A Comparison Study of Scheduled Block Times in China and Europe

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ICNS
10-April-2018
Part 1
Introduction
Introduction

Motivation

- Traffic growth have been seen in civil aviation in both Europe and China. In 2016, the raise of number of flights was 2.4% in Europe and 7.89% in China.
- Traffic growth supports thriving economics. Enhancing air traffic performance while not impeding the traffic grow remains a great challenge.

Flight Scheduling

- Flight schedule design is a key function in airline business planning. It also plays a core role in determining air traffic demand.
- Good scheduling improves air traffic performance by influencing capacity-demand-balance.
Introduction

Scheduled Block Time (SBT)

- **Block time & scheduled block time**

  ![Diagram of block time and scheduled block time](image)

- **SBT is a lever that affects reliability and profitability.**
  It's a key component of an airline's operational and cost performance. It also points at the efficiency impact of air navigation.
Part 2
Methodology
Methodology

Study Approach

Original Database of China

Data Pre-Processing

Chinese Dataset for Modeling

Hub Airport Analysis

Multiple Regression Model

Chinese SBT Model

European Dataset for Modeling

European SBT Model

Coefficients Comparing

Differences in SBT Setting Behavior between CHN and EUR

Previous Results

Industry Practice
Methodology

SBT Modeling

• The SBT model for the study is based on literature and augmented for both, the Chinese and European, context.
• Multiple linear regression has been proved working well in SBT modeling in literature.

Data Preparation

• In Europe, the air traffic network was approximated by all flights between 40 main airports chosen based on the cumulative number of flights connections of OD pairs for 2014 through 2016. Approximately 5.08 million pieces of data were used for the fitting.
• In China, a dataset covering all flights from 2014 to 2016 was employed. After careful data cleaning, records of approximately 7.55 million flights were used in the modeling.
The work of this study was implemented in an open-source “eco-system”:

- Methodology
  - “Joint & Collaborative” Data Analysis – Reproducible Research

- The work of this study was implemented in an open-source “eco-system”:
  - Source data
  - Analytical data
  - Analysis, model
  - Results & visualisations
  - R/Rstudio
  - Rmarkdown, knitr
  - Git/github
  - Tidyverse “packages”
China and Europe show similarities in terms of their regional civil aviation systems, while the air traffic in Europe is approximately twice as high as the traffic in China.

<table>
<thead>
<tr>
<th>Year 2016</th>
<th>China</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airspace Area (10^6 km²)</td>
<td>10.8</td>
<td>11.5</td>
</tr>
<tr>
<td>Number of Air Traffic Controllers</td>
<td>8522</td>
<td>17370</td>
</tr>
<tr>
<td>Number of Flights (million)</td>
<td>4.96</td>
<td>10</td>
</tr>
<tr>
<td>Flight Density (flight hours p. km²)</td>
<td>0.71</td>
<td>1.3</td>
</tr>
<tr>
<td>Number of Airports</td>
<td>218</td>
<td>415</td>
</tr>
<tr>
<td>Data provider</td>
<td>ATMB</td>
<td>EUROCONTROL</td>
</tr>
</tbody>
</table>
China and Europe show similarities in terms of their regional civil aviation systems, while the air traffic in Europe is approximately twice as high as the traffic in China.
On the airport level there is a stronger difference between China and Europe in terms of air traffic characteristics and traffic concentration.
Part 4
Scheduled Block Time Modeling
## Model Description

- **Distribution of**

<table>
<thead>
<tr>
<th></th>
<th>ZBAA-ZSPD</th>
<th></th>
<th></th>
<th>EGLL-EDDF</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Departure Delay</td>
<td>Taxi-Out Time</td>
<td>En-Route Flying Time</td>
<td>Taxi-In Time</td>
<td>Departure Delay</td>
<td>Taxi-Out Time</td>
</tr>
<tr>
<td>Mean</td>
<td>32.511</td>
<td>23.051</td>
<td>105.906</td>
<td>7.561</td>
<td>10.587</td>
<td>20.146</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>2.436</td>
<td>1.254</td>
<td>0.100</td>
<td>0.836</td>
<td>2.120</td>
<td>0.330</td>
</tr>
</tbody>
</table>
Scheduled Block Time Model Components

- Basis: “historic” actual block time
  - taxi-out time
  - non-taxi-out time (elapsed time between actual take-off and actual in-block time)
  - departure delay

- Airport-pair characteristic (i.e. hub, non-hub)
- Aircraft type characteristic (i.e. wake vortex category)
- Flight characteristic – seasonal variation
- Temporal characteristic \(\rightarrow\) Great-circle distance
Scheduled Block Time Modeling

