Rail congestion in the French network

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1. What is railway congestion ?

A wide economic literature on road congestion pricing

Pigou (1920), Walters (1961), Vickrey (1963), Arnott, De Palma and Lindsey (1993), Chu (1995) or Verhoef (2001)…

A special feature of rail transport : scheduled traffic

— Traffic is scheduled, ie the infrastructure manager provides specific train paths to the railway operators in order to coordinate their demands

— Sometimes there is too much demand for train paths regarding the capacity of the infrastructure; the infrastructure manager is unable to provide the adequate train paths; this is a situation of scarcity

Congestion can appear when traffic is scheduled

— Airport industry (Carlin and Park, 1970, Levine, 1969, Morisson et al., 1989)

1. What is railway congestion ?

3 key notions linked together :

- Regularity (the real course of the train is in accordance with the scheduled path)
- Capacity (how many trains are able to use the infrastructure in a given time)
- Robustness of the schedule (the schedule is designed in order to cope with delays)

The schedule is designed with a slack time between the trains

➔ more slack time means a more robust schedule

➔ a more robust schedule means better regularity

➔ … but less real capacity

1. What is railway congestion ?

What is railway congestion ?

- The economic literature on railway congestion focus on scarcity (ie the lack of capacity regarding demand)
- Scarcity has not much to do with the technical capacity of the infrastructure
- With the same infrastructure, the infrastructure manager can provide :
  - a small number of train paths with a high robustness of the schedule (probability of delay : low)
  - a big number of train paths with a low robustness of the schedule (probability of delay : high)

1. What is railway congestion ?

From an economic point of view :

- There is an optimal trade-off between the robustness of the schedule and capacity (between the cost of the delays transmitted from one train to another, and the cost of scarcity)
- The optimal trade-off implies a less than perfect robustness
- Less than perfect robustness implies that some delays are transmitted from one train to another
- There is a relationship between traffic density and transmitted delays

Railway congestion reveals itself under two different forms :

➔ Transmitted delays (even if the robustness of the schedule is optimal)

➔ Scarcity

2. Measuring and valuing congestion

- **A useful information for the building of the schedule** (looking for the optimal robustness)
- **A useful information for the economic assessment of capacity investments**
- When there are different users on the network (a single user would internalize the externality of congestion)**, a price signal**
- Under certain hypotheses, there is **a link between congestion pricing and capacity investments financing** (more on that later)

2. Measuring and valuing congestion

Réseau Ferré de France recently investigates this topic using an internal dataset of traffic monitoring

- Since there is no **apparent** scarcity on the network, the study focus on transmitted delays
- Only one study previously in the literature (Gibson et al., 2002)
- Extensive econometric analysis (conducted by the consulting firm Microeconomix)
- Aim of the study
  - Propose a model to understand rail congestion
  - Corroborate the existence of a relationship between traffic density and delays
  - Estimate the marginal impact of a supplementary train
- A large data set
  - All the circulations recorded on 42 lines of the French railway network, with 3 measuring points of each line
  - In total, 6.4 million observations.

