Influence of urban form on urban freight trip generation

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Contents

Introduction

- The megacities of India continue to grow (census, 2011).
- The growing densities contribute to the economic prosperity of these cities while giving rise to freight trips.
- The interactions between the built environment and the location of these economic activity generators give rise to freight trips and further freight trips are required to service these centres (Martinez, 2000).

Introduction

- The relation of urban form to travel behaviour in the context of passenger movement with respect to several aspects of the built environment
- Urban freight trips are based on logistical decisions, once the quantity of freight to be shipped is decided based on the economics of demand and supply (Holguin-Veras et al., 2013).
- The logistical decisions are based on city level interactions between road characteristics, trip length, policy environment and the land use that determines the location of these facilities.
- The literature on urban form variables included in urban freight studies and its impact on freight trip generation is sparse.

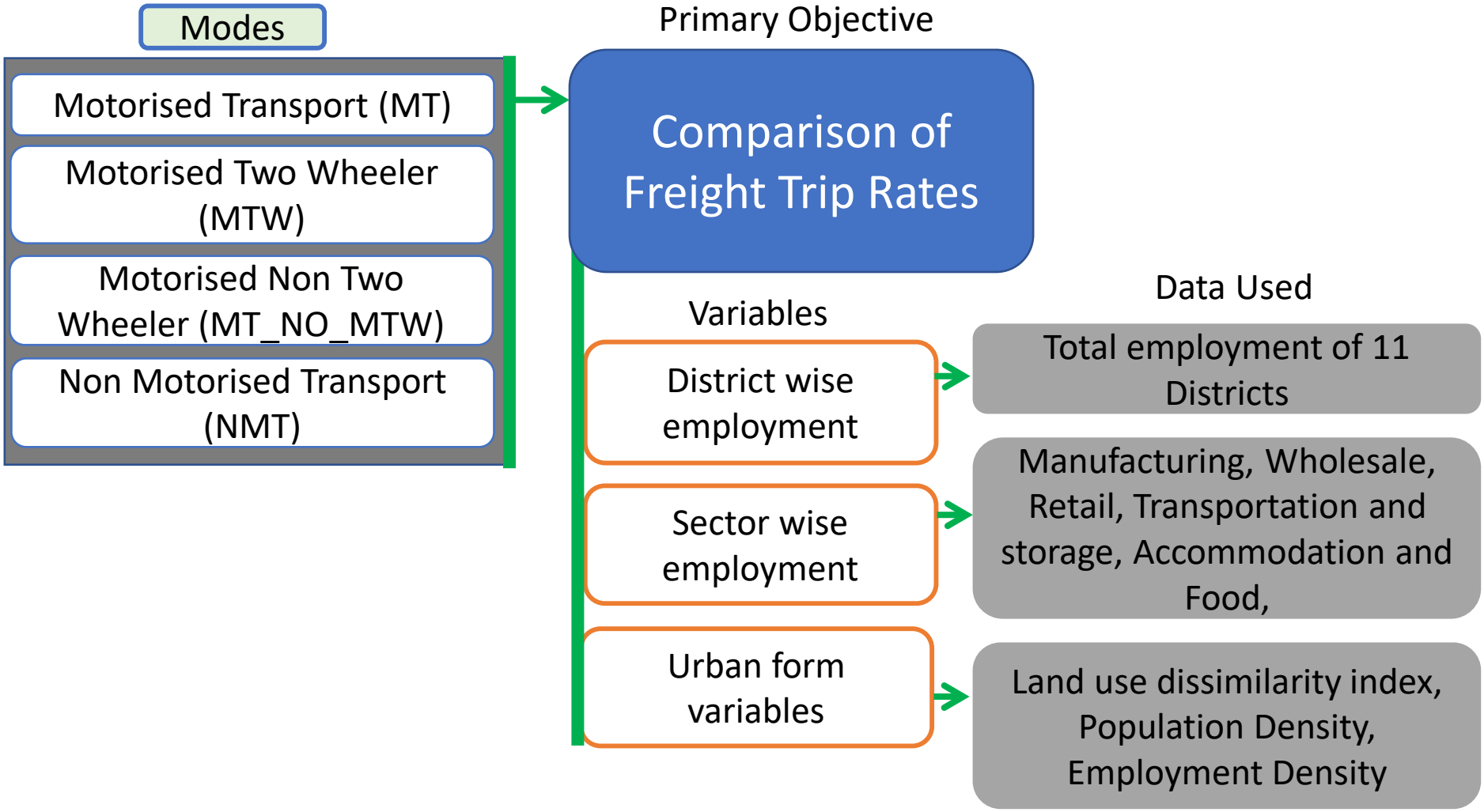
Literature Review –Urban Freight and Spatial relation

