Revealing Preferred Departure Times for Large-Scale Transport Modelling

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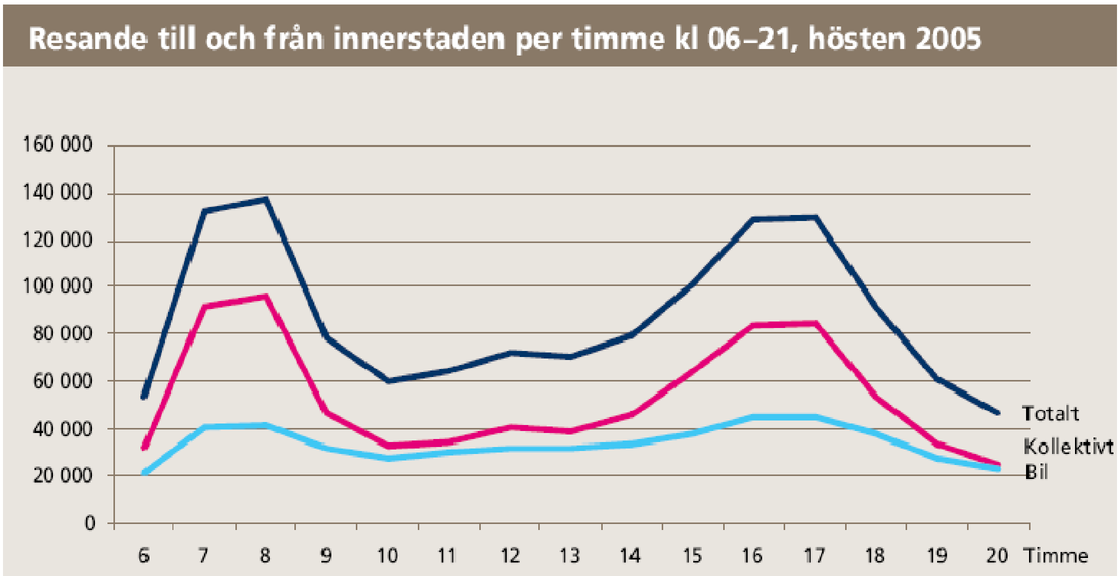
Congestion is time dependent

- Extra travel time and uncertainty
- Emissions
- Incidents
- Noise

- Similar working/school times
- Trip chains
- Shopping times

Time of day variation



Source: Stockholm County Planning and Transportation Office

Capacity extension

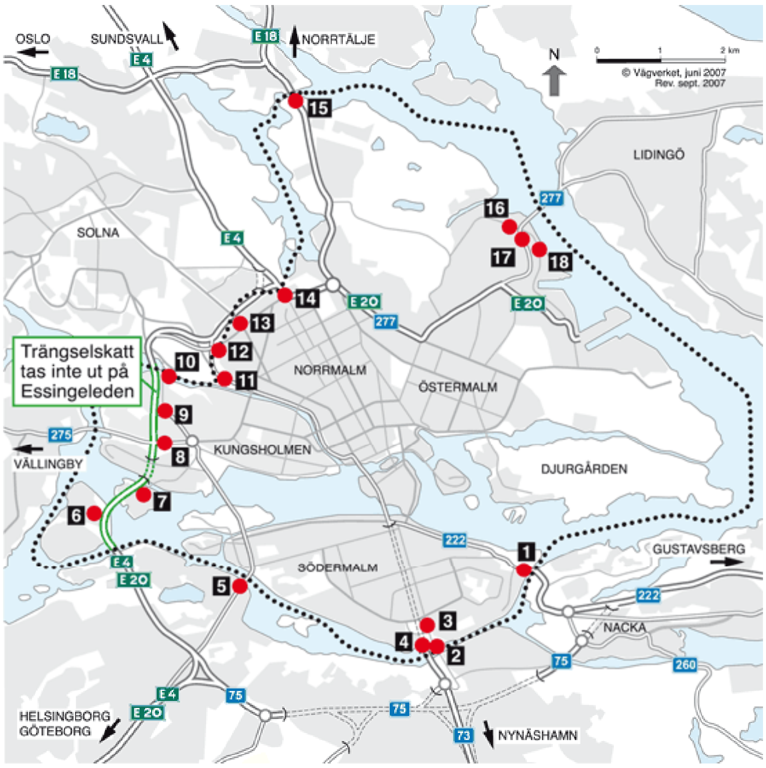
- Would it be possible to build roads that bear peak hour travel demand?
- Economically unacceptable (The capacity would not be used most of the day)
- Environmentally unacceptable (intrusion)
- Induced demand
- Cf parking large enough for Xmass shopping

