Demand Management

Amedeo R. Odoni
T. Wilson Professor
Aeronautics and Astronautics
Civil and Environmental Engineering
Massachusetts Institute of Technology

Objective
To discuss the characteristics, advantages and disadvantages of alternative approaches to demand management

Topics
Motivation for Demand Management
Description of Fundamental Approaches
International Experience
Lessons Regarding Policies
Reference: Chapter 12

Objective and Application
Help maintain efficient operations at congested airports by
• reducing total demand and/or
• shifting demand from peak to off-peak periods

“Access control”

Application involves
• use of non-capital alternatives
• mitigation in the short and medium terms
• peak-period problems
Motivation for Demand Management at Congested Airports

- Mitigate delays which are already very large, knowing that at these levels of operation delay is extremely sensitive to even modest changes in demand or in capacity
- Other potential benefits:
  - Reduce demand surges, keeping traffic within manageable levels most of the time
  - Improved level of service
  - Reduced operational costs through more efficient utilization of available personnel, facilities and equipment

Scheduled aircraft movements at LGA before and after slot lottery

Estimated average delay at LGA before and after slot lottery in 2001
Basic Precept

- Capacity expansion should be the fundamental means for accommodating growth of demand
- Demand management should be considered only when capacity expansion becomes unreasonably expensive; or is faced by insurmountable political, social or environmental barriers
- In such cases, the forms of demand management that should be considered are the ones that interfere the least with a deregulated and competitive market

Demand Management Approaches

- Administrative [Slot Allocation]
  - Administrative fiat
  - “Schedule Coordination”
  - Lotteries
- Economic
  - Congestion pricing (peak-period pricing, marginal cost pricing, etc.)
  - Minimum landing fees
- Hybrid
  - Slots plus peak period pricing
  - Slot auctions
  - Buy-and-sell of slots

Administrative Approaches

Based on the notion of a “slot” (= a time interval available for scheduling an arrival or departure)
Each airport has a declared number of slots per hour; this number is determined by the capacity of the most restricting element of airport
Potential allocation criteria:
  - Historical precedent
  - Stimulating competition ("new entrants")
  - Access to new markets
  - Regular vs. occasional service
  - Size of market to be served
IATA Schedule Coordination Process

Level 1 (“non-coordinated”)
Level 2 (“coordinated” or “schedules facilitated”) (~ 75 airports)
Level 3 (“fully coordinated”)
~ 140 international airports (practically all busiest ones outside US)
Coordinator appointed by appropriate authority, usually assisted by a coordination committee
IATA Schedule Coordination Conferences (SCC); in June and November for subsequent season
Attended by 300 air carriers, airport reps, airport coordinators, etc.

IATA Schedule Coordination Process [2]

• Air carriers must submit slot requests 27 days before SCC
• During SCC and post-SCC, coordinators resolve conflicts, finalize schedules
• Historical precedent is primary criterion
• Carriers may exchange slots
• Use-it-or-lose-it clause (80% use required)
• New entrants obtain up to 50% of “free” slots
• Several restrictive clauses re. new entrants
• Other allocation criteria: size and type of market, length of period of operation, curfews, etc.

Note: Declared capacities determined at local level

LHR Slots: Time of Day Variations

Aircraft Movements

Time of Day (local)
Slot Availability at LHR

Slot limits at selected international airports

<table>
<thead>
<tr>
<th>Airports</th>
<th>Limit of Scheduled Movements Per Interval (2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 day</td>
</tr>
<tr>
<td>London Heathrow</td>
<td>N/A</td>
</tr>
<tr>
<td>Tokyo/Narita</td>
<td>07</td>
</tr>
<tr>
<td>Frankfurt/Main</td>
<td>78</td>
</tr>
<tr>
<td>Seoul/Incheon</td>
<td>37</td>
</tr>
<tr>
<td>Osaka/Kansai</td>
<td>81</td>
</tr>
<tr>
<td>Tokyo/Kansai</td>
<td>81</td>
</tr>
</tbody>
</table>

Long-Term Trend: Summer LHR Slots
Congestion Pricing: A Key Observation

The marginal congestion cost associated with an airport user has 2 components
-- Cost of delay to that user (internal cost)
-- Cost of additional delay to all other users (external cost)
• At congested airports, this second component can be very large -- often much more than $1000 per aircraft movement

