

ASSESSMENT OF FREIGHT VEHICLES CHARACTERISTICS: THE CASE OF DELHI

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TRIPP

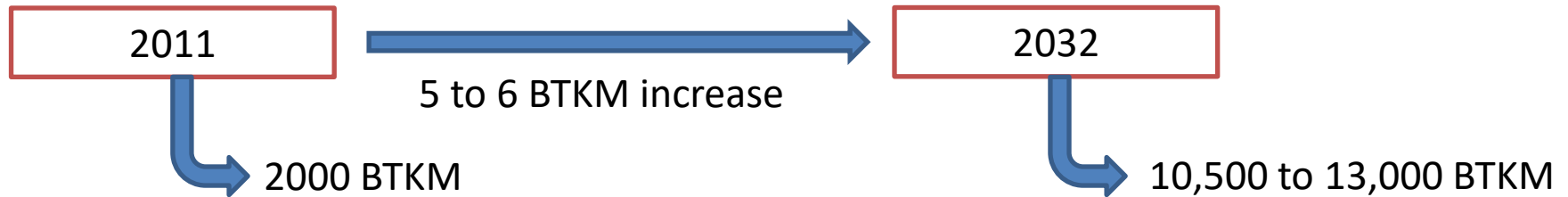
Indian Institute of Technology, Delhi

Outline

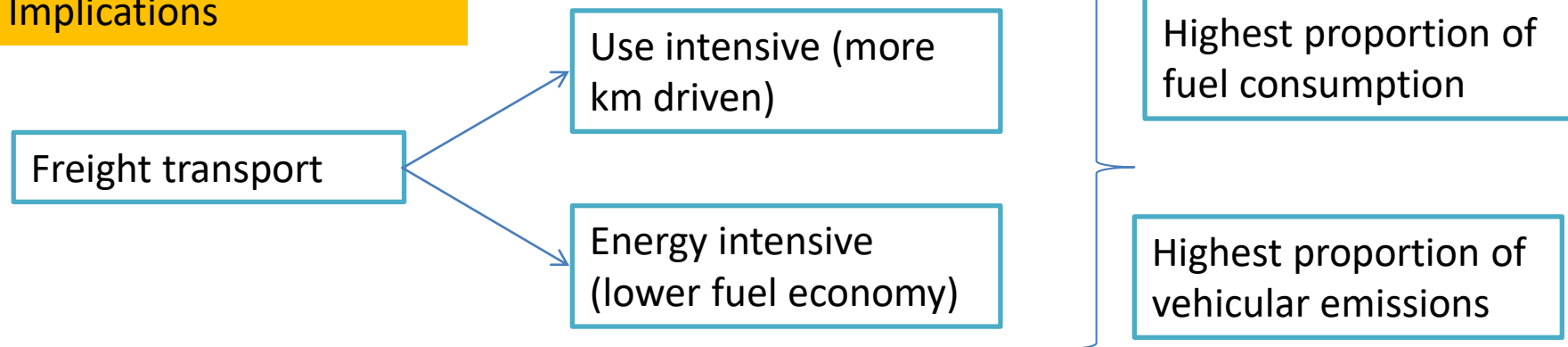
- Introduction
- Data collection and methodology
- Results
- Main findings and Way forward

Introduction

- Efficient freight movements backbone of economy
- NTDP (2014) estimates freight activity:

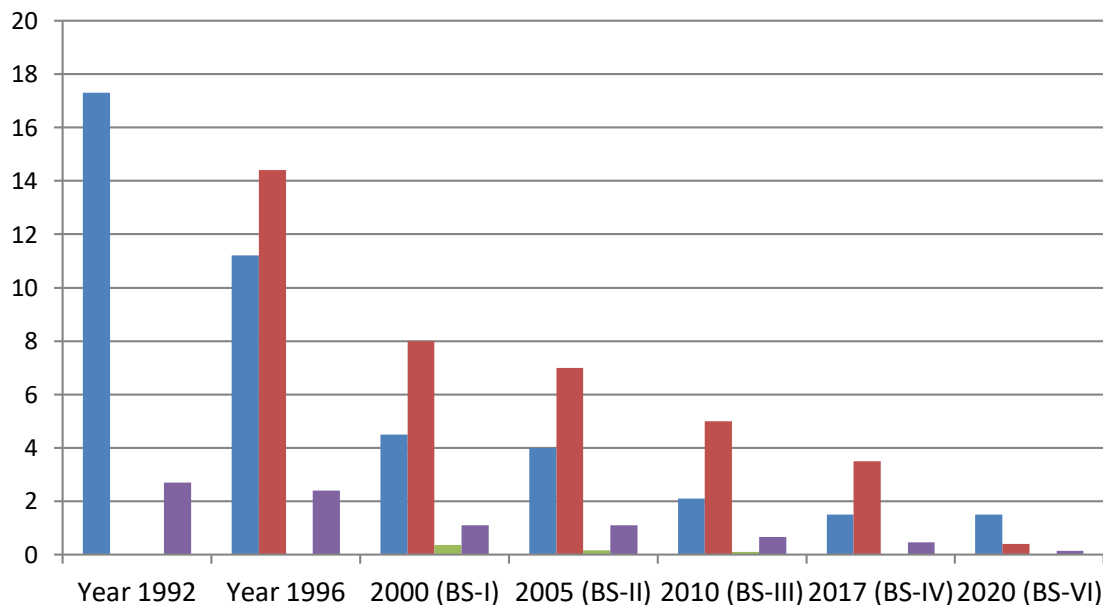
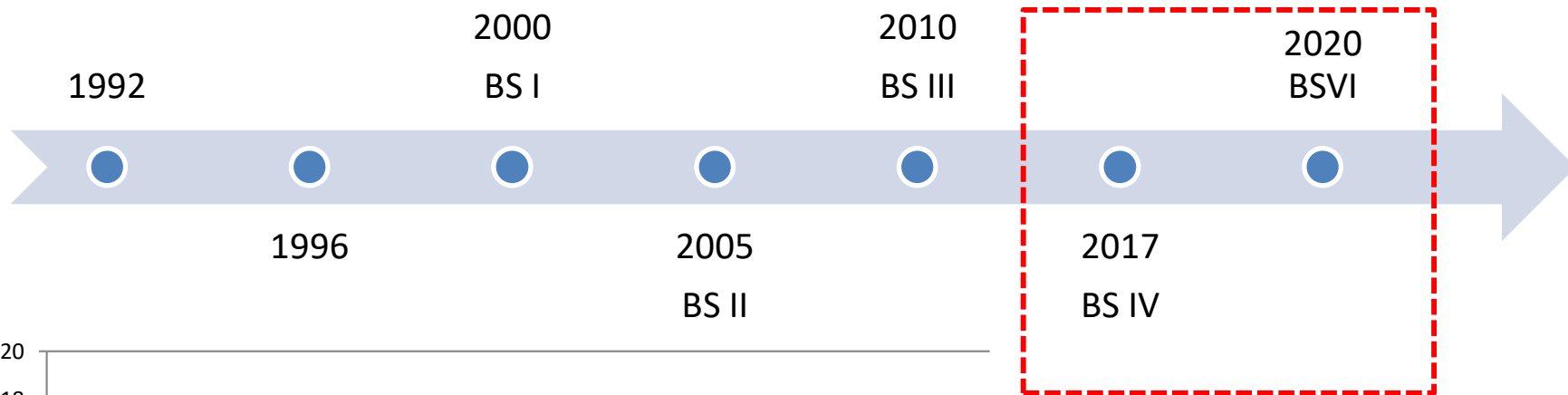


Energy and Environment Implications



Policy Environment freight vehicles- Nationwide

Timeline Emission standards- India



Proposed emission standards nationwide

- CO
- Nox
- PM
- HC

Other proposed policy interventions

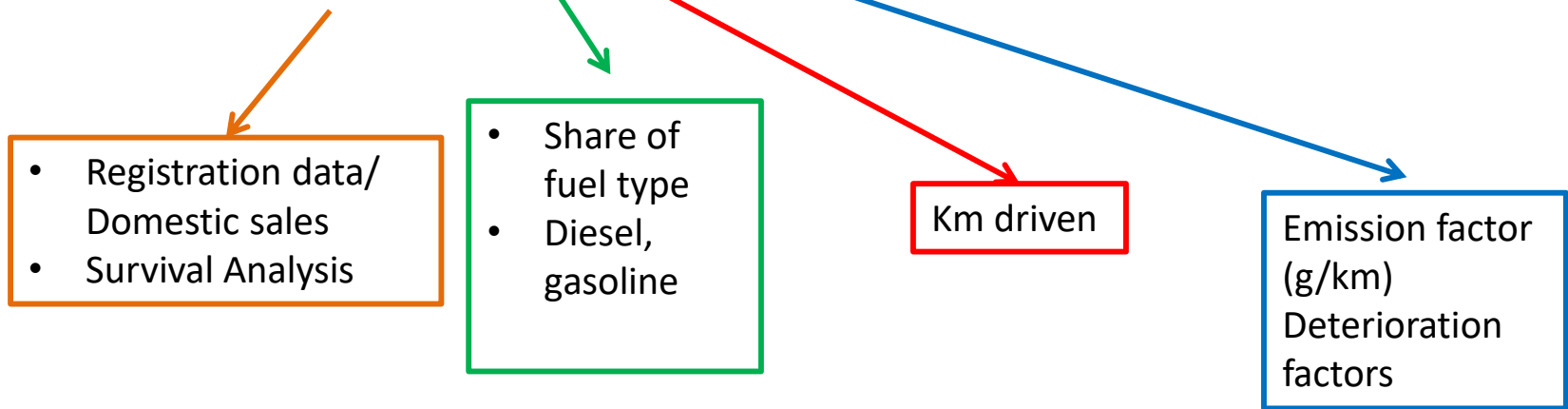
- Fuel economy standards
- Scrappage policy

