Flight Overbooking: Models and Practice

16.75J/1.234J Airline Management

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Lecture Outline

- Overbooking Terminology and Relationships
- Evolution of Airline Overbooking Models
  - Manual/Judgmental
  - Deterministic Model
  - Probabilistic/Risk Model
  - Cost-Based Overbooking Model
- Costs of Denied Boardings and Spoilage
- Customer Service and Goodwill Issues
Background: Flight Overbooking

- Determine maximum number of bookings to accept for a given physical capacity.

- Minimize total costs of denied boardings and spoilage (lost revenue).

- U.S. domestic no-show rates can reach 15-20 percent of final pre-departure bookings:
  - On peak holiday days, when high no-shows are least desirable
  - Average no-show rates have dropped, to 10-15% with more fare penalties and better efforts by airlines to firm up bookings

- Effective overbooking can generate as much revenue gain as fare class seat allocation.
Overbooking Terminology

- Physical Capacity: CAP
- Authorized Capacity: AU
- Confirmed Bookings: BKD $\leq$ AU
- Waitlisted passengers: WL
- Go-show passengers: GS
- Stand-by passengers: SB
Overbooking Terminology (cont’d)

- No-shows • NS
- Show-ups • SU
- No-show rate • NSR
- Show-up rate • SUR
- Passengers Boarded • PAX
- Denied Boardings • DB
- Spoilage • SP
Overbooking Relationships

1. $\text{PAX} = \min \left[ \text{BKD} - \text{NS} + \text{GS} + \text{SB}, \text{CAP} \right]$
   $$= \text{BKD} + \text{GS} - \text{NS} + \text{SB} - \text{DB}$$

2. $\text{BKD} = \text{NS} + \text{SU}$

3. $\text{SU} = \text{PAX} + \text{DB} - \text{GS} - \text{SB}$

4. $\text{NSR} = \left( \text{BKD} - \text{SU} \right) / \text{BKD}$

5. $\text{SUR} = \text{SU} / \text{BKD} = 1.0 - \text{NSR}$

6. $\text{SP} = \text{CAP} - \text{PAX}, \text{ only when BKD} = \text{AU}$
Evolution of Airline Overbooking Models

• Overbooking models try to minimize:
  – Total costs of overbooking (denied boardings plus spoilage)
  – Risk of “excessive” denied boardings on individual flights, for customer service reasons

• Mathematical overbooking problem:
  – Find $OV > 1.00$ such that $AU = CAP \times OV$
  – But actual no-show rate is highly uncertain
1. Manual/Judgmental Approach

• Relies on judgment of human analyst to set overbooking level:
  – Based on market experience and perhaps recent no-show history
  – Tendency to choose $OV = 1 + NSR$ (or lower)
  – Tendency to focus on avoidance of DB

• For $CAP=100$ and mean $NSR=.20$, then:

  $$AU = 100 \times (1.20) = 120$$
2. Deterministic Model

• Based on estimate of mean NSR from recent history:
  – Assume that BKD=AU (“worst case” scenario)
  – Find AU such that \( AU - NSR \times AU = CAP \)
  – Or, \( AU = \frac{CAP}{1-NSR} \)

• For \( CAP=100 \) and \( NSR=0.20 \), then:
  \[ AU = \frac{100}{1-.20} = 125 \]
3. Probabilistic/Risk Model

- Incorporates uncertainty about NSR for future flight:
  - Standard deviation of NSR from history, STD

- Find AU that will keep DB=0, assuming BKD=AU, with a 95% level of confidence:
  - Assume a probability (Gaussian) distribution of no-show rates

- Keep show-ups less than or equal to CAP, when BKD=AU:
  - Find SUR*, so that AU x SUR* = CAP, and Prob[AU x SUR* > CAP] = 5%

- From Gaussian distribution, SUR* will satisfy:
  \[
  Z = 1.645 = \frac{SUR^* - SUR}{STD}
  \]
  where SUR = mean show-up rate
  STD = standard deviation of show-up rate
• Optimal AU given CAP, SUR, STD with objective of DB=0 with 95% confidence is:

\[
AU = \frac{\text{CAP}}{\text{SUR} + 1.645 \times \text{STD}} = \frac{\text{CAP}}{1 - \text{NSR} + 1.645 \times \text{STD}}.
\]

• In our example, with STD= 0.05:

\[
AU = \frac{100}{(1-0.20 + 1.645 \times 0.05)} = 113
\]

• The larger STD, the larger the denominator and the lower the optimal AU, due to increased risk/uncertainty about no-shows.
1. Reduce level of confidence of exceeding DB limit:
   – Z factor in denominator will decrease, causing increase in AU

2. Increase DB tolerance to account for voluntary DB:
   – Numerator becomes (CAP+ VOLDB), increases AU

3. Include forecasted empty F or C cabin seats for upgrading:
   – Numerator becomes (CAP+FEMPTY+CEMPTY), increases AU
   – Empty F+C could also be “overbooked”

4. Deduct group bookings and overbook remaining capacity only:
   – Firm groups much more likely to show up
   – Flights with firm groups should have lower AU
4. Cost-Based Overbooking Model

• Find AU that minimizes:
  \[ \text{Cost of DB} + \text{Cost of SP} \]

• For any given AU:
  \[
  \text{Total Cost} = DB \times E[DB] + SP \times E[SP]
  \]
  $DB$ and $SP$ = cost per DB and SP, respectively
  $E[DB]$ = expected number of DBs, given AU
  $E[SP]$ = expected number of SP seats, given AU

• Mathematical search over range of AU values to find minimum total cost.
Example: Cost-Based Overbooking Model

Expected Denied Boardings and Spoilage
CAP=120 NSR = 0.15, Sigma =0.08
Example: Cost-Based Overbooking Model

Denied Boarding and Spoilage Costs
DB Cost = $50, SP Cost = $100
Cost Inputs to Overbooking Model

• Denied Boarding Costs:
  – Cash compensation for involuntary DB
  – Free travel vouchers for voluntary DB
  – Meal and hotel costs for displaced passengers
  – Space on other airlines
  – Cost of lost passenger goodwill costs

• Many airlines have difficulty providing accurate DB cost inputs to these models.
Cost Inputs (cont’d)

• Spoilage Costs:
  – Loss of revenue from seat that departed empty

• What is best measure of this lost revenue:
  – Average revenue per seat for leg?
  – Highest fare class revenue on leg (since closed flights lose late-booking passengers)?
  – Lowest fare class revenue on leg (since increased AU would have allowed another discount seat)?

• Specifying spoilage costs is just as difficult.
Customer Service and Goodwill

• Many airlines tend to view aggressive overbooking in negative terms:
  – Denied boardings associated with poor customer service and loss of passenger goodwill

• But revenue loss of spoiled seats can be greater than DB costs:
  – Objective is to reduce both actual costs and loss of goodwill due to denied boardings
  – Comprehensive Voluntary DB program needed
Voluntary vs. Involuntary DBs

• Comprehensive Voluntary DB Program:
  – Requires training and cooperation of station crews
  – Identify potential volunteers at check-in
  – Offer as much “soft” compensation as needed to make the passenger happy

• US airlines very successful in managing DBs:
  – 2004 involuntary DB rate was 0.62 per 10,000
  – 95% of DBs in U.S. are volunteers
  – Good treatment of volunteers generates goodwill
2004 US Involuntary DBs per 10,000