Author	Variables considered	Conclusions
Nationwide Freight Generation Models : A Spatial Regression Approach **(Novak et al., 2008)**	**Dependent Variable:** Freight Generation (Tonnage) **Independent Variables:** Employment (sector wise), Population Density, Highway length, railway length, Port Variables.	The application of spatial regression modelling techniques can improve model fit and eliminate problems associated with the spatial autocorrelation.
Examination of the Relationship between Built Environment Characteristics and Retail Freight Delivery **(Kawamura and Miodonski, 2011)**	**Dependent Variable:** Freight generation (Tons of freight delivered) **Independent Variable:** road density, intersection density and socioeconomic variables such as population density, employment density, % born in Us, median HH Income, % of houses built after 1990 etc	The amount of retail goods delivered per person seems to decrease with household density,

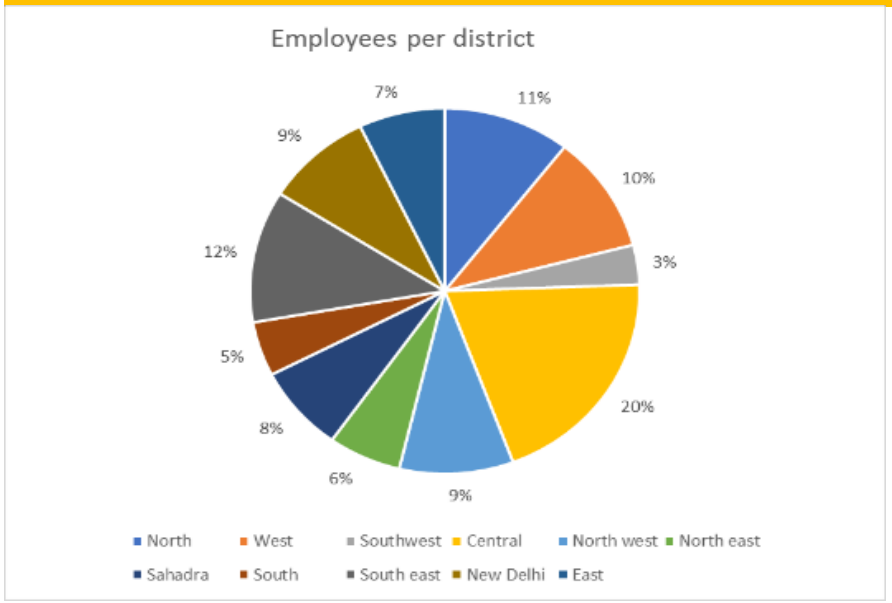
Literature Review

Author	Variables considered	Conclusions
An exploratory analysis of spatial effects on freight trip attraction. **(Sánchez-Díaz et al., 2014)**	**Dependent Variable:** Freight Trip Attraction **Independent Variables:** Land-use variables (Land Market value, NYCZR, Geographic location), Economic attributes (NAICS, Types of establishment, commodity type, Number of vendors, Employment), Network Characteristics (Distance to truck route, Distance to the primary network, Minimum distance to an LTG, Mean distance to LTG, Width).	Larger establishments have higher FTA than small establishments. FTA increases at a diminishing marginal rate. The use of locational variables, and nonlinear spatial effects specifications enhance FTA models.

