Airport Capacity Consequences Leveraging Aviation Integrated Modelling (ACCLAIM)

Airline Behaviour Model

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Objectives

- Simulate the local and global consequences of airport capacity expansions anywhere in the world.
- This requires (among others):
  - Modelling the behaviour of airlines—the setting of airfares, flight frequency, fleet choice and network structure—in a competitive environment.
  - Modelling how passengers may respond to changes in airline supply, taking into account: airfares, airport, airline, and itinerary choice and passenger heterogeneity.

Method

The ACCLAIM project takes the Aviation Integrated Model, a model of the worldwide passenger aviation industry, and adds to its core a multi-airline competition model.

Each airline has the ability to compete with others by changing airfare and itinerary flight frequency. Airlines adjust these parameters, on each route, to maximise profit. The profit function for each airline is:

$$\text{PROFIT} = \sum_{i \in \text{itineraries}} \text{airfare}_i \times \text{pax}_i - \sum_{i \in \text{itineraries}} \text{operating cost}_i \times \text{flights per year}_i - \sum_{i \in \text{itineraries}} \text{cost per pax}_i \times \text{pax}_i$$

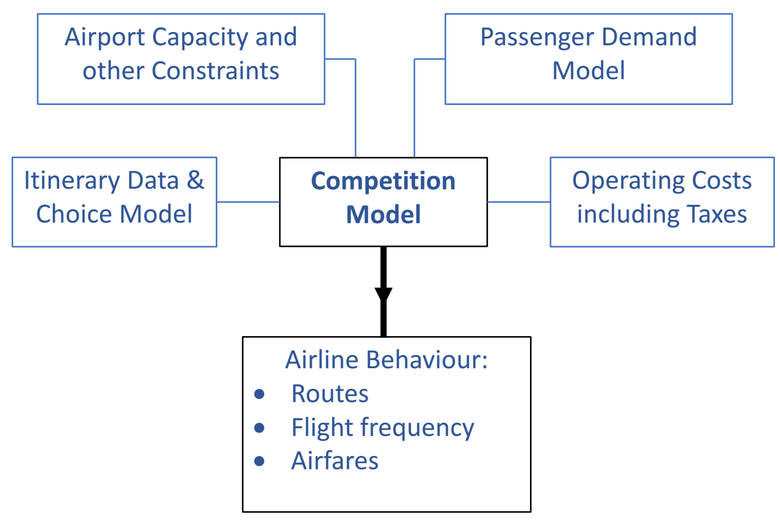
And is subject to constraints for each route, r, and airline, a:

$$\text{itinerary pax}_{a,r} \leq \text{seats per flight}_{a,r} \times \text{flights per year}_{a,r}$$

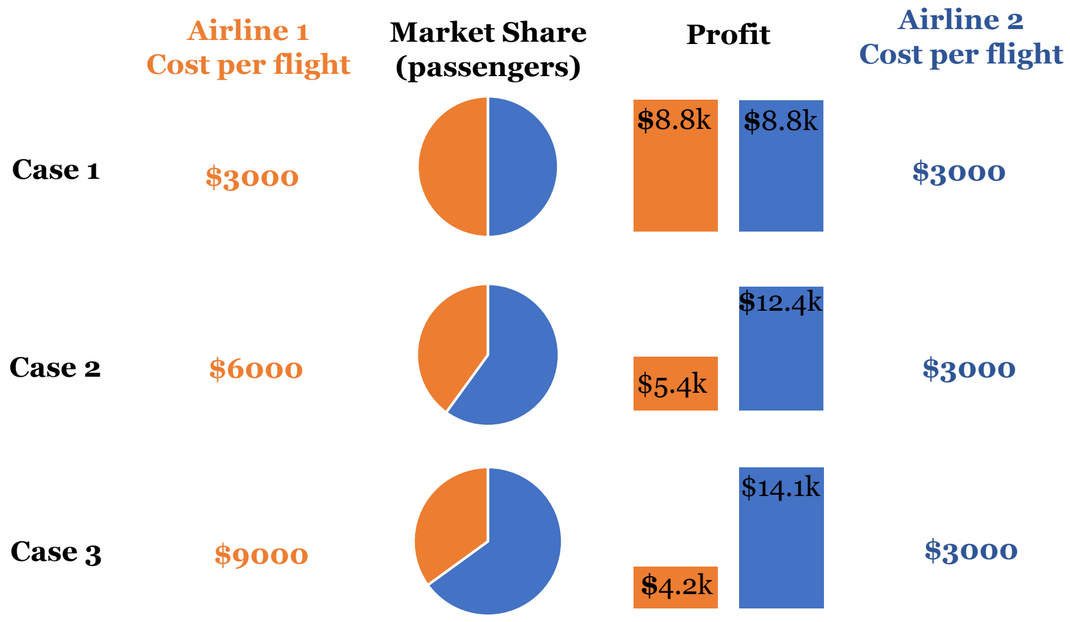
$$\text{itinerary pax}_{a,r} \leq \text{market share}_{a,r} \times \text{overall route demand}$$

There are also constraints due to airport capacity. The constraints and profit equations are first linearised. The airlines are only allowed to vary fares and flight frequency slightly between time steps, so that the linear approximation holds. We use linear programming techniques to find the best-response airfare and flight frequency of each airline within this sub-problem. The model is updated with these new flight frequencies and fares, and the process is iterated until convergence to a stable equilibrium.

