Airport Costs, Capacity, and Metropolitan Economic Development

Pat McCarthy
School of Economics
Georgia Institute of Technology
Overview

- Question
- Relevant Literature
- Methodology
- Model Outputs
- Estimation Model and Variables
- Data
- Results
- Conclusions and Next Steps
Question

- Can we identify the economic development impact of additional airport runway capacity?
 Relevant Literature

- **Public Capital Studies**
  - Deno (1988) – mfg firm input demands
  - Duffy, Deno, and Eberts (1991) – per capita income
  - Lynde and Richmond (1992) – production costs in private sector
  - Morrison and Schwartz (1996) – mfg productivity

- **Airport Specific**
  - **Urban Development**
    - Goetz (1992) – air passenger flows and growth
    - Hakfoort et al. (2001) – employment
    - Brueckner (2003) – employment
  - **Infrastructure**
Methodology

- MSAs with one commercial (OEP) airport
- Airport short run operating costs
- Runways are quasi-fixed factor of production
- Cost minimizing behavior
- Focus on airport rather than social costs

\[ C_{it} = C(q_{it}, p_{itj} ; k_{it}, \tau) \]

- Estimate cost function and relate costs to MSA economic development
Model Outputs

- Economies of capital utilization
- Input demand elasticities
- Input substitution elasticities
- Average cost of output
- Marginal cost of output
Data

Sources

- Passengers – BTS*
- Operating Costs – CATS*
- Prices – QCEW*, BLS*
- Runways – NFDC*

* BTS – Bureau of Transportation Statistics; CATS – FAA’s Compliance Activity Tracking System; NFDC – National Flight Data Center; QCEW – Quarterly Census of Earnings and Wages; BLS – Bureau of Labor Statistics
### MSA Airport Output and Operating Costs ($)
**Panel of 35 Airports, 1996 - 2007**

<table>
<thead>
<tr>
<th>Group</th>
<th>Variable</th>
<th># Obs</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Sample</td>
<td>Contractual, Repair/Maintenance Costs $</td>
<td>420</td>
<td>27,802,392</td>
<td>23,466,241</td>
</tr>
<tr>
<td></td>
<td>General Airport Operations Costs</td>
<td>420</td>
<td>16,302,538</td>
<td>15,590,252</td>
</tr>
<tr>
<td></td>
<td>Operating Costs, Personnel compensation and benefits ($)</td>
<td>420</td>
<td>27,481,877</td>
<td>18,878,676</td>
</tr>
<tr>
<td></td>
<td>Operating Expenses, Total ($)</td>
<td>420</td>
<td>71,586,808</td>
<td>49,350,531</td>
</tr>
<tr>
<td></td>
<td>Passengers</td>
<td>420</td>
<td>9,069,000</td>
<td>6,567,000</td>
</tr>
<tr>
<td>Over Airports</td>
<td>Contractual, Repair/Maintenance Costs $</td>
<td>12</td>
<td>27,802,392</td>
<td>51,661,244</td>
</tr>
<tr>
<td></td>
<td>General Airport Operations Costs</td>
<td>12</td>
<td>16,302,538</td>
<td>9,722,917</td>
</tr>
<tr>
<td></td>
<td>Operating Costs, Personnel compensation and benefits ($)</td>
<td>12</td>
<td>27,481,877</td>
<td>38,780,191</td>
</tr>
<tr>
<td></td>
<td>Operating Expenses, Total ($)</td>
<td>12</td>
<td>71,586,808</td>
<td>95,975,873</td>
</tr>
<tr>
<td></td>
<td>Passengers</td>
<td>12</td>
<td>9,069,000</td>
<td>4,198,000</td>
</tr>
<tr>
<td>Over Years</td>
<td>Contractual, Repair/Maintenance Costs $</td>
<td>35</td>
<td>27,802,392</td>
<td>70,547,339</td>
</tr>
<tr>
<td></td>
<td>General Airport Operations Costs</td>
<td>35</td>
<td>16,302,538</td>
<td>45,826,112</td>
</tr>
<tr>
<td></td>
<td>Operating Costs, Personnel compensation and benefits ($)</td>
<td>35</td>
<td>27,481,877</td>
<td>60,614,206</td>
</tr>
<tr>
<td></td>
<td>Operating Expenses, Total ($)</td>
<td>35</td>
<td>71,586,808</td>
<td>155,802,680</td>
</tr>
<tr>
<td></td>
<td>Passengers</td>
<td>35</td>
<td>9,069,000</td>
<td>22,531,000</td>
</tr>
</tbody>
</table>