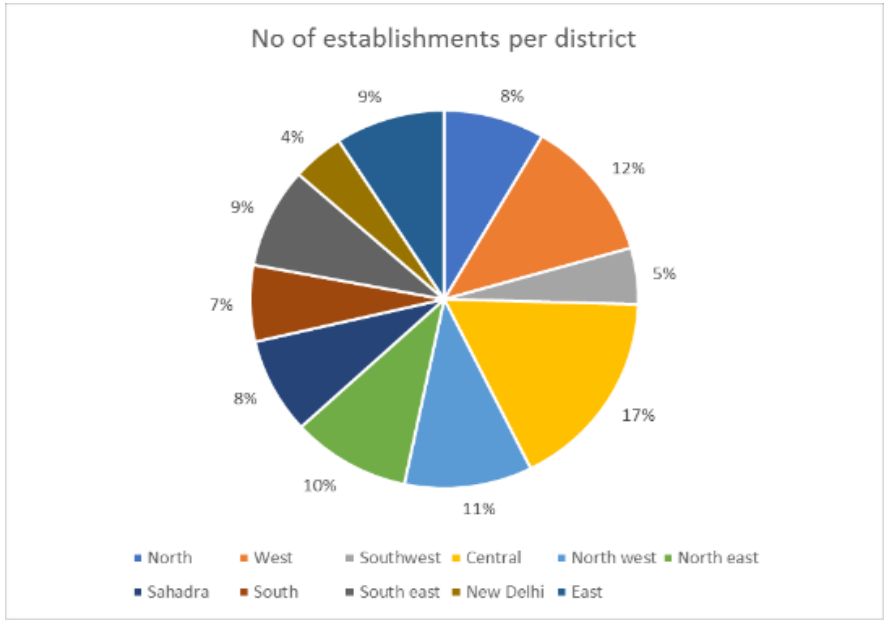
Study Methodology



Data Description - Delhi NCT



- Distribution of employment
  (North 11%, West 10%, Southwest 3%, Central 20%, Northwest 9%, Northeast 6%, Shahadra 8%, South 5%, Southeast 12%, New Delhi 9%, East 7%).

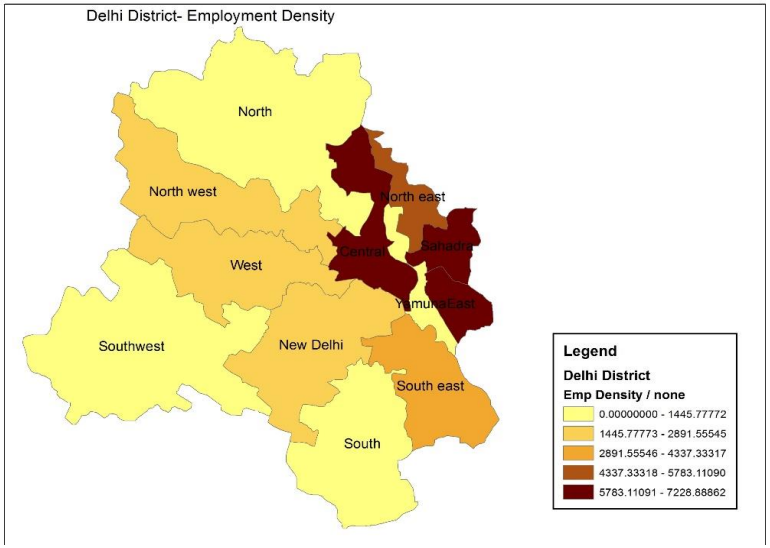


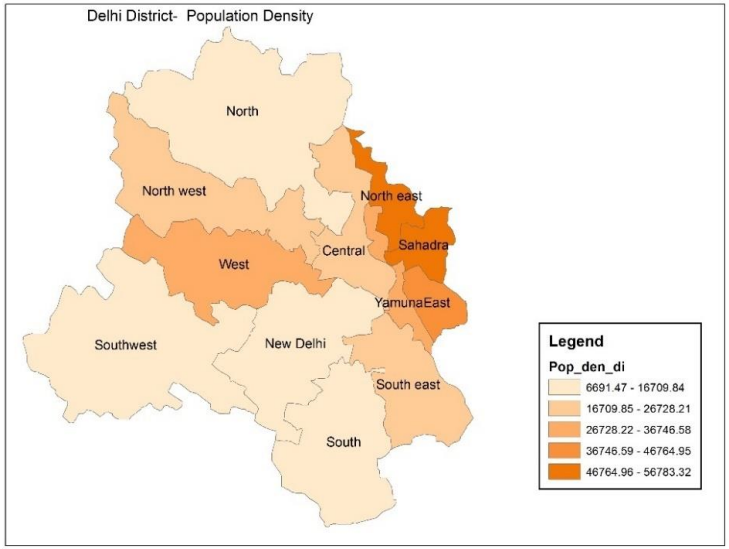
- Distribution of establishment
  (North 8%, West 12%, Southwest 5%, Central 17%, Northwest 11%, Northeast 10%, Shahadra 8%, South 7%, Southeast 9%, New Delhi 4%, East 9%).

