Welfare Effect of a Carbon Tax in the Long-Distance Passenger Market

ISA Workshop #3

Marc Ivaldi
Toulouse School of Economics
Institute for Sustainable Aviation

Joint work with

Frédéric Cherbonnier TSE
Catherine Muller-Vibes TBS
Karine Van der Straeten TSE

Motivation

Transportation

- 25% of all EU GHG emissions
- The only sector with growing sources of GHG

Motivation

Transportation faces major environmental challenge

- Technological solutions are decades away
- Consider market-based measures

Motivation

Market-based measures

- New cars to be zero-emissions by 2035
- Fuel costs
  - EU Emissions Trading System (ETS)
  - Carbon tax
- Alternatives
  - Banning cars in center cities
  - Expanding rail infrastructure

Objective

Evaluating the welfare effect of a carbon tax

- Different levels of the carbon tax
- Different values of carbon
  - € 190 in 2024 (U.S. EPA)

  Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances
- Adding the impact of electric cars

in the context of intermodal competition
in the long distance passenger market

Empirical literature

Relatively scarce

- Hideki – Miyoshi, *Transportation Research D, 2017*
- Jiang, *Transportation Research B, 2021*
- Bolic – Laplace – Lenoir – Paul – Roucolle (2024)

Empirical literature

Related models

- **Cherbonnier – Ivaldi - Muller-Vibes -Van Der Straeten**
  “Competition For Versus In the Market of Long-Distance Passenger Rail Services”
  ***Review of Network Economics*, 2018**

- **Ivaldi - Vibes**
  “Price Competition in the Intercity Passenger Transport Market: a Simulation Model”
  ***Journal of Transport Economics and Policy*, 2008**

Methodology

1. Calibration of a model of intermodal competition
    - One data point in 2019 for one OD market
    - Oligopoly with differentiated products
2. Simulations

Main results

on the welfare effects of a carbon tax

- Carbon tax at € 190 is welfare-neutral
- Electric car is strongly welfare enhancing
  - Large decrease in carbon externalities
- Rail is not a powerful carbon-externalities killer
  - Subsidies remain necessary to rail

Data

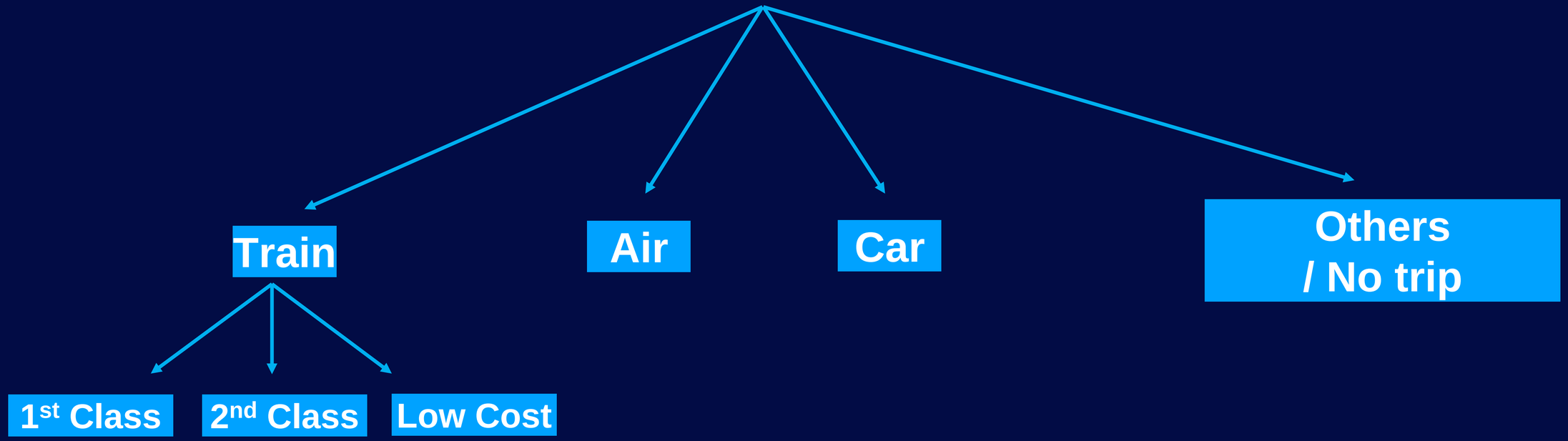
- Paris – Marseille, around 750 km
- Market for leisure trips in 2019

Data

Mode	#Passengers	Price	Marginal Cost	Market Share %
Rail 1st Class	451067	62.3	45	8.3
Rail 2sd Class	1407107	53.4	38	25.9
Rail Low Cost	1260150	30.5	24	23.2
Air	591438	110.7	70	10.9
Car	1649816	88.6	88.6	30.4

Model

Demand side: nested-logit specification



$$ln(s_j) - ln(s_0) = \psi_j - hp_j + \sigma\, ln(s_{j|rail}) \quad \text{for} \quad j = 1,2,3$$

Calibration

Supply side: Price competition

- Car = non strategic mode
  - Price = marginal cost
- Air = profit maximizing mode
- Train = profit maximizing + regulatory constraints

$$\underset{p_1,p_2,p_3}{\text{Max}} \sum_{i=1}^{3}\left(p_i - c_i\right)s_i N - \mu\sum_{i=1}^{3}\left(p_i s_{i|rail} - \overline{p}\right) - \lambda\left(p_3 - \overline{p}_3\right)$$

