Public Transport Congestion: the Paris Subway Case

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MIT, September 2010
Starting point

- Great similarity between road congestion and public transport congestion
- Great disparity between abundance of studies on road congestion and scarcity of studies on PTC (Stockholm)

--> a gap to be filled
Illustration: A simple model of road and subway congestion in an urban area

Unit costs

Ic = Individual cost by car
Sc = Social cost by car
ZM = Subway cost without congestion
Im = Individual cost by subway
Sm = Social cost by subway

Without subway congestion:
A = Natural equilibrium
B = Optimal equilibrium

With subway congestion:
D = Natural equilibrium
E = Optimal equilibrium
Paris case study

- Paris: 3rd largest world agglo in GDP (725 G$ in 2007)
- Paris municipality (2 M people) small part of Paris agglo (11 M)
- Car dominates in agglo (2/3); PT, mostly subway, dominates in municipality (2/3)
- Subway congestion increases: 2002-7:
  
  Delta in supply (seats*km) +4%
  Delta in demand (pass.*km) +13%
  Delta in demand/supply +8%
Contingent Analysis Survey

WTP (to travel in uncongested conditions) = f (congestion, income, trip length, etc.)

For WTP, 2 questions:
(a) $\Delta$ price for no congestion (cf 1rst class)
(b) $\Delta$ tile for no congestion

To appraise congestion (density): well established RATP methodologies

Line 1: good congestion variance.

Brief questionnaires. Randomness. Well received. 600 usable questionnaires. 30% answers pour (a), 70% for (b).

--> A 600 lines x 20 columns matrix
Descriptive statistics

**Cardinal:**
- Age : 36,6 (9,9)
- Income (€/mois) : 2000-2500 (870)
- Subjective congestion (index 0-5) : 3,4 (1,1)
- Objective congestion (pers/m2) : 2,1 (0,7)

**Binary:**
- Sex: male: 49%
- Purpose : work: 86%
- Résidence : Paris : 57%
- Car availability : 32%
- Comfort v. time :
  - No with n= 5 min : 29%
  - Yes with n = 5-10 min : 39%
  - Yes with n = 10-15 min : 27%
  - Yes with n = 15-20 min : 3%
  - Yes with n = 20 min : 1%
- Comfort v. money (1rst class):
  - No, at any price : 71%
  - Yes with delta price +10% : 8%
  - Yes with delta price +10-50% : 15%
  - Yes with delta price +50-100% : 7%
Econometric analyses

- Discrete choice models (ordered logit or probit): measured congestion, trip length, answer to first class question, and car availability do explain WTP.
- Multiple regression models: same results
- Simple regression models with constraint:
  \[ \text{WTP} = 0.68 \times \text{Congestion} \quad (R^2=0.71) \]
Implications

• WTP to travel without congestion: 1,4 €/trip (with value of time of 18 cents/minute)
• Congestion cost : 1,9 billion euros/year (relative to an unrealistic situation of complete no congestion)
• Costs of recent congestion increases ( +8% on 2000-2007) : 75 M€/year
• Cost of planned modal shift (-40% car trips) : 470 M€/year
• Marginal congestion cost: 1,36 €*density
• Subway investment justification : 6% congestion reduction justifies 1 billion € investment
Improvements needed

• Replace « situation of no-congestion » by « with seats available »
• Try a direct question on WTP
• Eliminate anchor biases
• Take into account time delays caused by congestion
• Estimate effective congestion profiles
• Take into account congestion distribution on various lines to extrapolate
• Refine econometric treatments
Computable Model of Combined Car & Subway Transportation in Paris

- Qm : Number of subway trips to, within or from Paris municipality/ year (in 2002, Qm=1.25 G)
- Qc : Number of car trips (0.69 G)
- Im(Qm) : individual cost of a subway trip: Im = 5.9 + 1.0288*Qm, which can be expressed as a function of Qc (since Qm=1.94-Qc) : Im = 7.9 - 1.0288*Qc
- Ic(Qc) : individual cost of a car trip : money cost (3.4€/trip) + time cost, including congestion cost, which is a function of speed, which is a function of Qc : Ic = 3.4 + 64.8/(28-16*Qc)
- Sm(Qm) : Social cost of a subway trip = Im(Qm)+Im(Qm)*Qm : Sm(Qm) = 5.9 - 2.026*Qm, which can also be expressed as a function of Qc : Sm(Qc) = 9.9 - 2.056*Qc
- Sc(Qc) : Social cost of a car trip, is similarly calculated : Sc(Qc) = 3.4 + 64.8(28-16*Qc) + 1037/(28-16*Qc)^2

Equipped with these cost curves, we can calculate:
- the equilibrium number of car trips, Qc for which Ic(Qc)=Im(Qc) —> 0.69 G
- the optimal number of car trips, Qc for which Sc(Qc)=Sm(Qc) —> 0.46 G
- the required car toll and subway toll required to reach this optimum
  - car toll = Sc(0.46) - I(0.46) = 2.43 €/trip
  - subway toll = Sm(0.46) - Im(0.46) = 1.53 €/trip