Source: Delhi Economic census 2013-14

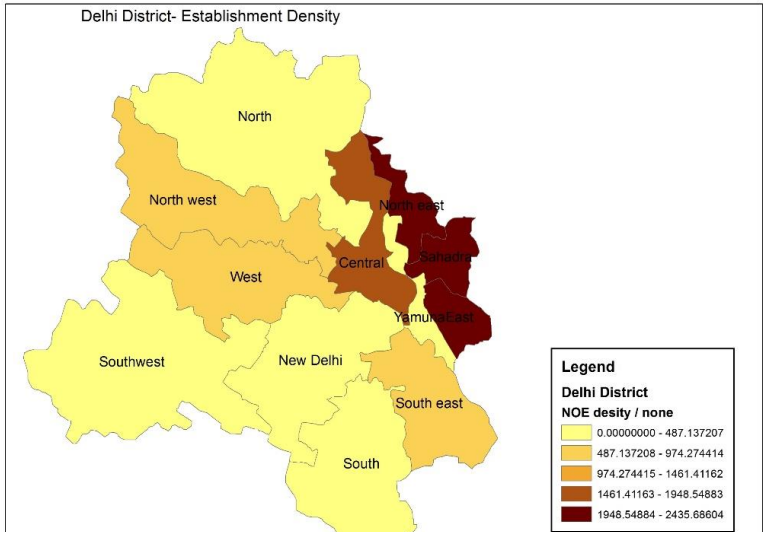
Data Description – Delhi NCT

Density –Employment and Population



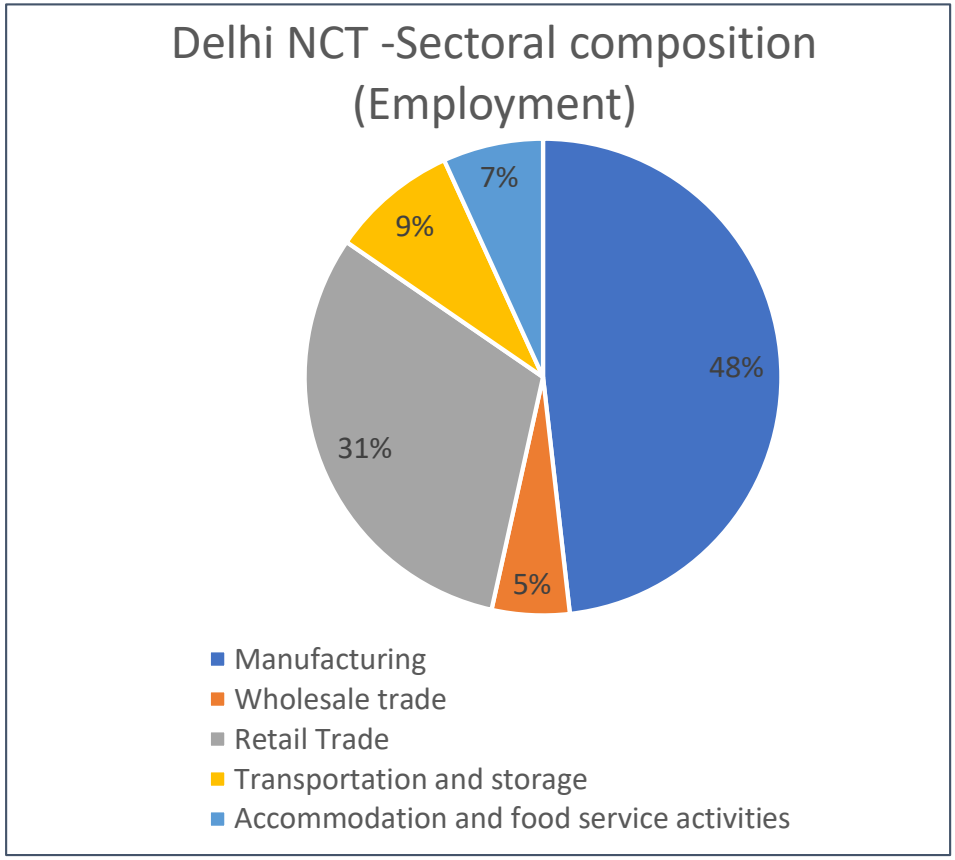


Source: PCA 2011 - Delhi



Source: Delhi Economic census 2013-14

Data Description - Delhi NCT



Source: Delhi Economic Census 2013-14

- According to literature surveys, these are the most freight intensive sectors.
- Manufacturing employs the most number of people. Wholesale trade, transportation and storage and accommodation and food account to 21% of the employment.
- Retail employs 31% of the work force.

Data Description - Survey

- An establishment survey was conducted for 1800 samples in the final survey which included 38 Markets, 62 commercial streets and mixed use streets.
- The survey was designed as a spatially random survey.
- The sample analysed for the current paper includes a data set of 1421 establishments of freight intensive sectors such as Manufacturing, Retail, Wholesale, Transport and storage and Accommodation and food.
- The sample is a well represented as the employment distribution mirrors the population employment distribution at a confidence level of 95%.

Data Description – Survey Instrument

- The survey instrument was based on NCFRP 25 included questions on
- Establishment Information
- Business Activity
- Employment information
- Site and Gross floor area
- Number of vehicles operated from this address
- Trips related to the goods and supplies based on modes used
- Cargo produced and received by the establishment
- Trips related to services
- Employees working in shifts

Data Description – Survey

Sector	%Share of the sector
Agricultural Activity	0.55%
Manufacturing	33.21%
Electricity, gas, steam and air conditioning supply	0.54%
Water supply, sewerage, waste management and remediation activities	0.24%
Construction	1.39%
Whole sale trade, retail trade & repair of motor vehicles & motor cycle	3.29%
