Enhancing the Transferability Accuracy of Urban Freight Demand Models using a Novel Establishment Typology

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Why Freight Demand Models?

Truck Movement

Congestion

Pavement
Deterioration

Pollution

# Why Freight Demand Models?

INDIAN SCENARIO

- More importance to passenger traffic

- Manufacturing sector in India was highly influenced by the launch of the 'Make in India' program

- Due to exponential growth of industries, the nationwide freight movement is estimated to *grow annually at 9.7% by 2031-32 and will surpass 13,000 BTKM* (Billion-Ton-Kilometer) (National Transport Development Policy Committee, 2014)

Why Transferability?

- *Limited resources* for data collection
- As per the literature, the total establishment-based freight survey (EBFS) costs were around *$600,000* in Calgary during 2000 ($198 per completed response) and $800,000 in Edmonton ($185 per completed response) during 2002 (Hunt et al., 2006).
- The unit cost was €400 (approximately $500) per completed response in Paris during 2012 (Toilier et al., 2016).
- It is apparent that the choice of survey method influences to the EBFS cost. For example, face-to-face interviews aided with postal or telephonic contact is relatively costlier and time consuming than other methods.
- Postal and web- based questionnaire surveys are reported with significantly less cost than erstwhile methods (Lawson, 2002). The cost of web-based survey conducted in USA was $40,000 ($126 per establishment or $40 per shipment response).

Data Description

- Study Area: Kerala State

- Establishment-based Freight Survey (EBFS) – Face to face interview - 432 responses

- Variables: Weekly Freight Attraction (FA), Number of employees (NE), Gross Floor Area of establishment (GFA)
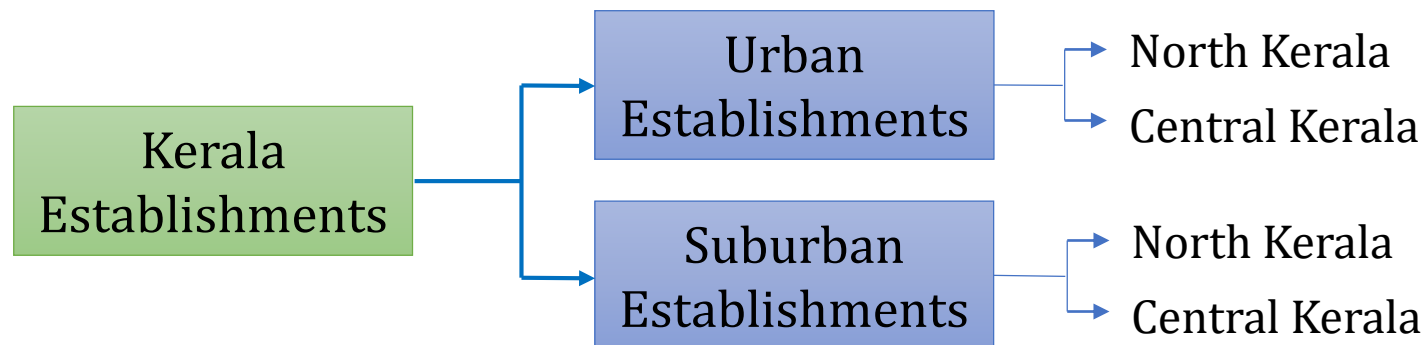
Modelling Methods

- Parametric Models
  - Ordinary Least Square (OLS) Regression
  - Robust Regression
- Non-parametric Models
  - Multiple Classification Analysis
  - Support Vector Regression

Summary of Parametric Models

Term	OLS	RR	Term	OLS	RR
Employment-based FP Models			**Area-based FP Models**		
North Kerala Urban (NKU) Establishment Models					
NE	0.620***	0.389***	GFA	2.569***	1.834***
R^2	0.505	0.646	R^2	0.589	0.681
MAE	12.821	12.625	MAE	12.313	11.729
North Kerala Suburban (NKS) Establishment Models					
NE	1.665***	1.610***	GFA	3.469***	2.966***
R^2	0.844	0.857	R^2	0.729	0.841
MAE	13.470	13.400	MAE	15.821	14.892
Central Kerala Urban (CKU) Establishment Models					
NE	0.620***	0.389***	GFA	1.933***	1.575***
R^2	0.505	0.646	R^2	0.561	0.701
MAE	12.763	12.797	MAE	12.408	11.996
Central Kerala Suburban (CKS) Establishment Models					
NE	0.518***	0.491***	GFA	2.135***	1.825***
R^2	0.591	0.707	R^2	0.517	0.724
MAE	15.533	15.329	MAE	15.743	15.226

