Comparing Scheduled Block Time Setting in Europe and China Based on Multiple Linear Regression

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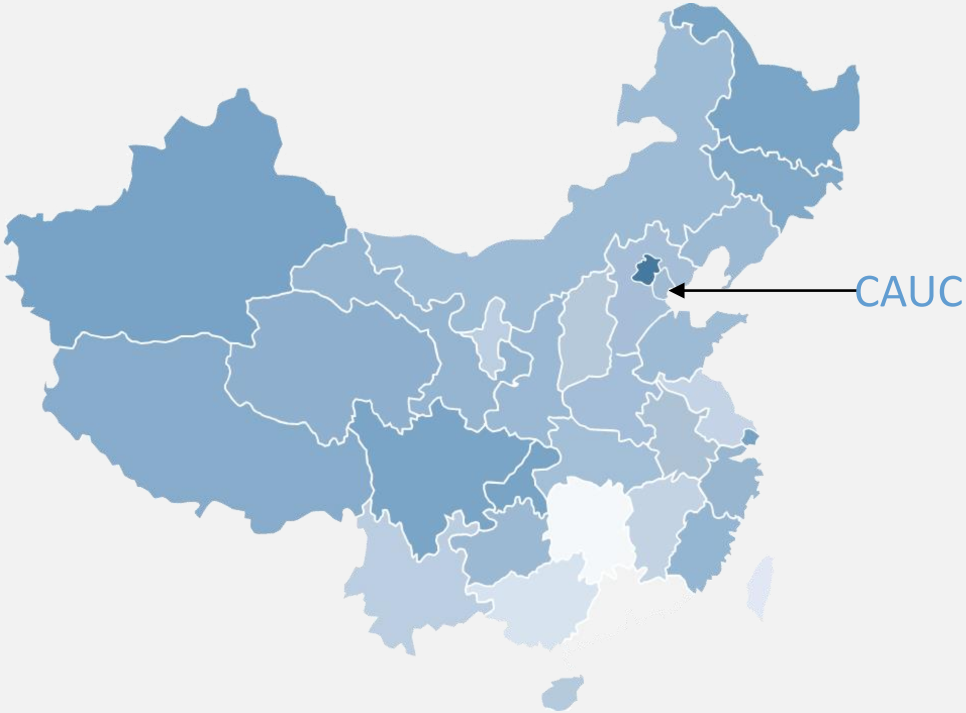
Where are we



1000+ Teachers

20,000+ Undergraduate Students

1200+ Graduate Students

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PART 01

Part 1
Introduction

Motivation

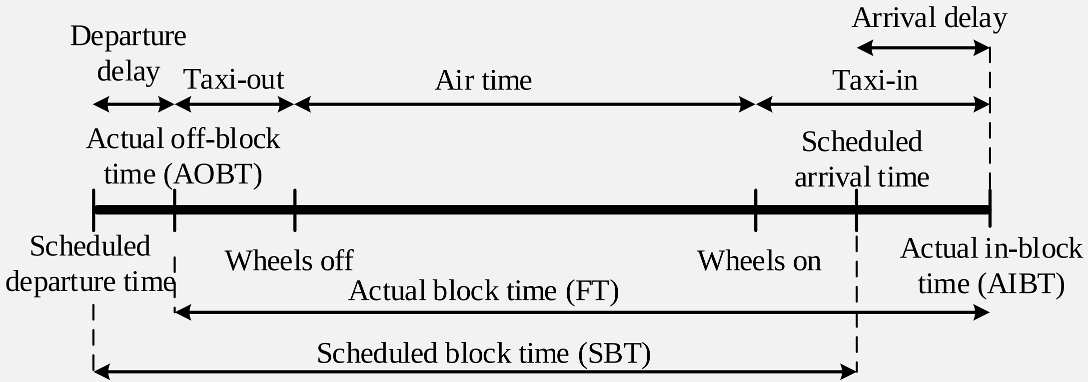
- Traffic growth have been seen in civil aviation in both Europe and China.
  In 2016, the raise of number of flights was 2.4% in Europe and 7.89% in China.
- Traffic growth supports thriving economics. Enhancing air traffic performance while not impeding the traffic growth remains a great challenge.