Chronology of emission standards for heavy duty vehicles- India

Motivation

- Paucity of freight characteristics in spite of vital contribution of the freight vehicles:
 - Travel activities (Annual Kilometre driven)
 - Age distribution
 - Fuel distribution
 - Fuel economy

• $E_{p,v,a,f} = \text{Vehicle in use}_{v,a} \times S_f \times VKT_{v,a} \times EF_{p,v,a,f}$ (Emission of criteria pollutant)



$E_{p,v,a,f} = \text{Vehicle in use}_{v,a} \times S_f \times VKT_{v,a} \times FE_{v,a,f} \times P_{p,f}$ (Emissions CO₂)

Fuel economy

The Case of Delhi

- Unfortunately known to be among 20 world's most polluted cities of the world (WHO, 2016)
- Pollution by freight vehicles cause of concern
- Documented and published results on the passenger vehicle characteristics
- Pollution estimates for freight vehicles **borrowed assumptions**

Freight oriented Policies- Delhi

Time Restriction

Non Destined external freight vehicles prohibited

Pollution tax



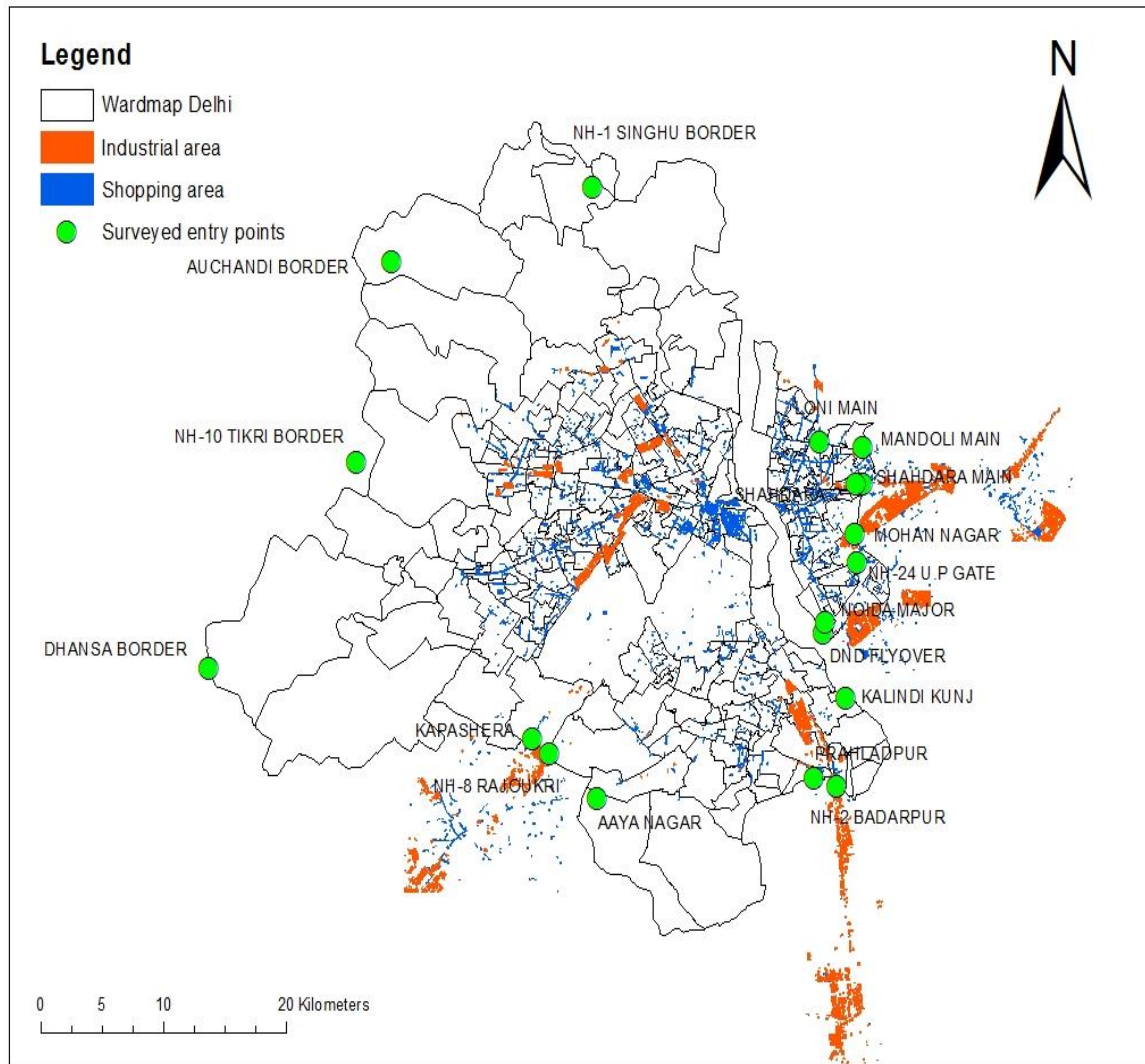
External to Internal freight trips in Delhi

