Improved estimation of travel demand from traffic counts based on a new linearization of the network loading map

Gunnar Flötteröd, Michel Bierlaire

October 7, 2009

Outline

Introduction

Proportional network loading

Local regression

Global regression

Outlook and summary

Outline

Introduction

Proportional network loading

Local regression

Global regression

Outlook and summary

Problem statement

- microsimulation-based dynamic traffic assignment (DTA)
  - disaggregate demand simulator (one traveler at a time)
  - disaggregate supply simulator (all travelers jointly)
- calibration of DTA microsimulators
  - use, e.g., traffic counts to improve microscopic demand
  - must identify how demand affects link flows
- linearization of network loading map answers "what if" questions

Some notation

- disaggregate demand consists of travelers $n = 1 \dots N$

$$u_{ni}(k) = \begin{cases} 1 & \text{if } n \text{ plans to enter link } i \text{ in time step } k \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

- link demand

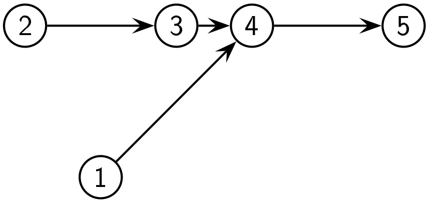
$$d_i(k) = \sum_{n=1}^{N} u_{ni}(k). \tag{2}$$

- network loading maps link demands $\{d_i(k)\}$ on link flows $\{q_i(k)\}$
- linearize this mapping for arbitrary microsimulations

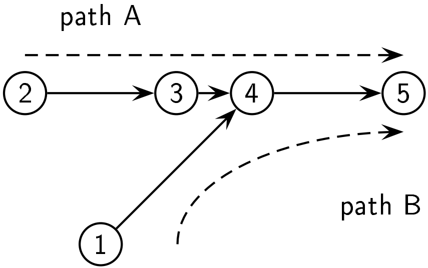
TRANSP-OR

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Test case

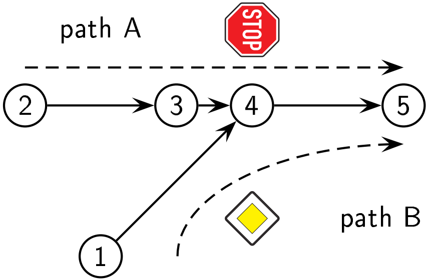


Test case



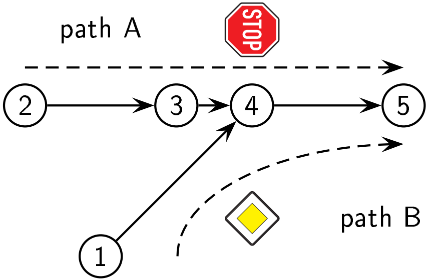
- microsimulation: 1800 potential travelers on either path
- simple choice model: prob. of making a trip is 2/3
- avg. demand D_A, D_B for path A, B is 1200 veh

Test case



- demand d_{45} for link 45 is 2·1200 veh
- capacity of all links is 1800 veh
- realized flow q_{34} on link 34 is 600 veh

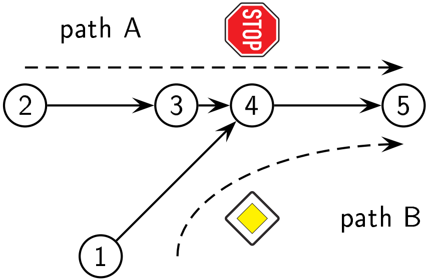
Test case



- spillback on link 34, mathematically:

$$\frac{\partial q_{34}}{\partial D_A} = \frac{\partial q_{34}}{\partial d_{23}} + \frac{\partial q_{34}}{\partial d_{34}} + \frac{\partial q_{34}}{\partial d_{45}} = 0 \quad \frac{\partial q_{34}}{\partial D_B} = \frac{\partial q_{34}}{\partial d_{14}} + \frac{\partial q_{34}}{\partial d_{45}} = -1 \tag{3}$$

Test case



- calibration scenario: flow of 900 veh is measured on link 34
- $\partial q_{34}/\partial D_A = 0$ and $\partial q_{34}/\partial D_B = -1$ explain this
- cause is demand for path B, which is not 1200 but 900 veh

Calibration

- use Cadyts ("Calibration of dynamic traffic assignment") tool
- free software, `http://transp-or2.epfl.ch/cadyts/`
- calibrates arbitrary demand dimensions from traffic counts
- relies on a linearized network loading map

Outline

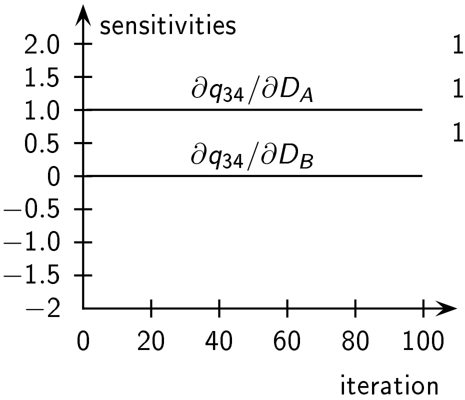
Proportional network loading: specification

