Passenger Delay Impacts of Airline Schedules and Operations
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Cynthia Barnhart (cbarnhart@mit.edu)
Douglas Fearing (dfearing@hbs.edu)
Vikrant Vaze (vikrantv@mit.edu)
Passenger Delays

- Depend on flight delays, flight cancelations, missed connections, and re-accommodation
  - Flight delays alone are not enough (Bratu & Barnhart, 2005)

- Cost U.S. passengers billions of dollars per year

- Multiple methodologies, cost estimates for 2007:
  - Air Transport Association ($5 billion), U.S. Senate Joint Economic Committee ($7.4 billion) (ignoring flight cancelations & passenger connections)
  - Sherry and Donahue ($8.5 billion) (ignoring passenger connections)

- Exact amount unknown because data is proprietary
Outline of Talk

• Passenger travel estimation
• Passenger delay estimation
• Annualized cost of passenger delays
• Regression model to simplify delay estimation
• Selected findings
Passenger Travel Estimation

- Developed statistical model of itinerary shares
  - Regression function includes time-of-day, day-of-week, connection time, cancelations, and seats
  - Trained on one quarter of booking data from a large carrier

- Generate potential non-stop and one-stop itineraries from flight schedule data

- Randomly allocate passengers to itineraries based on estimated proportions
  - Using aggregated passenger demand data to determine total number of passengers and one-stop route proportions
Passenger Delay Calculation

• Extension of Passenger Delay Calculator developed by Bratu & Barnhart (2005)
  – To account for multiple carriers

• Disrupted passengers are determined by analyzing historical (realized) flight schedule data

• Passengers are re-accommodated on alternative itineraries in the order they are disrupted
  – Attempt re-accommodation on ticketed carrier and partner carriers first, and then consider all carriers

• Maximum delay of 8 hours for daytime disruptions (5:00am - 5:00pm) / 16 hours for evening disruptions
Annualized Costs of Delays

• Estimated 244.5 million hours of U.S. domestic passenger delays in 2007

• Total cost of $9.2 billion
  – Assuming $37.60 per hour value of passenger time (same value as used in other reports)

• Out of all passenger delay,
  – (only) 52% due to flight delays
  – 30% due to cancelled flights
  – 18% due to missed connections

• Average passenger delay of 30.15 minutes
  – Compared to average flight delay of 15.32 minutes
Regression Model to Bypass Passenger Allocation Procedure

- Simplified one-step approach to passenger delay estimation using public data directly
- Dependent variable = Average passenger delay
- Independent variables = Aggregate attributes of airline schedules, passenger itineraries etc
  - Average flight delay
  - Fraction of canceled flights
  - Fraction of connecting passengers
  - Fraction of flights with at least 60 minutes of delay
  - High load factor dummy
- Regression model estimated using the allocation based delay estimates
Error Comparison at Different Aggregation Levels

- Regression-based estimation has slightly larger error than the complicated process

<table>
<thead>
<tr>
<th>Aggregation Level</th>
<th>Passenger Allocation and Delay Calculation</th>
<th>Regression-based Delay Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>By Carrier-Day</td>
<td>11.1%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Daily</td>
<td>10.3%</td>
<td>12.4%</td>
</tr>
<tr>
<td>Monthly</td>
<td>3.3%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Quarterly</td>
<td>2.7%</td>
<td>8.0%</td>
</tr>
</tbody>
</table>

- Passenger delay estimation for 2008 (a sample application of the direct approach)
  - Model inputs: Flight schedules and aggregate passenger flows
  - 6% fewer passengers and 6.7% lower avg. passenger delays compared to 2007 resulting in 12.2% lower total passenger delays
Finding #1

- The ratio of average passenger delay to average flight delay is maximum for regional carriers, and minimum for low-cost carriers, owing primarily to their cancellation rates and connecting passenger percentages
  - Overall ratio = 1.97
  - Overall Cancellation rate = 2.4%
  - Overall Connecting passengers = 27.2%

<table>
<thead>
<tr>
<th></th>
<th>Regional</th>
<th>Legacy</th>
<th>Low-cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg Pax Delay to Avg Flight Delay Ratio</td>
<td>2.61 (Range: 2.27 to 2.99)</td>
<td>2.03 (Range: 1.65 to 2.23)</td>
<td>1.61 (Range: 1.49 to 1.89)</td>
</tr>
<tr>
<td>Cancellation Rate</td>
<td>3.4%</td>
<td>2.2%</td>
<td>1.2%</td>
</tr>
<tr>
<td>% Connecting Passengers</td>
<td>39.6%</td>
<td>31.0%</td>
<td>17.0%</td>
</tr>
</tbody>
</table>
Finding #2

- **EWR, ORD, LGA, IAD, JFK and PHL are the worst transfer airports for connecting passengers in terms of average passenger delays. These are also the only 6 airports in the US where at least 10% of the connecting passengers get disrupted.**

<table>
<thead>
<tr>
<th></th>
<th>6 worst airports</th>
<th>Other airports</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Avg. Passenger Delay (min)</strong></td>
<td>78.5</td>
<td>45.6</td>
<td>32.9</td>
</tr>
<tr>
<td><strong>Avg. Due to Flight Delay (min)</strong></td>
<td>23.1</td>
<td>15.9</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Disrupted Passengers</strong></td>
<td>12.2%</td>
<td>6.9%</td>
<td>5.3%</td>
</tr>
</tbody>
</table>
Finding #3

- Average delay to disrupted nonstop passengers on routes with at least 10 daily flights per carrier is 30% lower than overall average; and on routes with at most 3 daily flights per carrier is 13% higher than the overall average
  - Overall avg. delay to disrupted nonstop passengers is 443.6 min
  - With daily nonstop frequency of at least 10 flights, it decreases to 304.1 min
  - With daily nonstop frequency of at most 3 flights, it increases to 511.5 min
Finding #4

- **Average evening passenger delay (37.8 min) is 86.8% greater than average morning passenger delay (20.3 min)**
  - Main reason is that the average evening flight delay (18.5 min) is 89.4% greater than average morning flight delay (9.8 min)
  - But fraction of disrupted passengers is only 18.9% greater in evening (3.52%) than in the morning (2.96%)
  - But greater ease of rebooking for morning passengers is evident as average delay to disrupted passengers in the evening (532.6 min) is 66.3% greater than that for morning passengers (320.3 min)
Finding #5

- **Southwest Airlines has the lowest average passenger delay, nearly 55% lower than its competitors, even though its average flight delay is only 36.3% lower. Primary reason is fewer disruptions.**
  - 1.0% cancellations as compared to 2.8% for other carriers
  - 0.4% missed connections as compared to 1.4% for other carriers
    ...because of,
    1) Fewer connecting passengers: 15.5% compared to 30.0% for other carriers
    2) Longer connections: 41.9% connections longer than 1.5 hours, compared to 36.1% for other carriers
Thank you. Questions?