Objectives

- Fleet Characteristics
 - a) Age distribution
 - b) Fuel economy
 - c) Fuel type distribution
- Volume and travel activity
 - a) percentage of non-destined freight vehicles
 - b) vehicle kilometre travelled in Delhi
 - c) Percentage of the empty non-destined trips
 - d) Entry/Exit patterns of the non-destined trips.
- Freight trip attraction model

**Focus External to
Internal freight
transport**

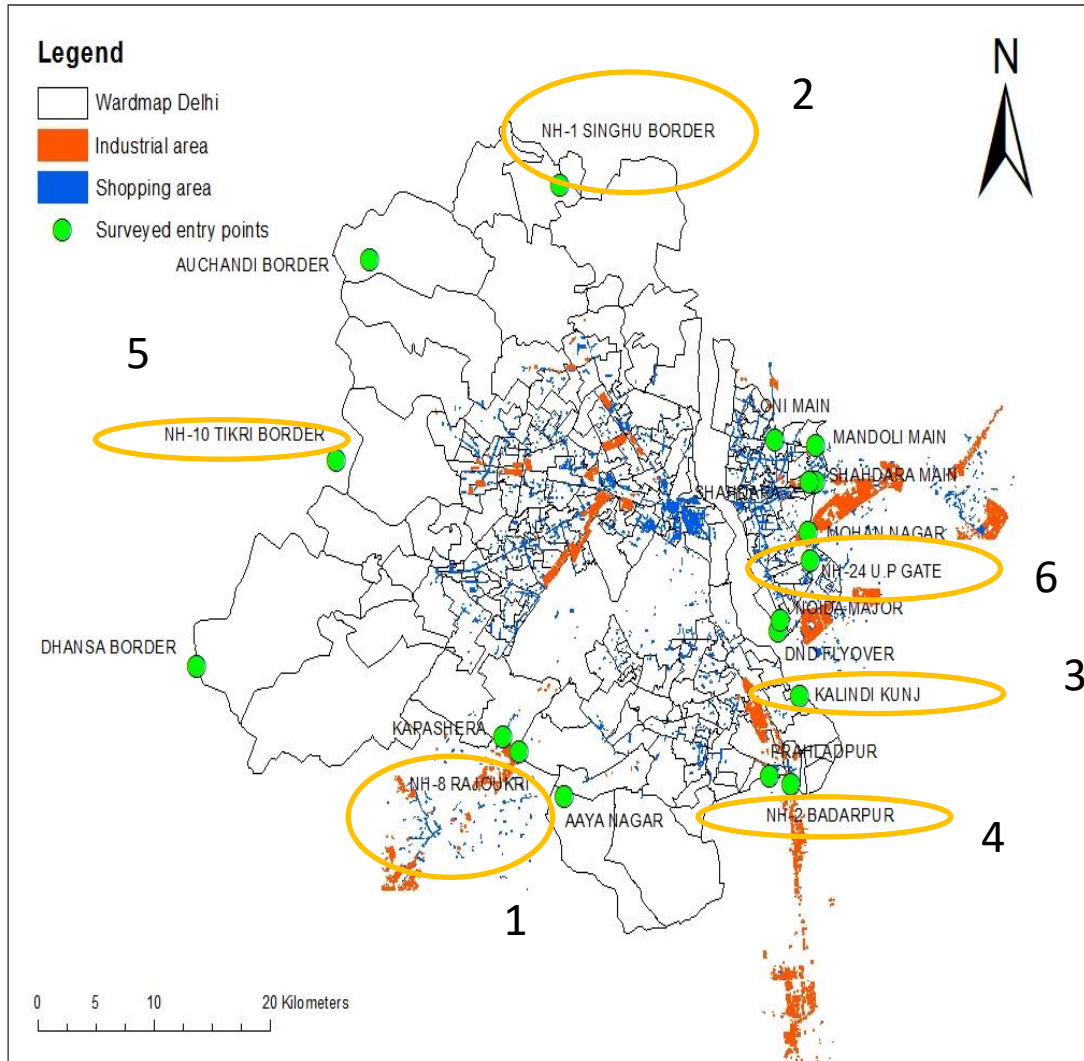
Methodology



- Cordon Inventory
- 72-hour manual traffic counts
- Origin and destination (O&D) surveys (6865 samples collected)
 - Vehicle registration number
 - Vehicle type
 - Fuel used
 - Model year
 - Ownership
 - Odometer reading
 - Fuel mileage
 - Commodity carried
 - Origin and destination zones
 - Exit locations
 - Fuel sales data

Details of Surveyed locations

External freight flow analysis of Delhi



57,500 external annual average daily freight traffic is observed.

- 38% of the medium commercial vehicles (3.5 to 7.5 tonne)
- 19% of 3-axle trucks
- 14% of light commercial vehicles

Distribution of vehicle as per the registration

Why Necessary?

