Methods to Estimate Vehicular Characteristics in Indian Cities

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Transport Emissions

\[
\text{Total Annual Emissions} = \text{Number of Vehicles} \times \text{Annual Mileage} \times \text{Fuel Efficiency} \times \text{Pollutant Content}
\]

- Share of Fuel among Vehicles
- Age Profile of Vehicles
<table>
<thead>
<tr>
<th>Transport Emissions</th>
</tr>
</thead>
</table>

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<tr>
<th>Total Annual Emissions</th>
<th>Number of Vehicles</th>
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<th>Fuel Efficiency</th>
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</tr>
</thead>
<tbody>
<tr>
<td>=</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>
In 2011, Delhi has 2.3 Million Cars!!
Car Ownership in Delhi

Cars in Delhi (2011) = 2,300,000
Number of Households (Census 2011) = 3,440,000
Average car per household = 1.3

Car Ownership ~ 50%

Delhi Car Ownership ~ 20% (Census 2011)
Vehicles (like humans) aren’t Immortal!
Issues with Official Registration Data

• Private vehicles in India required to re-register after 15 years
• No mechanism in place to ascertain which vehicles have retired / taken-off the road
• Result: Registration data overestimates number of in-use vehicles
• How much overestimation? We don’t know!
Transport Emissions

Total Annual Emissions = Number of Vehicles \times Annual Mileage \times Fuel Efficiency \times Pollutant Content

Total Annual Emissions =

Number of Vehicles

Annual Mileage

Fuel Efficiency

Pollutant Content
Annual Mileage

- Annual kilometers-travelled
- Varies for different vehicle types and cities
Transport Emissions

Total Annual Emissions = Number of Vehicles × Annual Mileage × Fuel Efficiency × Pollutant Content
Fuel Efficiency

- Auto manufacturers - fuel efficiency values - often an overestimate

- Possible due to differences in the driving cycle - actual and lab

- For fleet in the city - fuel efficiency values need to be weighed proportional to their share
Surveys and Databases

- Fuel Station Surveys
- Pollution under Control (PUC) Database
- Road side survey
- Vehicle Registration Data- Time Series
Fuel Station Surveys- Sampling

- Suitable sample locations for a representative sample
- Sampling of locations – critical for a representative sample
- Highways/by-passes within city boundaries will bias results due to high proportion of taxis and inter-city traffic
Fuel Station Surveys - Sampling in Delhi

• Covered Land-use types:
  – Major urban arterial
  – Residential
  – Mixed Use

• And, geographical areas:
  – South, North and North-West Delhi
Fuel Station Surveys

- Selected a sample of fuel stations in Delhi
- Interviewed a sample of drivers arriving for re-fuelling

- Make and Model
- License Plate Number
- Type of Vehicle
- Fuel Type
- Model Year

Questionnaire
Age Distribution of Cars

Average Age: 5 Years
Correction Factor

Total In-use Cars = Vehicles Registered during last 5 years

% Cars within 5 years of Age

51% of total registered cars

Method 1
## Survival Function of Vehicles

- Probability of a car surviving till age $k$ years

<table>
<thead>
<tr>
<th>Model Year</th>
<th>Vehicles Registered</th>
<th>Age Distribution (%)</th>
<th>Vehicles In-Use</th>
<th>Survival Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>169,790</td>
<td>15.8</td>
<td>160,458</td>
<td>99%</td>
</tr>
<tr>
<td>2010</td>
<td>159,643</td>
<td>15.4</td>
<td>157,214</td>
<td>97%</td>
</tr>
<tr>
<td>2009</td>
<td>154,310</td>
<td>14.4</td>
<td>143,595</td>
<td>95%</td>
</tr>
<tr>
<td>2008</td>
<td>129,675</td>
<td>12.1</td>
<td>128,875</td>
<td>89%</td>
</tr>
<tr>
<td>2007</td>
<td>139,823</td>
<td>10.6</td>
<td>113,296</td>
<td>83%</td>
</tr>
<tr>
<td>2006</td>
<td>123,231</td>
<td>8.6</td>
<td>97,265</td>
<td>75%</td>
</tr>
<tr>
<td><strong>Total In-use</strong></td>
<td><strong>1,405,800</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Survival Function of Cars

Log-logistic Function

\[ S_{i,k} = \left[ 1 + \left( \frac{k}{a_i} \right)^{b_i} \right]^{-1} \]

K is the age of vehicle
A and B are estimated parameters

Method 2
Survival Function - Issues

- Calibrated for Delhi - a large metropolitan, and relatively affluent
- Once calibrated for smaller urban areas, could potentially be used as a generic curve for Indian scenario
- Can be used to estimate current in-use vehicles as well as for forecast
Pollution Under Control (PUC) Data

- Vehicle Type
- Make and Model
- Engine Type
- Fuel Type
- Date of Manufacture
- Date of Test
- Pollution Numbers - Carbon Monoxide and Hydrocarbon
## Petrol Report

Note: Please enter the vehicle registration number to get the details of the vehicle.