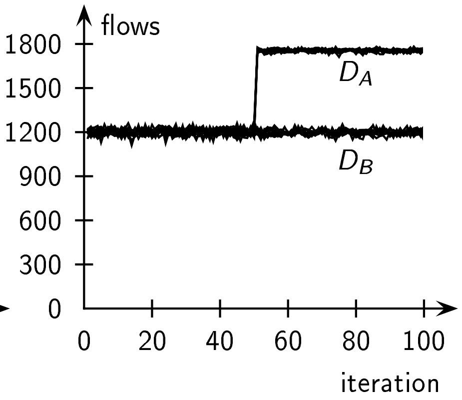
- assume that all link demand is served by the network

$$q_i(k) = d_i(k) \qquad \forall i, k. \tag{4}$$

- does not account for spillback
- good approximation only for uncongested conditions
- local scope

Proportional network loading: calibration results





TRANSP-OR

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Outline

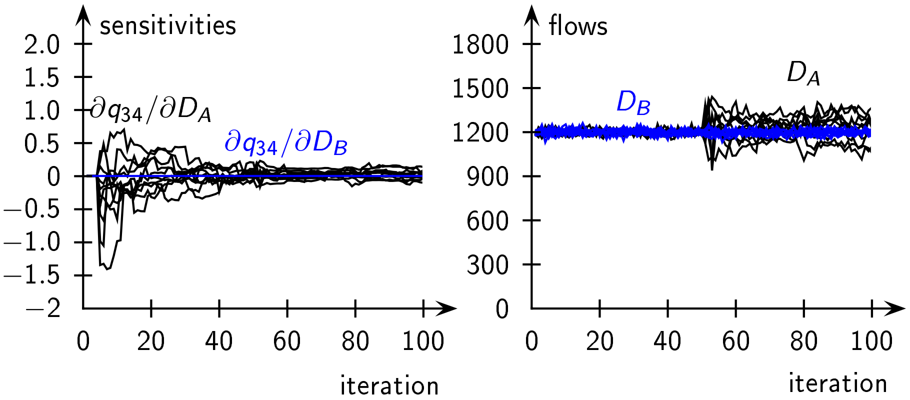
Local regression: specification

- essentially, a parametrized proportional network loading

$$q_i(k) = \alpha_i(k) + \beta_i(k)d_i(k) \tag{5}$$

- coefficients α, β are updated from simulated (demand/flow) tuples
- switches off proportional network loading during spillback
- still local scope

Local regression: calibration results



Outline

Global regression: specification 1

- naive approach

$$q_i(k) = \alpha_i(k) + \sum_j \beta_{ij}(k) d_j(k) \qquad (6)$$

  is cumbersome

  - too many parameters
  - identifiability issues

- preprocess demand by principal component (PC) analysis

Global regression: specification 2

- assume fixed plan choice distributions and

$$\mathrm{VAR}\{d_i\} \propto \mathrm{E}\{d_i\}$$

(e.g., Poission)

- then,

$$\mathrm{COV}\{d_i, d_j\} \propto \mathrm{E}\{d_{ij}\} \tag{7}$$

where

$$d_{ij} = \sum_{n=1}^{N} u_{ni} u_{nj} \tag{8}$$

is number of travelers that enter both link i and j

TRANSP-OR

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

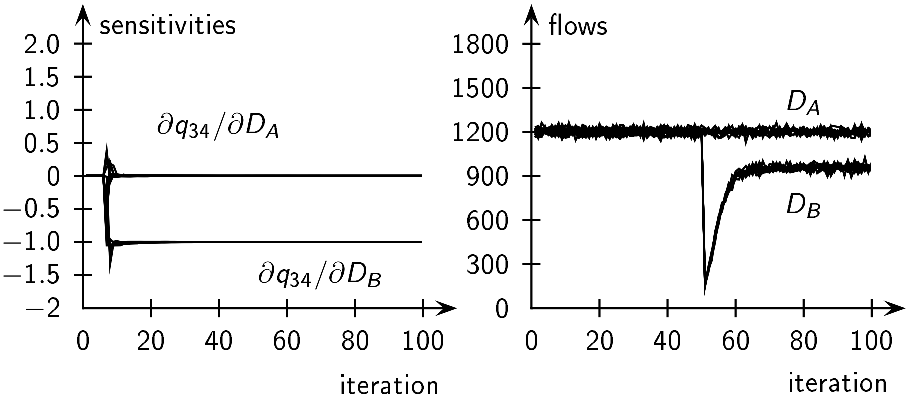
Global regression: specification 3

- M largest eigenvectors $\mathbf{b}_m$, $m = 1 \dots M$, of link demand covariance matrix constitute "demand PCs"
- calculation only requires to iterate over plans
- resulting regression model:

$$q_i(k) = \alpha_i(k) + \sum_{m=1}^{M} \beta_{im}(k) \cdot \langle \mathbf{d}(k) - \mathrm{E}\{\mathbf{d}(k)\}, \mathbf{b}_m(k) \rangle \quad (9)$$

- example network: 2 non-zero eigenvectors$\longrightarrow$3 regression parameters