Staggered implementation
emission standards

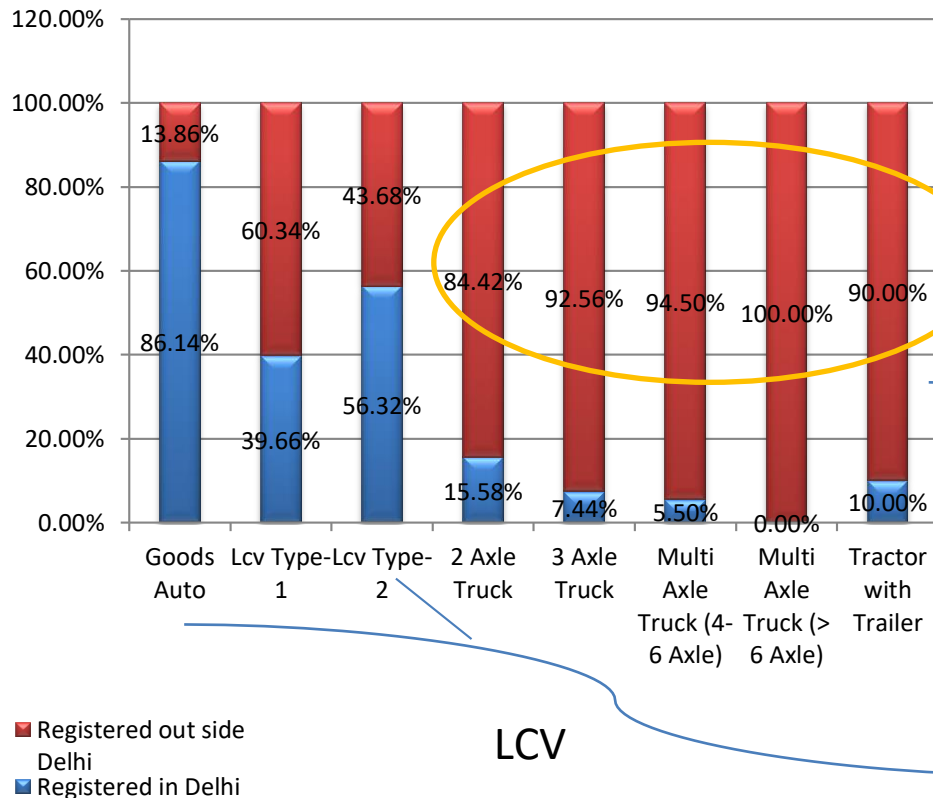


Emission factors (g/km)
change

HCV

Higher %age of LCVs registered
in Delhi in comparison to HCVs

- Shorter trip lengths



Destined vs. Non-Destined vehicles

- 19% HCV of the total freight traffic entering is non destined to Delhi
- 2,40,539 vehicle-kilometre is driven in Delhi by non-destined vehicles daily.

Product

Destined to Outside Delhi Trips Matrix As per per its In and Out Point																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5A	15	16	17	18	Total IN
1	0	23	0	16	95	0	0	0	0	19	5	0	0	0	0	1	2	32	0	193
2	11	0	0	0	25	0	1	0	104	0	1	0	0	0	0	0	0	0	0	142
3	0	5	0	0	7	0	0	0	0	5	3	0	0	0	0	0	2	0	0	22
4	2	17	0	0	55	0	0	0	1	0	1	10	0	0	0	6	0	0	0	92
5	5	40	1	91	1	1	0	0	1	0	0	0	0	0	0	0	2	0	0	142
6	0	2	0	1	16	0	0	0	0	0	1	0	0	0	0	2	0	0	0	22
7	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	25
8	0	0	0	1	0	4	0	0	19	0	0	0	0	0	0	0	0	0	0	24
9	1	89	0	64	3	0	0	25	0	0	0	0	0	0	0	0	1	0	0	183
10	9	0	0	30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
11	1	5	1	9	3	0	0	0	2	0	1	1	0	0	0	0	1	1	1	25
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	21	0	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35
14	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
5A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	4	0	0	8	1	0	2	0	0	0	0	0	0	0	0	0	11	1	0	27
16	22	3	1	4	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	33
17	8	2	0	49	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	62
18	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4
Total Out	91	190	16	275	212	6	3	25	125	27	15	11	1	0	0	26	18	34	1	1076

Distance(Kms) Matrix As per per its In and Out Point																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5A	15	16	17	18
1	0	54	32	52	44	58	50	55	48	37	29	35	32	21	0	48	39	40	58
2	54	0	51	32	23	29	35	3	11	27	32	27	31	62	0	27	16	16	64
3	32	51	0	34	45	91	35	52	0	42	39	41	42	24	0	48	47	48	25
4	52	32	34	0	32	11	3	32	33	38	35	36	38	51	0	37	29	30	38
5	44	23	45	32	0	31	35	25	14	9	14	9	12	58	0	24	7	8	64
6	58	29	91	11	31	0	10	28	27	36	37	35	38	60	0	34	27	27	41
7	50	35	35	3	35	10	0	38	39	38	36	35	39	48	0	37	30	31	34
8	55	3	52	32	25	28	38	0	12	28	32	27	31	65	0	28	16	17	61
9	48	11	0	33	14	27	39	12	0	20	23	19	23	58	0	18	7	7	62
10	37	27	42	38	9	36	38	28	20	0	6	1	4	47	0	5	12	12	63
11	29	32	39	35	14	37	36	32	23	6	0	5	4	44	0	11	17	17	59
12	35	27	41	36	9	35	35	27	19	1	5	0	4	48	0	6	13	13	58
13	32	31	42	38	12	38	39	31	23	4	4	4	0	42	0	9	15	16	62
14	21	62	24	51	58	60	48	65	58	47	44	48	42	0	0	57	52	53	53
5A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	48	27	48	37	24	34	37	28	18	5	11	6	9	57	0	0	8	9	65
16	39	16	47	29	7	27	30	16	7	12	17	13	15	52	0	8	0	1	60
17	40	16	48	30	8	27	31	17	7	12	17	13	16	53	0	9	1	0	58
18	58	64	25	38	64	41	34	61	62	63	59	58	62	53	0	65	60	58	0

