Assessing The Role of Transportation Demand Management Policies on Urban Air Pollution: A Case Study of Mashhad, Iran

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Background

- Transportation problems
  - Air pollution
  - Noise pollution
  - Daily delay
  - Depletion of energy
  - Road casualties
  - Water pollution
  - Waste production
  - ...

A Solution to discount transportation problems:

- Transportation Demand Management (TDM)

More efficient use of transportation resources
Background

- Need for long-term evaluation of TDM policies:
  - Difficulties in alternative/innovative practical solutions

- Special considerations:
  - Effects of TDM on attitudes and behavior is a long-term process
  - Factors may change during a long-term period
  - Probability of adding another policy
    - (Combination of policies)
Problem statement

- Assessing the role of TDM policies on air pollution of the city of Mashhad
  - Single and simultaneous policies
  - Over a 20-year period
  - Through a system dynamics model
- Evaluating a single policy
- Evaluating simultaneous policies
  - Combinations of specific policies
  - Conceptual procedure of policy integration
  - Developing an optimization procedure to identify optimal strategies
  - Extending the synergy function of TDM policies
  - Developing an option generation tool to find the best pair-wise combination and complement policy

References:
- Pendyala
- Vieira et al.
- May et al.
- Habibian and Ker
- Kelly et al. 2008 and May et al. 2012
Case study

- The city of Mashhad
  - a metropolis in North-East of Iran
  - The city population is about 2.6 million (2nd populated city in Iran)
  - As a religious city, Mashhad attracts 15 million visitors annually.
Map of the city
Transportation network of the city
Methodology

- System dynamics model
  - Based on: “every thing is dependent and changing”
  - An approach to understanding the behavior of complex systems over time
  - Deals with internal feedback loops and time delays that affect the behavior of the entire system
Partial presentation of the adopted model
Emissions

Motorcycle:

\[
CO = 76.7601/61v + 0.0095v^2 + 95.91/v \\
HC = 25.47 - 0.43v + 0.0024v^2 + 178.48/v
\]

Car and taxi:

\[
CO = 127.64 - 2.68v + 0.016v^2 + 160.12/v \\
HC = 6.06 - 0.10v + 0.00056v^2 + 42.57/v \\
NO_2 = 0.7 + 1.92/[1 + 93.54e^{-0.049v}]
\]

Bus and truck:

\[
NO_2 = 19.63 - 0.32v + 0.0037v^2 + 21.13/v
\]

TDM policies

- Increasing parking cost
- Increasing fuel cost
- Cordon pricing
Increasing parking cost

- Current state:
  - Implemented in main streets and the central part of the city
  - Price mechanism: Hourly (3000 Rials)

- Investigated levels:
  - 9000, 15000, 21000 Rials/hr

Note: 32000 Rials = 1 USD
Increasing fuel cost

- **Current state:**
  - Fixed price in all gas stations (4000 Rials/Liter)
  - About 320 Rials/Km

- **Investigated levels:**
  - 960, 1600, 2240 Rials/km
Cordon pricing

- Current state:
  - Implementation in central part of the city
  - Fixed price per entrance (25000 Rials/entrance)

- Investigated levels:
  - 50000, 75000, 100000 Rials/entrance into the extended central part of the city
Evaluating the imposed cost

\[ I_c = \sum_{n=1}^{20} \sum_{i=1}^{3} (C_{NO_2,n,i} + C_{CO,n,i} + C_{HC,n,i}) \]

- where, \( C_{NO_2,n,i} \), \( C_{CO,n,i} \), \( C_{HC,n,i} \):
- Cost caused by emission of NO\(_2\), CO and HC, all imposed by vehicle type \( i \) (i.e., car, bus, motorcycle) in the year \( n \), respectively.

Cost of the studied pollutants

<table>
<thead>
<tr>
<th>Item</th>
<th>Variable</th>
<th>Unit</th>
<th>Cost (Rials)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NO(_2)</td>
<td>Vehicle-km</td>
<td>4800</td>
</tr>
<tr>
<td>2</td>
<td>CO</td>
<td>Vehicle-km</td>
<td>1500</td>
</tr>
<tr>
<td>3</td>
<td>HC</td>
<td>Vehicle-km</td>
<td>1700</td>
</tr>
</tbody>
</table>

Source: Based on Victoria transport policy institute (VTPI), 2009
Imposed cost of air pollution ($I_C$)

![Graph showing the imposed cost of air pollution ($I_C$) with varying policy levels. The graph compares parking cost, cordon pricing, and fuel cost across different policy levels.]
Fuel cost and Perking cost (F&P)

The Cost of NO$_2$, HC & CO emissions (Rials)

Parking cost (P)

Fuel cost (F)
Fuel Cost and Cordon Pricing (F & C)

The Cost of NO₂, HC & CO emissions (Rials)

Cordon price (C)

Fuel cost (F)
Parking Cost and Cordon Pricing (P & C)

The Cost of NO\textsubscript{2}, HC & CO emissions (Rials)

- Parking cost (P)
  - 6.8E+13 - 6.6E+13
  - 6.6E+13 - 6.4E+13
  - 6.4E+13 - 6.2E+13
  - 6.2E+13 - 6.0E+13
  - 6.0E+13 - 5.8E+13
  - 5.8E+13 - 5.6E+13
  - 5.6E+13 - 5.4E+13
  - 5.4E+13 - 5.2E+13

- Cordon price (C)
  - 6.8E+13 - 6.6E+13
  - 6.6E+13 - 6.4E+13
  - 6.4E+13 - 6.2E+13
  - 6.2E+13 - 6.0E+13
  - 6.0E+13 - 5.8E+13
  - 5.8E+13 - 5.6E+13
  - 5.6E+13 - 5.4E+13
  - 5.4E+13 - 5.2E+13
Assessing the role of 3 TDM policies on imposed cost of air pollution to a city

Policies sorted by their efficiency:
1. Increasing parking cost (P)
2. Cordon pricing (C)
3. Increasing fuel cost (F)

Assessing the pair-wise combinations of policies:
- P&C is the most effective
Future Works

- Investigating more TDM policies
- Investigating more pollutants
- Comparing the results of investigating similar TDM policies in other cities
- Applying different models to more elaborate on interactions of policies
Acknowledgement

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Questions

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