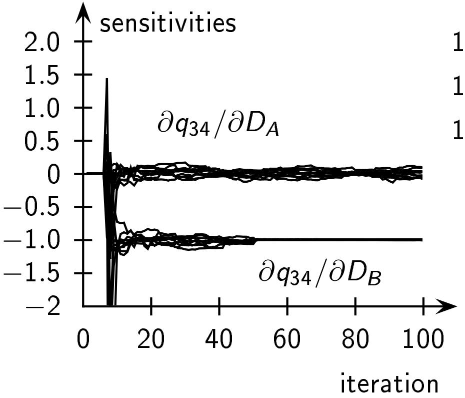
Global regression: calibration results

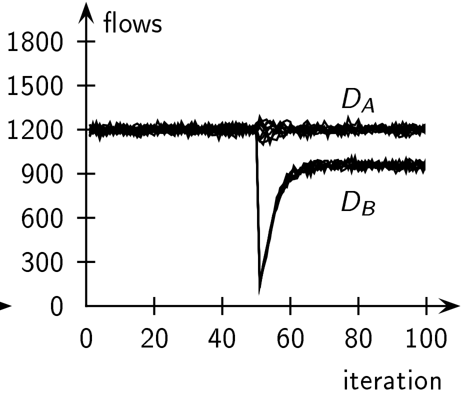


TRANSP-OR

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Global regression, $\sigma = 5\,\text{veh}$

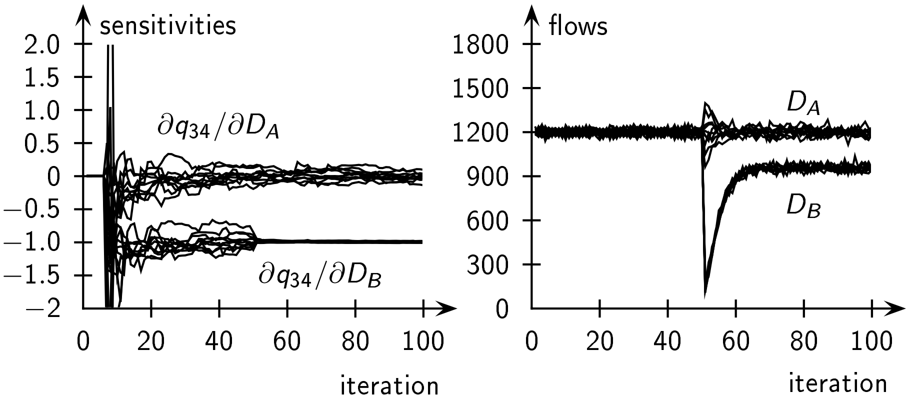




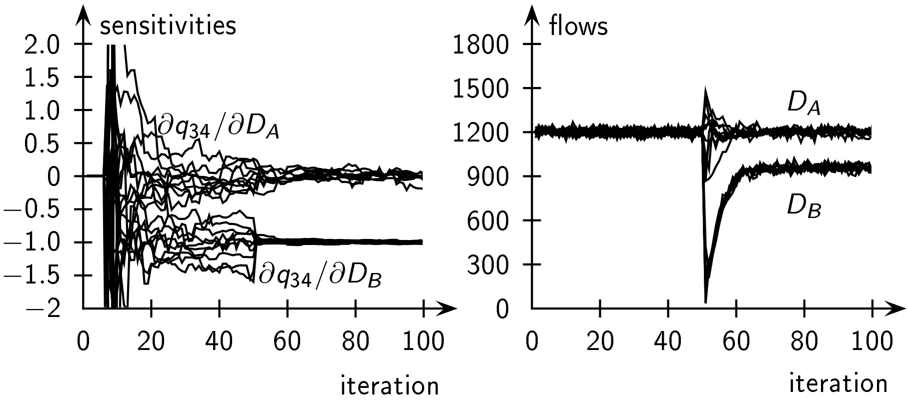
TRANSP-OR

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Global regression, $\sigma = 10\,\text{veh}$

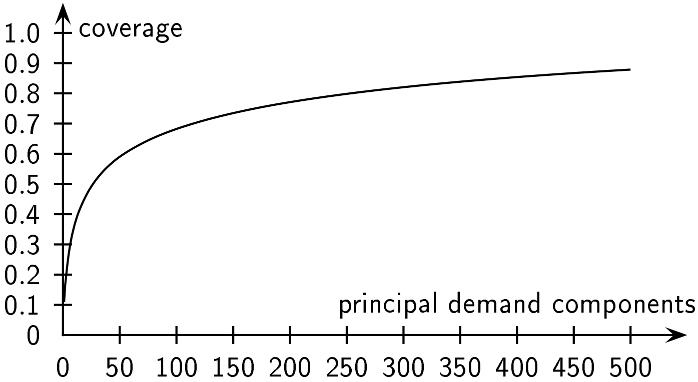


Global regression, $\sigma = 20\,\text{veh}$



Outline

An aggregate demand representation



Summary

- proportional network loading fails in congested conditions
- local regression switches off local regression when it fails
- global regression captures spillback-induced effects