Substitution path between air and rail in Europe: a measure of demand drivers

Work in progress

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EUROPEAN PARTNERSHIP

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Motivation

- Context
  - increasing environmental awareness, regulatory measures, capacity shortages across different modes, and the need for a more seamless passenger journey
  - optimization and alignment of multimodal transport in Europe to improve the overall performance of the (future) transport system

  → Modus Project (https://modus-project.eu/)

- Objective of this paper
  - identifying the determinants of passengers' choice of transportation

  ➢ ***assessing the substitution paths between air and rail for French, German and Spanish city-pairs***

Literature review

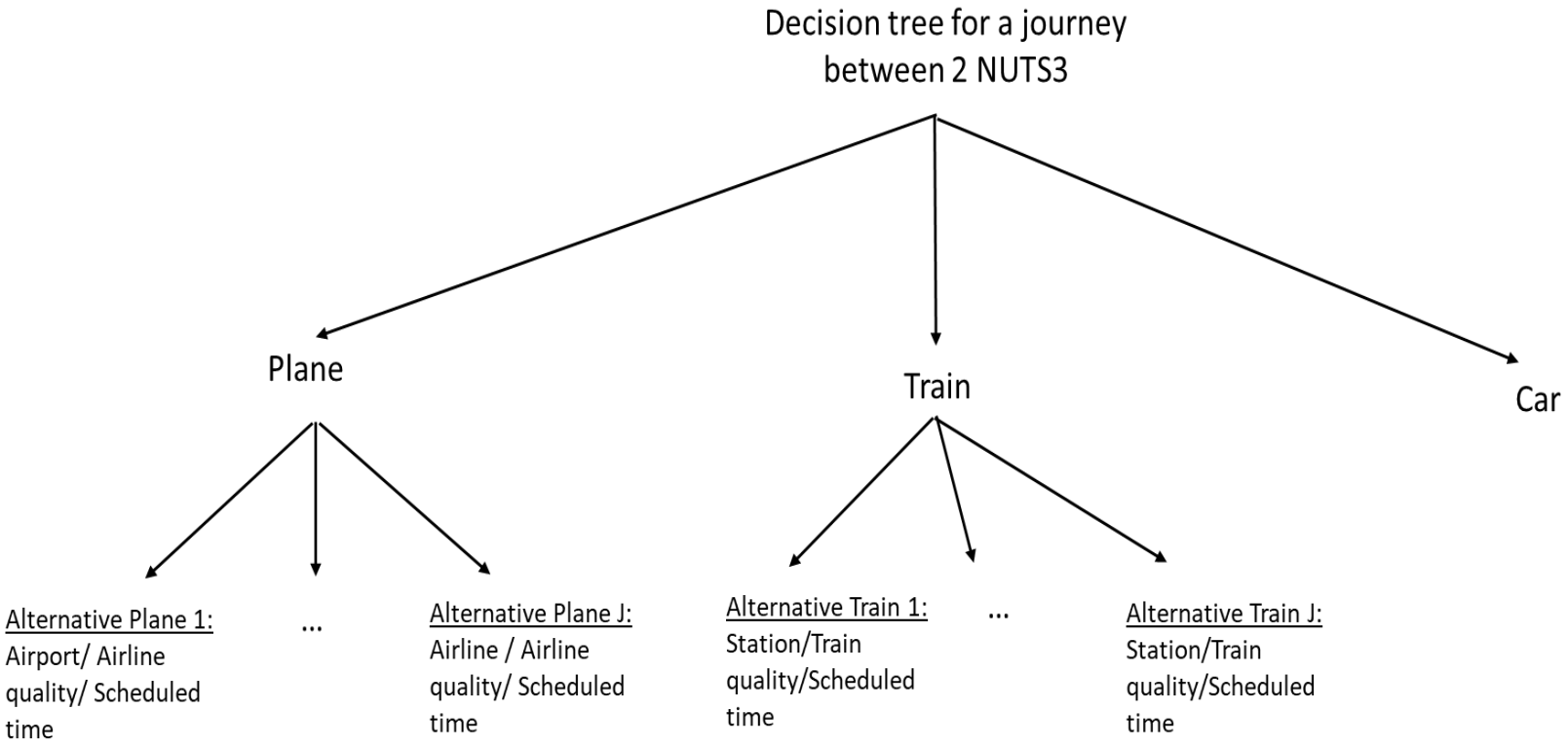
- Inter-modal competition has been extensively studied in the literature
  - Most focus on air-rail competition only ((Albalate et al., 2015), (Behrens & Pels, 2012), (Ortúzar & Simonetti, 2008), (Park & Ha, 2006), (Ivaldi & Vibes, 2008))
  - Others consider sets of other modal alternatives as bus, car-pooling and private cars (Bergantino & Madio, 2020)
- Some authors consider inter and intra-modal competition (Bergantino et al. 2015),(Ivaldi & Vibes, 2008))
- In this paper, we ambition to go ahead with the work of Ivaldi and Vibes (2008) by considering a much larger network