Variation greater over years than over airports
## Data

**Input Price Indices (1996 = 100)**

*Panel of 35 Airports, 1996 - 2007*

<table>
<thead>
<tr>
<th>Group</th>
<th>Variable</th>
<th># Obs</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Sample</td>
<td>Price Index, Contractual, Repair/Maintenance</td>
<td>420</td>
<td>128.905</td>
<td>25.321</td>
</tr>
<tr>
<td></td>
<td>Price Index, Airport Operations</td>
<td>420</td>
<td>139.745</td>
<td>27.975</td>
</tr>
<tr>
<td></td>
<td>Price Index, Personnel</td>
<td>420</td>
<td>126.787</td>
<td>16.881</td>
</tr>
<tr>
<td>Over Airports</td>
<td>Price Index, Contractual, Repair/Maintenance</td>
<td>12</td>
<td>128.905</td>
<td>155.898</td>
</tr>
<tr>
<td></td>
<td>Price Index, Airport Operations</td>
<td>12</td>
<td>139.745</td>
<td>172.248</td>
</tr>
<tr>
<td></td>
<td>Price Index, Personnel</td>
<td>12</td>
<td>126.787</td>
<td>98.017</td>
</tr>
<tr>
<td>Over Years</td>
<td>Price Index, Contractual, Repair/Maintenance</td>
<td>35</td>
<td>128.905</td>
<td>4.841</td>
</tr>
<tr>
<td></td>
<td>Price Index, Airport Operations</td>
<td>35</td>
<td>139.745</td>
<td>5.329</td>
</tr>
<tr>
<td></td>
<td>Price Index, Personnel</td>
<td>35</td>
<td>126.787</td>
<td>12.920</td>
</tr>
</tbody>
</table>

Variation greater over airports than over years
Results

1. Cost Elasticity 0.37

2. Economies of Runway Utilization 2.48

3. Input Demand Elasticities

<table>
<thead>
<tr>
<th></th>
<th>( \eta_{ll} )</th>
<th>( \eta_{le} )</th>
<th>( \eta_{ee} )</th>
<th>( \eta_{lm} )</th>
<th>( \eta_{em} )</th>
<th>( \eta_{mm} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \eta_{ll} )</td>
<td>-0.825</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \eta_{le} )</td>
<td>0.956</td>
<td></td>
<td>-3.722</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \eta_{lm} )</td>
<td>-0.131</td>
<td></td>
<td></td>
<td>1.977</td>
<td></td>
<td>-1.027</td>
</tr>
</tbody>
</table>

4. Morishima Elasticities of Substitution

<table>
<thead>
<tr>
<th></th>
<th>( \sigma_{ll} )</th>
<th>( \sigma_{el} )</th>
<th>( \sigma_{ml} )</th>
<th>( \sigma_{ee} )</th>
<th>( \sigma_{me} )</th>
<th>( \sigma_{mm} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma_{ll} )</td>
<td>-</td>
<td>2.570</td>
<td>0.683</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \sigma_{le} )</td>
<td>4.678</td>
<td></td>
<td></td>
<td></td>
<td>4.891</td>
<td></td>
</tr>
<tr>
<td>( \sigma_{lm} )</td>
<td>0.897</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Author’s Calculations. l – Personnel; e – General Airport Operations; m – Contractual and Repair/Maintenance.

\( \eta_{ij} \) – Elasticity of input l with respect to a change in the price of input j.