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.

Scheduled Block Time (SBT)

- **Block time & scheduled block time**



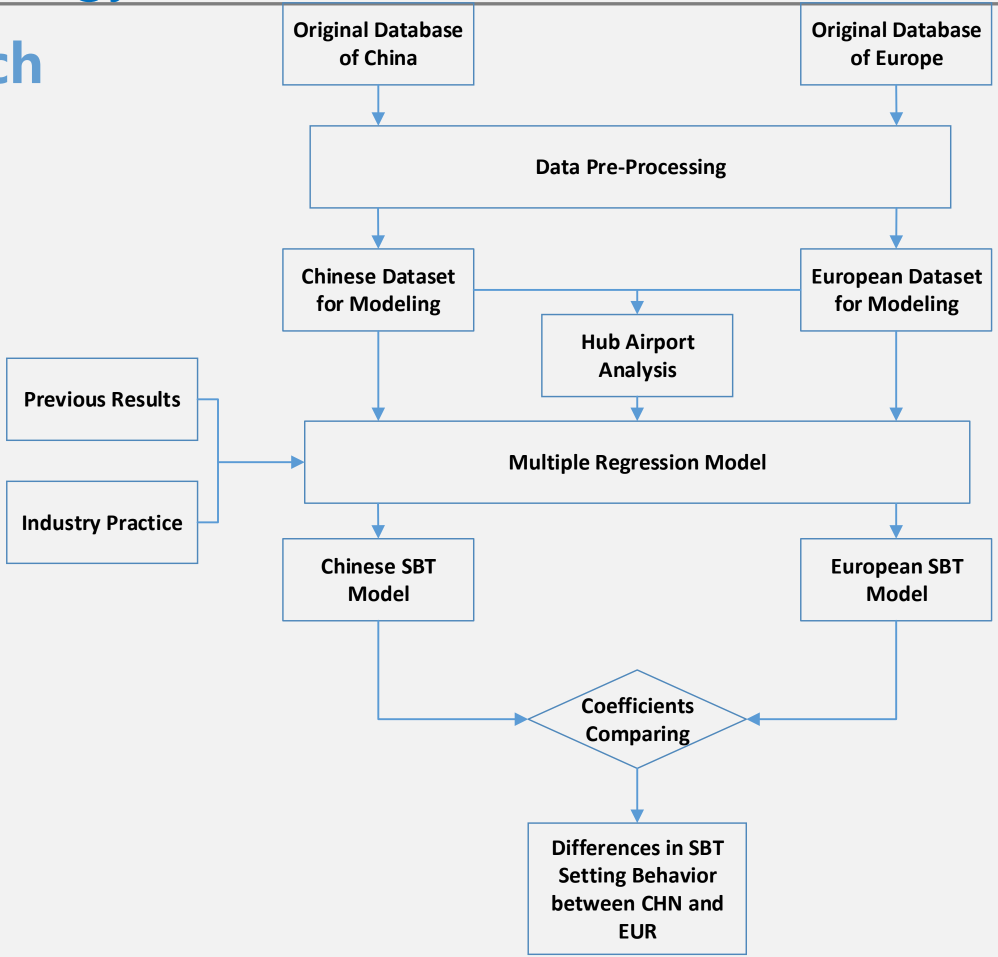
- **SBT is a lever that affects reliability and profitability.**
  It's a key component of an airline's operational and cost performance.
  It also points at the efficiency impact of air navigation.

PART 02

Part 2

Methodology

Study Approach



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.

