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Travel Behavior Modeling: Exploring Household Characteristics as Predictors

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Urbanization



Transportation system is an essential component of urban planning.

"If urban transport is not managed well, it has the potential to choke cities and bring economic activity to a grinding halt." (Agarwal et al., 2014)



Need of Study

- Obtaining household information and trip characteristics in India poses a difficult undertaking
- Availability of data only from city transportation master plans and reports of other development plans
- Travel patterns are highly dynamic and are influenced by various socioeconomic and city development patterns; hence the data from the secondary sources loses credibility with every passing year
- To determine the per capita trip rate (PCTR), a specific set of instructions or a manual is needed

India is lacking in a set of guidelines or manuals for trip estimation for the *Per Capita Trip Rate (PCTR).*



Literature Review

Authors	Country	No. of HH Samples	Age	HH size	HH Income	No. of working member	No. of Students	Vehicle Ownership	Trip Characteristics	Type of Model	Method
(Shbeeb 2022)	Jordan	681		✓	\checkmark	✓	~	✓		Trip Rates	MLR
(Roorda et al. 2008)	Canada	5 % of total HH	✓	\checkmark	✓			\checkmark		Trip Rates	MLR
(Downes and Morrell 1981)	England	3288	✓	\checkmark	✓	\checkmark	✓	\checkmark	\checkmark	Trip Rates	MLR
(Saad and Al-Hassani 2011)	Bagdad	4000	✓	✓	✓	✓	~	✓		Trips / HH (Total / Work / Education / Shopping / Other)	MLR
(Abu-Eisheh et al. 2017)	Jericho	713		\checkmark	\checkmark	\checkmark	\checkmark			Trips / HH	MLR
(Prasad and Molugaram 2018)	India	-		✓	✓	✓		✓		Trip Rates / Zone	
(Altaher et al. 2019)	Egypt	5116		\checkmark	✓	\checkmark	✓	\checkmark		Trip Rates / Zone	MLR
(Faghri and Aneja 1986)	US	-		\checkmark	✓			\checkmark		Trips / HH	MLR & ANN
(Aderibigbe and Gumbo 2022)	Nigeria	512	✓	✓	✓	✓	~			Trips / HH	MLR

* ANN = Artificial Neural Network, CC = Cross-classification, MLR = Multiple Linear Regression.



Study Area



(Source: Surat Municipal Corporation (SMC) website)

Category	Variables	Surat
	Avg. HH Size	4.2
	Male (M) & Female (F) (%)	57 & 43
Socio-Demographic	Sex ratio (F/1000 M)	758
Characteristics	Literacy rate (%)	96.62
	Avg. Monthly Income / HH (Rs.)	31300
	WPR	46
	Avg. Vehicle Ownership / HH	1.36
Vahiala Orun anghin	2w/1000 population	273
venicie Ownersnip	4w / 1000 population	23
	Vehicles growth % (2017-18)	9
Trip Characteristics		
	2w & 4w	37.5
	NMT (walk/cycle)	42.3
Mode Share (%)	IPT	10.3
	PT & other	9.9
	Work	43.7
Puposes	Education	30.2
	Other	26.1
	All Modes	5.01
Avg. Trip Length (Km)	Including Walk	4.8
	Excluding Walk	5.7
Avg. Travel Time (min)		13-15
Avg. Por Capita Trip Poto	Total	1.6
Avg. Fel Capita IIIp Kale (PCTP)	Motorised	0.93
	Excluding walk (0.5 km)	Q.96
Road Network		3859

Source: Surat CMP-2046 (September 2018)

Questionnaire

DA	TE		Develop FC	ment of DRMAT E	Govern Trip Gen 3: Travel	nment reration Survey	of India n Manual for s – Househo	Indian Cir Ids (HH)	ties-		IR रा	
1 N	FBR	Project	Sponsor	ed by C	SIR New	Delhi, I	Nodal Agend	y-CSIR-CR	RI	Date:		
2. N	lame o	of the city.			3. Loc	ation Na	me:		4. Ward No			
louse	hold	Informat	ion								+-	
5. N	lame o	of the Res	pondent:					Address/ I	h No.			
6. R	elation	of respo	ndent with	Head of th	ne Family m	nember: -						- i
7. Bi	uilding	Type: C	Own house	C Re	nted 🗖	Apartme	ent 🗖 Stud	io Flat 🗖 F	armhouses 🗖			1.1
8. H	ouse t	vpe:	1внк С	J 28	нк 🗖	ЗВНК	4BHI		lore than 4BHK			- H- H
9. FI	loor ar	ea of the	House:	Sa.	mt/Sa. ft/ G	GAJ/ Sa v	ards					- i
10. N	lo of F	amily Me	mbers:									1.1
11. N	lo of k	ids (unde	r age 6 yea	rs):								
12. N	lo of E	arning me	embers:									-i -
13. N	lo of V	ehicles of	wned: Tota	al	/ 4W	-/2W	/Cycle	/3W	/ others			1.1
14. M	Ionthh	y Income	of the Hou	se hold:	wa		-	1010299298	100000000000000000000000000000000000000			
15. M	Ionthh	y Expendi	ture on Tra	nsport:								- i - i
16. H	ouset	old Men	bers infor	mation								1
Pers	Aq	Relati	Gender	Educati	Occupati	Offi	ce/ College	Income/	Transport	Driving	1	
on	e	on	(M/F)	on	on		ocation	Month	Exp.	Lic.		
1										-		- i
2				-								1.1
3	65	6		6								
4				s						9 0		- i - i
5												_i
6											╘╾╼┝╸	-,
17. T	rip Inf	formation	n									- i
Person	n no	Trip no	Origin	Destin	ation	Mode	Trip Purpose	Trip Lengt	h Trip Time	Frequency		1
	-						-					
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	3				-		8			-		1.1
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Socio-Economic (Part-A)