\( \sigma_{ij} \) – Elasticity of substitution between inputs i and j due to a change in the factor price ratio.
## Results

- \( MC < AC \)

### Average and Marginal Cost

$ Million per million passengers

<table>
<thead>
<tr>
<th></th>
<th>Average Cost</th>
<th>Marginal Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Sample</td>
<td>8.634</td>
<td>3.166</td>
</tr>
<tr>
<td>Large Hubs</td>
<td>9.695</td>
<td>3.557</td>
</tr>
<tr>
<td>Medium Hubs</td>
<td>7.740</td>
<td>2.834</td>
</tr>
</tbody>
</table>
### Results

#### AC and MC by Airport

Large hubs more efficient than small hubs

<table>
<thead>
<tr>
<th>Airport</th>
<th>Average Cost (per million)</th>
<th>Average Cost (per pax)</th>
<th>PAX Marginal Cost (millions)</th>
<th>Marginal Cost (per million)</th>
<th>Marginal Cost (per pax)</th>
<th>Per Runway Marginal Cost (per pax)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Large Hubs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pittsburgh International, PIT</td>
<td>9.47</td>
<td>1.46 **</td>
<td>7.43</td>
<td>3.48</td>
<td>0.54</td>
<td>0.13 #</td>
</tr>
<tr>
<td>San Diego International, SAN</td>
<td>4.08</td>
<td>0.53</td>
<td>7.73</td>
<td>1.50</td>
<td>0.19 *</td>
<td>0.19 #</td>
</tr>
<tr>
<td>Tampa International, TPA</td>
<td>7.47</td>
<td>0.97</td>
<td>7.75</td>
<td>2.74</td>
<td>0.36</td>
<td>0.12</td>
</tr>
<tr>
<td>Honolulu International, HNL</td>
<td>8.33</td>
<td>1.06</td>
<td>7.89</td>
<td>3.06</td>
<td>0.39</td>
<td>0.06</td>
</tr>
<tr>
<td>Cincinnati/Northern Kentucky, CVG</td>
<td>6.77</td>
<td>0.80</td>
<td>8.69</td>
<td>2.47</td>
<td>0.29</td>
<td>0.09</td>
</tr>
<tr>
<td>Baltimore-Washington International, BWI</td>
<td>6.56</td>
<td>0.75</td>
<td>8.96</td>
<td>2.41</td>
<td>0.28</td>
<td>0.07</td>
</tr>
<tr>
<td>Salt Lake City International, SLC</td>
<td>7.23</td>
<td>0.77</td>
<td>9.41</td>
<td>2.65</td>
<td>0.28</td>
<td>0.07</td>
</tr>
<tr>
<td>General Edward Lawrence Logan, BOS</td>
<td>17.01</td>
<td>1.63 **</td>
<td>10.47</td>
<td>6.24</td>
<td>0.60</td>
<td>0.12</td>
</tr>
<tr>
<td>Philadelphia International, PHL</td>
<td>8.30</td>
<td>0.77</td>
<td>10.96</td>
<td>3.04</td>
<td>0.28</td>
<td>0.08</td>
</tr>
<tr>
<td>Charlotte/Douglas International, CLT</td>
<td>2.34</td>
<td>0.21 *</td>
<td>11.45</td>
<td>0.86</td>
<td>0.08 *</td>
<td>0.03</td>
</tr>
<tr>
<td>Lambert-St. Louis International, STL</td>
<td>8.19</td>
<td>0.89</td>
<td>11.63</td>
<td>2.99</td>
<td>0.32</td>
<td>0.06</td>
</tr>
<tr>
<td>Seattle-Tacoma International, SEA</td>
<td>11.48</td>
<td>0.89</td>
<td>12.79</td>
<td>4.21</td>
<td>0.33</td>
<td>0.16</td>
</tr>
<tr>
<td>Orlando International, MCO</td>
<td>7.12</td>
<td>0.53</td>
<td>13.38</td>
<td>2.61</td>
<td>0.20 *</td>
<td>0.06</td>
</tr>
<tr>
<td>Detroit Metro Wayne, DTW</td>
<td>7.94</td>
<td>0.54</td>
<td>14.68</td>
<td>2.91</td>
<td>0.20 *</td>
<td>0.06</td>
</tr>
<tr>
<td>Minneapolis-St.Paul International, MSP</td>
<td>8.78</td>
<td>0.60</td>
<td>14.68</td>