Congestion pricing aims at increasing efficiency of resource utilization by forcing users to “internalize external costs” by paying a congestion toll

Fundamental Principle

• Optimal use of a congested transportation facility cannot be achieved unless each additional (marginal) user pays for the delay costs that (s)he imposes on all other users (Vickrey, 1967; Carlin + Park, 1970)
• Application to airports is complicated by difficult technical and sociopolitical issues
• No real application exists to date

LGA: Marginal delay caused by an additional operation by time of day

Marginal delay (Aircraft-hours) vs. Time of day of incremental operation (e.g., 5 = 0500-0559)
LGA: Marginal external delay cost per additional movement vs. average landing fee per movement

<table>
<thead>
<tr>
<th>Time of day</th>
<th>Marginal delay cost ($ per movt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>$5,000</td>
</tr>
<tr>
<td>7</td>
<td>$10,000</td>
</tr>
<tr>
<td>9</td>
<td>$15,000</td>
</tr>
<tr>
<td>11</td>
<td>$20,000</td>
</tr>
<tr>
<td>13</td>
<td>$25,000</td>
</tr>
<tr>
<td>15</td>
<td>$30,000</td>
</tr>
<tr>
<td>17</td>
<td>$35,000</td>
</tr>
<tr>
<td>19</td>
<td>$40,000</td>
</tr>
<tr>
<td>21</td>
<td>$45,000</td>
</tr>
<tr>
<td>23</td>
<td>$50,000</td>
</tr>
<tr>
<td>1</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

Congestion pricing: observations

- Estimating the marginal delay cost that each additional operation causes to all other movements at an airport is central to congestion pricing
- At non-hub airports with many operators holding a limited share of airport activity, marginal delay cost is not internalized
- Current landing (and take-off) fees at US airports bear little relationship to true external costs

Important to note...

- The external costs computed, in the absence of congestion pricing, give only an upper bound on the magnitude of the congestion-based fees that might be charged
- These are not “equilibrium prices”
- Equilibrium prices may turn out to be considerably less than these upper bounds
- Equilibrium prices are hard to estimate
Possible Forms of Congestion Pricing

Due to the many practical difficulties, the realistic possibilities for application of congestion pricing seem limited to charging during peak periods:

- A surcharge in addition to the weight-based landing fee
- A flat fee independent of aircraft weight (or variation thereof)
- A multiplier applied to the weight-based landing fee
- A landing fee equal to the larger of a specified minimum charge and of the weight-based landing fee

Slots plus Congestion Pricing: Landing Fees, BAA (2001)

<table>
<thead>
<tr>
<th>Aircraft weight (tons)</th>
<th>Heathrow Peak</th>
<th>Heathrow Off-peak</th>
<th>Gatwick Peak</th>
<th>Gatwick Off-peak</th>
<th>Stansted Peak</th>
<th>Stansted Off-peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTOW &lt;= 16</td>
<td>£ 410</td>
<td>£ 130</td>
<td>£ 310</td>
<td>£ 75</td>
<td>£ 80</td>
<td>£ 70</td>
</tr>
<tr>
<td>16 &lt; MTOW &lt;= 50</td>
<td>£ 465</td>
<td>£ 195</td>
<td>£ 345</td>
<td>£ 85</td>
<td>£ 120</td>
<td>£ 85</td>
</tr>
<tr>
<td>55 &lt; MTOW &lt;= 250</td>
<td>£ 465</td>
<td>£ 335</td>
<td>£ 345</td>
<td>£ 115</td>
<td>£ 195</td>
<td>£ 95</td>
</tr>
<tr>
<td>MTOW &gt; 250</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>£ 335</td>
</tr>
</tbody>
</table>

Apply to domestic and international flights

Note: “Peak” varies by airport (Heathrow peak: 07:00-09:59 and 17:00-18:59 GMT, April 1-Oct. 31)


Landing fee = \( T \cdot P \cdot K \cdot W \)