- Household Size & Structure
- Gender
- Age
- Income
- Vehicle Ownership
- Monthly Expenditure on Transportation

Travel Characteristics (Part-B)

- Origin-Destination
- Trip length
- Trip cost
- Travel time
- Travel Frequency
- Trip purpose

Validate the Samples Representativeness to the Population

Mean Trip Rate	Sample Data	СМР	Std Dev.	Z value	P- value
	1.57	1.6	0.59	-0.86	>0.05
Household Size	Sample Data	СМР	Std Dev.	Z value	P- value
	3.67	4.20	1.08	-1.60	>0.05

CMP: Comprehensive Mobility Plan

The result of the Z-test indicate that there was no significant difference between the mean values, which supports the dataset representing the population of the city

Data Description

Descriptive Analysis of Sampled Data

Variables	Male & Female (%)	Sex ratio (F/1000 M)	Literacy rate (%)	Avg. HH Size	Avg. Vehicle Ownership / HH	Avg. Monthly Income / HH (Rs.)	Avg. Trip Length (Km)	Avg. Per Capita Trip Rate (PCTR)
Surat	55 & 45	800	97.2	3.67	2.35	68380	6.5	1.57
						Durrance	DCT	D
						Purpose	PCT	ĸ
Purpose	WTR	ETR	SHTR	OTR	Total	WTR	0.82	
PCTR	0.82	0.46	0.13	0.16	1.57	ETR	0.46	
							0.13	
						OTR	0.16	
Inco	oma Catagory V	Wise Employ	nant in the Stu	du Area		Total	1.57	

Income Category-wise Employment in the Study Area

Income Group	Govt. Sector	Private Sector	Business	Self Employed	Retired	Worker/ Labor	Total
LIG	3%	21%	7%	5%	4%	9%	49%
MIG	4%	15%	9%	3%	4%	2%	37%
HIG	3%	4%	4%	1%	2%	0%	14%
Total	10%	40%	20%	9%	10%	11%	100%

Linear Regression (LR) Results

	Dependent Variable		blo	Indonandant Variabla	Independent Variable R Square		4	Const	Cooffi
	Depend	ent varia	Earning	school-college Vehicle	K Square	Sig.	Ľ	Const.	Cueili.
	Variables	HH size	member	HH Size ownership	1 9 <u>.</u> 09	TTR <u>0.05</u>	WTR _{-2.82} ETI	R 1.73 ST	R -0.05OTR
			member	Earning Members	0.05	0.00	6.49	1.34	0.15
	HH size	TTŖ 00		School/college going	0.02	0.00	3.94	1.48	0.08
Γ		0.20	1.00	Vehicle Ownership	0.01	0.03	2.15	1.48	0.04
	Earning members	0.39	1.00	Income Group	0.01	0.00	3.10	1.44	0.08
	School-college			HH Size	0.10	0.00	-9.63	1.29	-0.14
		0.43	-0.20	Eathing Members	0.41	0.00	24.46	0.29	0.37
	Students	WTR		School/college going	0.25	0.00	-17 19	1.03	-0.24
	Vehicle			Vehicle Ownership	0.01	0.36	-0.93	0.82	-0.01
	0.38 0.27		0.27	01h@ome Group 1.00	0.02	0.24	1.18	0.76	0.02
	ownership			HH Size	0.11	0.00	10.37	-0.04	0.15
	IG	0.22	0.22	Eagging Members 0.52	1.001	0.00	-10.47	0.75	-0.19
		ETR	0.00	School/college going	0.86	0.00	73.70	0.05	0.44
	TTR	-0.21	0.09	Vehicle Ownership 0.03	00.90	1.000.22	1.22	0.45	0.02
	WTR	-0.31	0.49	_0.02	09090	0.46 0.74	1.00 -0.33	0.49	-0.01
Γ	LAD	0.00	0.01	HH Size	0.30	0.00	-5.16	0.29	-0.05
	EIR	0.20	-0.31	Earning Members 0.02	-0.01	0.130.02	-0.44 -2.44 1.00	0.17	-0.03
	STR S	HT <mark>R14</mark>	-0.09	School/college going_0.08	-02031	0.40.00	0.08 -3.42 -0.0	7 0.16 _{1.0} 6	-0.03
Γ	OTD	0.07	0.02	Vehicle Ownership	0.01	0.01	-2.55	0.17	-0.02
	UIK	-0.07	-0.03	-Uneome Group 0.06	00.00	0.5.0.59	0.08 -0.54 -0.1	+ 0.44 0.05	-0.01 1.00
				HH Size	0.00	0.23	-1.21	0.19	-0.01
	TTTT	170.		Earning Members	0.00	0.27	-1.10	0.16	-0.02
	• HH size a	Ø# _R irip	kates sh	now a negative relation excer	t ior _{0.62} 1 K	0.00	-3.63	0.18	-0.04
				Vehicle Ownership	0.00	0.10	1. <u>6</u> 6	0.10	0.02
	 No of Stud 	dents in	HH are	e more with uncreasing HH size	e shows the	positave	correlation	0.09	0.03