Alternative measure: time dependent congestion charges

06.30-06.59	10 kr
07.00-07.29	15 kr
07.30-08.29	20 kr
08.30-08.59	15 kr
09.00-15.29	10 kr
15.30-15.59	15 kr
16.00-17.29	20 kr
17.30-17.59	15 kr
18.00-18.29	10 kr
18.30-06.29	0 kr

Photo: Mikael Ullén

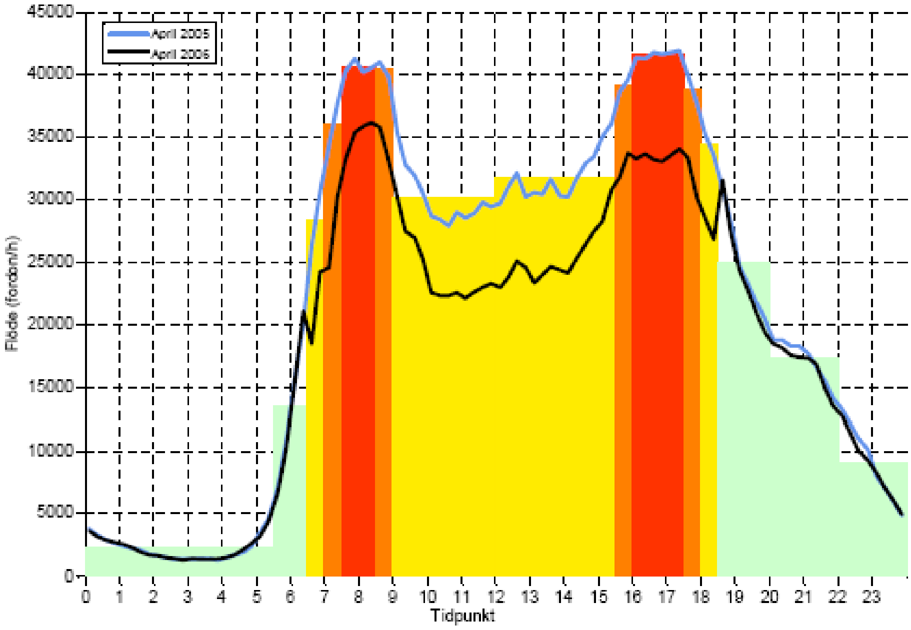
Cordon location in Stockholm



Traffic flows before and during the Stockholm Trial

Veh/h over the cordon (directions combined)

Mean for April 2005 (blue) and April 2006 (black)



Source: Summary of Stockholm Trial analysis

Analysis

- The peaks lowered but did not spread
- Is it possible to modify the charges in order to spread the peaks?
- What charge levels and timetables are suitable?
- Inappropriate to test in practice → use models and simulation

What should be in the model?

- The travel demand is influenced by changes in charges, travel time and uncertainty
- Impact on
  - Route
  - Mode
  - Departure time
- Development of modell including the choice of departure time

Basic idea for choice of departure time

The traveller weights departure time against travel cost (time, uncertainty, charge)

Shall I go when I prefer and risk to get in a queue or shall I avoid queues by starting earlier at the expense of shorter sleep?