Calibration

Solving for the unknown parameters

- Step 1
  - Solving the FOCs associated with price competition
    - Parameters $\mu \quad \lambda \quad \sigma \quad h$
    - Assuming
      - Outside good market share = 50%
      - Different behavior for the train operator
- Step 2
  - Solving the demand equations for the quality indexes
    - Parameters ψ_j

Calibration

Mode	Own price elasticity	Quality index
Rail 1st Class	-8.12	0.93
Rail 2sd Class	-4.82	0.79
Rail Low Cost	-2.94	0.19
Rail	-0.83	
Air	-2.72	0.67
Car	-1.95	1.12

Simulation

Data for the reference year 2019 on Paris-Marseille

Mode	Emissions kgCO2/pax	Carbon tax or ETS value	Carbon cost €	Marginal cost €	% Carbon cost
Air	152	**25**	3.8	50	7.6
Car	66.1	**44.6**	2.95	88.6	3.3
Rail	0				

Simulations

- Reference scenario
  - Carbon taxes at the reference values
  - Carbon tutelary value = € 190

- Scenarios
  1. Carbon tax = € 130
  2. Carbon tax = € 190
  3. Carbon tax = € 250
  4. Carbon tax = € 190 + electric vehicle
  5. Carbon tax = € 190 + deregulation

Scenario 1: Carbon tax = € 130

Mode	Change in prices %	Change in market share %	Change in CO_2 %
Rail 1st Class	0.0	+4.4	0.0
Rail 2nd Class	0.0	+3.9	0.0
Rail Low Cost	0.0	+4.1	0.0
Air	+13.8	-30.0	-30.0
Car	+6.3	-10.0	-10.0

Scenario 1: Carbon tax = € 130

Change	M €	%
Consumer Surplus	**-16.4**	**-5.8**
Profit	**-6.0**	**-9.7**
Train	+1.5	+4.1
Air	-7.5	-31.2
CO2 externalities	**-7.2**	**-19.1**
Transfer to State	**+13.8**	**+194.0**
Welfare	**-1.4**	**-0.4**
Welfare with cost of public fund	**1.4**	**+0.4**

$$\Delta Welfare = \Delta CS + \Delta Profit + \Delta TaxCO2 - \Delta CO2Value$$

$$\Delta Welfare = \Delta CS + \Delta Profit + (1 + 0.2)\Delta TaxCO2 - \Delta CO2Value$$

Scenario 2: Carbon tax = € 190

Mode	Change in prices %	Change in market share %	Change in CO_2 %
Rail 1st Class	0.0	+6.9	0.0
Rail 2nd Class	0.0	+6.1	0.0
Rail Low Cost	0.0	+6.5	0.0
Air	+21.7	-43.1	-43.1
Car	+10.9	-17.2	-17.2

Scenario 2: Carbon tax = € 190

Change	M €	%
Consumer Surplus	**-25.4**	**-8.8**
Profit	**-8.3**	**-13.5**
Train	+2.4	+6.3
Air	-10.7	-44.5
CO2 externalities	**-10.9**	**-28.9**
Transfer to State	**+19.8**	**+278.0**
Welfare	**-3.1**	**-0.95**
Welfare with cost of public fund	**0.9**	**0.29**

Scenario 4: Carbon tax = € 190 + Electric car

Mode	Change in prices %	Change in market share %	Change in CO_2 %
Rail 1st Class	0.0	+1.1	0.0
Rail 2nd Class	0.0	+1.0	0.0
Rail Low Cost	0.0	+1.1	0.0
Air	+21.7	-45.9	-45.9
Car	-4.0	+10.9	-100.0

Scenario 4: Carbon tax = € 190 + Electric car

Change	M €	%
Consumer Surplus	**-4.4**	**-1.5**
Profit	**-11.0**	**-17.8**
Train	+0.4	+1.1
Air	-11.4	-47.3
CO2 externalities	**-28.6**	**-75.5**
Transfer to State	**+2.1**	**+30.0**
Welfare	**+15.3**	**+4.8**
Welfare with cost of public fund	**+15.7**	**+5.0**

Scenario 5: Carbon tax = € 190 + Deregulation

Mode	Change in prices %	Change in market share %	Change in CO_2 %
Rail 1st Class	+46.1	+47.0	0.0
Rail 2nd Class	+57.4	-24.4	0.0
Rail Low Cost	+129.4	-96.6	0.0
Air	+22.0	-31.7	-31.7
Car	+10.9	+0.2	+0.2

Scenario 5: Carbon tax = € 190 + Deregulation

Change	M €	%
Consumer Surplus	**-103.8**	**-36.3**
Profit	**+35.9**	**+57.9**
Train	43.8	+116.0
Air	-7.9	-32.9
CO2 externalities	**-5.4**	**-14.2**
Transfer to State	**+25.3**	**+356.0**
Welfare	**-37.2**	**-11.7**
Welfare with cost of public fund	**-32.2**	**-10.0**

Concluding remarks

Evaluating the welfare effect of a carbon tax

- Carbon tax at € 190 is welfare-neutral
- Electric car is strongly welfare enhancing
  - Large decrease in carbon externalities
- Rail is not a powerful carbon-externalities killer
  - Subsidies remain necessary to rail

Concluding remarks

Evaluating the welfare effect of a carbon tax

- Simple tool
- Results look realistic

Thank your for your attention