ISSN: 2513-2504

An Examination of the Relationship between Built Environment and Mode Choice

H M W T Rathnayake and A B Jayasinghe
University of Moratuwa, Sri Lanka

1. Introduction

Rapid urbanisation in cities in developing countries has led to a sudden jump in traffic volume and caused several problems such as traffic congestion, road accidents, and air pollution. Accordingly, many researchers have highlighted that a thorough understanding of the relationship between built environment and travel characteristics of a city is essential for city planning as well as transport planning. The results of previous research have repeatedly claimed that built form factors such as density (i.e. population and employment) [1] diversity (i.e. land use) [1], design (i.e. transport facility) [1], [2] and accessibility (i.e. to activities and transport facilities) [1], [2], [3] significantly influence travellers' mode choice . However similar studies are limited in the Sri Lankan context. Against this backdrop, this study aims to investigate the relationship between built environment characteristics and mode choice decisions of travellers in Colombo, Sri Lanka.

2. Methodology

This study is principally built upon the database of 'CoMTrans-2014, JICA' and study area comprises 306 Traffic Analysis Zones (TAZ) within the Colombo Metropolitan Area. The dependent variable for analysis was defined as 'mode share' and the study uses seven independent variables (refer table 1), which represent built environment characteristics [4], [5].

In analysis stage, each built environment variable was plotted against mode share according to mode (i.e. car, motor cycle, and three-wheel and public bus) in a bivariate analysis in an XY scatter plot. This allowed visual inspection of the data relationship. A trend line was added to the plot to provide the equation and R-squared correlation of determination for the data. Each of the variables was assessed for the correlation strength and direction of the observed relationship (positive or negative). Then, the study employed the Multi-Layer Perceptron analysis in SPSS to identify non-linear relationship of the variables. In Multi-Layer Perceptron analysis, using hidden layers create one pattern to all input layers and give output value for non-linear variables. All analysis was conducted at origin and destination level.

Table 1: Independent variables

Built environment characteristics	Independ variables and method of computation
Density	1. Population Density=Number of population in a TAZ/Area of TAZ 2. Employment Density=Number of Employment coming to the TAZ/Area of TAZ
Diversity	3. Land use balance; used Land use entropy index [6]
Design	4. Junction Density=Number of junctions in each TAZ/Area of TAZ 5. Street Density=Number of Streets in TAZ/ Area of TAZ
Accessibility	6. Closeness; Aggregate TAZ closeness values [7] 7. Betweenness; Aggregate TAZ betweenness values [7]

Table 2: Summary of Multi-Layer Perceptron Analysis - Origin by modes

Variables	Car		Motor Cycle		Three-wheel		Bus		NMT	
	Importance	Normalized Importance (%)	Importance	Normalized Importance (%)	Importance	Normalized Importance (%)	Importance	Normalized Importance (%)	Importance	Normalized Importance (%)
Closeness	.078	27.1	.195	100.0	.109	45.7	.115	53.8	.068	38.3
Betweenness	.180	62.8	.193	98.9	.127	53.1	.103	48.6	.160	90.2
Connectivity	.027	9.5	.066	33.8	.054	22.7	.058	27.1	.104	58.6
Junction Density	.279	97.4	.193	99.2	.140	58.9	.047	22.3	.091	51.3
Street Density	.042	14.7	.124	63.5	.055	23.2	.093	43.5	.153	86.4
Diversity	.021	7.2	.037	18.8	.061	25.4	.213	100.0	.178	100.0
Employment Density	.086	30.2	.133	68.1	.239	100.0	.174	81.6	.107	60.5
Population Density	.287	100.0	.060	31.0	.215	90.2	.198	93.1	.138	77.9

Table 3: Summary of Multi-Layer Perceptron Analysis - Destination by modes

Variables	Car		Three-wheel		Bus	
	Importance	Normalized Importance (%)	Importance	Normalized Importance (%)	Importance	Normalized Importance (%)
Closeness	.228	75.3	.159	95.3	.137	73.8
Betweenness	.043	14.1	.116	69.5	.046	24.7
Connectivity	.086	28.5	.087	51.8	.160	86.3
Junction Density	.053	17.4	.070	41.6	.171	92.1
Street Density	.040	13.1	.161	96.6	.026	13.9
Diversity	.302	100.0	.167	100.0	.134	72.3
Employment Density	.186	61.5	.096	57.4	.141	76.3
Population Density	.063	20.9	.144	86.4	.185	100.0