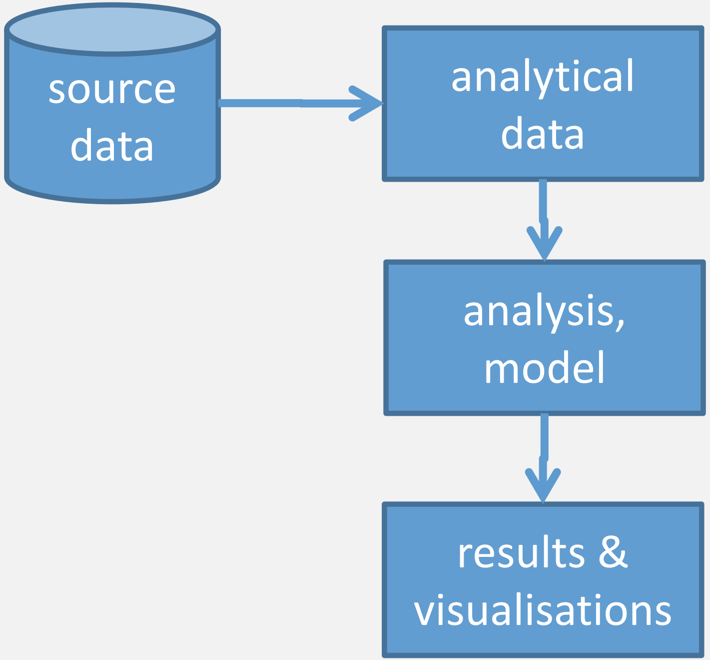
Data Preparation

- In Europe, the air traffic network was approximated by all flights between 20 main airports chosen based on the cumulative number of flights connections of OD pairs for 2014 through 2016. Approximately 2.55 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.

Methodology

"Joint & Collaborative" Data Analysis – Reproducible Research

- **The work of this study was implemented in an open-source "eco-system":**



R/Rstudio
Rmarkdown, knitr
Tidyverse "packages"

Git/Bitbucket

PART 03

Part 3
EUR/CHN System Specifications

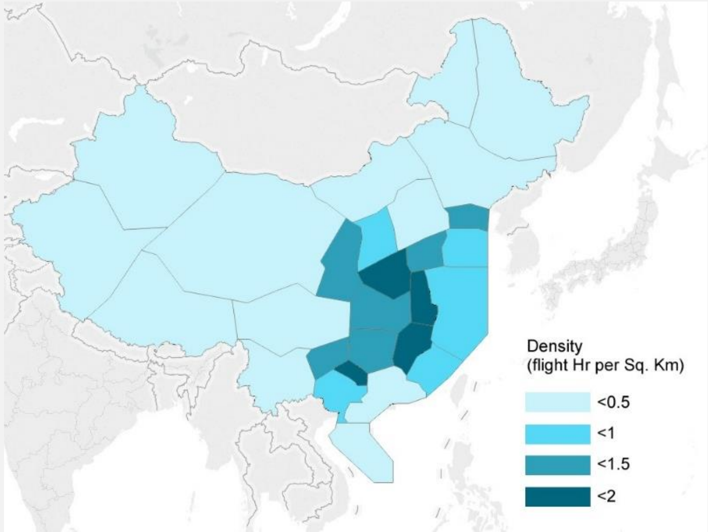
EUR/CHN System Specifications

- **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.**

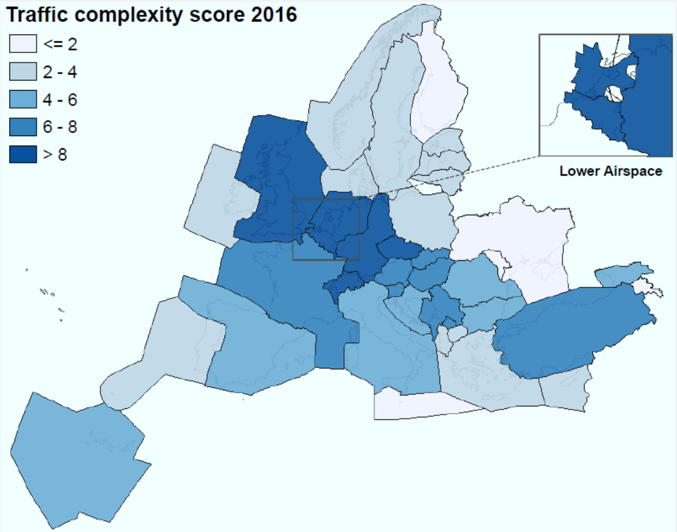
Year 2016	China	Europe
Airspace Area (10^6 km^2)	10.8	11.5
Number of Air Traffic Controllers	8522	17370
Number of Flights (million)	4.96	10
Flight Density (flight hours p. km^2)	0.71	1.3
Number of Airports	218	415
Data provider	ATMB	EUROCONTROL

