The Influence of Airline Business Models on Hydrogen Aircraft Uptake in Europe

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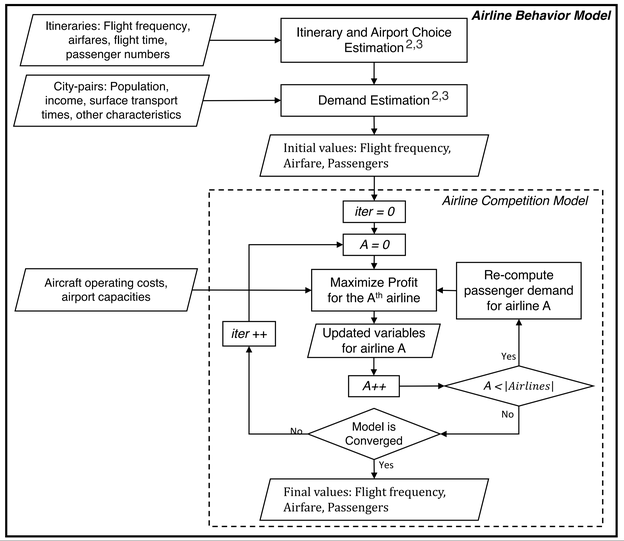
Introduction

- Hydrogen aircraft are a potential **critical technology** to reduce aviation's carbon footprint.
- Their **economic feasibility** has not yet been carefully examined.
- This study explores the **potential uptake** of **larger single-aisle liquid hydrogen (LH2) aircraft** for a range of different fossil jet fuel and hydrogen price scenarios, within the European aviation market.

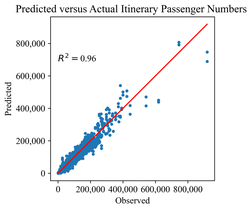
Methodology

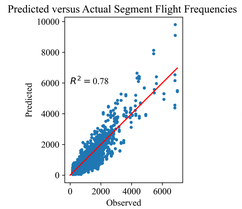
- **The European aviation market is simulated using UCL' s Airline Behaviour Model (ABM)[1]:**
  - Captures network competition between airlines.
  - An n-player, non-cooperative game theoretic approach.
  - Objective: Airlines **maximize** their **Profit** sequentially.
  - Airlines can change **flight frequency** per aircraft type and **airfares** across the network.
  - Passengers can choose itinerary, mode and whether or not to travel.