Whole sale trade	3.63%
Retail trade	21.44%
Transportation and storage	5.93%
Accommodation and Food services	4.69%
Information & communication	1.79%
Financial and insurance activities	2.07%
Real estate activities	1.53%
Professional, scientific & technical activities	3.22%
Administrative and support service activities	2.47%
Education	4.68%
Human health & social work activities	3.92%
Arts entertainment, sports & amusement and recreation	0.40%
Other service activities not else where classified	5.02%
Total	**100%**

These account to 68.91% of the employment in the sectors and 83% of the trips surveyed

Source: Delhi Economic census 2013-14

Model Results – Regression based on economic variable district wise employment

	FTA	FTP
All Modes	75%	25%
MT	75%	25%
MTW	55%	45%
M_NO_MTW	81%	19%
NMT	75%	25%

- FTA -75% of the freight trips are attractions and only 25% are productions, for every FTP there are 3 trip attractions for Motorised as well as NMT
- MTW form 55% of FTA and 45% of FTP
- FTA by Motorised_Non MTW accounts for 81% of the trips and 19% forms FTP.

Model Results- Mode wise Trip Attraction and Production – districtwise employment

Ordinary Least Square Regression (OLS) include Freight Trip Attractions (FTA) and Freight Trip Productions (FTP) using employment as an independent variable

	Freight Trip Attractions								Freight Trip P						
Model	Variables	Obs	c	T-stat	b	T-stat	Adj R	RMSE	Obs	c	T-stat	b	T-stat	Adj R	RMSE
All modes	TE	11	183.13	2.88	-0.01	-0.35	0.01	145.11	11	61.82	1.79	0.01	0.38	-0.09	78.93
MT	TE	11	132.16	2.62	-0.01	-0.29	-0.10	115.11	11	44.62	1.6	0.01	0.51	-0.08	63.67
NMT	TE	11	51.08	2.87	0.00	-0.45	-0.09	40.65	11	17.20	1.88	0.00	-0.12	-0.11	20.86
MTW	TE	11	22.78	2.33	0.00	0.19	-0.11	22.35	11	18.31	2.17	0.00	-0.59	0.07	19.3
M _No MTW	TE	11	109.19	2.38	-0.01	-0.36	-0.10	104.71	11	26.30	1.16	0.01	0.84	-0.03	51.63

- The best models for all modes are a constant only model. The independent variable is not significant.