Model Description

- SBT Model

\[
SBT^{f,y} = \alpha_1 \times T0_{0.5} + \alpha_2 \times nonT0_{0.5} + \alpha_3 \times dep_{0.5} \\
+ \sum_{i=1}^{5} \beta_i \times dTO_{i+4,i+5} + \sum_{i=1}^{5} \gamma_i \times dnonT0_{i+4,i+5} + \sum_{i=1}^{5} \lambda_i \times ddep_{i+4,i+5} \\
+ \varepsilon_1 \times HUB_O + \varepsilon_2 \times HUB_D + \delta \times Vortex + \pi \times GCD + \mu \times Season \\
+ \text{const}
\]

- \text{XX}_{0.5} 50^{th} \text{ percentile}
  \text{XX}_{i+4,i+5} \text{ difference between adjacent 10^{th}-percentiles (characterisation of distribution)}
Scheduled Block Time Modeling

Hub Airport Analysis

- In the absence of a globally accepted definition of hub airport, this project studied a numerical approach to qualify hub characteristic.

- The ratio of non-regional connections to the total number of air services at an airport has been studied.
Scheduled Block Time Modeling – Model Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>China</th>
<th></th>
<th>Europe</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coefficient</td>
<td>p value</td>
<td>coefficient</td>
<td>p value</td>
</tr>
<tr>
<td>Intercept</td>
<td>13.6613</td>
<td>&lt; 0.0001</td>
<td>6.8292</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>TO0.5</td>
<td>0.1845</td>
<td>&lt; 0.0001</td>
<td>0.7420</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>nonTO0.5</td>
<td>0.5421</td>
<td>&lt; 0.0001</td>
<td>0.9258</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>dep0.5</td>
<td>0.0317</td>
<td>&lt; 0.0001</td>
<td>0.2092</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>dTO5,6</td>
<td>0.0823</td>
<td>&lt; 0.0001</td>
<td>0.4424</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>dTO6,7</td>
<td>0.0262</td>
<td>&lt; 0.0001</td>
<td>0.3120</td>
<td>&lt; 0.0001</td>
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<tr>
<td>dTO7,8</td>
<td>0.0267</td>
<td>&lt; 0.0001</td>
<td>0.1480</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>dTO8,9</td>
<td>-0.0235</td>
<td>&lt; 0.0001</td>
<td>-0.3926</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>dTO9,10</td>
<td>0.0008</td>
<td>&lt; 0.0001</td>
<td>0.0066</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>dnonTO5,6</td>
<td>0.4680</td>
<td>&lt; 0.0001</td>
<td>0.1140</td>
<td>&lt; 0.0001</td>
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<tr>
<td>dnonTO6,7</td>
<td>0.5017</td>
<td>&lt; 0.0001</td>
<td>0.2968</td>
<td>&lt; 0.0001</td>
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<tr>
<td>dnonTO7,8</td>
<td>0.4644</td>
<td>&lt; 0.0001</td>
<td>0.0749</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>dnonTO8,9</td>
<td>0.4805</td>
<td>&lt; 0.0001</td>
<td>0.2398</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>HUBO</td>
<td>7.7746</td>
<td>&lt; 0.0001</td>
<td>0.4528</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>HUBD</td>
<td>2.3286</td>
<td>&lt; 0.0001</td>
<td>0.5654</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Vortex</td>
<td>-0.2849</td>
<td>&lt; 0.0001</td>
<td>-1.2851</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>GCD</td>
<td>0.0362</td>
<td>&lt; 0.0001</td>
<td>0.0070</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Season</td>
<td>1.9948</td>
<td>&lt; 0.0001</td>
<td>0.7614</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>R²</td>
<td>0.8499</td>
<td></td>
<td>0.8268</td>
<td></td>
</tr>
</tbody>
</table>

ordinary least-square (OLS) method was used for the linear regression to estimate coefficients of fitting
Scheduled Block Time Modeling

Model Results

Coefficients of taxi-out (TO)

Coefficients of nonTO

Coefficients of departure delay
Part 5
Conclusions and Discussions
Conclusions and Discussions

- The SBT model shows a good fit for the Chinese (~85%) and European (~82%) context to model SBT setting behaviour in both regions.
  ➔ supports comparison and explanation of system similarities and differences

- Conceptually, higher flight phase times or delays should be positively related to the SBT. A variety of variable coefficients with a negative sign suggest that SBT decreases when the respective variable increases!
  ➔ This can lead to misleading interpretation of the results of the model fitting.

- The model is based on the literature. Both, the approach (multiple linear regression with OLS) and the identification of variables strongly influence the results.
  ➔ further research needed concerning
  • expressiveness of the model variables
  • linear correlation
  • level of aggregation of flight time phases

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Thank You!