<td>3.22</td>
<td>0.22 *</td>
<td>0.03</td>
</tr>
<tr>
<td>McCarran International, LAS</td>
<td>7.62</td>
<td>0.45</td>
<td>17.15</td>
<td>2.79</td>
<td>0.17</td>
<td>0.04</td>
</tr>
<tr>
<td>Phoenix Sky Harbor International, PHX</td>
<td>4.90</td>
<td>0.27</td>
<td>18.18</td>
<td>1.80</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Denver International, DEN</td>
<td>10.60</td>
<td>0.58</td>
<td>18.37</td>
<td>3.89</td>
<td>0.21</td>
<td>0.04</td>
</tr>
<tr>
<td>Hartsfield-Jackson Atlanta International, ATL</td>
<td>2.85</td>
<td>0.08 *</td>
<td>35.56</td>
<td>1.05</td>
<td>0.03 *</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Medium Hubs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacksonville International, JAX</td>
<td>1.76</td>
<td>4.79 **</td>
<td>2.57</td>
<td>4.44</td>
<td>1.76 **</td>
<td>0.88 #</td>
</tr>
<tr>
<td>Southwest Florida International, RSW</td>
<td>2.10</td>
<td>5.72 **</td>
<td>2.76</td>
<td>5.52</td>
<td>2.10 **</td>
<td>2.10 #</td>
</tr>
<tr>
<td>General Mitchell International, MKE</td>
<td>1.24</td>
<td>3.37 **</td>
<td>2.95</td>
<td>3.59</td>
<td>1.24 **</td>
<td>0.25</td>
</tr>
<tr>
<td>Port Columbus International, CMH</td>
<td>1.61</td>
<td>4.38 **</td>
<td>3.25</td>
<td>5.18</td>
<td>1.61 **</td>
<td>0.80 #</td>
</tr>
<tr>
<td>Albuquerque International, ABQ</td>
<td>0.91</td>
<td>2.48 **</td>
<td>3.44</td>
<td>3.12</td>
<td>0.91</td>
<td>0.23</td>
</tr>
<tr>
<td>Austin-Bergstrom International, AUS</td>
<td>0.93</td>
<td>2.53 **</td>
<td>3.60</td>
<td>3.34</td>
<td>0.93</td>
<td>0.46 #</td>
</tr>
<tr>
<td>Indianapolis International, IND</td>
<td>1.47</td>
<td>4.01 **</td>
<td>3.75</td>
<td>5.52</td>
<td>1.47 **</td>
<td>0.49 #</td>
</tr>
<tr>
<td>Raleigh-Durham International, RDU</td>
<td>0.61</td>
<td>1.67 **</td>
<td>4.09</td>
<td>2.46</td>
<td>0.61</td>
<td>0.20</td>
</tr>
<tr>
<td>Sacramento Metro, SMF</td>
<td>0.95</td>
<td>2.60 **</td>
<td>4.30</td>
<td>4.05</td>
<td>0.95</td>
<td>0.48 #</td>
</tr>
<tr>
<td>New Orleans International, MSY</td>
<td>0.49</td>
<td>1.34 **</td>
<td>4.58</td>
<td>2.13</td>
<td>0.49</td>
<td>0.16</td>
</tr>
<tr>
<td>Nashville International, BNA</td>
<td>0.67</td>
<td>1.82 **</td>
<td>4.62</td>
<td>3.09</td>
<td>0.67</td>
<td>0.17</td>
</tr>
<tr>
<td>Memphis International, MEM</td>
<td>0.60</td>
<td>1.63 **</td>
<td>4.88</td>
<td>2.91</td>
<td>0.60</td>
<td>0.15</td>
</tr>
<tr>
<td>Cleveland-Hopkins International, CLE</td>
<td>0.59</td>
<td>1.62 **</td>
<td>5.46</td>
<td>3.21</td>
<td>0.59</td>
<td>0.13</td>
</tr>
<tr>
<td>Kansas City, International, MCI</td>
<td>0.51</td>
<td>1.40 **</td>
<td>5.87</td>
<td>2.99</td>
<td>0.51</td>
<td>0.17</td>
</tr>
<tr>
<td>Portland International, PDX</td>
<td>0.49</td>
<td>1.34 **</td>
<td>6.39</td>
<td>3.15</td>
<td>0.49</td>
<td>0.16</td>
</tr>
<tr>
<td>San Antonio International, SAT</td>
<td>0.29</td>
<td>0.78</td>
<td>7.73</td>
<td>2.22</td>
<td>0.29</td>
<td>0.10</td>
</tr>
</tbody>
</table>
# Results