Model Results – Regression based on economic variable sector wise employment

	FTA	FTP
All Modes	79%	21%
MT	96%	4%
NMT	58%	42%
MTW	0%	100%
M_NO MTW	100%	0%

- Trip attractions for these 5 sectors are split in a ratio of 4:1
- Motorised FTA accounts to 96% of the trips.
- Motorised Two Wheelers are primarily used for trip generations in these sectors and not for FTA
- While Motorised _non MTW trips are seen in attractions.
- Non motorised trips are seen in both FTA and FTP in a 3:2 ratio.

Model Results – Regression based on economic variable sector wise employment

	Freight Trip Attractions								Freight Trip Productions						
Model	Variables	Obs	c	T-stat	b	T-stat	Adj R	RMSE	Obs	c	T-stat	b	T-stat	Adj R	RMSE
All Modes	Manu emp	11	32.25	0.81	-0.05	-0.82	**0.76**	**67.69**	11	8.60	0.28	-0.01	-1.36	**0.95**	**16.97**
	Retail emp				0.64	2.85						0.24	2.53		
	Wholesale emp				0.50	2.02						-0.33	-5.15		
	TS emp				0.00	-0.06						0.61	10.54		
	AF emp				0.41	1.39						-0.01	-1.70		
MT	Manu emp	11	20.97	0.75	-0.06	-1.31	**0.81**	**47.27**	11	0.22	0.01	-0.05	-1.65	**0.67**	**35.28**
	Retail emp				0.44	2.81						0.35	2.98		
	Wholesale emp				0.39	2.24						-0.14	-1.13		
	TS emp				0.46	2.23						0.53	3.43		
	AF emp				0.00	0.08						0.00	0.08		

- The best models are ones where constant and independent variable is significant.

Model Results – Regression based on economic variable sector wise employment

	Freight Trip Attractions								Freight Trip Productions						
Model	Variables	Obs	c	T-stat	b	T-stat	Adj R	RMSE	Obs	c	T-stat	b	T-stat	Adj R	RMSE
NMT	Manu emp	11	11.33	0.59	0.01	0.2	0.29	32.76	11	8.38	0.62	-0.01	-0.52	-0.35	23.01
	Retail emp				0.2	1.84						0.09	1.14		
	Wholesale emp				0.11	0.94						-0.06	-0.73		
	TS emp				-0.05	-0.36						0.08	0.83		
	AF emp				0.00	-0.24						0.00	-0.32		
MTW	Manu emp	11	-0.38	-0.08	0.00	0.35	**0.87**	**7.80**	11	10.25	1.00	-0.03	-1.66	**0.13**	**17.37**
	Retail emp				0.17	6.45						0.13	2.20		
	Wholesale emp				0.00	0.09						-0.12	-1.83		
	TS emp				0.00	-0.14						0.11	1.45		
	AF emp				0.00	0.39						0.00	-0.35		

- NMT- Non-motorised FTA are primarily seen in retail and wholesale . FTP are seen in Retail, transport and storage.

- MTW FTA are significant for retail and FTP of retail and wholesale. And FTP is significant for retail, wholesale, Manufacturing and transport and storage

Model Results – Regression based on economic variable sector wise employment

	Freight Trip Attractions								Freight Trip Productions						
Model	Variables	Obs	c	T-stat	b	T-stat	Adj R	RMSE	Obs	c	T-stat	b	T-stat	Adj R	RMSE
M_NO MTW	Manu emp	11	20.98	0.80	-0.06	-1.48	**0.80**	**44.58**	11	-10.03	-0.71	-0.03	-1.23	**0.78**	**24.06**
	Retail emp				0.28	1.87						0.22	2.77		
	Wholesale emp				0.38	2.35						-0.03	-0.34		
	TS emp				0.47	2.41						0.42	3.99		
	AF emp				0.00	0.03						0.00	0.37		

- M_MTW FTA are primarily seen in Manufacturing, retail, wholesale, transport and storage and FTP is seen in manufacturing, retail, transport & storage.