City-pairs and transport supply

- City-pair definition and selection
  - Selection of geographic areas larger than the cities: NUTS3 level
    - ➢ *Several airports and railway stations in departure and arrival OD*
  - Selection of OD where both air and rail are available – direct routes
  - Characterization of demand on city-pairs : socio-economic indicators

- Quality in transport supply
  - Train: HSR, Intercity, Night
  - Plane: Majors, Low-Cost Carriers
    - ➢ *High quality supply: HSR, Majors*
    - ➢ *Low quality supply: Intercity, Night, LCC*
  - Car as another possible mode of transportation

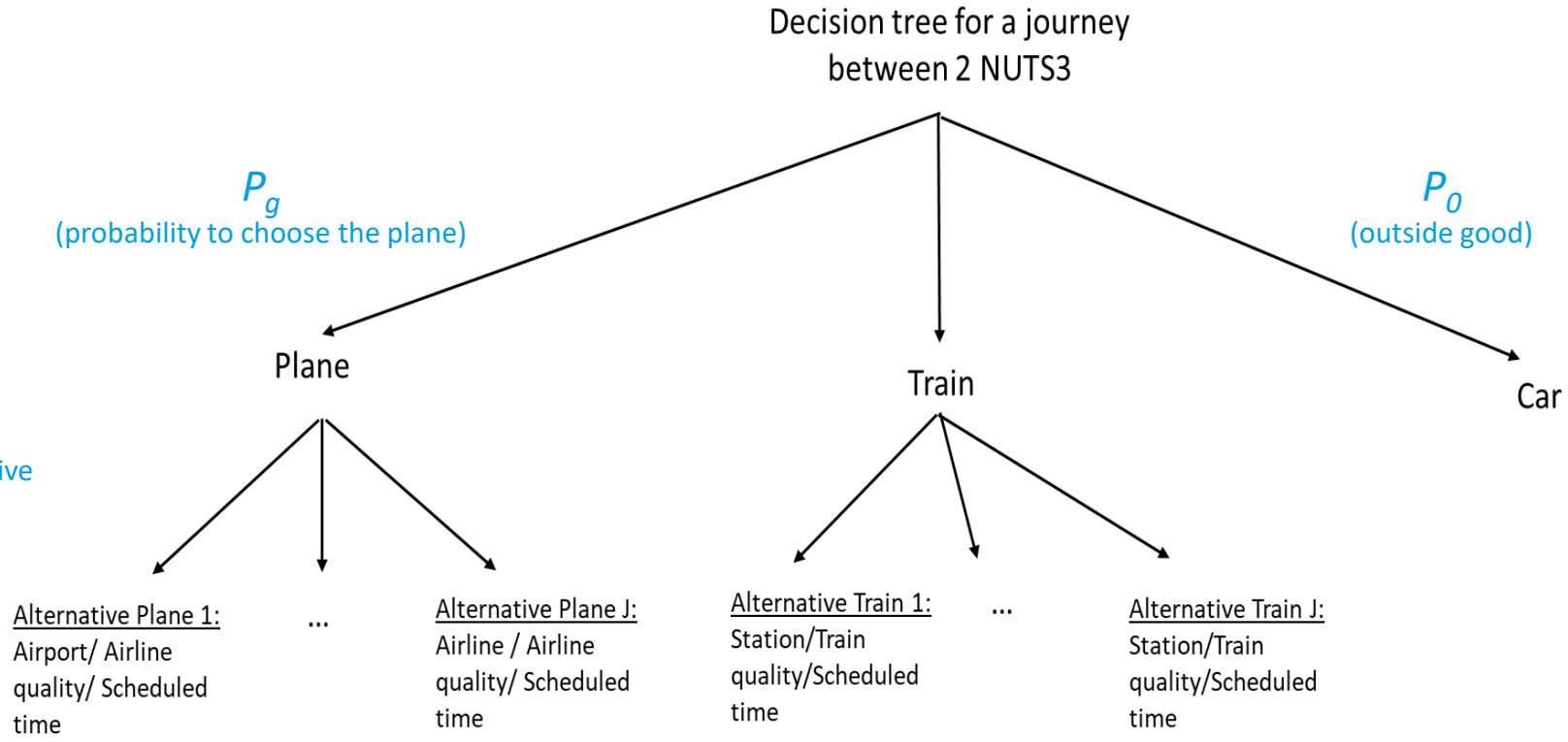
A two-stages decision model



Alternative: combinaison of a mode, service provider (airline/airport or rail station), quality AND corresponding price

- *Demand for each alternative correspond to the probability to choose the alternative*
- *Demand expressed in terms of market share*

Theoritical model



P_g (probability to choose the plane)

P_0 (outside good)