EUR/CHN System Specifications

- **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.**



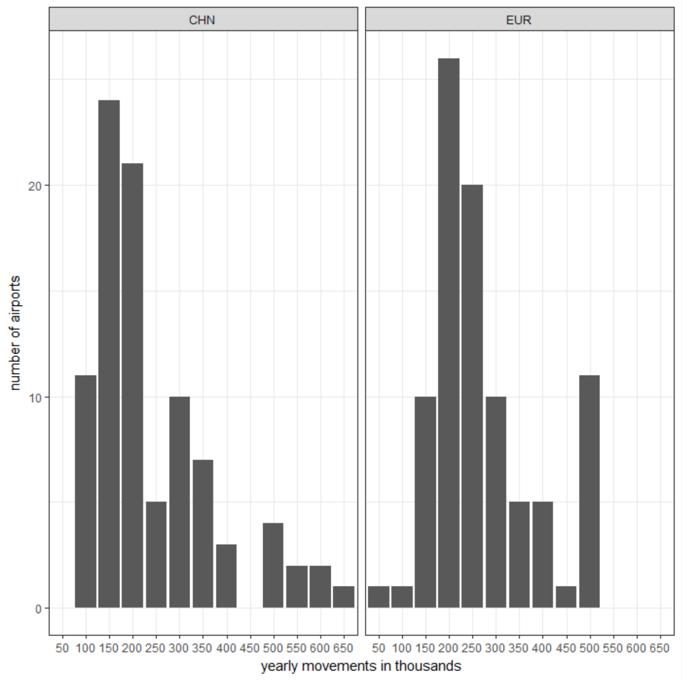
Distribution of traffic density in China

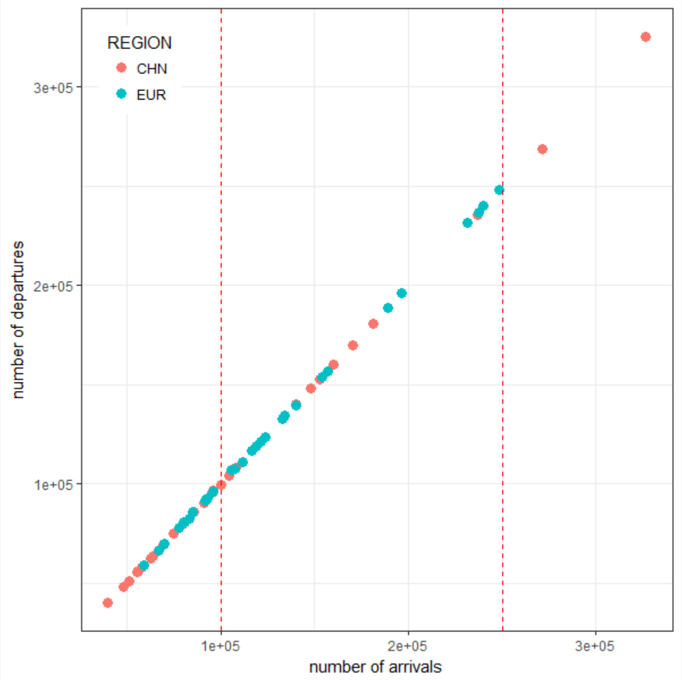


Distribution of traffic complexity score in Europe

EUR/CHN System Specifications

- **On the airport level there is a stronger difference between China and Europe in terms of air traffic characteristics and traffic concentration.**