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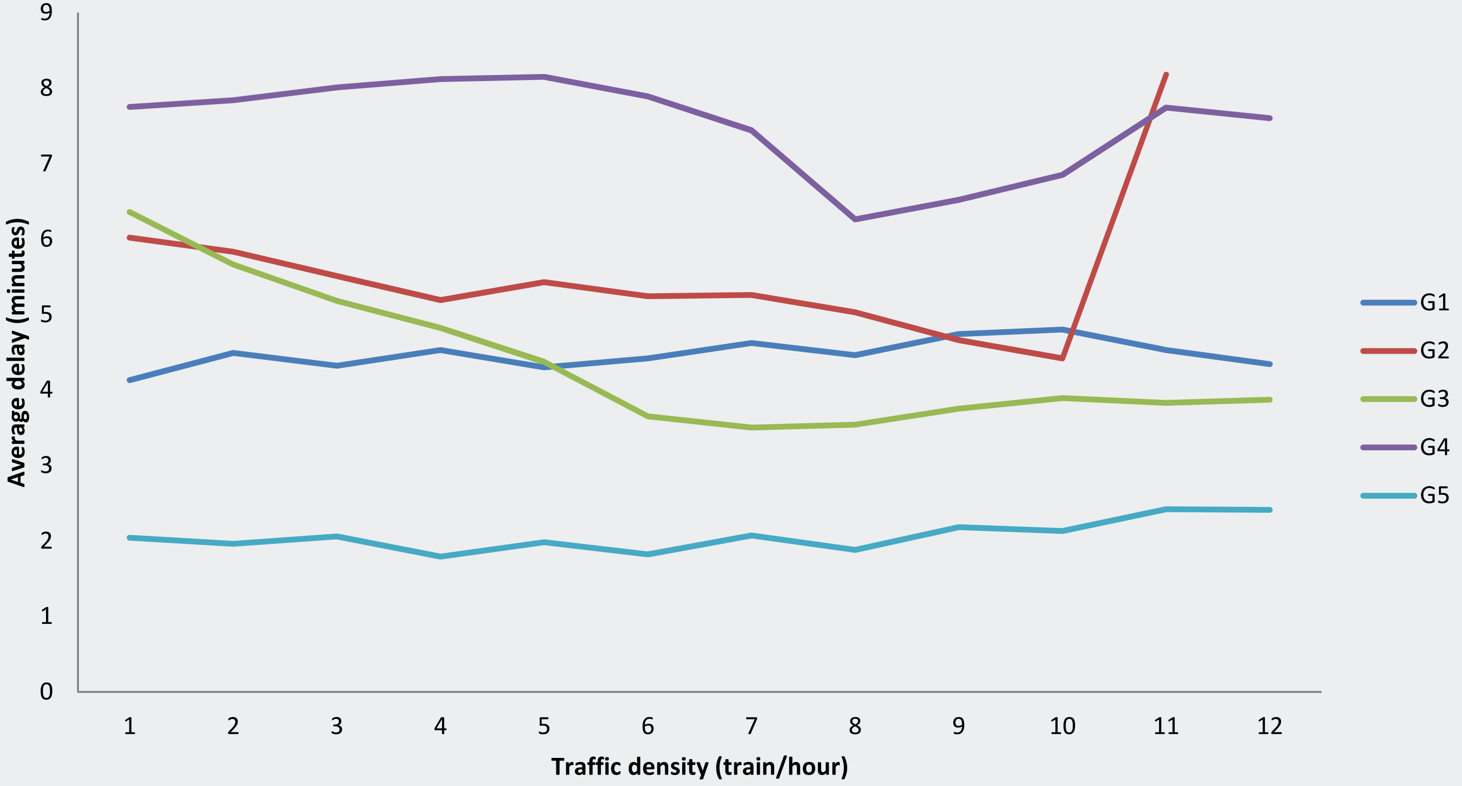
2. Measuring and valuing congestion

The regressions have been estimated for 9 groups of lines

- The econometric analysis allows to estimate the marginal effect of a train to delays of other trains
- **An empirical confirmation of rail congestion**
  - **Estimations are statistically significant** for every groups of lines excepted the group of low traffic intercity lines
  - **The marginal effect of an additional train is between 0,2 and 7 minutes**, depending on traffic density
- Tests have been realized
  - A first test is realized in order to verify the existence of the relationship with another definition of delay (delay higher than 3 minutes and delay higher than 5 minutes)
  - Some regressions analyses are also conducted for several specific points.
  - These tests confirms the previous conclusions.