$P_{j/g}$ (probability to choose Alternative j given plane is choosen)

P_j (probability to choose Alternative j)

P_j, $P_{j/g}$, P_g : theoretical probabilities

- we observe the empirical probabilities: market share s_j, $s_{j/g}$, s_g

$\sum_j P_j = 1$ and $\sum_j s_j = 1$

Demand is expressed in terms of market share

Demand function

$$ln(s_j) - ln(s_0) = \psi_j + hp_j + \sigma ln(s_{j/g})$$

- s_j : market share of alternative *j*
- $s_{j/g}$: market share of alternative *j* given the choice of mode *g*
- s_0 : market share of the outside good - assumed to equal 0.85
- ψ_j : vector of characteristics for the alternative j
  - quality of the service
  - proxy for the size of the market, GDP or population or household average income in departure and arrival areas
- p_j : price of alternative *j*
- *h* : part of the measure of demand sensitivity to price
- σ : measure of the degree of intra-group correlation; σ belongs to [0,1]

Data collection

Network

French, german and Spanish domestic origin-destination (NUTS3 level)
Only ODs were air and rail transport modes are in competition

Data sources:

For air: OAG Schedule Analyzer, FRACS (France Aviation Civile Services) database, airline annual reports, IATA paxIS

For rail: MERITS (UIC database), SNCF, RENFE

Data aggregation

Per route and month in 2016
Per transport mode, operator and equipment
we observe the frequency, the total number of passengers and the average price

- *frequency is used as a weight in our analysis*.

Estimation - results

- One model per country
- Statistical significance of the estimated parameters
- ***Price:*** correct negative sign
- ***Intra-mode correlation:*** high for Germany and Spain, low for France
- GDP as a proxy of market size – NUTS3 level

Use of ***instrumental variable*** method to control for endogeneity between price and market-share

Instrumental variables: Current (monthly 2016) and lagged (monthly 2015) price of energy

Variables	Model France	Model Germany	Model Spain
Price (Price Minimum for Spain)	-0.0443***	-0.0191***	-0.0561***
	(0.00392)	(0.000870)	(0.0101)
Ln(sj/g)	0.428***	0.936***	0.929***
	(0.0589)	(0.0160)	(0.0725)
GDP NUTS 3 departure (thousand)	0.00248	0.0539***	0.0316***
	(0.00641)	(0.00421)	(0.0112)
GDP NUTS 3 arrival (thousand)	0.00265	0.0591***	0.0327***
	(0.00602)	(0.00441)	(0.0106)
Attributes of alternatives	YES	YES	YES
Market fixed effect	YES	YES	YES
Carrier fixed effect	YES	YES	YES
Month fixed effect	YES	YES	YES
Observations	2,162	3,086	386
Model Statistics			
R-squared	0.841	0.947	0.973
F-Test	666.5	5437	1303
loglikelihood	-3281	-2908	-288.6
Tests of instrumental variables			
Kleibergen-Paap rk LM	128.9	272.7	73.68
p value	0	0	0
Cragg-Donald Wald F	228.6	442.4	99.21
Kleibergen-Paap rk Wald F	114	469.5	148.4
Hansen J	3.552	2.539	2.041
Chi-sq() P-val	0.0595	0.111	0.153
Endogeneity_test	216.8	441.5	41.46
Chi-sq() P-val	0	0	1.21e-10

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Measures of demand sensitivity

Price elasticity of demand

$$\eta_j = \frac{dq_j}{dp_j} \times \frac{p_j}{q_j} = hp_j \left(s_j - \frac{1}{1-\sigma} + \frac{\sigma}{1-\sigma} s_{j/g} \right)$$

Country	Obs	Mean	Std. Dev.
France	1,961	-5.338775	1.5893
Germany	2,582	-9.111078	7.718956
Spain	272	-10.78422	9.738804

	France		Germany		Spain	
	Major	LCC	Major	LCC	Major	LCC
Plane	-6.031224	-4.736655	-6.112864	-13.54269	-17.58631	-28.53074
	(1.184566)	*(1.898135)*	*(7.043973)*	*(6.996517)*	*(7.067902)*	*(0.5595279)*
Train	-5.205173	-3.006067	-4.618281	-13.44553	-1.537412	-14.32159
	(1.396839)	*(1.541632)*	*(4.132778)*	*(7.827844)*	*(0.3750869)*	*(6.238468)*

Conclusion

- Main results
  - Strong sensitivity of modal market shares to changes in the level of fares
  - Intra-mode correlation: high for Germany and Spain, low for France
    - Competition between modes is higher when intramode competition is lower.
  - Higher price sensitivity of travelers using low quality supply
  - Higher price sensitivity of air travelers

- Next steps:
  - Test of models' robustness, especially for the outside good market share
  - Improving the overall relevance of the models
  - Models can then be used to test the potential impacts of regulatory measures

THANK YOU FOR YOUR ATTENTION

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