Optimal Air Traffic Delays

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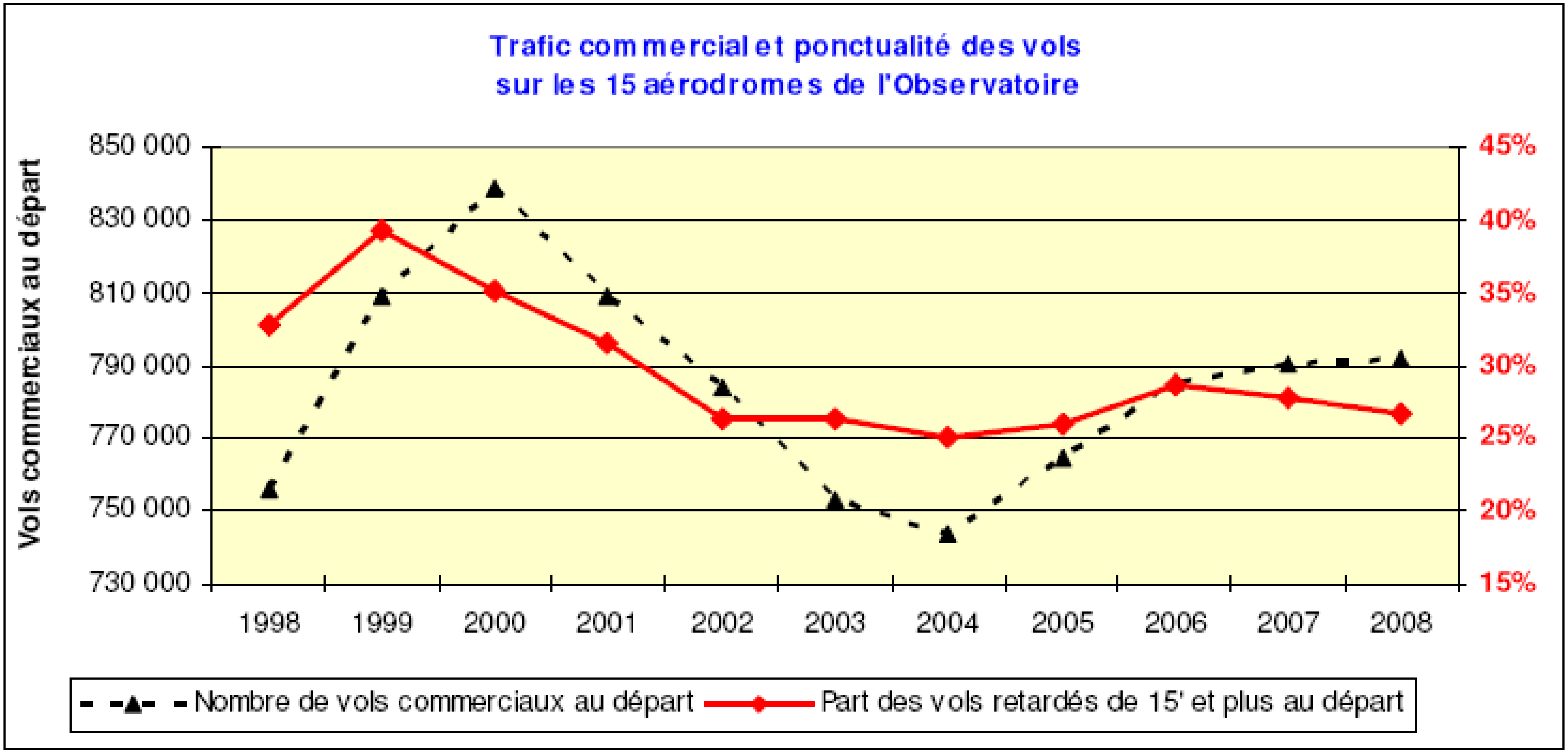
Commercial flights and delays at the 15 biggest airports in France



Legislation

- European Commission (2005) " Strengthening passenger rights within the European Union "
  - Increase monetary compensations for denied boarding
  - Includes compensations for some kind of delays
  - Include compensations for long delays
- Airlines: increase in costs that will be translated to an increase in price.