Note: (1) *** represents $p < 0.001$; (2) GFA in 100 m^2; (3) FP in tons per week

Summary of Non-Parametric Models

Multiple Classification Analysis

Employment Levels	North Kerala Urban	North Kerala Suburban	Central Kerala Urban	Central Kerala Suburban
0 – 15	11.990	13.470	11.637	11.249
15 – 30	25.025	30.370	21.722	19.077
30 – 45	23.987	65.390	18.379	36.508
≥ 45	40.011	125.00	37.975	40.744
R^2	0.203	0.744	0.200	0.245
MAE	13.484	13.160	13.099	15.997
Area Levels (in m^2)	North Kerala Urban	North Kerala Suburban	Central Kerala Urban	Central Kerala Suburban
0 – 400	11.804	8.640	9.478	15.724
400 - 800	18.655	21.080	17.468	24.674
800 - 1200	21.862	43.890	18.379	32.293
≥ 1200	39.436	77.390	34.489	37.188
R^2	0.225	0.490	0.165	0.123
MAE	13.165	16.850	13.099	16.641

Support Vector Regression

Employment-based FP Models					Area-based FP Models			
	NKU	NKS	CKU	CKS		NKU	NKS	CKU	CKS
MAE	11.241	13.549	11.553	14.240	MAE	11.035	16.098	11.820	14.036

Note: In all the SVR models, the radial basis kernel function is used

Transferability Assessment

$$Relative\ Absolute\ Transfer\ Error\ \%\ (RATE\ \%) = \left| \frac{RMSE_{transfer} - RMSE_{local}}{RMSE_{local}} \right| \times 100$$

$$Root\ Mean\ Square\ Error\ (RMSE) = \sqrt{\frac{\sum_{i=1}^{n} \left(Y_i - \hat{Y}_i\right)^2}{n}}$$

Ranking of Modelling Approaches based on RATE%

Application Context	Estimation Context	Transferability ranking based on RATE%
Employment-based FP models		
NKU	NKS	SVR >> RR >> MCA > OLS
	CKU	MCA >> SVR > RR > OLS
	CKS	SVR ≈ OLS > MCA > RR
NKS	NKU	MCA ≈ SVR >> OLS >> RR
	CKU	SVR > MCA >> OLS > RR
	CKS	MCA > SVR >> OLS > RR
CKU	NKU	RR > MCA > SVR >> OLS
	NKS	SVR >> MCA > RR > OLS
	CKS	RR > OLS > SVR > MCA
CKS	NKU	RR > MCA > SVR >> OLS
	NKS	SVR >> MCA >> RR ≈ OLS
	CKU	RR >> OLS > SVR > MCA
Area-based FP models		
NKU	NKS	SVR ≈ RR > OLS >> MCA
	CKU	MCA > RR ≈ OLS > SVR
	CKS	RR > SVR ≈ OLS > MCA
NKS	NKU	OLS >> RR > MCA ≈ SVR
	CKU	OLS > SVR > MCA > RR
	CKS	OLS > SVR > MCA ≈ RR
CKU	NKU	MCA ≈ SVR > RR >> OLS
	NKS	SVR > RR >> OLS >> MCA
	CKS	OLS > RR > SVR >> MCA
CKS	NKU	OLS > SVR ≈ MCA > OLS
	NKS	SVR ≈ RR >> MCA ≈ OLS
	CKU	RR > OLS > MCA > SVR

Summary of Preferred Modelling Approaches

			Application Context						
		Employment-based FP models				Area-based FP models			
		North Kerala		Central Kerala		North Kerala		Central Kerala	
		Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban
Estimation Context North Kerala	Urban	-	SVR	MCA	SVR, OLS	-	SVR, RR	MCA	RR
	Suburban	MCA, SVR	-	SVR	MCA	OLS	-	OLS	OLS
Central Kerala	Urban	RR	SVR	-	RR	MCA, SVR	SVR	-	OLS
	Suburban	RR	SVR	RR	-	OLS	SVR, RR	RR	-

Closing Remarks

Among all the modelling approaches, the non-parametric models show better prediction ability

The employment and area-based FP models show that the direction of transferability is not symmetric.

In both models, the extent of transferability of models developed with non-parametric approaches is more than that of models developed with parametric methods.

In intra-regional (urban to urban or suburban to suburban) transferability, the extent of transferability of non-parametric approaches is more.

If the urban model is transferred to suburban, it is seen that both parametric and non-parametric models have shown good transferability.

Selected References

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Thank You