Commodity Delivered External freight trips

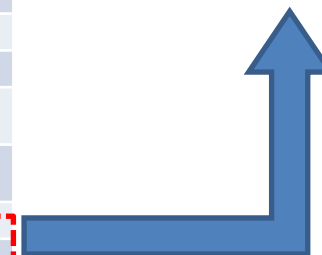
Trip Distribution As per Commodity Type

S.no	Type of Commodity	% share
1	FOOD GRAINS / PULSES & SPICES	4.72%
2	MILK, FRUITS & VEGETABLES	10.87%
3	PROCESSED /PACKAGED FOOD / EDIBLE OIL	3.20%
4	COTTON / CLOTHING or SYNTHETIC YARN / FIBRES	2.18%
5	TEXTILES / CLOTHING / READYMADE GARMENTS	1.37%
6	LEATHER PRODUCTS	0.13%
7	HANDICRAFTS	0.01%
8	PETROLEIM PRODUCTS / HSD / PETROL	1.94%
9	MINERALS and ORES	1.06%
10	IRON & STEEL (ALUMINUM or METAL) ROAD / BARS / SHEETS	7.27%
11	METAL SETRAP	0.16%
12	TIMBER / WOOD and PRODUCTS	2.08%
13	PAPER/PARCEL	4.30%
14	COKE / COAL	0.57%
15	AUTOMOBILES & AUTO SPARE PARTS	1.86%
16	MACHINES & AUTO SPARE PARTS	1.30%
17	RUBBER / PLASTICS	2.68%
18	TYRES	0.38%
19	CHEMICALS / FERTILIZERS	0.84%
20	PHARMACEUTICAL PRODUCTS	0.50%
21	BUILDING MATERIALS	13.66%
22	ELECTRONIC / COMPUTERS/ ELECTRICAL APPLIANCES	1.41%
23	OTHERS	4.60%
24	EMPTY	32.89%

Why Necessary?

- Empty Trips: Inefficient freight distribution
- If commodity daily purpose—lost VKm compensation by other mode

84% Destined to Delhi



Age Distribution

Distribution of vehicle according Age										
S.No	Age of Vehicle	Vehicle Type								Total
		Goods Auto	Lcv Type-1	Lcv Type-2	2 Axle Truck	3 Axle Truck	Multi Axle Truck (4-6 Axle)	Multi Axle Truck (> 6 Axle)	Tractor with Trailer	
1	<= 2 years	25.34%	20.54%	17.59%	16.98%	15.35%	18.05%	0.00%	15.00%	18.92%
2	2 to 4 years	24.34%	19.78%	16.32%	19.57%	15.90%	21.02%	100.00%	20.00%	19.27%
3	4 to 6 years	20.85%	24.34%	26.21%	23.38%	25.37%	21.72%	0.00%	20.00%	23.92%
4	6 to 8 years	16.10%	16.84%	18.39%	16.88%	20.99%	20.17%	0.00%	15.00%	18.06%
5	8 to 10 years	7.87%	10.53%	8.39%	11.97%	12.53%	9.31%	0.00%	25.00%	10.46%
6	10 tpo 12 years	3.12%	4.17%	4.25%	6.77%	3.37%	4.51%	0.00%	5.00%	4.36%
7	12 tp 15 years	2.00%	2.85%	8.05%	3.90%	5.72%	4.94%	0.00%	0.00%	4.31%
8	> 15 year (if any)	0.37%	0.95%	0.80%	0.56%	0.78%	0.28%	0.00%	0.00%	0.70%

62%

10%

Fuel Economy (km/l)