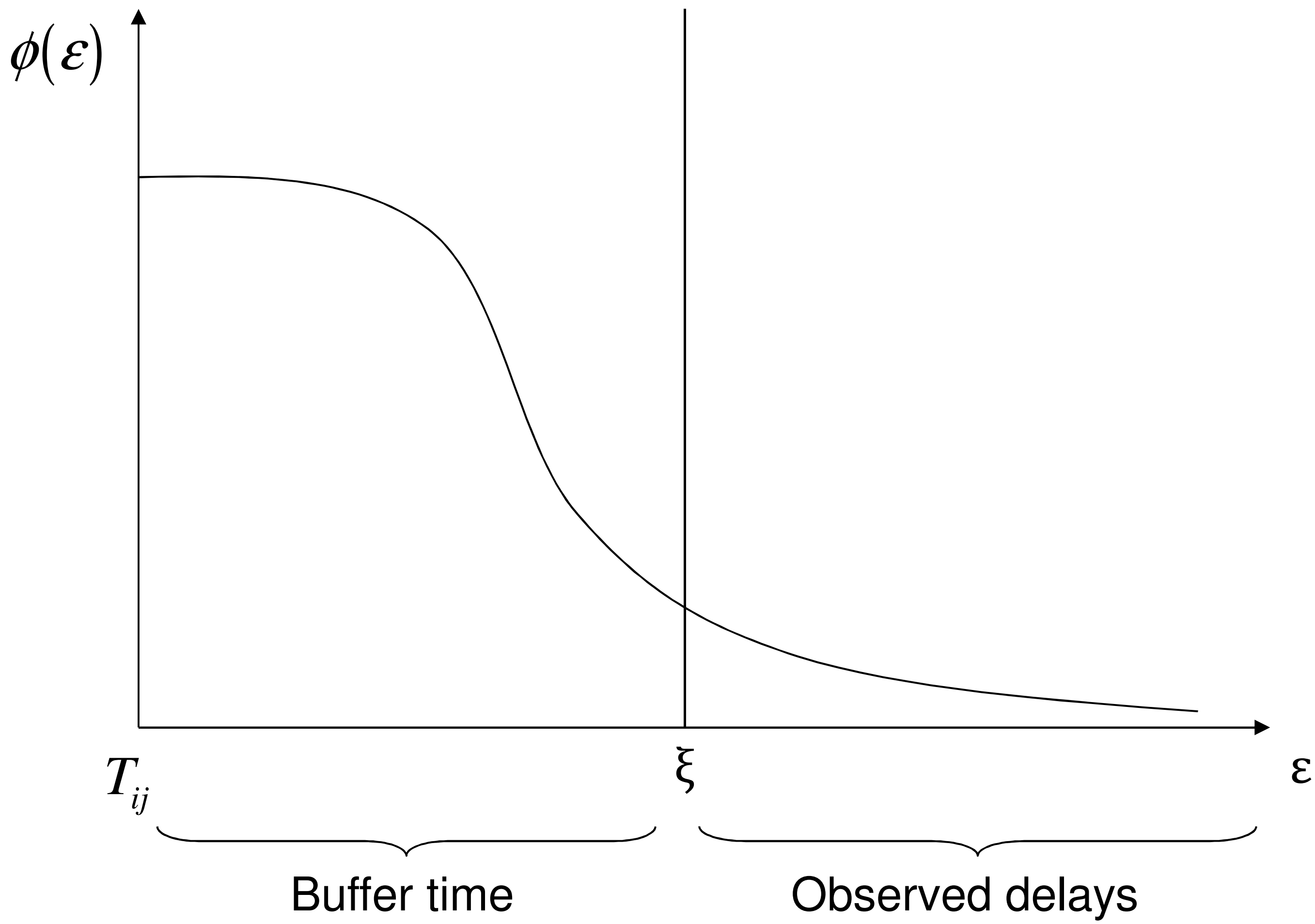
Two issues

- How do we measure delays?
- Are delays so bad?

Definition of delays

- Difference between scheduled arrival time and real arrival time
- Buffer time or buffer delays: extra time added to the minimum required travel time
- Few studies about buffer time:
  - Morrison, Winston, Bailey and Khan (1989)
  - Mayer and Sinai (2003)

Buffer time



Empirical Studies

		ITA	Madrid Airport	Westminster Study
Market and time coverage		Europe 1999	Madrid Airport July 1997-2000	Europe 2004
Studied costs		Passengers and airlines	Passengers and airlines	Airlines
Delays		Schedule and buffer	Schedule	Schedule and buffer
Estimated Costs	Airlines	2364-2916 €/hour	5000 €/hour	4320 €/hour
	Passengers	44.6-60 €/hour	15,9 €/hour	

Theoretical Models of Congestion

- Modeling the queues due to congestion
- Brueckner (2002): carriers internalize the congestion they impose in themselves
- Mayer and Sinai (2003): Delays appear due to network benefits from hubbing and congestion externalities.
- To study delay costs, we should not consider the whole delay.