2. Measuring and valuing congestion

An average delay nearly steady and independent on the traffic, but…



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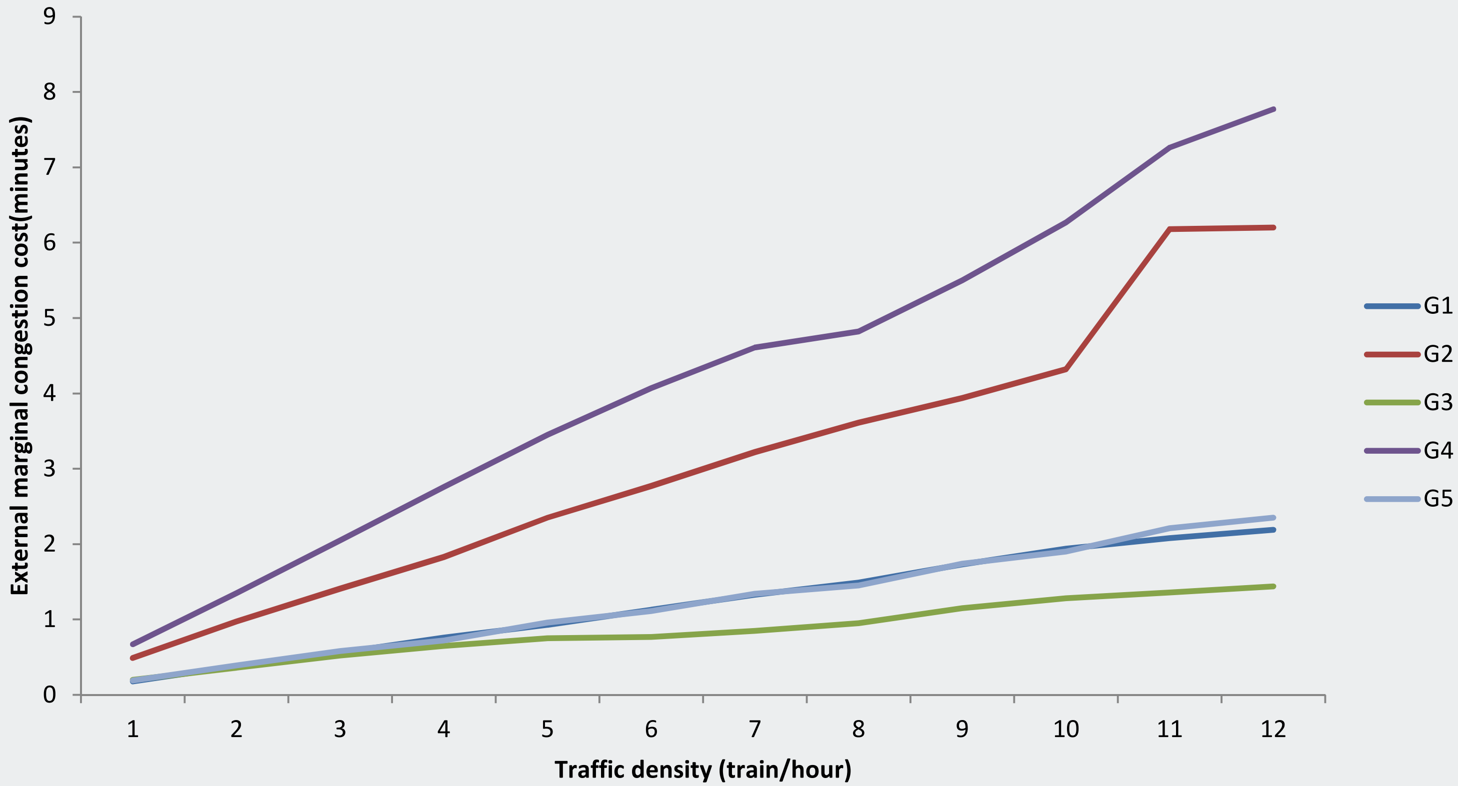
2. Measuring and valuing congestion

...a marginal external delay correlated with the traffic density.



However, congestion is not observed with the same intensity in all the groups

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2. Measuring and valuing congestion

Main conclusions of the study :

- ✓ Most of the network is not congested
- ✓ Most of the delays are not due to congestion
- ✓ Congestion occurs only on a very small part of the network :
  - in and around Paris,
  - around the biggest cities (Lyon, Marseille, Lille)
  - on high speed lines
- ✓ One must keep in mind that the observed reliability rates depend on :
  - the features of the line,
  - the trade-off between capacity and robustness for the design of the train paths
  - the way train paths are allocated between different trains

2. Measuring and valuing congestion

How to translate this marginal effect of congestion into a monetary cost?

The cost of congestion is the cost of delays for rail passengers.

➔ We need to assess the willingness to pay of rail passengers for an increased regularity

Numerous academic papers deal with the valuation of the regularity or punctuality for car drivers or train passengers, in particular stated-preferences surveys.

Kroes et al. (2006) on the value of punctuality for suburban trains in the Paris region

Réseau Ferré de France realizes SP surveys to value regularity for regional and high speed trains users

- High-speed passengers (2011-2012)
- Suburban trains (2012)
- SP surveys for regional rail in course (2013)

2. Measuring and valuing congestion

Reliability Multiplier - results from our study and the literature

Source	Value	Transport mode
RFF (2012)	8,9	High speed rail (France)
RFF (2012)	4,0	Suburban trains (Paris)
PDFH (1984)	2,5	Urban transport (Switzerland)
De Palma (1996)	2,7	Urban transport (Switzerland)
Rietveld et al. (2001)	2,5	Intermodal urban transport (Netherlands)
Wardman (2001)	7,4 in average	Meta-analysis, every transport modes (330 studies)
PDFH (2005)	4,4 / 6,1	Rail transport (UK)
Kroes & Duchâteau (2006)	4 / 12	Suburban rail transport (Paris)
Abrantes & Wardman (2011)	6,4 in average	Meta-analysis, every transport modes (226studies)
Börjesson & Eliasson (2011)	7 / 17	Rail transport (Sweden)

