the relationships between variables in this case for the revenue trips rates are given below in Table 12 through regression weights. Similar to first two cases, the vehicle ownership and household categories have significant role on revenue trips but it is slightly reduced compared to first two cases as fare rates increases as mentioned earlier. Further, it is observed that income plays least role on affecting revenue trips as discussed before.

Table 12: Regression weights for the revenue trip in the third case

			Estimate	S.E.	C.R.
SEC	<---	H_Size	.241	.061	3.982
SEC	<---	V_ Own	.702	.191	3.676
SEC	<---	Income	.161	.181	.890
SEC	<---	H_Cat	.727	.101	7.169
PstTrip	<---	SEC	.571	.043	13.296
PsntTrip	<---	SEC	1.000		
F1	<---	SEC	1.092	.029	37.122
F2	<---	SEC	1.045	.020	53.005
F3	<---	SEC	1.015	.017	58.119
NFS	<---	SEC	.811	.035	22.978

Table 13: Total Effects on the revenue trips in the third case

	H_Cat	Income	V_ Own	H_Size	SEC
SEC	0.727	0.161	0.702	0.241	0.000
NFS	0.590	0.131	0.569	0.195	0.811
F3	0.738	0.163	0.713	0.245	1.015
F2	0.760	0.168	0.734	0.252	1.045
F1	0.794	0.176	0.767	0.263	1.092
PsntTrip	0.727	0.161	0.702	0.241	1.000
PstTrip	0.415	0.092	0.401	0.138	0.571

4.3.2. Model Results for Household Trip Rates

The regression weights for the household trips in the third model are presented in the Tables 14. Further observations suggest that income plays major role on number of household trips to be made by rural people as seen in Table 15. It is also found that vehicle ownership has the second major significant role on influencing the household trip rates and the effects of household size are least among the other attributes. As fare rates is the most in this case, the overall effects of all the attributes are marginally decreased, which is a very apparent trend in this overall study.

Table 14: Regression weights for the household trip in the third case

			Estimate	S.E.	C.R.
SEC	<---	H_Size	.062	.024	2.639
SEC	<---	V_ Own	.188	.074	2.531
SEC	<---	Income	.314	.074	4.245
SEC	<---	H_Cat	.088	.038	2.295
PstTrip	<---	SEC	.710	.079	9.006
PsntTrip	<---	SEC	1.000		
F1	<---	SEC	1.184	.073	16.288
F2	<---	SEC	1.098	.050	21.786
F3	<---	SEC	1.075	.047	22.990

			Estimate	S.E.	C.R.
NFS	<---	SEC	.955	.076	12.595

Table 15: Total Effects on the household trips in the third case

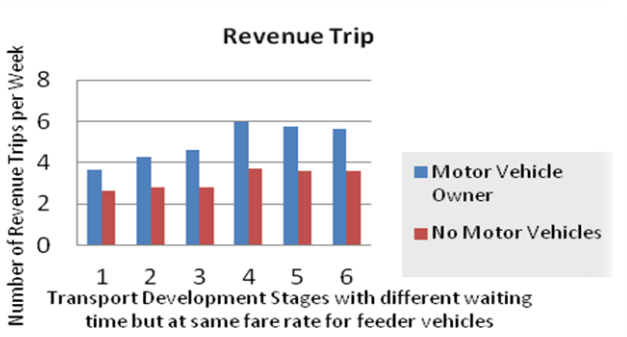
	H_Cat	Income	V_ Own	H_Size	SEC
SEC	.088	.314	.188	.062	.000
NFS	.084	.300	.180	.060	.955
F3	.095	.338	.202	.067	1.075
F2	.097	.345	.207	.068	1.098
F1	.104	.372	.223	.074	1.184
PsntTrip	.088	.314	.188	.062	1.000
PstTrip	.063	.223	.134	.044	.710

