Impact of Aircraft Size and Service Frequency on Airlines' Demand and Market Share

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Presentation Outline

- Motivation and objective
- A framework of demand and market share analysis
- Data source and estimation results
- Implications and applications
- Summary

Motivation (1)

- Airlines' using larger aircraft can alleviate airport congestion
  - Building new runways or ATC systems is expensive
  - Increase of air travel demand can be accommodated through increase of service frequency or aircraft size or both
  - Airport throughput will be increased if airlines use larger aircraft
  - Major airports have large proportion of operations of small aircraft, especially in short-haul markets
  - Future aircraft size: small (Boeing's opinion) or large (Airbus' opinion)?

Motivation (2)

- What's the impact of airport expansion and government regulation on airlines' decisions on service?
  - Airport capacity expansion, through either building new runways or ATC systems, influences airlines' choice of aircraft size, service frequency and routing network
  - Government regulation, such as landing fee policy, also influence airlines' choices

Motivation (3)

- Aircraft fleet simplification in airlines' reconstruction process after September 11th, 2001
  - Only the most profitable aircraft are retained in the fleet
  - In practice, there is no model capturing the role of aircraft size specifically

Objective and Goals

- Study the role of aircraft size and service frequency in airlines' demand and market share
  - In duopoly markets
  - At the market level
  - To account for "seat availability": proportion of seats available to local passengers

“Aircraft Size”

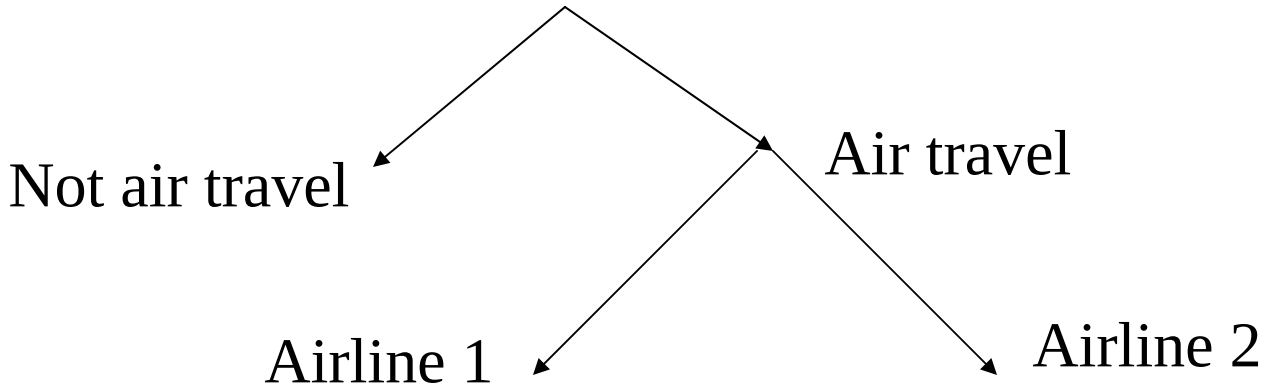
Aircraft	Seat Capacity
B737-1/2	110
B737-5/6	111
B737-3/7	130
B737-4	143
B727-2	148
B757	185
B767-2	188
B767-3	234
B747-2/3	401
B747-4	432

- Focus on jet aircraft
- Not including small regional aircraft (with fewer than 60 seats)
- Ranging from 100 seats to 400+ seats
- Seat capacity is based on actual seat configurations by each carrier

Source: Form 41

Analysis Framework

- Study the role of aircraft size and service frequency, together with other service attributes, in demand and market share
- Focus on duopoly (i.e. two airlines) non-stop markets (at the market level)
- Traveler choice-based two-level nested-logit model



Market Share and Demand Models

- Low-level result (for market share)

$$S_{im} = \frac{\exp(V_{im})}{\sum_j \exp(V_{jm})}$$

V_{im} : deterministic utility if choosing airline i in market m

- High-level result (for total air travel demand)

$$Q_m = D_m \frac{\left(\sum_j \exp(V_{jm})\right)^{\theta}}{\exp(V_{om}) + \left(\sum_j \exp(V_{jm})\right)^{\theta}}$$

D_m : saturation demand

θ : "nested coefficient"

V_{Om} : deterministic utility for "not air travel"

Passenger Utility Function

$$V_{jm} = \alpha \ln(Freq_{jm}) + \beta \ln(Size_{jm}) + \eta \ln(Aval_{jm}) + \gamma Fare_{jm}$$

- For non-stop markets with connecting passengers in flight
- Availability: percentage of seats available in local market
  - (total seats-connecting passengers)/total seats
- Effects captured by the specified airline service variables
  - Capacity effect: total seats= frequency*size*availability
  - Schedule delay: frequency
  - Safety, speed and amenity effect: size
  - RM effect (likelihood to get a seat): seats per flight =size* availability
  - Traffic mix effect: availability
  - Price effect: fare
- Two reasons to use “log” form
  - Diminishing returns from increasing flights or seats
  - Passengers’ choice of airlines is an aggregation of choice of flights or seats
- Different coefficients reveal different contributions or roles