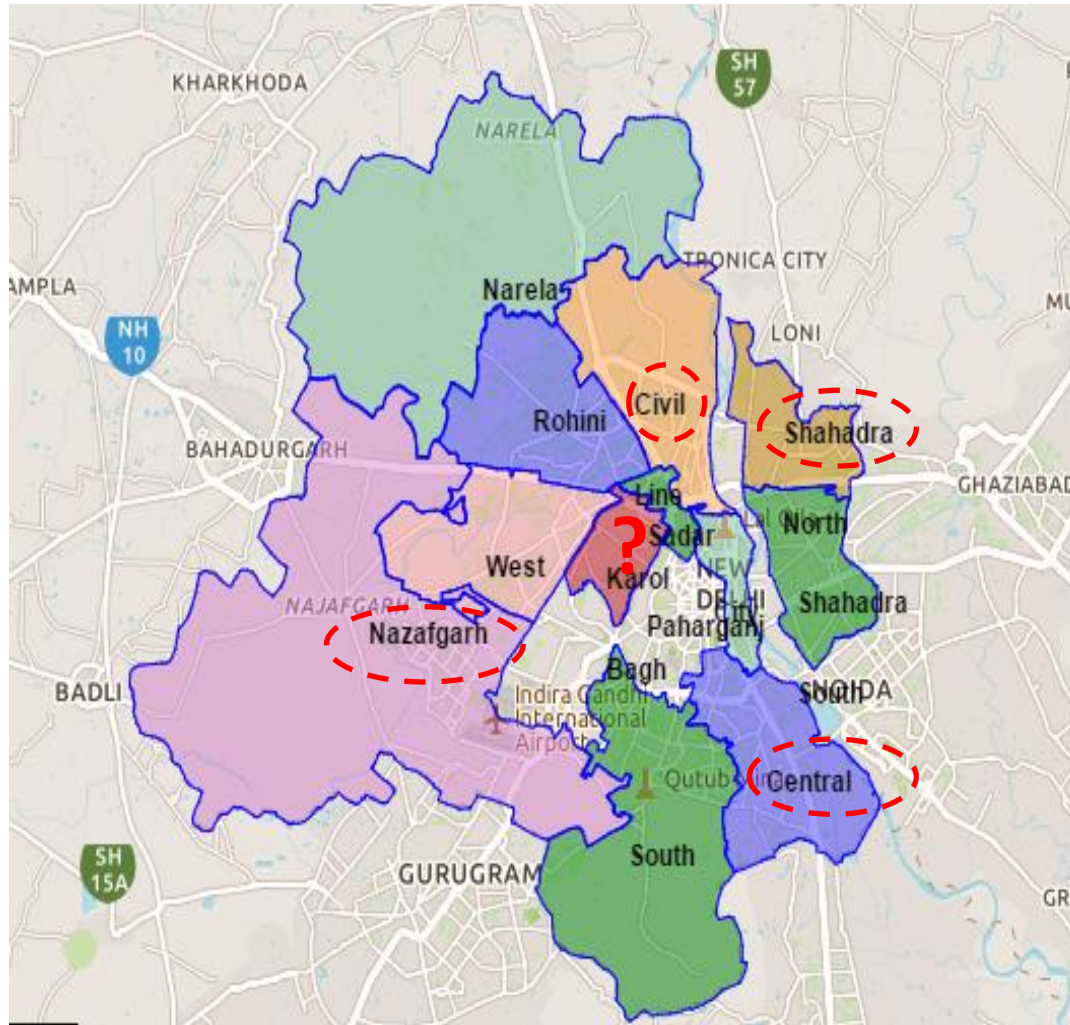
Based on Drivers' experience

Avg. Fuel economy (Km/Liter) of Diesel Vehicle According to their Age									
S.No	Age of Vehicle	Vehicle Type							
		Goods Auto	Lcv Type-1	Lcv Type-2	2 Axle Truck	3 Axle Truck	Multi Axle Truck (4-6 Axle)	Multi Axle Truck (> 6 Axle)	Tractor with Trailer
1	<= 2 years	14.06	8.33	15.03	3.56	3.36	3.08	-	6.33
2	2 to 4 years	12.06	7.87	12.02	3.46	2.96	2.99	2.00	5.38
3	4 to 6 years	12.14	7.80	11.84	3.08	2.82	2.78	-	5.38
4	6 to 8 years	13.50	7.81	11.22	3.06	3.15	2.98	-	5.00
5	8 to 10 years	10.00	7.58	10.84	2.90	3.01	2.83	-	4.80
6	10 to 12 years	-	7.56	10.43	2.68	2.67	2.94	-	4.50
7	12 to 15 years	-	7.15	9.41	2.26	2.48	2.12	-	-
8	> 15 year (if any)	-	7.25	9.75	2.50	2.00	-	-	-
Average		13.08	7.87	11.96	3.15	3.01	2.90	2.00	5.28

Fuel economy decrease observed in LCV

No clear relationship with age observed for HCV

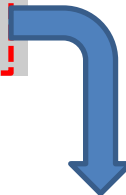
External to Internal freight trips attraction models



- MCD 12 Zones-272 wards
- Preliminary Analysis
 - Civil line- Dairy and wholegrain; Centre to Wazir pur industrial area, Azad Pur Fruit Market, Rajasthan Udyog Nagar
 - Nazafgarh-Metal and timber products

External to Internal freight trips attraction models Contd.