Utility maximisation, discrete choice model (Small 1982)

$$\min_{DT} \alpha(DT-PDT)_{+} + \beta(PDT-DT)_{+} + \gamma t_{DT} + \delta c_{DT} + \varepsilon$$

SILVESTER – SImuLation of choice betWEen Starting TimEs and Routes

- Model for Stockholm with suburbs (ca 1.5 mln)
- Drivers in the baseline scenario
- Extended peak (06:30-09:30)
- Travellers choose DT between 15 minutes intervals based on deviation from their PDT, travel time, travel time uncertainty and charge for that DT
- Even possible to depart before 06:30, after 09:30 or switch to public transport

The model of departure time choice (1)

- Estimation based on SP and RP data trips in Stockholm County
- Same respondents in SP and RP surveys
- Takes into account higher correlation of the error term between closer time periods
- Takes into account heterogeneity of drivers' preferences

The model of departure time choice (2)

- Purpose segments:

  Trips to work with fixed office hours and trips to school

  Business trips

  Trips to work with flexible office hours and other trips

- Result: For each trip purpose *k* and OD-pair *w*, the probability to choose a departure time period given a preferred departure time period

$$P_{t\tau}^{kw} = \mathrm{Prob}\left(DT = t \mid PDT = \tau\right)$$

Application of the model (1)

The number of trips starting at time *t*

$$q_t^{kw} = \sum_{\tau} P_{t\tau}^{kw} v_{\tau}^{kw}$$

where v_{τ}^{kw} is the number of trips with PDT = τ

$$\mathbf{q}^{kw} = \mathbf{P}^{kw}\mathbf{v}^{kw}$$

for each trip purpose *k* and OD-pair *w*

Application of the model (2)

Preferred travel demand v_{τ}^{kw}

Departure time choice model $P_{t\tau}^{kw}$

Realised travel demand q_{t}^{kw}

CONTRAM
Mesoscopic model
Queuing dynamics
Iterations until steady state

Traffic flows

Travel times

Road network, Charges

Calibration of the model (1)

Baseline situation

Preferred travel demand **v**

Departure time choice model **P**

Realised travel demand **q**

CONTRAM
Mesoscopic model
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Road network, ~~Charges~~

Calibration of the model(2)

Stage 1: Time-dependent OD matrix estimation COMEST, performed before the model estimation

Stage 2: OD matrix subdivision by trip purposes *k*

Stage 3: Revealing the preferred departure times for each trip purpose *k* and OD-pair *w*

$$\mathbf{q}^{kw} = \mathbf{P}^{kw}\mathbf{v}^{kw} \qquad \mathbf{v}^{kw} = \left(\mathbf{P}^{kw}\right)^{-1}\mathbf{q}^{kw}$$

(Reversal Engineering)

Reversal engineering

- Good: P is usually nice
- Bad: P^{-1} is never positive

  Feasibility of the solution depends on q

  Some $v_\tau^{kw} < 0$ although all $q_t^{kw} > 0$
- Two methods proposed:

  Aggregation of OD pairs

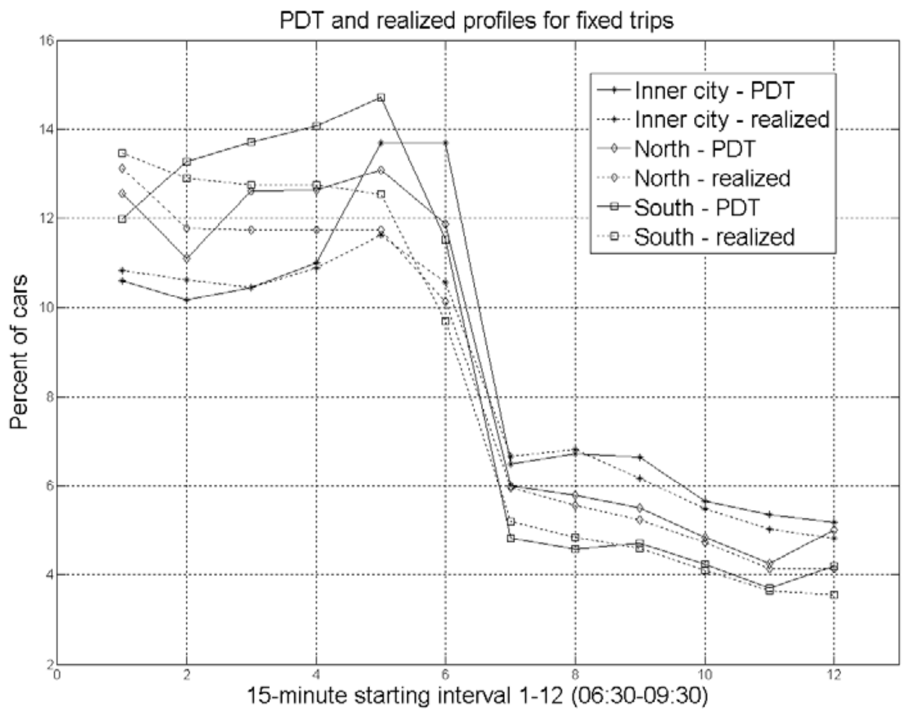
  Bounded variation

Aggregation of OD pairs

- OD's are grouped by geographical or socio-economical properties (origin zone, destination zone, distance, income,…)
- An optimal PDT profile is sought for each group by the least square method
- If the profiles are similar on infeasible, the groups are united

