ACCHANGE

Building economic models for understanding ATC performance

Sesar Innovation Days
25 November 2014
Introduction

- ACCHANGE project
  - Can change within ATM cannot come from within the sector
  - Today:
    - Very much top down regulated
    - Implementation different policies have not (yet) met expectations

- This paper (based on D4.1)
  - What about the regulatory framework for ANSPs?
    - How does the regulatory framework look like and what are key variables?
    - What incentives does this give to ANSPs for efficiency and quality of services?
  - Using a regulatory economics framework
    - Based on public utility model of Laffont & Tirole
    - Evaluate efficiency
    - Evaluate capacity

- Full report will be available on website
  http://www.tmleuven.be/project/acchange/home.htm
Outline presentation

• Introduction
• Economic agents and their objectives
• Theoretical framework
  – Cost and information
  – Performance regulation
• Theoretical analysis
• Numerical illustrations
• Union bargaining model
• Conclusions
Economic agents and objectives

- Air navigation service providers
  - Attach value to the revenues of their customers: airports, airlines, passengers: $\gamma_1^{ANSP}$
    - Many ANSPs have representatives of airports and airlines in their boards
    - Many ANSPs are more or less controlled by their national governments
      - Governments put value on profits/employment at airports and national flag carriers
  - Attach value to their own revenues: $\gamma_2^{ANSP}$
    - They need to be able to recover their costs
    - Profits can be used to reinvest
    - Since performance regulation building up some reserves is not unrealistic
  - Attach value to national interests: $\gamma_3^{ANSP}$
    - Labour interest represented by unions
    - Other national interests such as sovereignty, manufacturers benefits, etc.
Economic agents and objectives

• Regulators
  – EC sets regulatory framework in collaboration with Eurocontrol
  – National supervisory authorities implement performance regulation
  – Not the focus of this presentation, more developed in paper
Theoretical framework: cost and information

- Cost per flight depends on ANS capacity
  - Inefficiency: Potential for efficiency improvement
  - Efficiency and effort to improve efficiency by ANSP management imperfectly observable

\[ c = a + \theta - e \]

\[ c(cap, e) = \frac{Cost(cap) + Other cost}{flightkm} + \theta - e \]

- Efficiency effort is costly

\[ \frac{Cost(e)}{flightkm} = \frac{\phi \cdot e^2}{2} \]
Theoretical framework: Performance regulation

- Goal is to provide efficiency incentives
  - Perfect information: \( e^* = 1/\emptyset \)
  - Rate of return regulation (cost+):
    \[
    ans_{\text{cost}+} = \frac{\text{Tot Cost}}{\text{flightkm}}
    \]
  - Price-cap regulation (based on determined costs principle):
    \[
    ans_{\text{cap}} = \frac{E(\text{Tot Cost})}{E(\text{flightkm})}
    \]
  - Adding financial incentive for outperforming performance targets
    - Reduce incentives to cut back on capacity (could increase delays)
      \[
      -(\text{del}(\text{cap}) - \text{del}_0) \cdot \text{BM} \cdot \frac{\text{flight}}{\text{flightkm}}
      \]
Theoretical framework: Performance regulation

- Current regulation
  - Mixed regulation

\[
\text{ansp}_{\text{charge}} = (1 - B) \cdot \text{ansp}_{\text{cap}} + B \cdot \text{ansp}_{\text{cost}} + (\text{del}(\text{cap}) - \text{del}_0) \cdot BM \cdot \frac{\text{flight}}{\text{flight km}}
\]

Power of the price-cap \( B \)

Strength of financial incentive for reaching performance target \( BM \)

Strength of performance monitoring \( BM \)
Theoretical analysis

• Effect of performance regulation on ANSP efficiency incentives

\[ e^* = \frac{\gamma_2^{ANSP} + B \cdot (\gamma_1^{ANSP} - \gamma_2^{ANSP})}{(\gamma_2^{ANSP} + \gamma_3^{ANSP}) \cdot \phi} \]

• Pure price-cap (B=0):

\[ e^* = \frac{\gamma_2^{ANSP}}{(\gamma_2^{ANSP} + \gamma_3^{ANSP}) \cdot \phi} \]

• Cost+ (B=):

\[ e^* = \frac{\gamma_1^{ANSP}}{(\gamma_2^{ANSP} + \gamma_3^{ANSP}) \cdot \phi} \]
Theoretical analysis