In all the three cases, the revenue trips are affected more by vehicle ownership and household category but the effect is decreasing as the fare rate is increasing (see Tables 4, 8, 12) and the overall effects are slightly lesser than the previous cases. This means the revenue trips are going to be slightly less with the increase in fare rates of feeder vehicles. Based on the collected data, it is observed that businessman and serviceman expected to travel more than other categories of the household. Further observations suggest that income is having relatively lower impact on revenue trips as people have to make minimum revenue trips to earn minimum amount of money for their livings. Good transportation facilities can be seen as more earning opportunities and therefore more frequent trips are expected to be made for income. The household trips are mostly affected by income and vehicle ownership rather than household category (see Tables 6, 10, 14). This type of trips does not vary significantly with changes in average waiting time of feeder service. The result of this work also shows that household size is having more effect on revenue trips than household trips. This means if the member of a household is more, the household income seemingly to be more, therefore the revenue trips have to be more in order to an anticipation of increase in income. It is also observed that the effects of socioeconomic characteristics on trips are increasing with decrease in average waiting time of feeder service in all the cases and sub cases. The total number of trips per week will be decreasing to some extent as the fare rate of feeder services is increasing. The difference between trips is significant when there is some difference in fare rates than the difference in average waiting times of feeder services. It is also being observed that people with high-income category and motor vehicle owners travel more for both revenue and household trips than people with low-income category and non-motor vehicle owners.

4.4. Effect of Transportation Developments on the Trip Making Behaviour

The effect of transportation developments on the revenue trip rates is observed with the help of the graph plotted as shown in Figure 3(a) and 3(c). At the fourth point, an average trip rate is reaching its highest value because it represents the highest form of development as described in the respective figures. Along the horizontal axis, the first point which is the lowest level of development that has no feeder service and no roads has very low trip rates. The trip rates are high at fourth point along horizontal axis as this is the highest form of transportation development considered for the study and it is decreasing from fourth point onward through to sixth point as average waiting time and fare rates for feeder service are increasing. Comparing figure 3(a) and 3(c), it is observed that the rural commuters are more sensitive to increases in fare compare to increasing in average waiting time. Vehicle ownership has also had significant effects on numbers of revenue trips. Household trip rates are also shown in figure 3(b) and 3(d). It can be seen that

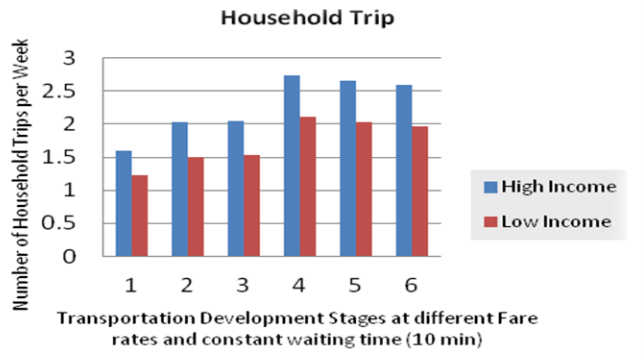
household trips rates are more sensitive to changes in fare rates than average waiting time but not as much as revenue trips rates. Income does have positive effect on household trips compared to revenue trips and higher income group of people make more household trips than lower income group people.



Description of transportation development for number codes used along the horizontal axis

1 Past condition (no road and no feeder service)
2 Bituminous road without feeder service (hypothetical condition)
3 Present condition (bituminous road and few feeder service operational)
4 Hypothetical case of 10 min Average Waiting Time for Feeder vehicle and constant fare rate
5 Hypothetical case of 20 min Average Waiting Time for Feeder vehicle and constant fare rate
6 Hypothetical case of 30 min Average Waiting Time for Feeder vehicle and constant fare rate

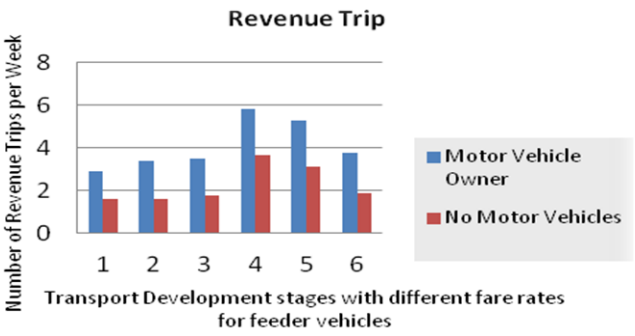
(a) Revenue Trip rate vs Different Transportation Developments with different average waiting time and constsnt fare rate for feeder service



Description of transportation development for number codes used along the horizontal axis

