Congestion Charging Model for Bogota, Colombia

Model City 2014

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Quick introduction

- British independent transport consultancy
- ~ 300 consultants
- Latin-America
  - Mexico, Bogota, San Juan, Santiago, Sao Paulo
- North America
  - Boston, Denver, Vancouver, Toronto
Outline

- City Overview
- Model Structure
- Results- examples
- Modelling issues
- Acknowledgments
City Overview

- Bogota:
  - 7.67 million inhabitants (2013)
  - Peak Hour: 6:30 - 7:30 a.m.
  - Average travel time (2011): from 40 to 77 minutes
  - GDP (2012): 90,232 USD Millions
  - Car Ownership (2012):
    - 129 Automobiles per 1000 inhabitants
    - 40 motorcycles per 1000 inhabitants
  - License plate restriction: Mon – Fri. Affects 13% of car owners.
  - No urban toll roads or on-street parking charge

- Over 857,000 total trips during peak hour (2011)
City Overview

- Trip generation and attraction (2011, Household and roadside surveys)
City Overview

- Car Ownership

![Graph showing vehicle ownership vs GDP per capita](image)
Modelling Objectives

- To support the City Administration in the design of a scheme that aims at reducing car usage at certain times and areas of the city and raise revenue for transport marked investments
  
Specific questions

- Where to implement the scheme?
- How much should be charged?
- What are the main impacts/changes on
  - Modal share
  - Traffic volumes
  - Travel times
  - Accessibility Measures
- What is the revenue raised from the charge?
- What are the aggregated travel time values and costs in the city?
- How do the scheme features change when provisions for discounts or special considerations like free through-traffic in selected roads are allowed?
Model Structure – main features

- Four stage - trip based model (under development since 1999)
- Trip generation/attraction: based on household survey (2011)
- Modal Split: discrete choice model based on internet-based adaptable stated preferences surveys conducted for this study
- Traffic Assignment:
  - Updated Road Network (higher detail in “candidate” areas)
  - Microanalysis was performed separately to identify “case by case” issues
  - Calibration/validation using observed speeds and auto volume flows
  - Assignment: parallel/duplicated networks. Fees in nodes, routes and links (transit)
  - Generalized cost from each assignment serves as feedback for utility functions that affect modal choice until it reaches convergence
- 945 TAZ
- 4 user classes depending on income segmented by mode
- Total of 16 matrices to be assigned (mode and income level)
Assignment Procedures

• Traffic Assignment
  • Fixed Demand
  • Generalized Cost multiclass assignment with path analysis
  • Stores matrices related with each component of cost for each user type/class:
    – Travel time
    – Monetary cost
    – Generalized cost

• Transit Assignment
  • Fixed Demand
  • Complex network with free/charged transfers between regular buses-BRT and future scenarios LRT + HRT
  • Fees are charged through links, nodes and routes
  • Additional options assignment: stores matrices related to each type of fee applied
  • Uncongested transit assignment but checks were performed on capacity to iterate when necessary with added penalties
Representing the Charge: Duplicated Road Network

A macro was created to duplicate a selected set of links in the network and check consistency, updating link types that allow for discounts or special charge schemes.
Representing the Charge: Duplicated Road Network

- Road network
- Congestion charging zone
- Charged borders of the zone
- Duplicated road network
- Connectors
Calibration

- Structure of Volume – Delay Functions: Akcelik
- Special consideration for queue formation in the analysis
- Model was checked mainly with space-time diagrams (on 20 main corridors) rather than flows, flows of course were also observed and checked (+200 check points)
Results - examples

- Changes in auto volumes during peak hour applying 3 USD charge
Modelling issues / strong assumptions

- Integrating choice and route assignment models included calibration of scale parameter for the mode choice model. Validation using household survey and assumption that the scale parameter holds even when new alternatives are included in future scenarios.

- Long term effects in land use or choice of housing location could not be determined and a simple trip-distribution model was used accounting for changes in trip generation and attraction. Gravity based models based on travel out-of-pocket costs for car users were desirable but lacked data (budget and time) to be developed. An existing model was only applicable to public transport users.

- Model was used as a design tool and not only for forecasting purposes for a set of assumptions. Area, charges, and scheme features derived for an iterative process that integrated model results to a multicriteria evaluation. It required long programming time in preparing results dashboards and output data sets.
Modelling issues / strong assumptions

- Constant checks for transit capacity were required to add penalties when needed to produce “credible” forecasts.

- Modelling taxi as a mode in the choice model and then replicate generalized costs in traffic assignment remains a difficult task.

- Modelling impact of motorcycles in volume-delay function is an open area for research. We used the results of recent research projects developed in Universidad de los Andes (Bogota) and observation on traffic. Key issue is that equivalency factor to pcu changes with traffic density. Motorcycle volumes in certain areas of the city may account for more than 50% of the observed vehicle flows. In other cities in Colombia we have adjusted iterative the travel time based on assigned flows of motorcycles and cars.

- Results from the model were required to feed other work streams and adhere to project schedule implied cutting on the number of iterations or stopping some processes (running only mode choice and assignment models)
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