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3. Price signal and capacity investment financing

If there is more than one operator on the network, a price signal equal to the marginal cost of congestion is needed

The revenue of congestion pricing will partly or fully cover the cost of infrastructure

- A classical finding of transport economics (Mohring & Harwitz 1962, Arnott & Kraus., 1998)
- Indivisibilities and returns to scale matters
  - If there are increasing returns to scale, congestion pricing revenues will only partly cover the cost of infrastructure
  - If there are decreasing returns to scale, congestion pricing revenues will exceed the cost of infrastructure, including the cost of the relevant capacity investment.
- On the French railway network, congestion occurs in densely populated area, where building new capacity is more and more costly ➔ decreasing returns to scale

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3. Price signal and capacity investment financing

Role of the regulator : comparing the price signal, the cost of congestion and the cost of increasing capacity

- Price signal : comparing infrastructure charges and congestion costs
- Train-paths scheduling : assessing the efficiency of the robustness/capacity trade-off
- New capacity **:** Comparing the total welfare costs of the capacity shortage and the cost of increasing the capacity of the network (building and operating)

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Conclusions

From an economic perspective, railway congestion is a standard externality problem

➔ high traffic density during peak-hours generates an external cost on other users.

The observed congestion effects depend on many factors

➔ features of the line, of the trains, trade-off between capacity and robustness…

Because there is a downstream market, the assessment of congestion costs requires a systemic approach, taking into account both the effects of delays and scarcity on the downstream market (and final users) :

➔ cost of delays, cost of overcrowding, cost of shifts from the desired departure time, cost of the unsatisfied demand.

On this basis, it is possible to optimize the schedule and the allocation of the paths, to implement a congestion pricing scheme, and to provide the optimal capacity

Conclusions

Operational conclusions

- Most of the network is not congested
- Most of the delays are not due to congestion
- Congestion occurs only on a very small part of the network

  in and around Paris, around the biggest cities (Lyon, Marseille, Lille), on high speed lines

Therefore one should probably

- Deal with the other causes of delay first (the performance regime provides the adequate price signal)
- Implement a careful analysis of the congestion cases
- Implement congestion pricing where it is needed and where it can be linked with capacity investments

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ANNEX

ANNEX – The model

The marginal effect of a train on total delays is decomposed in two effects:

$$\frac{\partial[Q_i E(R_i|Q_i)]}{\partial Q_i} = E(R_i|Q_i) + \frac{\partial[E(R_i|Q_i)]}{\partial Q_i}$$

Direct effect — Indirect effect

The direct effect is the expected delay given a certain traffic. As $E(R_i|Q_i) = p(R_i > 0|Q_i)E(R_i > 0|Q_i)$, one can rewrite the indirect effect:

$$\frac{\partial E(R_i|Q_i)}{\partial Q_i} = \frac{\partial[p(R_i > 0|Q_i)E(R_i > 0|Q_i)]}{\partial Q_i} = \frac{\partial p}{\partial Q_i}E(R_i > 0|Q_i) + \frac{\partial E(R_i > 0|Q_i)}{\partial Q_i}p(R_i > 0|Q_i)$$

The indirect effect is decomposed in four terms :

- Some of them a computed using the data : the parameter $E(R_i > 0|Q_i)$ is the expected delays of delayed trains with a traffic *Qi* and the parameter $p(R_i > 0|Q_i)$ is the probability of being late given the traffic *Qi*
- Two parameters are estimated using econometric analysis:
  - The parameter $\frac{\partial p}{\partial Q_i}$ corresponds to the marginal effect of an additional train on the probability of being late, it is estimated using a discrete choice model (probit).
  - The parameter $\frac{\partial E(R_i>0|Q_i)}{\partial Q_i}$ is the marginal effecr of an additional train on the expected delay, it is estimated using a linear regression.

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ANNEX - Congestion pricing in the current regulatory framework

- UE Directive allows charging capacity shortage
  - Directive 2001/14/EC, article 7-4: “The infrastructure charge may include a charge which reflects the scarcity of capacity of the identifiable segment of the infrastructure during periods of congestion”
- French regulatory framework points out the role of congestion pricing
  - According the decret 97-446 of 5 May 1997 (article 6), the reservation charge can be differentiated according the time period of use, the scarcity of a congested line or section, or the limited capacity of a line or section
  - In practice, RFF infrastructure charges varies according the time period of use or the section used.
  - According the rail industry regulator (ARAF), congestion is a crucial issue for the railway system and that track access charges shall provide incentives for a better use of the network (statement 2011-002 of the 2nd February 2011)

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