Urban form Indices

The indices used in this study to measure urban form are:

- Density Index: (Kockelman, 1997)
  - Population Density
  - Employment Density

- Land Use Mix (Dissimilarity) Index (Kockelman, 1997)

Model Results – Regression based on urban form variables

	FTA	FTP
All Modes	78%	22%
MT	73%	27%
NMT	100%	0%
MTW	63%	37%
M_NO MTW	74%	26%

- NMT trips generated using Urban form variables shows 100% of the trips as FTA.
- The percentage breakup of FTA and FTP estimated using sector wise employment is comparable with the results using the urban form variables.

Model Results – Regression based on urban form variables

	Freight Trip Attractions								Freight Trip Productions						
Model	Variables	Obs	c	T-stat	b	T-stat	Adj R	RMSE	Obs	c	T-stat	b	T-stat	Adj R	RMSE
All Modes	Land Use Mix (Dissimilarity Index)	11	-288.90	-0.98	2691.10	1.54	0.05	135.23	11	-16.49	-0.10	696.76	0.70	-0.05	77.25
	Pop den				0.00	-0.31						0.00	-0.60		
	Emp den				0.05	1.45						0.01	0.64		
MT	Land Use Mix (Dissimilarity Index)	11	-245.68	-1.02	2269.58	1.59	-0.01	110.48	11	-48.15	-0.38	811.49	1.08	0.10	58.11
	Pop den				0.00	0.20						0.00	-0.37		
	Emp den				0.03	0.93						0.01	0.39		

- All modes: the variables that effect FTA by all modes are Dissimilarity and employment density and FTP is Dissimilarity Index.
- Motorised modes – the significant variables in FTA are Land use dissimilarity Index and Employment Density and FTP is dissimilarity Index.
- Thus, business size and dissimilarity play a major role in freight trip attractions by all modes and Motorised transport. And for FTP only the dissimilarity index is significant.

Model Results – Regression based on urban form variable sector wise employment

	Freight Trip Attractions								Freight Trip Productions						
Model	Variables	Obs	c	T-stat	b	T-stat	Adj R	RMSE	Obs	c	T-stat	b	T-stat	Adj R	RMSE
NMT	Land Use Mix (Dissimilarity Index)	11	-42.98	-0.68	419.59	1.11	0.438	29.22	11	31.66	0.67	114.73	-0.41	-0.20	21.70
	Pop den				-0.00	-2.18						-0.00	-1.13		
	Emp den				0.02	3.18						0.00	0.72		
MTW	Land Use Mix (Dissimilarity Index)	11	-10.715	-0.27	171.91	0.72	0.249	18.41	11	10.55	0.24	83.52	0.33	-0.14	19.93
	Pop den				-0.00	-1.85						0	-0.19		
	Emp den				0.01	2.28						-0.00	-0.23		
M_No MTW	Land Use Mix (Dissimilarity Index)	11	-234.56	-1.06	2096.14	1.6	-0.033	101.71	11	-58.71	-0.55	727.96	1.15	0.06	49.31
	Pop den				0.00	0.55						0	-0.37		
	Emp den				0.01	0.59						0.00	0.55		

- FTA by NMT and MTW shows population density, employment density are significant at 95% and the dissimilarity index is significant. FTP by NMT are influenced by Population density and the business size but not the dissimilarity index.
- FTA and FTP Motorised-Non MTW shows dissimilarity index as motorised modes are extensively used in areas where the commercial and industrial.

Conclusions

- Urban form variables are significant for modes NMT and MTW with population density and employment density as significant variables in FTA. Urban form variables are not significant for MTW FTP and report better models for MTW FTP using economic variables.

- The models-All modes, motorised freight, motorised two-wheeler is best explained by the economic variables based on the sector wise employment. FTA and FTP models for MT and NMT, FTP of All modes and MTW clearly indicate trip rate based on the number of employees in the sector

- Contrary to models from the previous research, the urban form variables show a constant and independent variable model for FTA.

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