Multiple Linear Regression (MLR) Results

Model	Independent variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	\mathbf{R}^2	
		В	Std. Error	Beta				
	(Constant)	1.635	0.066		24.952	0		
	Income Group	0.058	0.025	0.078	2.274	0.023		
Enton	HH Size	-0.265	0.022	-0.479	-11.846	0	0.22	
Enter	Earning members	0.305	0.025	0.439	12.41	0	0.22	
	School/college Students	0.281	0.023	0.482	12.243	0		
	Vehicle Ownership	0.03	0.018	0.058	1.629	0.104		
	(Constant)	1.635	0.066		24.934	0		
	Income Group	0.076	0.023	0.102	3.322	0.001		
Backward	HH Size	-0.257	0.022	-0.464	-11.773	0	0.21	
	Earning members	0.308	0.025	0.443	12.546	0		
	School/college Students	0.281	0.023	0.48	12.2	0	1	

Backward Elimination MLR Results

Dependent variable	Independent variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	\mathbf{R}^2
		В	Std. Error	Beta			
	(Constant)	1.64	0.07		24.93	0.00	
	Income Group	0.08	0.02	0.10	3.32	0.00	
TTR	HH Size	-0.26	0.02	-0.46	-11.77	0.00	0.21
	Earning members	0.31	0.03	0.44	12.55	0.00	
	Sch-clg students	0.28	0.02	0.48	12.20	0.00	
	(Constant)	0.98	0.03		28.46	0.00	
WTR	HH Size	-0.23	0.01	-0.50	-23.65	0.00	0.64
L	Earning members	0.44	0.01	0.76	36.17	0.00	
	(Constant)	0.31	0.02		15.32	0.00	
ЕТЪ	HH Size	-0.08	0.01	-0.18	-13.12	0.00	0.60
EIK	Income Group	-0.01	0.01	-0.02	-2.05	0.04	0.89
	Sch-clg students	0.49	0.01	1.02	77.02	0.00	
	(Constant)	0.30	0.04			- 0.00 -	
CLITD	HH Size	-0.03	0.01	-0.12	-2.64	0.01	0.04
SHIK	Earning members	-0.03	0.01	-0.08	-1.93	0.05	0.04
	Sch-clg students	-0.02	0.01	-0.08	-1.78	0.08	
	(Constant)	0.19	0.03		6.13	0.00	
OTT	Earning members	-0.04	0.02	-0.10	-2.76	0.01	0.02
OIR	Sch-clg students	-0.06	0.01	-0.16	-4.50	0.00	0.03
	Vehicle Ownership	0.03	0.01	0.09	2.68	0.01	

• Work and education purposes showed higher R-square values, likely due to their daily nature

Equations for predicting future trip rates are to be Generated

$WTR = 0.98 - 0.23X_1 + 0.418X_2$	$(R^2 = 0.64)$
$ETR = 0.31 - 0.08X_1 + 0.487X_3 - 0.014X_4$	$(R^2 = 0.89)$

Where,

- WTR = Work Trip Generation Rate
- ETR = Education Trip Generation Rate
- X_1 = Household Size
- X_2 = Number of Earning members in the household
- X_3 = Number of school/college students in the HH
- X_4 = Monthly Income group of households

Thank you.....