1 Past condition (no road and no feeder service)
2 Bituminous road without feeder service (hypothetical condition)
3 Present condition (bituminous road and few feeder service operational)
4 Hypothetical case of 10 min Average Waiting Time for Feeder vehicle and constant fare rate
5 Hypothetical case of 20 min Average Waiting Time for Feeder vehicle and constant fare rate
6 Hypothetical case of 30 min Average Waiting Time for Feeder vehicle and constant fare rate

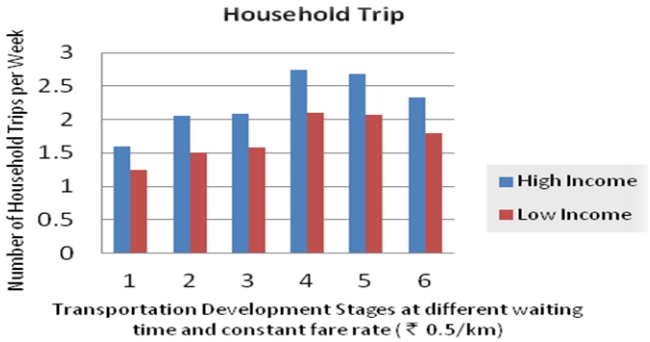
(b) Household trip rate vs Different Transportation Developments with different fare rates and constant average waiting time



Description of transportation development for number codes used along the horizontal axis

1 Past condition (no road and no feeder service)
2 Bituminous road without feeder service (hypothetical condition)
3 Present condition (bituminous road and few feeder service operational)
4 Hypothetical case of Rs. 0.50/km for Feeder vehicle and constant average waiting time
5 Hypothetical case of Rs. 1.00/km for Feeder vehicle and constant average waiting time
6 Hypothetical case of Rs. 1.50/km for Feeder vehicle and constant average waiting time

(c) Revenue Trip rate vs Different Transportation Developments with different fare rates and constant average waiting time



Description of transportation development for number codes used along the horizontal axis

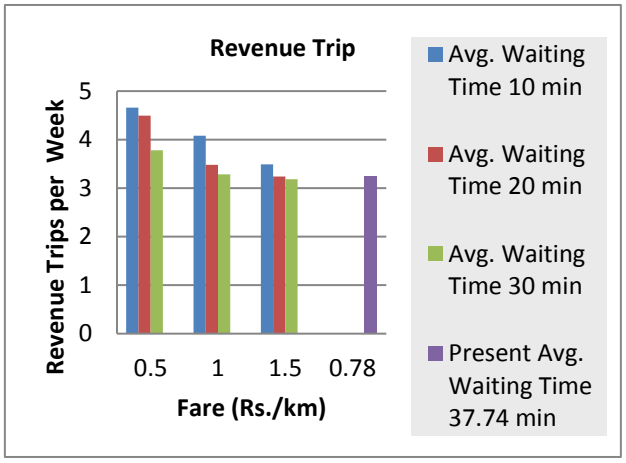
1 Past condition (no road and no feeder service)
2 Bituminous road without feeder service (hypothetical condition)
3 Present condition (bituminous road and few feeder service operational)
4 Hypothetical case of Rs. 0.50/km for Feeder vehicle and constant average waiting time
5 Hypothetical case of Rs. 1.00/km for Feeder vehicle and constant average waiting time
6 Hypothetical case of Rs. 1.50/km for Feeder vehicle and constant average waiting time

(d) Household trip rate vs Different Transportation Developments with different average waiting time and constant fare rate for feeder service

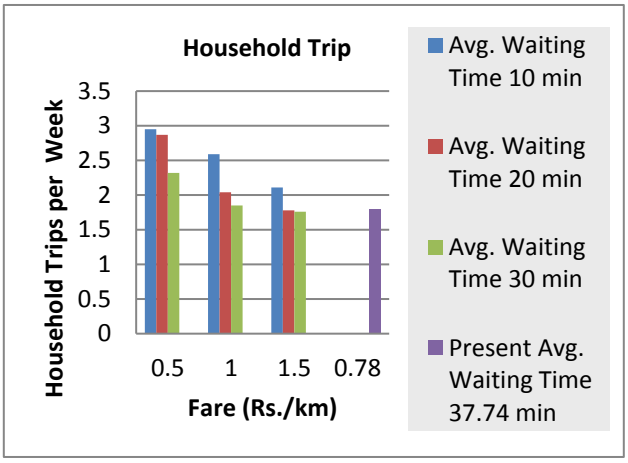
Figure 3: Trip rates vs Different Transportation Developments