### Enter Vehicle Registration No.: 

![Image](image.png)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Customer name.</th>
<th>Center Name</th>
<th>Puccko</th>
<th>Reg.No</th>
<th>Reg.date</th>
<th>Model</th>
<th>Category</th>
<th>TestDate</th>
<th>Valid Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NA</td>
<td>MOOLCHAND SHRIPAL JAIN</td>
<td>P042100096</td>
<td>DL5CF0414</td>
<td>Wednesday, July 07, 2004</td>
<td>CAR</td>
<td>4 W</td>
<td>Tuesday, September 14, 2010</td>
<td>Monday, December 13, 2010</td>
<td>Pass</td>
</tr>
<tr>
<td>2</td>
<td>NA</td>
<td>BATRA OIL COMPANY</td>
<td>P532104261</td>
<td>DL5CF0414</td>
<td>Monday, February 07, 2000</td>
<td>SX4</td>
<td>4 W</td>
<td>Friday, January 07, 2011</td>
<td>Wednesday, April 06, 2011</td>
<td>Pass</td>
</tr>
<tr>
<td>3</td>
<td>NA</td>
<td>BATRA OIL COMPANY</td>
<td>P532105479</td>
<td>DL5CF0414</td>
<td>Monday, February 07, 2000</td>
<td>SX4</td>
<td>4 W</td>
<td>Wednesday, June 08, 2011</td>
<td>Wednesday, September 07, 2011</td>
<td>Pass</td>
</tr>
<tr>
<td>4</td>
<td>NA</td>
<td>BATRA OIL COMPANY</td>
<td>P532112399</td>
<td>DL5CF0414</td>
<td>Monday, February 07, 2000</td>
<td>CAR</td>
<td>4 W</td>
<td>Saturday, January 05, 2013</td>
<td>Thursday, April 04, 2013</td>
<td>Pass</td>
</tr>
<tr>
<td>5</td>
<td>NA</td>
<td>Fortune Service Station</td>
<td>P507141701</td>
<td>DL5CF0414</td>
<td>Wednesday, July 04, 2007</td>
<td>SX4</td>
<td>4 W</td>
<td>Wednesday, April 03, 2013</td>
<td>Tuesday, July 02, 2013</td>
<td>Pass</td>
</tr>
<tr>
<td>6</td>
<td>NA</td>
<td>A M AUTOMOBILES</td>
<td>P638101621</td>
<td>DL5CF0414</td>
<td>Wednesday, July 04, 2007</td>
<td>SX4</td>
<td>4 W</td>
<td>Friday, August 02, 2013</td>
<td>Friday, November 01, 2013</td>
<td>Pass</td>
</tr>
</tbody>
</table>
PUC Compliance- On-road Survey

Cars have a compliance rate of 73%
Estimation of Total In-Use Vehicles

Number of Unique Cars Checked at PUC

Compliance Rate

59%

Of total registered cars

Method 3
## Correction Factor for Registration Data

<table>
<thead>
<tr>
<th>City</th>
<th>MTWs</th>
<th>Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi</td>
<td>40-45</td>
<td>51-59</td>
</tr>
<tr>
<td>Visakhapatnam</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Rajkot</td>
<td>51</td>
<td></td>
</tr>
</tbody>
</table>
Fuel Share of Cars in Delhi

- Petrol
- Diesel
- CNG/LPG
Fuel Efficiency (Km/Litres)

- Diesel Cars (all engine sizes): 14-15.3
- Diesel Cars (<=1600 cc): 16.1-17.4
- Diesel Cars (>1600 cc): 10.8-11.9
- Petrol Cars: 15.3-16.2
- MTWs: 48.5 - 52.3
Annual Mileage for MTWs

The difference can partially be explained by city structures.
International Perspective
Average Age of Cars

- Delhi
- EU
- USA
Fuel Efficiency

- Highest share of small cars
- 75% in the small car segment, globally it is 25%
- Lowest average weight of the cars

Source: GFEI, 2011
Summary

Fuel Station Surveys
- Number of In-use Vehicles
- Fuel Efficiency
- Annual Mileage
- Age Distribution

PUC Data
- Number of In-use Vehicles
- Compliance Rate
- Share of Vehicle Models
- Share of Fuels
Questions?