Data & Input

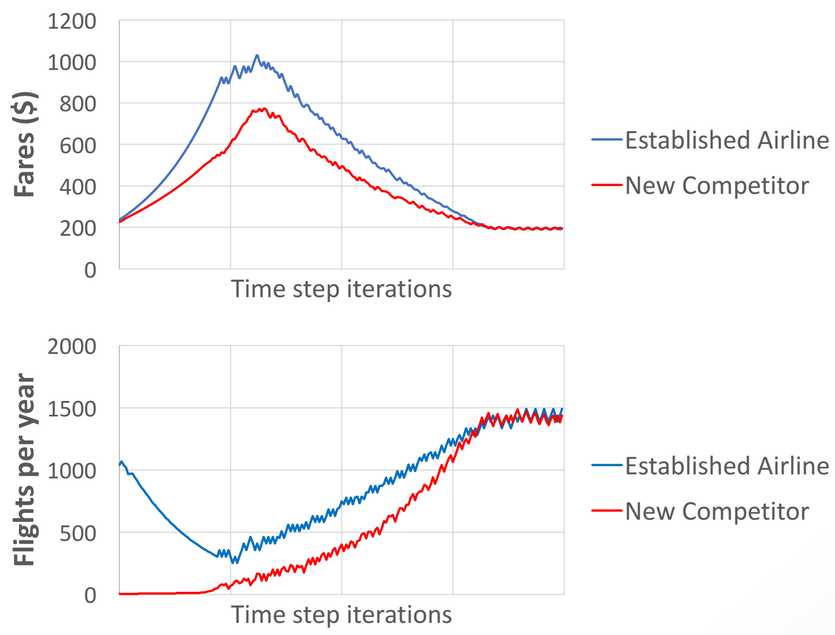


Operating costs affect market share and profitability



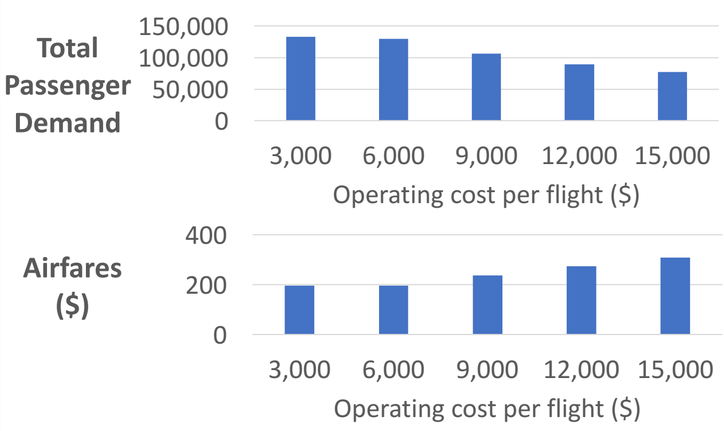
The competition model is able to work out the market effects of different operating costs between competitors. This is crucial to SAECA, as it will help elucidate the effect of electric aircraft adoption, given that these aircraft will have different operating costs compared to standard aircraft. Carbon taxes could help offset, negate, or reverse this effect and increase the rate of uptake for emissions-free aircraft.

Airline competition on a route



The addition of a new airline to a previous monopoly creates fluctuations in fares and flight frequency as the airlines compete. Fares and flight frequency eventually stabilise to a new equilibrium value.

Increased airline costs will reduce demand



The bar chart shows total demand for a competitive route versus operating costs, predicted by the competition model. It predicts airlines will, at first, mitigate additional costs by increases in efficiency (by increasing the load factor of each flight for example), and demand remains stable. Eventually airlines put fares up, as predicted in the second chart. Demand and profit reduces. Without an emission-free alternative technology, carbon taxes on the aviation industry could have a similar effect.

Future Capabilities

- Provide airline/alliance level detail of the global passenger aviation industry.
- Model the outcome of capacity constraints, enabling us to see the effects on the whole aviation network.
- Make future projections that estimate effects of new technology uptake and usage.
- Identify routes where potential for more competition exists.
- Understand which airlines are best placed within the industry to cope with future market scenarios.
- Identify how changes in taxation (such as carbon taxes) will affect networks, airline profitability, economies and the environment.

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