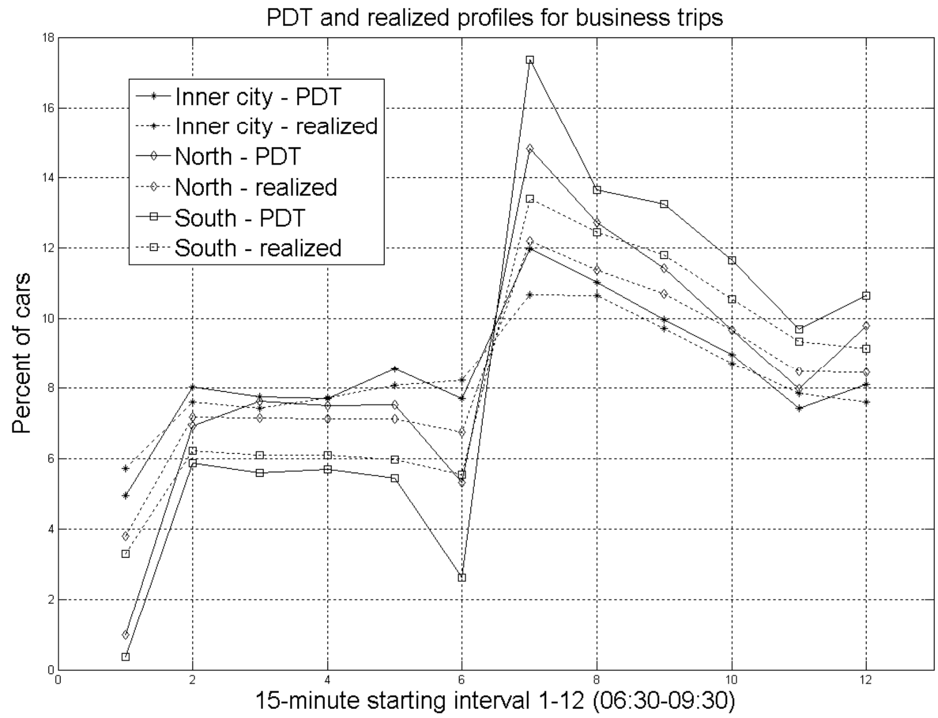
Fixed time work trips and school trips

- 3 OD groups by origin zone



Business trips

- 3 OD groups by origin zone

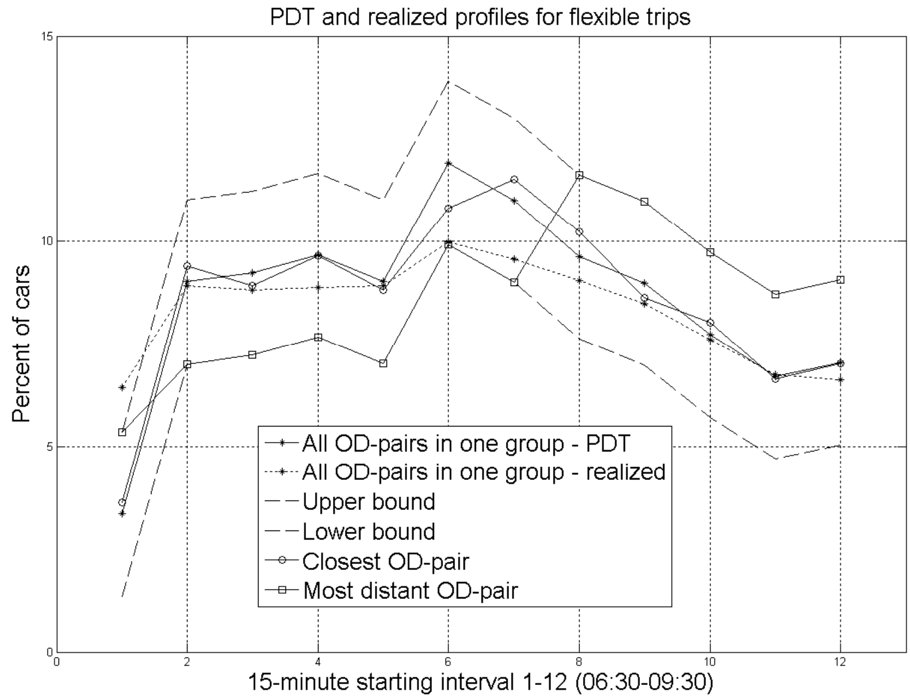


Bounded variation

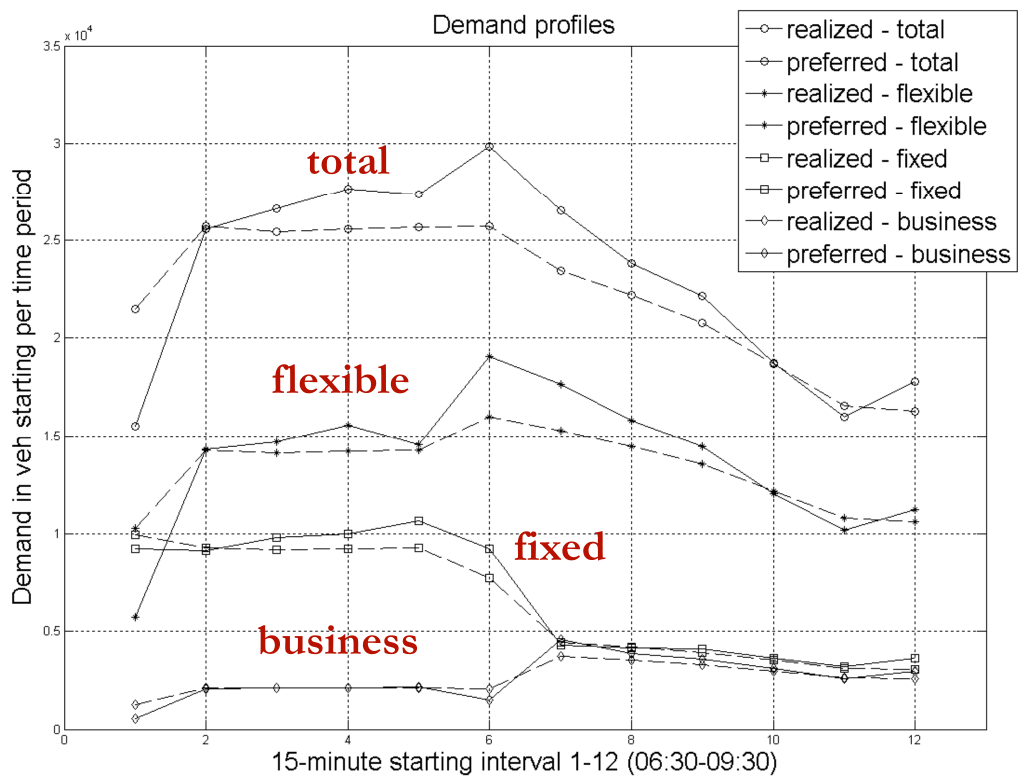
- Find a best common PDT profile for all OD pairs (the least square method)
- For each OD pair, find a best PDT profile within a certain strip around the common profile

Flexible trips to work and other trips

- Solution for 4% wide strip around the common



PDT and DT for the three trip purposes



Conclusion

- The **Reversal engineering** approach for estimation of preferred departure times is applicable for a large urban network
- The result is consistent with skimmed travel times and the departure time choice model
- The least square method for groups of OD pairs relieves the problem of negative solutions and delivers reasonable PDT profiles