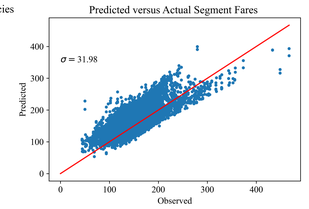


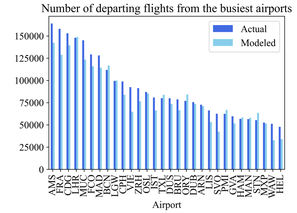
Results

- **Base Year:** 2015 - Model Validation

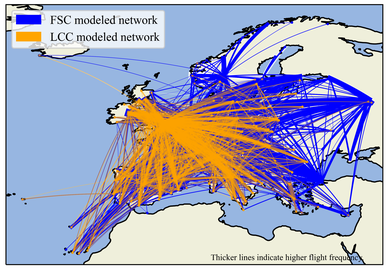


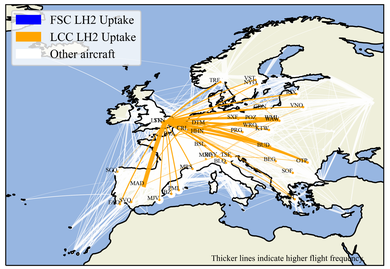


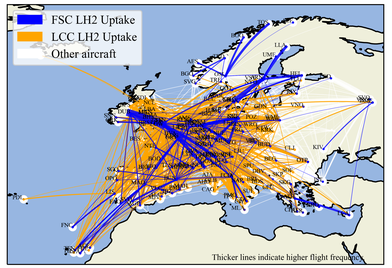


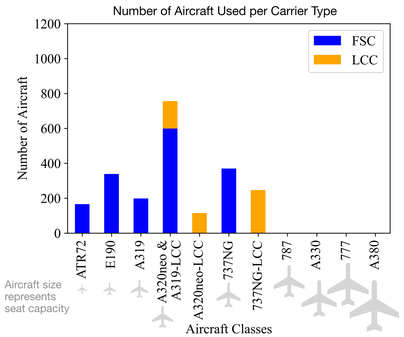


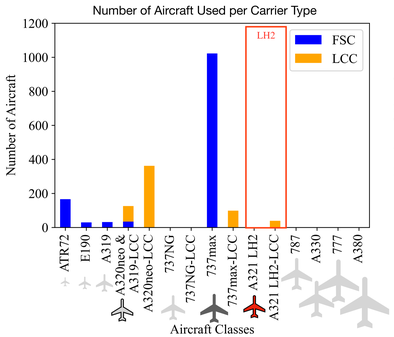
- **LH2 Uptake Scenarios:** Given unlimited number of LH2 aircraft* & next-generation larger single-aisle conventional aircraft (energy equivalent LH2 price= $1.4/kg), for low-cost carriers (LCC) and full service carriers (FSC):
  - **Base:** Jet fuel price= $0.7/kg
  - **Scenario A:** Jet fuel price= $1.3/kg.
  - **Scenario B:** Jet fuel price= $1.6/kg

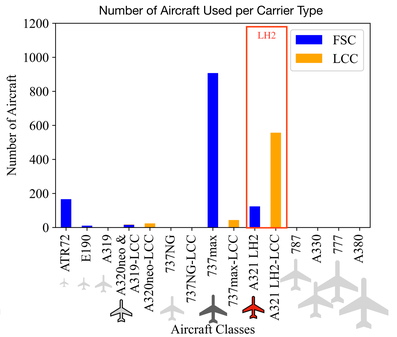












* The LH2 aircraft has size/weight and direct operating cost characteristics of an A321 class aircraft, with seating capacity of a small A320 (~156 seats)

Discussion

- **In Scenario B**, when LH2 fuel is cheaper per unit energy, **LCCs adopt more LH2 aircraft** since,
  - LCCs can reduce costs to compete on price, as this is their business model.
  - The LH2 aircraft is similar in seating capacity to much of LCCs' existing fleet (specifically the A319/A320); this makes it a good fit for their missions.
- **In Scenario A**, **LCCs** are the **only adopters of the LH2 aircraft** as aircraft characteristics (primarily fuel burn and seating numbers) make it only marginally profit-optimal in the competitive environment in routes shown in the LH2 aircraft route map of Scenario A.
- In Scenarios A and B, **CO_2 emissions decrease** compared to baseline, as jet fuel prices increase.
  - **In Scenario A, FSCs reduce more CO_2**, due to transitioning to larger and more fuel-efficient aircraft with reduced flight frequency.
  - **In Scenario B, LCCs reduce more CO_2**, owing to the greater adoption of the LH2 aircraft.

Future Studies

- Years **2030-2035** to be studied next, when a commercially viable LH2 aircraft is anticipated; fleet turnover & ordering strategies to be modeled.
- Examine how different **policies** affect uptake of low-CO_2 aircraft technologies.

References

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2. Jamin, S., A. Schäfer, M. E. Ben-Akiva, and I. A. Waitz, Aviation emissions and abatement policies in the United States: a city-pair analysis. Transportation Research Part D:Transport and Environment, Vol. 9, No. 4, 2004, pp. 295 – 317.
3. Dray, L., K. Doyme, J. Kuleszo, and A. Schäfer, Modelling the Impact of UK Hydrogen Aircraft Policy and Small Hydrogen Aircraft Characteristics on Domestic Uptake. Available at SSRN 4266724, 2022.