- Effect of performance regulation on service quality
  - Focus on capacity and link with delays

\[
del(cap) = \frac{\text{Tot delay cost}}{\text{flights}} = \frac{\delta}{\text{cap}}
\]

\[
pass(cap) = \frac{p_{\text{max}} - p_{\text{user}}(cap)}{\text{coef}}
\]
Theoretical analysis

• Case with no performance monitoring and no financial incentives (BM=0)
  o Cost+ approach:
    \[- \frac{\partial del}{\partial cap^*} = \frac{\partial a}{\partial cap^*} \cdot \frac{\text{flightkm}}{\text{flight}}\]

  o Price-cap approach: incentives to reduce capacity
    \[- \frac{\partial del}{\partial cap^*} \cdot \gamma_1^{\text{ANSP}} = \frac{\partial a}{\partial cap^*} \cdot \frac{\text{flightkm}}{\text{flight}}\]

  o ‘Traffic risk’: lower capacity reduction incentives, but depends on strength of demand response
    \[- \frac{\partial del}{\partial cap^*} \cdot \gamma_1^{\text{ANSP}} + \frac{\text{pass}^{(\text{cap})}}{\text{pass}(\text{cap})} \cdot TR \cdot (\text{profit & CS}) = \frac{\partial a}{\partial cap^*} \cdot \frac{\text{flightkm}}{\text{flight}}\]
Theoretical analysis

- Introduction of performance incentives (BM>0)
  - Optimal capacity condition in price-cap approach:
    \[- \frac{\partial del}{\partial cap^*} \cdot (\gamma_1^{ANS} \cdot (1 - BM) + BM) = \frac{\partial a}{\partial cap^*} \cdot \frac{flightkm}{flight}\]
  - Equivalent or better compared to cost+ approach if:
    \[(\gamma_1^{ANS} \cdot (1 - BM) + BM) > 1\]
  - Or if:
    \[BM > 1\]
Numerical illustrations - efficiency

- Take $\gamma_1^{ANSP} = 0.5$ and $\gamma_2^{ANSP} = 1$
- Example for centralized services: theoretical potential of 2.5% reduction in ANS costs in EU

<table>
<thead>
<tr>
<th>$\gamma_3$</th>
<th>B</th>
<th>1</th>
<th>0.8</th>
<th>0.6</th>
<th>0.4</th>
<th>0.2</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.25%</td>
<td>1.5%</td>
<td>1.75%</td>
<td>2%</td>
<td>2.25%</td>
<td>2.5%</td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>1.14%</td>
<td>1.36%</td>
<td>1.59%</td>
<td>1.82%</td>
<td>2.04%</td>
<td>2.27%</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>1.04%</td>
<td>1.25%</td>
<td>1.46%</td>
<td>1.67%</td>
<td>1.87%</td>
<td>2.08%</td>
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<tr>
<td>0.3</td>
<td>0.96%</td>
<td>1.15%</td>
<td>1.35%</td>
<td>1.54%</td>
<td>1.73%</td>
<td>1.92%</td>
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<tr>
<td>0.4</td>
<td>0.89%</td>
<td>1.07%</td>
<td>1.25%</td>
<td>1.43%</td>
<td>1.6%</td>
<td>1.78%</td>
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<tr>
<td>0.5</td>
<td>0.83%</td>
<td>1%</td>
<td>1.17%</td>
<td>1.33%</td>
<td>1.5%</td>
<td>1.67%</td>
<td></td>
</tr>
</tbody>
</table>
Numerical illustrations - capacity

- Data for EU wide ANSP performance (ACE reports, average values 2004-2011)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost/minute delay</td>
<td>83 €/min</td>
<td>University of Westminster, delay cost</td>
</tr>
<tr>
<td>En-route ATFM delays</td>
<td>11.8M min</td>
<td>ATM cost-effectiveness benchmarking 2011</td>
</tr>
<tr>
<td>Delay cost</td>
<td>980 M€</td>
<td>Calculation</td>
</tr>
<tr>
<td>Flight hours</td>
<td>13.5 M</td>
<td>ATM cost-effectiveness benchmarking 2011</td>
</tr>
<tr>
<td>Average delay cost/flight</td>
<td>72 €/flight hour</td>
<td>Calculation</td>
</tr>
<tr>
<td>Estimated capacity level</td>
<td>1.15 flight hour/min</td>
<td>Calculation</td>
</tr>
</tbody>
</table>
Numerical illustrations - capacity