PART 04

Part 4
Scheduled Block Time Modeling

Model Description

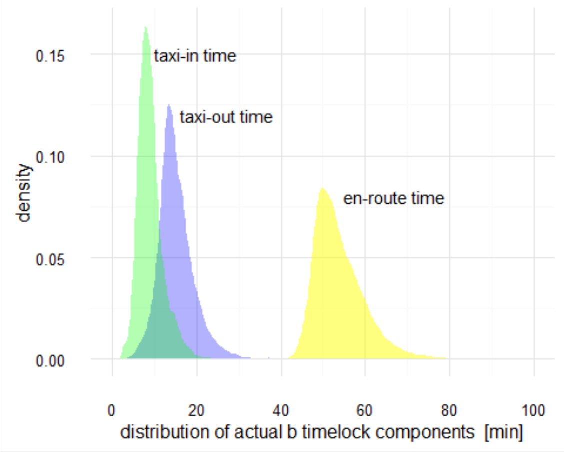
- **Distribution of difference phases of block times**

ZBAA-ZSPD	Departure Delay	Taxi-Out Time	En-Route Flying Time	Taxi-In Time
Mean	32.511	23.051	105.906	7.561
Standard Deviation	79.185	28.905	10.557	6.320
Coefficient of Variation	2.436	1.254	0.100	0.836

EGLL-EDDF	Departure Delay	Taxi-Out Time	En-Route Flying Time	Taxi-In Time
Mean	10.587	20.146	64.486	10.132
Standard Deviation	22.444	6.655	7.077	3.790
Coefficient of Variation	2.120	0.330	0.110	0.374

Scheduled Block Time Modeling

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)
- Temporal characteristic – seasonal variation
- Spacial characteristic → Great-circle distance

Model Description

- **SBT Model**

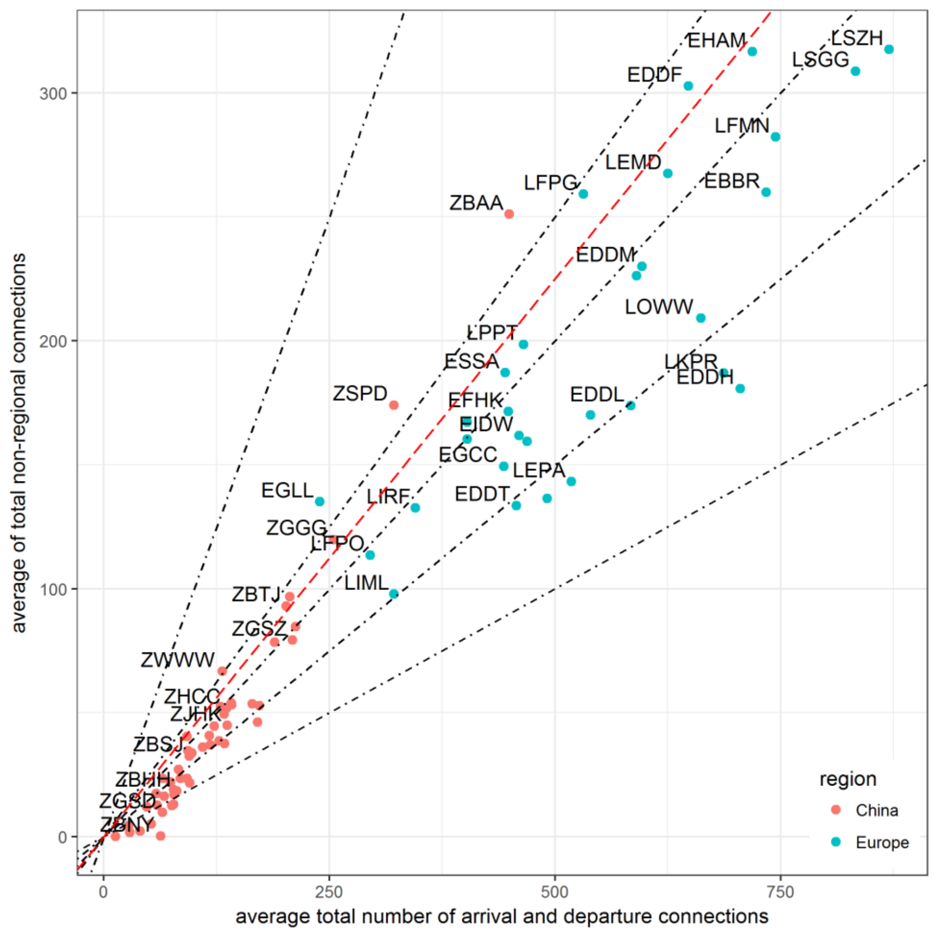
$$
\begin{aligned}
SBT^{f,y} = {} & \alpha_1 \times TO_{0.5} + \alpha_2 \times nonTO_{0.5} + \alpha_3 \times dep_{0.5} \\
& + \sum_{i=1}^{5} \beta_i \times dTO_{i+4,i+5} + \sum_{i=1}^{5} \gamma_i \times dnonTO_{i+4,i+5} + \sum_{i=i}^{5} \lambda_i \times ddep_{i+4,i+5} \\
& + \varepsilon_1 \times HUB_O + \varepsilon_2 \times HUB_D + \delta \times Vortex + \pi \times GCD + \mu \times Season \\
& + const
\end{aligned}
$$