3. Results

Table 4: Influence of independent variable selecting a mode (Origin Zone)

Built environment characteristics	Car	Motor cycle	Three-wheel	Bus	NMT
1. Population Density	100.0%	31.00%	90.20%	93.10%	77.90%
2. Employment Density	77.4%	68.10%	100.00%	81.60%	60.50%
3. Land use Diversity	7.2%	18.80%	25.40%	100.00%	100.00%
4. Junction Density	30.2%	99.20%	58.90%	22.30%	51.30%
5.Betweenness	62.8%	98.90%	53.10%	48.60%	90.20%
6. Closeness	27.1%	100.00%	45.70%	53.80%	38.30%

Table 5: Influence of independent variable selecting a mode (Destination Zone)

Built environment characteristics	Car	Motor cycle	Three-wheel	Bus	NMT
1. Population Density	66.80%	11.60%	23.60%	31.10%	16.40%
2. Employment Density	26.00%	14.10%	100.00%	20.90%	26.20%
3. Land use Diversity	40.30%	39.40%	17.00%	37.60%	27.20%
4. Junction Density	8.20%	3.50%	11.30%	16.90%	10.00%
5.Betweenness	99.00%	82.70%	56.90%	100.00%	100.00%
6. Closeness	100.00%	100.00%	63.10%	72.60%	30.70%

Tables 4 and 5 summarise the factor/s which most influence higher mode share in different types of modes. Results indicate that population density becomes the most influential factor for high share of car users at origin zone whereas closeness becomes most influential for a high share of car users at destination zone. Employment density becomes the most influential factor for a high share of three-wheel users at both origin and destination zone. Land use diversity become the most influence factor for high share of bus and non-motorised transport (NMT) users at origin zone where as betweenness become the most influential factor for high share of bus and non-motorised transport (NMT) users at destination zone.

4. Conclusion/Recommendation

This study examines the relationship between built environment characteristics and mode choice decisions of travellers in Colombo, Sri Lanka. The research finds how mode share is influenced by built environment characteristics, Further, the study identified the most influential factor for high mode share by different modes at trip origin as well as destination. Findings of this study can be useful for urban planners to identify which built environment characteristics promote a given kind of mods. Further,

transport planners and engineers can use these findings to develop mode choice models incorporating built environment characteristics.

References

[1] J. Scheiner and H.-R. C, “Travel Mode Choice: Affected by Objective or Subjective Determinants?,” Transportation;34(4), pp. 487-511, 2007.

[2] S. Bindong, E. Alireza and D. Bo, “Built environmental impacts on commuting mode choice and distance: Evidence from Shanghai,” Transportation Research Part D: Transport and Environment, 2017.

[3] A. Jayasinghe, K. Sano and H. Nishiuchi, “Explaining Traffic Flow Patterns Using Centrality Measures,” International Journal for Traffic and Transport Engineering (IJTTE), vol. 5, no. 2, pp. 134-149, 2015.

[4] J. Rodrigue, The geography of transport systems, 4 ed., New York: Hofstra University, 2017.

[5] R. Ewing and R. Cervero, “Travel and the built environment: a synthesis.,” Transport. Res. Rec. 1780, pp. 87-114, 2011.

[6] M. Zhang, “The role of land use in travel mode choice: Evidence from Boston and Hong Kong,” Journal of the American planning association, vol. 70, no. 3, pp. 344-360, 2004.

[7] A. K. S. a. K. R. Jayasinghe, “Application for developing countries: Estimating trip attraction in urban zones based on centrality,” Journal of Traffic and Transportation Engineering, vol. 4, no. 5, pp. 464-476, 2017.

Keywords: *Built Environment, Mode Choice, Centrality, Urban Planning, Colombo*