Dependent Variables	Independent Variables
Total freight trips attracted per day per hectare area of the ward	Number of Industries per hectare of the ward area
	Shopping area (in ha) per unit hectare of the ward area
	Residential density (Population per hectare area of the ward)

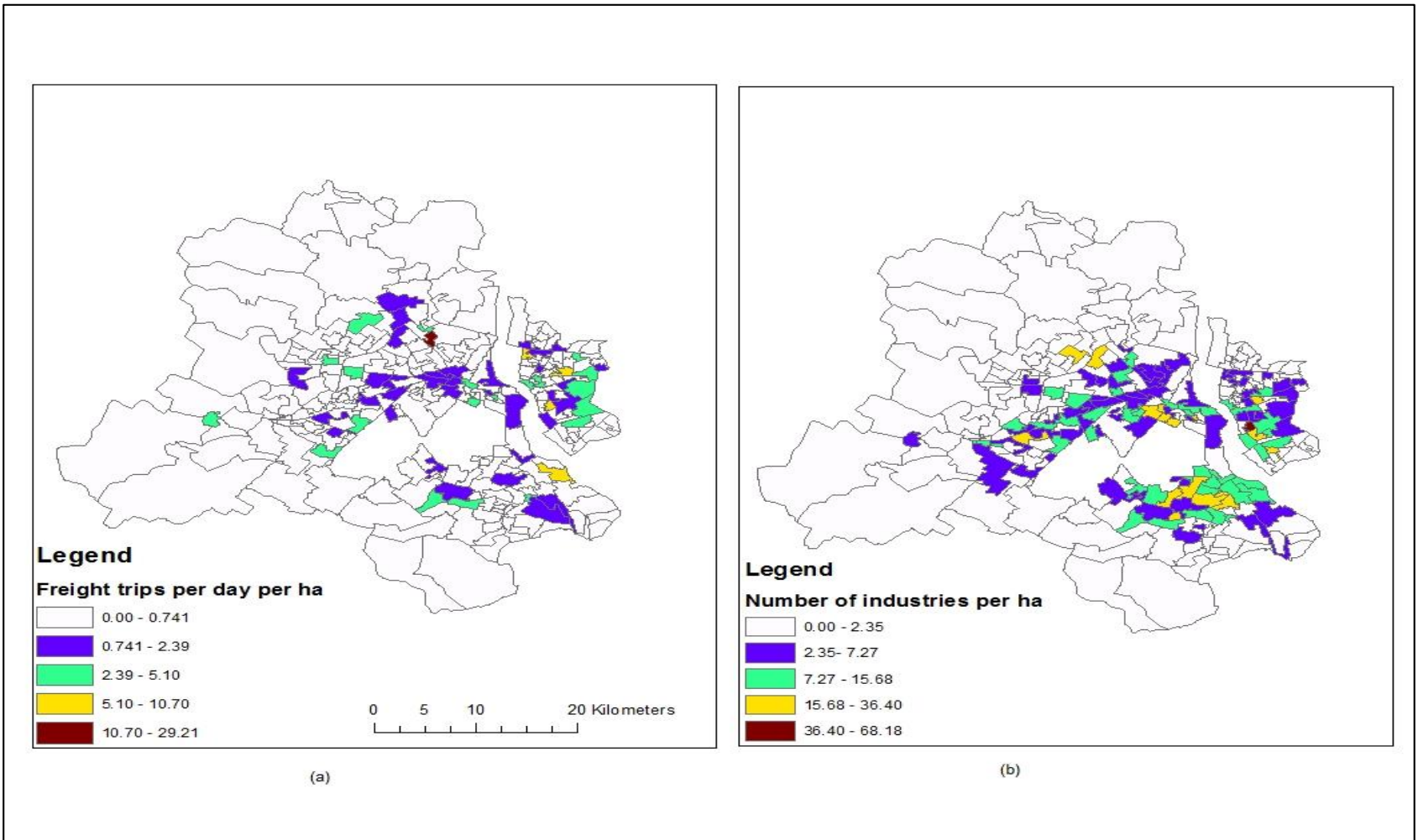


 Proxy variable to the floor area of industries per ward

Table: Results of Linear Regression Model

Independent parameters	Coefficient	Significance (p-value)
Constant	0.708	.153
Number of industries per unit ward area in ha	0.079	.017 95% significance
Shopping area(ha) per unit ward area in ha	.132	.080 90% significance
Residential density	8.98E-005	.881

External to Internal freight trips attraction models Contd.



Thematic map showing the relation between external trips attracted per unit ha and number of industries per ha

Major findings and Way forward

- Benchmark freight characteristics
 - A total of 57,500 annual average daily freight vehicles (38% Medium Commercial Vehicles share highest proportions)
 - 19% of the HCVs and MCVs are non-destined
 - 2,40,539 vehicle-kilometre is driven in Delhi by non-destined freight vehicles daily
 - 33% empty freight vehicles is entering in Delhi: 84% destined to Delhi
 - 10% freight vehicles older than 10 years
 - Fuel economy loss of 13%, 35%, 30%, 40%, 31% with age is observed in case of Lcv Type-1, Lcv Type-2, 2-axle, 3-axle, Multi-axle vehicle respectively.
 - “number of industries per ha” is found to significant at 95% significance level.
- Subsequent work: Contribution of emissions for External freight vehicles



Thank You

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