- \( T \) = unit rate (139 Bf)
- \( P \) = peak-period multiplier (1.5 between 8:00 and 11:00 and 17:00 and 20:00 local time)
- \( K \) = noise-related multiplier (ranges from 0.85 to 2.0 depending on noise category of aircraft – 5 categories – and time of day)
- \( W \) = MTOW of aircraft in metric tons
### Auctions

- No practical experience to date
- **Possible Scenario:**
  - Carriers submit sealed bids for any number of slots
  - Different amounts may be offered for different slots by each carrier
  - Final price of a slot is equal to amount actually offered or to the lowest successful bid in each time period
  - All slots are auctioned simultaneously

<table>
<thead>
<tr>
<th>Complexity of Slot Auctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Value an airline derives from a slot depends on what other slots it obtains</td>
</tr>
<tr>
<td>- Landings and takeoffs</td>
</tr>
<tr>
<td>- Alternative times for a given flight</td>
</tr>
<tr>
<td>- Network effects are also important</td>
</tr>
<tr>
<td>- A slot at a given time at airport A may be useless without a corresponding slot at airport B</td>
</tr>
<tr>
<td>- A follow-up market may be needed to adjust auctioned slot allocations</td>
</tr>
</tbody>
</table>

### Buy-and-Sell of Slots

- A hybrid approach: slots plus a market
- Slots are property of current holders
  - May be sold, leased, borrowed against, etc.
- Slot market may be restricted
- *Key question: Ownership and acquisition method at the start.*
- Duration and terms of ownership are important in determining value of slots
- May be disincentive for capacity expansion
Buy-and-Sell at High Density Rule
Airports (USA)

Four classes of slots: domestic carrier, domestic regional, EAS, international
EAS, international: not included in buy-and-sell
Other slots can be sold, leased, exchanged, etc.
Regional slots restricted to a/c with max of 55 seats
80% use-it-or-lose-it requirement
Each domestic slot has a “priority withdrawal number”; can be withdrawn by DOT for use as a
EAS or international slot
Operators with slots <9 are exempt from withdrawals
New slots distributed periodically; 15% reserved for
new entrants who will serve another HDR airport

Proposed Demand Management Alternatives
in the Case of LGA

• Three types of demand management strategies were put forward in June 2001:
  1. Congestion pricing: PANYNJ (two options)
  2. Auctions: PANYNJ (two options)
  3. Administrative: FAA (three options): e.g., “encourage use of larger aircraft”

• In fact, all options under 1 and 2 contained strong administrative components, as well

Example: Congestion Pricing, Option B

Assumes abolition of HDR slots and AIR-21 lottery slots
Target: demand total of 78 ops per hour; possible future revisions
Toll: surcharge on top of existing landing fee; all movts. 06:00-22:00 weekdays; 06:00-14:00 Sat; 09:00-22:00 Sun
Three classes of movements:
  1. Exempt from congestion fee: 80 movements per weekday that formerly qualified under AIR-21
     (allocated by lottery, 2 slots per airline per round of the lottery)
  2. Subject to congestion fee A: GA + all other movements formerly qualifying under AIR-21 (A = $350-700)
  3. Subject to congestion fee B: all other operations (B = $700-2,000)
Two Important Lessons

• Public policy objectives ("fairness", continuity, opportunity for new entrants, access for all operators, access for small communities) dictate use of hybrid demand management systems that combine administrative measures and market-based approaches

• The demand management systems that may eventually be implemented will have complex rules

General observations on demand management

• Responsiveness to local characteristics is essential

• Most appropriate environment for application of market-based demand management approaches:
  - Non-homogeneous traffic
  - Many airlines; no dominant ones
  - Mostly non-connecting traffic
  - Significant peaking of demand profile

• Very few (but important) US airports are good candidates

Distribution of Aircraft Size at LaGuardia

Average aircraft size at LGA is 102 seats, or 52,000 kg MTOW, corresponding to about USD $1,600/hr in direct operating costs
Hub demand - Atlanta

The Situation in the U.S.

Access to many airports is under-priced
But “excess revenues” from congestion pricing are politically sensitive
Prior to 9/11/01, local airport authorities were increasingly interested in demand management and public pressure for use of some form(s) of demand management is mounting
Any significant departure from the status quo will encounter serious resistance