4.5. Effect of Fare Rates and Average Waiting Time on Trips

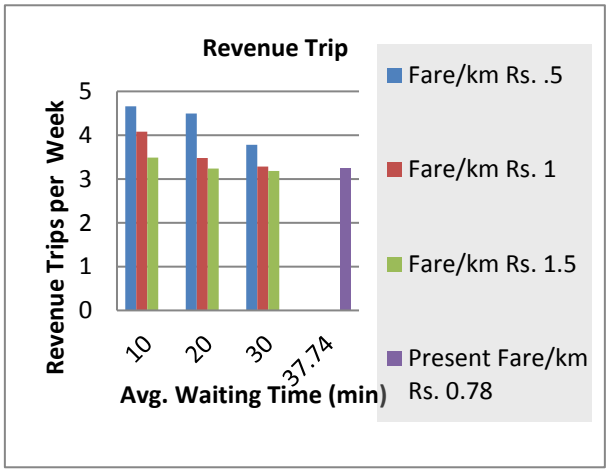
Changes in trip rates with changes in fare rates and average waiting time (AWT) are shown in Figure 4. It is observed from figure 4 (a) and 4 (c), that revenue trip rates are slightly reduced as fare rate is increasing for average waiting time of 10 minute. However, the reduction in number of revenue trips is slightly sharp from fare rate of Rs. 0.5/km to Rs. 1.0/km and the same is less from Rs. 1.0/km to Rs. 1.5/km for both AWT of 20 and 30 minute. Overall, it can be observed that trips made are slightly higher with less waiting time and much higher in the combination of less waiting time and less fare rates. Same pattern can be observed for the household trips from the figure 4 (b) and 4 (c) though household trips are lesser than the revenue trips. Therefore, it can be said that the number of both revenue trips and household trips will be increased from the conditions (i.e. AWT is 37.74 minute and fare rate is Rs. 0.78/km) if the waiting time can be reduced and fare rates is less or near the present fare rate.



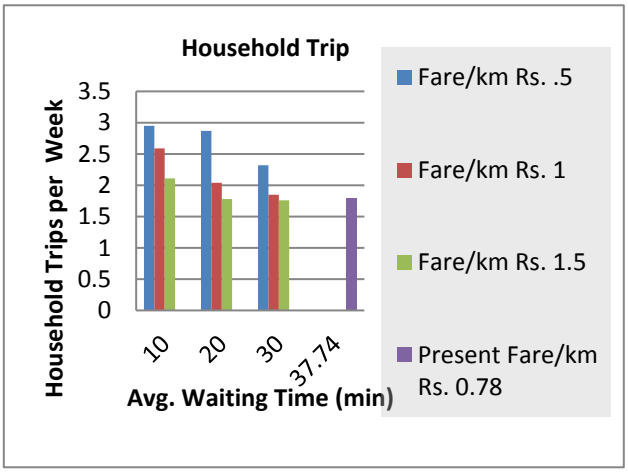
(a) Revenue Trip Rates per week Vs Fare Rates for different Average waiting time



(b) Household Trips vs Fare Rates for different Average waiting time



(c) Revenue Trip Rates per week Vs Average waiting time for different Fare Rates



(d) Household Trip Rates Vs Average waiting time for different Fare Rates

Figure 4: Variations in revenue and household trip rates with respect to fare rates and average waiting time for for feeder vehicles

4.6. Effect of Fare Rates and Average Waiting Time on Trips of different Household types

It can be observed from figure 5 that both revenue and household trip rates are much higher for business and service category household compared to cultivator and daily labour household categories. The revenue trips of cultivators are higher than that of daily labour but steadily declining as fare rates are increasing as observed from figure 5 (a). It can be sensed that cultivators will make more trips to sell the products in the market which is distant away if the transportation fare rates can be reduced. In the case of household trips, cultivator and daily labour makes almost same number of trips which are declining in a similar way with increase in fare rates but again trips made by business and service category are higher than that of cultivator and labour categories as depicted in figure 5 (b). The changing pattern of both household and revenue trips are same with respect to average waiting time as shown in figure 5 (c) and 5 (d) except the revenue trips of cultivators and daily labours. In the figure 5 (c), it can be observed that daily labour trips are higher than that of cultivators for a particular fare rate.