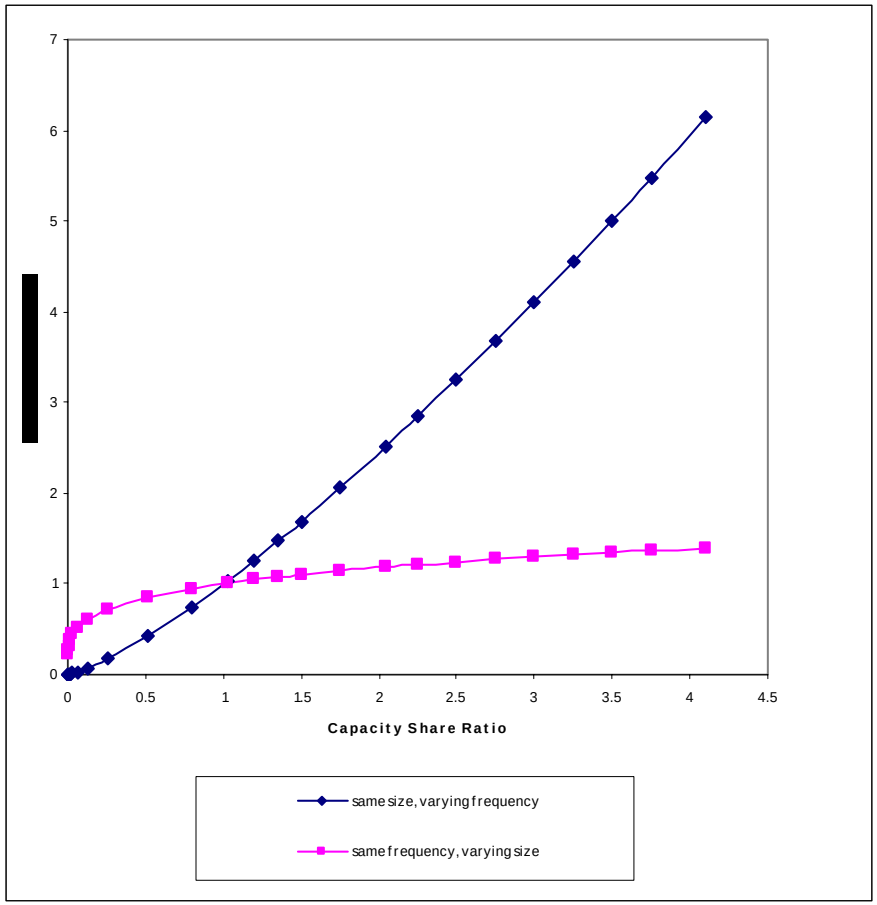
Coefficient Estimation Results

Parameters	Estimates	T statistics
α (Frequency)	**1.287**	41.43
β (Size)	**0.185**	2.45
η (Availability)	0.849	15.92
γ (Fare)	-0.002	-2.79
θ (Nested Coefficient)	**0.333**	10.21

$$\ln\left(\frac{S_{im}}{S_{jm}}\right) = \alpha \ln\left(\frac{freq_{im}}{freq_{jm}}\right) + \beta \ln\left(\frac{Size_{im}}{Size_{jm}}\right) + \eta \ln\left(\frac{Aval_{im}}{Aval_{jm}}\right) + \gamma\left(fare_{im} - fare_{jm}\right)$$

- Log-linear models for market share and total demand
  - Data sample: 13 non-stop duopoly markets from 1989 to 1999
- Different contributions of service attributes in airlines' demand and market share
  - Trade-off between aircraft size and frequency
  - S-curve effect from increase of frequency in market share
  - Higher returns from frequency
  - Coefficient for availability is higher than that for aircraft size

First Implication



- Passengers prefer increase of frequency rather than increase of aircraft size
  - Coefficient for service frequency is higher
- Airlines have no economic incentives to use aircraft larger than the least-cost aircraft
  - Market share ratio increases much faster with the increase of frequency than with the increase of aircraft size

Second Implication

- Passengers prefer smaller aircraft with higher availability rather than larger aircraft with lower availability
  - Convenience is more important than amenity
- Airlines' economies of scope realized by serving both connecting and local passengers are offset by reduction in service quality in hub-and-spoke network
  - Importance of traffic mix

Applications of Research Results (1)

- To predict and facilitate airlines' choice of aircraft size
  - For monopoly case: profit maximization problem
    - Extending duopoly demand model to monopoly case
  - For fixed utility (non-demand competition) case: constrained cost minimization problem
    - Airlines' trade-off between service frequency and aircraft size
  - Game-theoretical analysis in a general competitive environment
- Decision support on whether hub-and-spoke or direct service should be provided
  - Tradeoff between cost reduction and service quality reduction

Applications of Research Results (2)

- Social welfare and benefit analysis for airport capacity expansion and government regulations such as landing-fee policies
  - Airlines' choice of aircraft size, service frequency and routing network are affected by airport capacity and government policies
  - Impact can be quantified and monetized through the tradeoff between "fare" and other service variables in the demand model

Summary

- Impact of aircraft size and service frequency on airlines' demand and market share in non-stop duopoly markets
- A two-level nested-logit model framework
- Main findings:
  - Passengers prefer smaller aircraft size with higher service frequency and higher seat availability
  - Trade-off between size and service frequency; higher returns from increase of frequency
  - Importance of traffic mix effect; service quality reduction in hub-and-spoke network
- Applications and further studies