- **$XX_{0.5}$ 50th percentile**
  $dXX_{i+4,i+5}$ difference between adjacent 10th-percentiles (characterisation of distribution)
  100th percentile replaced by 99.8th to remove the outliers in actual calculation

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

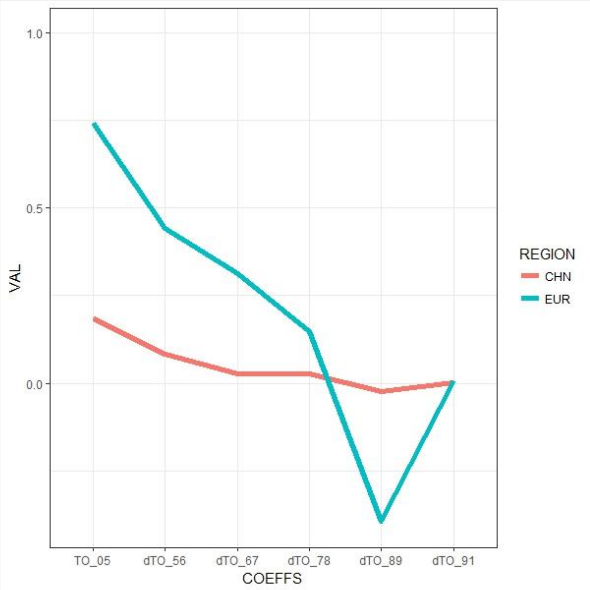
Variables	China		Europe	
	coefficient	p value	coefficient	p value
Intercept	13.6613	< 0.0001	6.8292	< 0.0001
$TO_{0.5}$	0.1845	< 0.0001	0.7420	< 0.0001
$nonTO_{0.5}$	0.5421	< 0.0001	0.9258	< 0.0001
$dep_{0.5}$	0.0317	< 0.0001	0.2092	< 0.0001
$dTO_{5,6}$	0.0823	< 0.0001	0.4424	< 0.0001
$dTO_{6,7}$	0.0262	< 0.0001	0.3120	< 0.0001
$dTO_{7,8}$	0.0267	< 0.0001	0.1480	< 0.0001
$dTO_{8,9}$	-0.0235	< 0.0001	-0.3926	< 0.0001
$dTO_{9,10}$	0.0008	< 0.0001	0.0066	< 0.0001
$dnonTO_{5,6}$	0.4680	< 0.0001	0.1140	< 0.0001
$dnonTO_{6,7}$	0.5017	< 0.0001	0.2968	< 0.0001
$dnonTO_{7,8}$	0.4644	< 0.0001	0.0749	< 0.0001
$dnonTO_{8,9}$	0.4805	< 0.0001	0.2398	< 0.0001