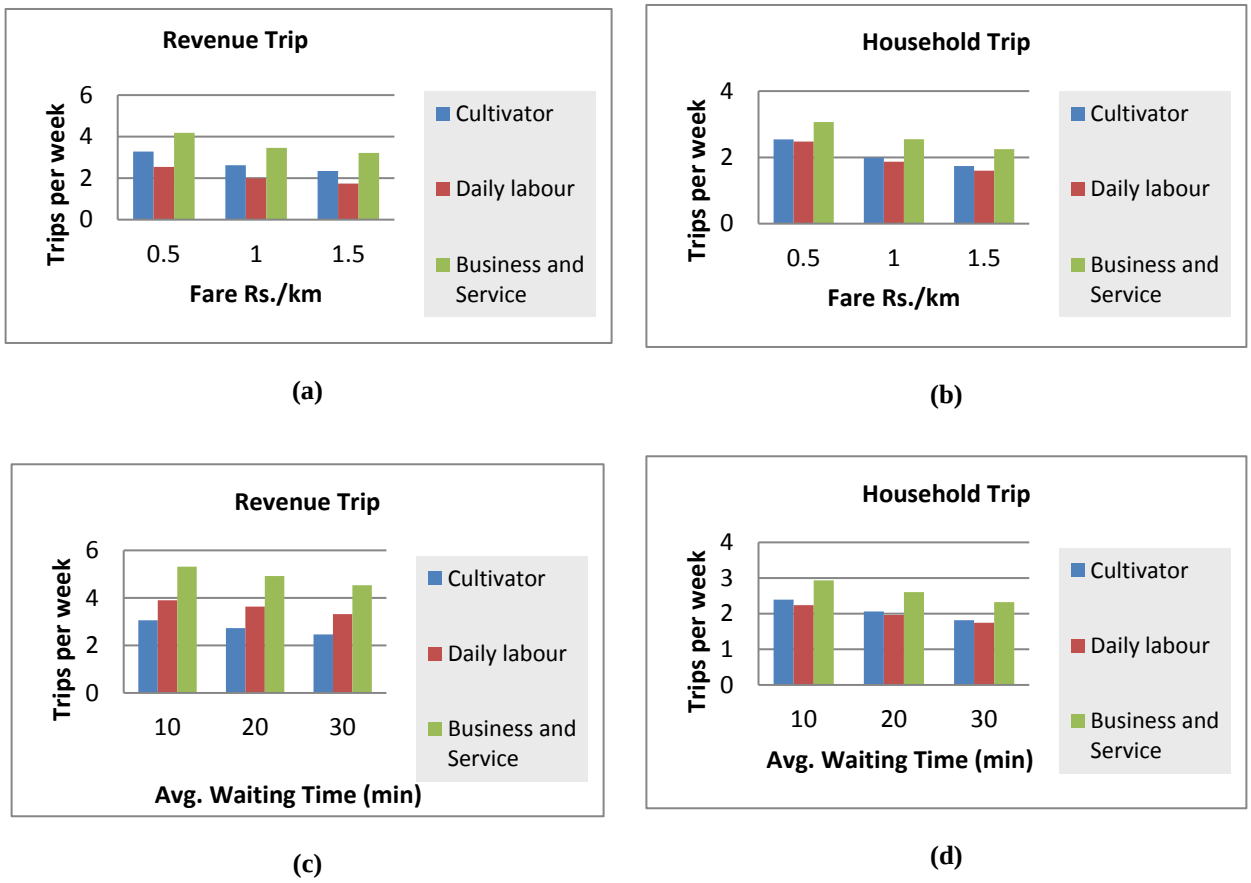


Figure 5: (a) Revenue trips per week vs Fare rates; (b) Household trips per week vs Fare rates; (c) Revenue trips per week vs Average waiting time; and (d) Household trips per week vs Average waiting time; all are for different types of household

5. Conclusions

A survey instrument was designed to include socioeconomic characteristics, travel information and stated preference responses which considered different scenarios of average waiting time and fare rates for feeder services to bus stops. The data that was collected from rural trip makes was analyzed by developing the purpose wise different trip rates model using basic structural modeling specifications. The estimated parameters of the models are found to be statistically significant and within acceptable ranges of the goodness of fit statistics.