- How does ATL compare with other large hub airports?

<table>
<thead>
<tr>
<th></th>
<th>Atlanta</th>
<th>Other Large Hubs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost Function Related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Elasticity</td>
<td>0.367</td>
<td>0.367</td>
</tr>
<tr>
<td>Additional Runway</td>
<td>-1.04%</td>
<td>0.12%</td>
</tr>
<tr>
<td>Average Cost per Passenger</td>
<td>0.080</td>
<td>0.762</td>
</tr>
<tr>
<td>Marginal Cost per Passenger</td>
<td>0.029</td>
<td>0.279</td>
</tr>
<tr>
<td>September 11, 2001 Attack</td>
<td>23%</td>
<td>5%</td>
</tr>
</tbody>
</table>
## Results

### Marginal Airport Cost and MSA Economic Development

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Metropolitan Employment</th>
<th>Number of Establishments</th>
<th>Real Gross Metropolitan Product</th>
<th>Real Gross State Product</th>
<th>Real Per Capita Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Marginal Cost</td>
<td>-0.275</td>
<td>-0.241</td>
<td>-0.261</td>
<td>-0.167</td>
<td>-0.004</td>
</tr>
<tr>
<td>(p-value)</td>
<td>(&lt; 0.0001)</td>
<td>(&lt; 0.0001)</td>
<td>(&lt; 0.0001)</td>
<td>(&lt; 0.0001)</td>
<td>(0.863)</td>
</tr>
<tr>
<td>911 × Atlanta</td>
<td>0.066</td>
<td>0.087</td>
<td>na</td>
<td>0.023</td>
<td>-0.058</td>
</tr>
<tr>
<td>(p-value)</td>
<td>(0.008)</td>
<td>(&lt; 0.0001)</td>
<td>-</td>
<td>(0.382)</td>
<td>(0.017)</td>
</tr>
</tbody>
</table>

Author’s Calculations. * All results except Real Gross Metropolitan Product (Real GMP) are based on a panel of 35 large and medium hubs, 1996 – 2007. Real GMP data are only available for 2001 – 2007. All models contain 34 fixed effects (Tampa International Airport is the reference airport) and 11 (6 for the Real GMP model) time effects (2007 is the reference year).
Conclusions

- Airport production technology
  - Homothetic and homogeneous
  - Increasing returns to capital utilization (i.e. runways)
  - Inelastic (elastic, unit elastic) demand for labor (general operations and maintenance/repair)
  - General operations substitutable for labor and maintenance/repair
Conclusions

- **Airport costs**
  - MC < AC over the sample
  - AC and MC per passenger smaller for large hubs
  - 911 terrorist attacks – ↑ airport operating costs 5% for the sample, 23% for ATL
  - **Scale matters** – ATL dominates the sample in terms of throughput, implying
    - Significantly lower AC and MC
    - Reduction in operating costs from additional runway in comparison with sample
Conclusions

- **Economic Development**
  - Analysis *establishes a link* between airport costs and economic development
  - 1% reduction in real airport costs
    - ↑ metropolitan employment 0.25%
    - ↑ # of metropolitan establishments 0.25%
    - ↑ gross state product 0.16%
    - Negative but insignificant impact on per capita income

**Consistent with Brueckner**
Next Steps

- Include multi-airport MSAs and small hubs
- Explore economies of scope with freight shipments
- Improve measures of runway capacity
- Incorporate airport heterogeneity (e.g. retail activities, car rental facilities)
- Model demand and cost together
Questions?