An Empirical Analysis of Airport Capacity Expansion

Paper 128
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23rd ATRS World Conference
Amsterdam, 2-5 July 2019
Background

• Currently around $600 billion in airport construction/expansion programmes worldwide (CIC, 2016)
• Demand projections suggest further expansions will be needed (Airbus, 2018; Boeing, 2018)
• Many expansion projects are highly controversial
  • Global CO$_2$ and local noise and air quality impacts need to be balanced against economic and connectivity benefits
  • Impact assessments are vital in evaluating these effects
• However:
  • Relatively few studies looking at what actually happened when airports were expanded
  • *Ex ante* impact assessments of large projects are frequently inaccurate (Flyvbjerg, 2009)
  • Projections of how airports/airlines will behave after expansion are often under ‘ideal’ conditions
Theoretical expectations

- When constraints are lifted, broadly expect:
  - More frequency competition, smaller aircraft
  - Reduction in fares
  - Possible return of routes that were abandoned due to capacity constraints

- At UCL: ACCLAIM project looking at how the global aviation system responds to capacity expansion
  - Includes response at other airports, via fleet redeployment, etc. (e.g. Doyme et al. 2018)
  - To do this we need to be sure assumptions for the expanded airport are correct

[Data: Dray et al., 2019; High-growth scenario shown]
Some complicating factors

• Expansion may change other airport characteristics
  • Funding expansion often requires increased landing charges
  • A longer runway may allow larger aircraft to use the airport
• There may be additional constraints:
  • Expansion conditional on noise/emissions/regional connectivity
  • Regulations on who can add flights and to where
  • Movement totals may be constrained (with intention e.g. to reduce delay)
  • Terminal and/or airspace capacity may need subsequent upgrades
• Other factors may change over the (10+ years) construction timescale
  • E.g. recession, airline bankruptcy, changes in fuel price, ...
  • Long-term system-wide trends in aircraft size/business models/etc.
• Response to congestion easing depends on how airport handles congestion
Ways airports can deal with congestion

• Allow unrestricted movements and let increasing delay at peak times act as a limit on demand

• Charge higher landing fees at peak times (congestion pricing)
  • This is unpopular with airlines and not much used

• Restrict the number of movements per hour to a value that can (usually) be operated at ‘acceptable’ delay (slot control)
  • In this case, slots are a valuable resource to airlines
  • IATA ‘use it or lose it’ – airlines forfeit a slot they use less than 80% of the time
  • 50% of non-allocated slots (new/forfeited) must be offered first to new entrants (new carrier and/or new route)

• Some airports allow slot trading
  • E.g., reportedly £15 million for a morning slot pair at LHR (Haylen & Butcher 2017)
The data

- Of the top 150 airports by scheduled flights in 2015 (Sabre, 2016)
  - 55 either added runways or were replaced by a higher-capacity airport between 2000 and 2016
  - Many smaller-scale expansions (e.g. rapid exit taxiways, CDM, runway lengthening)

[Data: Sabre, 2017, using slot control = IATA Level 3]
The data

• Initially European and North American airports dominate
• Significant increase in Asian airport expansions post-2005
• For each airport:
  • Schedule, fare and passenger data from Sabre (2017) and BTS (2018)
  • Expansion and capacity information from literature and media reports (e.g. FAA, 2014; Odoni & Morrisset, 2010; Zhang et al., 2018)
Measuring capacity constraints

- Use 95% hour to capture airport peak characteristics
  - If ranking hours by #flights, this is the 95th percentile value
- Capacity Utilisation Index (CUI; Gelhausen et al. 2013) is the movement ratio between 95% hour and average daytime hour
  - Measures how peaked the schedule is
  - Expect schedules to become flatter (CUI increases) as more capacity-constrained
- Declared capacity is usually maximum flights/hour that can be accommodated under typical weather/use conditions with acceptable delay
  - Exact usage depends e.g. on whether slot-controlled
Measuring capacity constraints

- These airports are **highly** constrained
  - Peak hour close to capacity and flat schedules
  - 32 airports:
    - 17 were expanded or replaced 2000-2016
    - 2 with runways under construction
    - 6 being replaced or supplemented by new airports
    - 3 have expansion plans moving through approval process
Measuring capacity constraints