From the developed model, the estimated parameters indicate that both vehicle ownership and household type play major role for revenue trips of rural commuters. Income and vehicle ownership play positive and significant roles on influencing household trip rates than the other socioeconomic attributes described in this study. The results also indicate that trip rates of people are more sensitive to change in fare for feeder vehicle and also to change in average waiting time for feeder vehicle. It is further observed that high income group of people who are mostly in the business and service category of household travel more frequently compared to low income group people for both revenue and household trips. Vehicle ownership also has some significant positive impact on revenue trips compared to household trips as mostly higher-income group people owned vehicle. People are willing to travel more for revenue trips in order to earn more if good transport facilities are provided within their affordable range in rural areas. More trips will be made for revenue purpose if household size is more for livings. Similarly more household trips expected to be made if the fare rate could be reduced. Evidently, it can be stated that both household and revenue trips anticipated be increased if good combination of transportation developments can be provided in rural areas which are in many cases lacking in transportation facilities. This may be very helpful for the overall development of these areas and also may help to generate reasonable amount of profits for the local authorities and government. However, there are many scopes, that, were not included in the present study may be explored in further research, may consists qualitative attributes such as comfort and safety in feeder vehicles, walking distances to access the feeder service and also to consider multiple study areas in order to observe the variation in travel behaviours in different areas.

References

1. Allaman, P. M., Tardiff, T. J., Dunbar, F. C., 1982. New Approaches to Understanding Travel Behavior. NCHRP Report 250, Transportation Research Board, Washington.
2. Bagley, M. N., Mokhtarian, P. L., 2002. The impact of residential neighborhood type on travel behavior: A structural equations modeling approach. The Annals of regional science, 36(2), 279-297.
3. Boomsma, A., Hoogland, J. J., 2001. The robustness of LISREL modeling revisited. Structural equation models: Present and future. A Festschrift in honor of Karl Jöreskog, 2(3), 139-168.
4. Browne, M. W., Cudeck, R., 1992. Alternative ways of assessing model fit. Sociological Methods & Research, 21(2), 230-258.
5. Census of India, 2011. Rural Urban Distribution of Population.
6. Charles River Associates, 1978. On the Development of a Theory of Traveler Attitude-Behavior Interrelationships. Final report DOT-TSC-RSPA-78-14. US Department of Transportation, Washington.
7. Choo, S., Mokhtarian, P. L., 2007. Telecommunications and travel demand and supply: Aggregate structural equation models for the US. Transportation Research Part A: Policy and Practice, 41(1), 4-18.
8. Dandapat, S., Maitra, B., 2015. An approach for identifying optimal service for rural bus routes. Case Studies on Transport Policy 3 (3), 287-294.
9. Das , S. S., Maitra, B., Boltz, M., 2009. Valuing Travel Attributes of Rural Feeder Service to Bus Stop: Comparison of Different Logit Model Specifications. Journal of Transportation Engineering, 135(6), 330-337.
10. Das , S. S., Maitra, B., Boltz, M., 2012. Planning of fixed-route fixed-schedule feeder service to bus stops in rural India. Journal of Transportation Engineering 138 (10), 1274-1281.
11. Den Boon, A.K., 1980. Opvattingen over Autogrebruik en Milieuvervuiling. Baschwitz Institute for Public Opinion and Mass Psychology, University of Amsterdam.