Variables	China		Europe	
	coefficient	p value	coefficient	p value
$dnonTO_{9,10}$	0.0430	< 0.0001	0.0004	< 0.0001
$ddep_{5,6}$	-0.0915	< 0.0001	-0.0722	< 0.0001
$ddep_{6,7}$	0.0055	0.0151	-0.0593	< 0.0001
$ddep_{7,8}$	-0.0097	< 0.0001	-0.1666	< 0.0001
$ddep_{8,9}$	0.0225	< 0.0001	0.0029	0.3900
$ddep_{9,10}$	0.0031	< 0.0001	0.0041	< 0.0001
HUB_O	7.7746	< 0.0001	0.4528	< 0.0001
HUB_D	2.3286	< 0.0001	0.5654	< 0.0001
Vortex	-0.2849	< 0.0001	-1.2851	< 0.0001
GCD	0.0362	< 0.0001	0.0070	< 0.0001
Season	1.9948	< 0.0001	0.7614	< 0.0001
R^2	0.8499		0.8268	

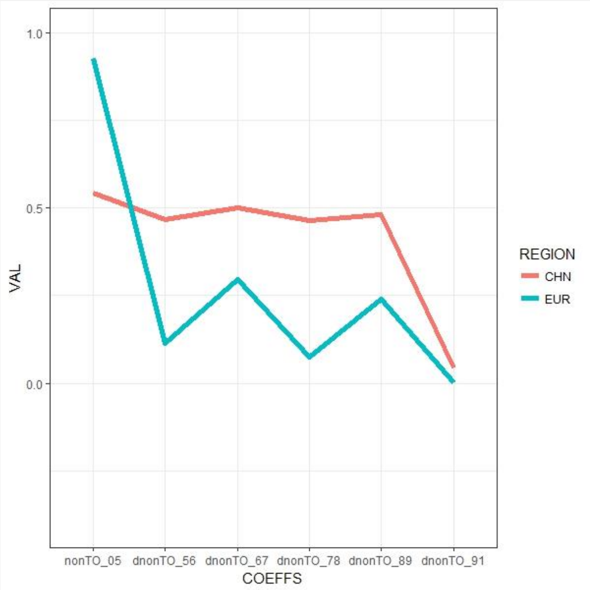
- **ordinary least-square (OLS) method was used for the linear regression to estimate coefficients of fitting**

Scheduled Block Time Modeling

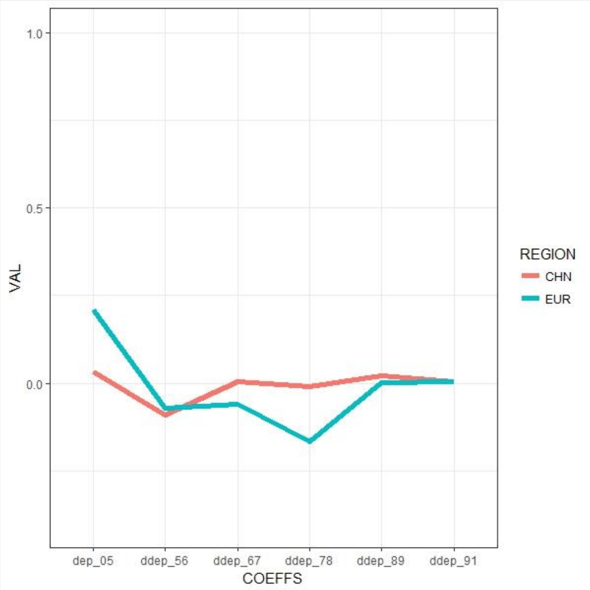
Model Results



Coefficients of taxi-out (TO)



Coefficients of nonTO



Coefficients of departure delay

PART 04

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.
- **Both the approach (multiple linear regression with OLS) and the identification of variables strongly influence the results.**
  ➔ further research is needed concerning
  - **expressiveness of the model variables**
  - **analysis of linear correlation**
- **Future work: analyzing the influence of the model on traffic demand and system performance by changing the value of coefficients.**

Thank You!