Airport capacity constraints & air travellers’ airport choice behaviour – from global constraints to local effects

Dr. Marc C. Gelhausen
Cumulative distribution of global ATMs on airports in 2008

- Top 100 Airports (4.1%) handle nearly 28 m ATMs (51%)
- Top 1,000 Airports (41%) handle about 52 m ATMs (95%)

Gini Coefficient = 0.8033

50% of the global air traffic is handled by less than 5% of 2,500 airports

Reichmuth/Berster/Gelhausen (2011), CEAS Aeronautical Journal 2 (1-4), pp. 21
Why consider capacity constraints in airport choice?

Limited airport infrastructure:

- Runways
- Terminals
- Night curfews
- Noise/emissions/political restrictions

Affects available airport capacity to handle air passenger demand
Hourly variation of flight movements at Frankfurt Airport

Frankfurt Intl Airport: Peak Week 2008: 22 - 28 September 2008 (9,459 ATMs)

Source: OAG, DLR
Development of air traffic volume 2000 – 2010 at LHR & FRA

Reichmuth/Berster/Gelhausen (2011), CEAS Aeronautical Journal 2 (1-4), pp. 21
Traffic ranking by hours of operation of the year 2008 at London Heathrow Airport; CUI = 0.85

Flight Movements at London Heathrow in 2008

Capacity Utilization Index:
Introduced by DLR in the global analysis as the ratio of average day time demand to 5% peak hour demand, as a proxy of capacity in the absence of comparable capacities of airports worldwide, for airports with high traffic volumes.

ATMs per Hour

Source: OAG, DLR
CUI analysis of airports worldwide

Gini-Coefficient = 0.4898

Airports with more than 100,000 aircraft movements/year

 Reichmuth/Berster/Gelhausen (2011), CEAS Aeronautical Journal 2 (1-4), pp. 21
General model structure of the capacity constraints forecast and hypothesis about interdependencies

- Acceptance & speed to improve airport capacities

- Attitude of Population towards Air Transport:
  - Welfare Level
  - Age Structure
  - Tourism
  - ...

- Government and social Values:
  - Democracy
  - Ministry of Environment
  - ...

- Location and Size of an Airport:
  - Noise
  - Number of Flights
  - Airport Category
  - ...

- Intermodal Substitution:
  - Railway Km
  - Country Size
  - ...

+: Positive wrt Improvement
-: Negative wrt Improvement
Main questions in modelling capacity constraints

How is the individual air passenger affected:

Given his chosen destination ...

• Does he change his departure airport (➔ he is crowded out)?
  or

• Does he pay a higher price at his favourite airport (➔ other passengers are crowded out)?
  or

• Does he cancel his air trip altogether (➔ he is crowded out)?
Possible consequences of capacity constraints at airports

- **Low Travel disutility**
  - Redistribution of demand among neighbouring airports
  - Restricted growth of local demand

- **High/Airport capacity expandable?**
  - No
  - Yes

“Mixed strategy”

Gelhausen (2009), Journal of Airport Management 3(4), pp. 366
Forecasting philosophy of a nested logit-model

Traveller: „Which alternative is the best for me?“

- Evaluation of alternatives by means of utility
- Lack of observability, measurement errors, …

Forecaster: „Which alternative is most likely the best for him?“

- Choice probabilities
- Summing up over homogenous populations

Market segment specific market shares of all alternatives

Modelling capacity constraints in airport choice - conceptual

**Idea:** The higher the loss in personal welfare (utility) from alternative to alternative, the higher the efforts to get a “slot” for the best alternative, e.g. by early booking or paying higher prices.

**Realisation:** Increase so-called “synthetic price” to reduce airport attractiveness and thus redistribute excess demand until capacity constraints are met.
Modelling capacity constraints in airport choice (I)

\[ P_i = \frac{e^{\mu V_i}}{\sum_{j} e^{\mu V_j}} \]
Modelling capacity constraints in airport choice (II)

Reduction of $P_i$ depends on level of $P_i$ and $\mu_{MS_i}$

$P_i = \frac{e^{\mu V_{i,sp}}}{\sum_j e^{\mu V_{j,sp}}}$

$\mu * V_{i,sp} = \mu * \left( \sum_k b_k * x_{k,i} - x_{i,sp} \right)$

Decay of $V_i$ to meet capacity constraints
Example: Airport choice in the Cologne region

Relative size of the market segments:
DOM L: 23.6%
DOM B: 36.4%
EUR S: 6.2%
EUR H: 15.2%
EUR B: 5.0%
INT L: 7.5%
INT B: 6.1%

Barcelona
Dallas
CGN
DUS
FRA
Cologne
Berlin etc.

Access (car, train etc.)
Flight
Cologne Trip origin
Berlin etc. Trip destination
CGN Cologne airport
DUS Düsseldorf airport
FRA Frankfurt/Main airport

### Willingness-to-pay by market segment

<table>
<thead>
<tr>
<th>Market segment</th>
<th>1 Euro equals</th>
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<tbody>
<tr>
<td>DOM Leisure</td>
<td>17.40</td>
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<tr>
<td>DOM Business</td>
<td>2.74</td>
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<tr>
<td>EUR Short stay</td>
<td>19.75</td>
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<tr>
<td>EUR Holiday</td>
<td>21.55</td>
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<tr>
<td>EUR Business</td>
<td>1.00</td>
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<tr>
<td>INT Leisure</td>
<td>5.39</td>
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<tr>
<td>INT Business</td>
<td>4.45</td>
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</table>
Total market share of DUS wrt capacity constraints

Gelhausen (2009), Journal of Airport Management 3(4), pp. 366
Market shares by segment at DUS wrt capacity constraints

Gelhausen (2009), Journal of Airport Management 3(4), pp. 366
Market shares by segment at STR wrt capacity constraints

Gelhausen (2011), Journal of Air Transport Management 17, pp. 116
Effects of capacity deficit at DUS on market segments at CGN

![Graph showing the share of unsatisfied demand at DUS due to limited capacity against market share of CGN per market segment. The graph includes lines for different market segments: DOM L - Berlin, DOM B - Berlin, EUR S - Barcelona, EUR H - Barcelona, EUR B - Barcelona, INT L - Dallas, INT B - Dallas. The x-axis represents the share of unsatisfied demand at DUS, and the y-axis represents the market share of CGN per market segment. Gelhausen (2009), Journal of Airport Management 3(4), pp. 366]
Conclusions

• Capacity constraints at one airport affect the whole airport system

• Demand is distributed among more airports, benefiting remote airports

• However, spill-over effects may lead to further capacity-constrained airports

• Welfare of air travellers is reduced due to higher prices and crowding out effects
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