12. Dobson, R., Dunbar, F., Smith, C. J., Reibstein, D., Lovelock, C., 1978. Structural models for the analysis of traveler attitude-behavior relationships. Transportation, 7(4), 351-363.
13. Fan, X., Thompson, B., Wang, L., 1999. Effects of sample size, estimation methods, and model specification on structural equation modeling fit indexes. Structural Equation Modeling: A Multidisciplinary Journal, 6(1), 56-83.
14. Fujii, S., Kitamura, R., 2000. Evaluation of trip-inducing effects of new freeways using a structural equations model system of commuters' time use and travel. Transportation Research Part B: Methodological, 34(5), 339-354.
15. Golob, T. F., 2001. Joint models of attitudes and behavior in evaluation of the San Diego I-15 congestion pricing project. Transportation Research Part A: Policy and Practice, 35(6), 495-514.
16. Golob, T. F., 2003. Structural equation modeling for travel behavior research. Transportation Research Part B: Methodological, 37(1), 1-25.
17. Golob, T. F., Hensher, D. A., 1998. Greenhouse gas emissions and Australian commuters' attitudes and behavior concerning abatement policies and personal involvement. Transportation Research Part D: Transport and Environment, 3(1), 1-18.
18. Hayduk, L. A., 1987. Structural equation modeling with LISREL: Essentials and advances. Jhu Press.
19. Hu, L. T., Bentler, P. M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural equation modeling: a multidisciplinary journal, 6(1), 1-55.
20. Louviere, J. J., 1988. Conjoint analysis modelling of stated preferences: a review of theory, methods, recent developments and external validity. Journal of transport economics and policy, 93-119.
21. Lu, X., Pas, E. I., 1999. Socio-demographics, activity participation and travel behavior. Transportation Research Part A: Policy and Practice, 33(1), 1-18.
22. Lyon, P.K., 1981a. Time-dependent Structural Equations Modelling of the Relationships Between Attitudes and Discrete Choices Behavior of Transportation Consumers. Dissertation, Northwestern University and Technical Report IL -11-0012, Office of Policy Research, Urban Mass Transportation Administration, Washington, DC.
23. Lyon, P.K., 1981b. Dynamic Analysis of Attitude-Behavior Response to Transportation Service Innovation. Report 423-II -2 Prepared for the Office of Policy Research, Urban Mass Transportation Administration, Transportation Center, Northwestern University, Evanston, IL.
24. Maitra, B., Ghosh, S., Das, S. S., Boltz, M., 2013. Effect of model specification on valuation of travel attributes: a case study of rural feeder service to bus stop. Journal of Transport Literature 7 (2), 8-28.
25. Masser, I., Svidén, O., Wegener, M., 1992. From growth to equity and sustainability: Paradigm shift in transport planning?. Futures, 24(6), 539-558.
26. Oud, J. H., Folmer, H., 2008. A structural equation approach to models with spatial dependence. Geographical Analysis, 40(2), 152-166.
27. Phanikumar, C. V., Maitra, B., 2007. Willingness-to-pay and preference heterogeneity for rural bus attributes. Journal of Transportation Engineering, 133 (1), 62-69.
28. Phanikumar, C. V., Maitra, B., 2010. Modeling willingness-to-pay values for rural bus attributes under different trip purposes. Journal of the Transportation Research Forum, 45 (2), 31-44.
29. Ramanayya, T. V., Nagadevara, V., and Roy, S. 2007. Quality expectations of transport services and willingness to pay: Case of KSRTC. AIMS Int. J. Management, 1(1), 39–52.

30. Ren, F., Kwan, M. P., 2009. The impact of the Internet on human activity–travel patterns: analysis of gender differences using multi-group structural equation models. Journal of Transport Geography, 17(6), 440-450.
31. Satishkumar, B., Maitra, B., Das, S. S., 2018. Temporal shift in willingness-to-pay for rural feeder service to bus stop. Travel Behaviour and Society 12, 102-107.
32. Sikdar, P. K., 2002. Pradhan Mantri Gram Sadak Yojana, for the people, by the people. Indian Highways, 6, 59–68.
33. Steiger, J. H., 1990. Structural model evaluation and modification: An interval estimation approach. Multivariate behavioral research, 25(2), 173-180.
34. Tardiff, T.J., 1976. Causal inferences involving transportation attitudes and behavior. Transportation Research 11, 397-404.
35. Van Acker, V., Witlox, F., 2010. Car ownership as a mediating variable in car travel behaviour research using a structural equation modelling approach to identify its dual relationship. Journal of Transport Geography, 18(1), 65-74.
36. Zegras, C., Sussman, J., Conklin, C., 2004. Scenario planning for strategic regional transportation planning. Journal of urban planning and development, 130(1), 2-13.