Model: Definition of delays

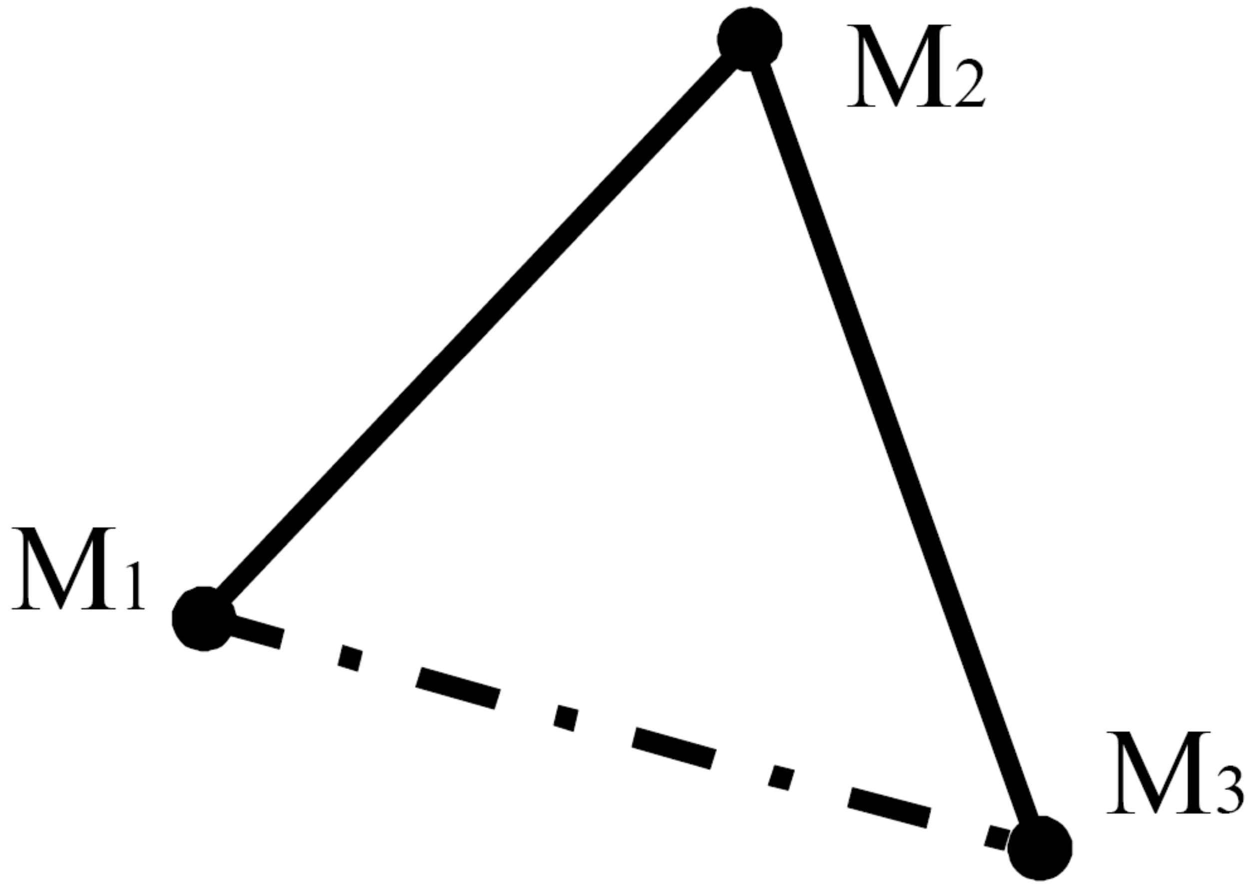
- Optimal delay
  - Value of delays that maximizes social welfare
  - Social welfare = Firm's profits + Consumer Surplus

- Equilibrium delay
  - Value of delays that maximizes firm's profit

Methodology

- Step 1: Computation of equilibrium delays
  - The observed data are assumed to obey the equilibrium conditions
  - Invert the relationship to obtain the parameters of demand
  - Recover welfare function from the demand function
- Step 2: Computation of optimal delays
  - Maximization of welfare
- Step 3: Evaluation of the cost of delays
  - Welfare at optimum-Welfare at equilibrium