- More data from PRB & PRU reports

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity cost elasticity</td>
<td>0.7</td>
</tr>
<tr>
<td>Average kilometers/hour</td>
<td>646</td>
</tr>
<tr>
<td>Average #passengers per flight</td>
<td>102</td>
</tr>
<tr>
<td>Current ANS capacity cost</td>
<td>0.156 €/flightkm</td>
</tr>
<tr>
<td>Passenger demand elasticity</td>
<td>-2.8%</td>
</tr>
</tbody>
</table>
Numerical illustrations - capacity

- Results with no monitoring of capacity performance target

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cost+ approach</th>
<th>Price-cap approach</th>
<th>Price-cap with traffic risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (flighthours/min)</td>
<td>1.17</td>
<td>0.59</td>
<td>0.656</td>
</tr>
<tr>
<td>Delay cost per flight hour</td>
<td>71€</td>
<td>141€</td>
<td>127€</td>
</tr>
<tr>
<td>Delay per flight</td>
<td>1.25 min</td>
<td>2.49 min</td>
<td>2.24 min</td>
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</tbody>
</table>
Numerical illustrations - capacity

- Results with financial incentive for capacity performance target

<table>
<thead>
<tr>
<th>BM</th>
<th>0</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (flight hours/min)</td>
<td>0.59</td>
<td>0.88</td>
<td>1.17</td>
<td>1.47</td>
<td>1.76</td>
</tr>
<tr>
<td>Delay cost per flight hour</td>
<td>141 €</td>
<td>94 €</td>
<td>71 €</td>
<td>56 €</td>
<td>47 €</td>
</tr>
<tr>
<td>Delay per flight (min)</td>
<td>2.49</td>
<td>1.66</td>
<td>1.25</td>
<td>0.99</td>
<td>0.83</td>
</tr>
</tbody>
</table>
Union bargaining

• Introduce bargaining stage between ANSP (managers) and labour unions
• Possible explanation for variation in efficiency between ANSPs

\[(Goal\ ANSP)^\delta \cdot (W \cdot L - W^0 \cdot L^0)^{1-\delta}\]
**Union bargaining**

- Result: the labour interest are able to extract part of the ANSP benefit, depending on the relative bargaining powers $\delta$ & $1 - \delta$

\[
W \cdot L - W^0 \cdot L^0 =
\]

\[
\frac{1 - \delta}{\delta} \cdot \left( \frac{\gamma_1^{ANSP} \cdot (CS) + \gamma_2^{ANSP} \cdot (Profit)}{\gamma_1^{ANSP} \cdot B + \gamma_2^{ANSP} \cdot (1 - B)} \right)
\]
Union bargaining

• Numerical illustration (for $\gamma_1^{ANSP} = 0.5$)

<table>
<thead>
<tr>
<th>$B \delta$</th>
<th>0.95</th>
<th>0.96</th>
<th>0.97</th>
<th>0.98</th>
<th>0.99</th>
<th>1</th>
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<tbody>
<tr>
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<td>64 583</td>
<td>47 938</td>
<td>31 633</td>
<td>15 657</td>
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<tr>
<td>0.25</td>
<td>93 233</td>
<td>73 810</td>
<td>54 787</td>
<td>36 152</td>
<td>17 893</td>
<td>0</td>
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<tr>
<td>0.5</td>
<td>108 772</td>
<td>86 111</td>
<td>63 918</td>
<td>42 177</td>
<td>20 875</td>
<td>0</td>
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<tr>
<td>0.75</td>
<td>130 526</td>
<td>103 333</td>
<td>76 701</td>
<td>50 612</td>
<td>25 051</td>
<td>0</td>
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<tr>
<td>1</td>
<td>163 158</td>
<td>129 167</td>
<td>95 876</td>
<td>63 265</td>
<td>31 313</td>
<td>0</td>
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</tbody>
</table>
Conclusions

- Cost+ leads to excessive cost and over-investment in capital
  - Price-cap gives an incentive to improve efficiency of operations
  - May also give an incentive to cut back on capacity (quality of service)
    - ‘Traffic risk’ not very effective in incentivizing service quality
      - Low demand elasticity for air navigation services
    - Performance monitoring or financial incentives can improve incentive structure with respect to choice of capacity
  - Union bargaining provides alternative view on source of ‘inefficiency’ and also reduces the scope of price regulation in addressing them
    - Bargaining positions more important for efficiency improvement than performance regulation
Way forward

• Develop a simple network model to analyze interrelationships between various European ANSPs

• Analyze leverages for change in air navigation service provision
  – Collaboration (horizontal, vertical)
  – Technological implementation
Thank you!

Questions?

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