- These airports are **relatively unconstrained**
  - However, 14 of them still expanded between 2000-2016
  - Reflects various factors:
    - FAA guidance to consider expansion when an airport reaches 60-75% of capacity (GAO, 2003)
    - Ambitions for future growth
    - Expansion for operational improvements rather than growth
Capacity constraints by 2016

- Of the 55 airports expanded between 2000 and 2016:
  - 15 have year-2016 peaks under 90% of pre-expansion capacity
    - 10 under 80%
  - 19 have year-2016 peaks over 90% of post-expansion capacity
    - 15 over 95%
  - i.e., over half of the expanded airports either aren’t using any of the extra capacity yet, or are still capacity constrained

- Many airports are also significantly affected by external events over this time period:
  - Recessions and airline bankruptcies (e.g. IAD, SEA, MEL, SYD)
    - In the case of AKL, construction was halted due to reduced demand
  - Regulator decisions about which flights airports can host (e.g. NRT, HND)
  - Opening of high-speed rail lines (BCN, MAD, Chinese airports)
Aggregate outcomes

- Compare average metrics for:

  - Capacity constrained airports
    - Slot controlled
      - Expanded
      - Not Expanded
    - Not slot controlled
      - Expanded
      - Not Expanded

  - Non capacity constrained airports
    - Slot controlled
      - Expanded
      - Not Expanded
    - Not slot controlled
      - Expanded
      - Not Expanded

- Note there are some differences in the groups
  - e.g. more non slot controlled, expanded airports in the US
  - Demand growth rates are not necessarily the same
Aggregate outcomes

- **Aircraft size** behaves similarly between expanded and non-expanded groups
  - Average is higher at constrained airports
  - Does not come down on expansion

- **Frequency to top destinations** increases across all constrained airports
  - Expanded and non-expanded groups behave similarly

- **% short-haul destinations** decreases on expansion
  - Constrained airports only

[Data: Sabre, 2017]
Aggregate outcomes

- **Number of carriers** increases on expansion
  - Average is highest at constrained, slot-controlled airports (50% growth 2000-2016)
  - Constrained, slot-controlled airports that were not expanded saw 20% drop

- **Number of destinations** increases across all constrained groups
  - More seasonality at non-constrained airports

- **CUI** does not decrease on expansion (on average)
  - Affects slot-controlled airports
  - Suggests schedules are not returning to peaked structure

[Data: Sabre, 2017]
Aggregate outcomes – fare and delay

• Less data available for fare and delay
  • Typically there is a short-term decrease in delay on expansion (as in e.g. Hansen et al. 2008)
    • Longer-term impacts are less clear
    • For those (US) airports with 2000-2016 data, little difference in average delay between expanded and non-expanded groups
  • Comparing congested, slot-controlled airports that were/were not expanded:
    • In 2010, average fare was 50% lower at the expanded group
    • By 2015, average fare was 23% lower at the expanded group
    • Might be fare changes on expansion from landing charge changes
    • But also might be impact of oil price changes/hedging on flights of different lengths
Conclusions

• Outcomes of airport capacity expansions vary widely
  - There were 55 major airport expansions in the top 150 airports between 2000 and 2016
  - By 2016, over half of these airports were operating below pre-expansion capacity or close to post-expansion capacity
  - These potential outcomes are usually not examined in impact assessments

• Expanded airports tend to add (longer-haul) routes and carriers rather than adding frequency on existing routes
  - Slot control regulations have a strong impact where present
  - Inertia on existing routes may be due to difficulty in changing schedules
  - Expected theoretical impacts (decreasing aircraft size, re-opening of domestic routes, etc.) are generally small compared to system-wide trends and airport-specific factors
  - This needs to be considered when modelling outcomes
For more information on ACCLAIM and aviation modelling at UCL: www.atslab.org
Extra slides
Schedule behaviour on expansion

- Divergence between slot-controlled and non slot-controlled airports
  - Likely reflects difficulty in moving slots
  - For many flights, changing time requires both an arrival and a departure slot
  - This means the schedule of an expanded airport remains different from one which was never capacity-constrained
- Slot control regulations are also likely part of the reason that expanded airports tend to add destinations and carriers rather than frequency

[Data: Sabre, 2017]