Estimation of the optimal delay in the case of a specific network



Components and assumptions of the model

- Hub-and-spokes network

$$C_{ij}\left(X_{ij}\right)=F+\left(\alpha+\beta X_{ij}\right)T_{ij}$$

- Stochastic delay $\varepsilon_{ij} \sim \Phi\left(\varepsilon_{ij}\right)$
- Airline introduce ζ_{ij} to control for delays
- Passengers connect at the hub
- Airline introduces δ and can introduce γ

$$\gamma \leq \delta$$

Demand functions

- Firm is a monopoly
- Faces 6 demands

$$X_{12} = a_{12} + b_{12}\left(P_{12} + v\left(T_{12} + \zeta_{12} + r\int_{\zeta_{12}+sd}^{\infty} (\varepsilon - \zeta_{12})\phi_{12}(\varepsilon)\,d\varepsilon \right)\right)$$

- Firm maximize profits with respect to $P_{ij},\ \zeta_{ij},\ \delta$ and γ

Demand functions

$$X_{23}=a_{23}+b_{23}\left(P_{23}+v\left(T_{23}+\zeta_{23}+r\left(\begin{array}{l}\int_{\zeta_{12}+\delta}^{\zeta_{12}+\delta+\gamma}\int_{\zeta_{12}+sd+\zeta_{23}+\delta-\varepsilon_{12}}^{\infty}(\varepsilon_{12}-\zeta_{12}-\delta+\varepsilon_{23}-\zeta_{23})\phi_{23}(\varepsilon_{23})\phi_{12}(\varepsilon_{12})\,d\varepsilon_{23}d\varepsilon_{12}\\+\left(\int_{0}^{\zeta_{12}+\delta}\phi_{12}(\varepsilon_{12})\,d\varepsilon_{12}+\int_{\zeta_{12}+\delta+\gamma}^{\infty}\phi_{12}(\varepsilon_{12})d\varepsilon_{12}\right)\int_{\zeta_{23}+sd}^{\infty}(\varepsilon_{23}-\zeta_{23})\phi_{23}(\varepsilon_{23})\,d\varepsilon_{ij}\end{array}\right)\right)\right)$$

$$X_{123}=a_{123}+b_{123}\left(P_{123}-C_{lf}\Pr loose+vEt_{123}\right)$$

$$Et_{123}=T_{12}+\zeta_{12}+T_{23}+\zeta_{23}+\underline{\delta}+\delta+$$

$$+r\left(\begin{array}{l}\int_{\zeta_{12}+\delta}^{\zeta_{12}+\delta+\gamma}\int_{\zeta_{12}+\zeta_{23}+\delta-\varepsilon_{12}+sd}^{\infty}(\varepsilon_{12}-\zeta_{12}-\delta+\varepsilon_{23}-\zeta_{23})\phi_{23}(\varepsilon_{23})\phi_{12}(\varepsilon_{12})\,d\varepsilon_{23}d\varepsilon_{12}+\left(\int_{0}^{\zeta_{12}+\delta}\phi_{12}(\varepsilon_{12})\,d\varepsilon_{12}+\int_{\zeta_{12}+\delta+\gamma}^{\infty}\phi_{12}(\varepsilon_{12})d\varepsilon_{12}\right)\int_{\zeta_{23}+sd}^{\infty}(\varepsilon_{23}-\zeta_{23})\phi_{23}(\varepsilon_{23})\,d\varepsilon_{ij}\\+Ewt\left(1-\Phi_{12}\left(\zeta_{12}+\delta+\gamma\right)\right)\end{array}\right)$$

Data

Direct Flights	**Toulouse-Paris**	**Paris-Nice**
Total passengers	177414	166831
Total number of flights	1432	1228
Average Passengers per flight	123.9	135.9
Travel time (minutes)	80	85
Frequencies [a]	23.5	20.1
Airplane [b]	A320	A320
Capacity [c]	161.9	168.1
Average occupation	76.5%	80.8%

a Average frequency of flights per day;
b Most frequent plane;
c Average capacity of the used planes on the route

Results

- Calibration

$$\left.\begin{array}{r} v\in(0.5,0.9) \\ r\in(0.95,1.96) \end{array}\right\} vr\in(0.84,0.93)$$

- Optimal delays and optimal buffer time
  - Buffer decreases more than 50%
  - Extra delays decreases and dissapears in most of the cases

Conclusions

- Under the assumptions of linear demand, monopoly and same value of time for all the passengers we obtain that the buffer time as well as extra delays introduced by the airline should decrease
- The introduction of compensation for long delays lead airlines to increase their prices. Overall effect over welfare is always negative