# China/Europe
## Comparison of Operational ANS Performance

CHINA EUROPE

中国民航 CAAC

EUROCONTROL

# China/Europe Comparison of Operational ANS Performance

CAAC and EUROCONTROL

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## Executive Summary

This report is a joint publication by the Civil Aviation Authority of China and the European Organisation for the Safety of Air Navigation. It represents the initial version of a regional ANS Performance comparison between China and Europe. The report was jointly developed by the Civil Aviation Authority of China, Civil Aviation University of China, Aviation Data Communication Corp., and the Performance Review Unit of EUROCONTROL.

The objective was to make a factual high-level comparison of operational air navigation system performance in China and Europe. The initial focus was to develop a set of comparable performance measures and harmonised data feeds in order to create a sound basis for factual high-level comparisons between both regions. The specific performance indicators are based on best practices from both groups and ICAO's Global Air Navigation Plan.

This report covers the period January 2019 through June 2021. Accordingly, the results also show the influence on operational performance caused by the unprecedented constraints on air transportation during the COVID pandemic.

The comparison shows similarities and differences in the air navigation service provision and observed performance in both regions:

- China's volume of continental airspace is about 84% of the European continental airspace. Traffic volumes in both regions differ. In 2019, the regional air traffic ranged with 5.81 million flights at approximately 53% of the European traffic of 11 million flights. Overall, the reduction of air transportation demand in 2020 was significantly milder in China with about 30% compared to the 55% reduction observed in Europe resulting in similar annual traffic levels, i.e. China/4.1 million vs Europe/4.96 million flights. The observed drop in peak day traffic at the studies airports is significantly higher in Europe than in China across the 2020 and the first half of 2021.
- For the first 6 months in 2021, overall traffic numbers in China overtook the European traffic volume. With a total of 2.3 million flights China observed about 10% more of traffic for the first half of the year.
- China and Europe have established system-wide traffic management facilities to ensure that traffic flows do not exceed what can be safely handled by air traffic controllers, while trying to optimise the use of available capacity. In China, there is one air navigation service provider compared to the 37 en-route service provider in Europe. The aggregated number of approach and area control centers is similar, i.e. China/72 vs Europe/76. The number of air traffic controllers servicing the air traffic is about 15% higher in Europe than in China.
- Punctuality and on-time performance shows similar patterns in Europe and China. The lower pressure in terms of air travel on both systems resulted in higher overall on-time performance in 2020 and the first half of 2021. On the airport level the variations across the years is higher in Europe.

- In this initial report, efficiency of operations is measured in terms of the additional taxi-out time observed at the studied airports. Taxi-out times in the first half of 2021 vary across the airports in both regions. On average, the average additional taxi-out time is lower in Europe in comparison to China.

This report showcases the high value in regional comparisons and benchmarking of operational performance as it supports the identification of best practices and drivers for performance. The report identified a series of ideas for future research that will help to better understand similarities/differences in both regions, including the underlying operational concepts or technological enablers.

This initial report will be updated throughout the coming years. Future editions will also enable to complement data time series and support the development of further use-case analyses. The lessons learnt of this joint project will also be coordinated with the multi-national performance benchmarking working group (PBWG) and ICAO GANP Performance Expert Group (GANP-PEG). This report may be useful to further harmonise the practice and development of the GANP KPIs.

# 1 Introduction

## 1.1 Overview

Air transport represents a strategically important sector that makes a vital contribution to the overall economy, is a driver for employment and growth, and provides pan-regional and international mobility. Despite the impact of the current COVID-19 pandemic on air transport demand and connectivity, air traffic is expected to grow globally over the long term. There is a joint political goal to foster high levels of safety and operational efficiency for airspace users. ICAO promotes the importance of a performance-based approach and invites States and (sub-)regions to engage and participate in performance benchmarking activities

This first China-Europe regional comparison report is jointly developed by the Civil Aviation Authority of China and the European Organisation for the Safety of Air Navigation (EUROCONTROL). The work was performed by the Civil Aviation Authority of China (CAAC), Civil Aviation University of China (CAUC), Aviation Data Communication Corp.(ADCC), and the Performance Review Unit (PRU). Both groups agreed to foster the understanding of operational performance in both regions on the basis of commonly agreed data and metrics.

## 1.2 Purpose

The purpose of this report is to establish a regional comparison of operational air navigation system performance for China and Europe. This comparison builds on commonly agreed definitions, data, and performance metrics. It supports the assessment and evaluation of the system-wide operational performance in both regions with a view to identify similarities and differences. The lessons learnt from these observations forms the basis for future research and deeper analysis.

The guiding principle is to compare, understand, and improve air navigation system related performance in both regions. For this reason, both groups investigated available data sources and harmonised the underlying data processing to establish a set of comparable data. Further work revolved around the identification and refinement of performance indicators used within the organisations and under the ICAO GANP Performance Framework. The work will therefore also serve as a reference for other interested parties to inform their operational performance analyses.

## 1.3 Scope

### 1.3.1 Geographical Scope

The geographical scope for this report comprises China and Europe. For both regions this comprises in general the volume of airspace above the national territories excluding oceanic airspace.

In this context,

- China is defined as the volume of airspace where air navigation services are provided by China.
- Europe is defined as the volume of airspace where Member States of EUROCONTROL (i.e. 41 States) provide air navigation services.

The focus of this regional comparison report is on performance measures supporting the network and airport level comparison. For this report, the top 10 airports in terms of air transport movements in 2019 have been chosen for which the data was available and comparable. These airports are listed in Table 1.1.

*Table 1.1: Top 10 airports in this study based on 2019 traffic*

| Rank | China | | Europe | |
|---|---|---|---|---|
| 1 | ZBAA | Beijing Capital International Airport | EDDF | Frankfurt Airport (Germany) |
| 2 | ZSPD | Shanghai Pudong International Airport | EHAM | Amsterdam Airport Schiphol (The Netherlands) |
| 3 | ZGGG | Guangzhou Baiyun International Airport | LFPG | Paris Charles de Gaulle Airport (France) |
| 4 | ZGSZ | Shenzhen Bao'an International Airport | EGLL | London Heathrow Airport (United Kingdom) |
| 5 | ZUUU | Chengdu Shuangliu International Airport | LEMD | Adolfo Suarez Madrid-Barajas Airport (Spain) |
| 6 | ZPPP | Kunming Changshui International Airport | EDDM | Munich Airport (Germany) |
| 7 | ZLXY | Xi'an Xianyang International Airport | LEBL | Josep Tarradellas Barcelona-El Prat Airport (Spain) |
| 8 | ZUCK | Chongqing Jiangbei International Airport | LIRF | Leonardo da Vinci Rome Fiumicino (Italy) |
| 9 | ZSHC | Hangzhou Xiaoshan International Airport | EGKK | London Gatwick Airport (United Kingdom) |
| 10 | ZSSS | Shanghai Hongqiao International Airport | LSZH | Zurich International Airport (LSZH) |

Figure 1.1 provides an overview of both regions and the geographic location of the chosen study airports within the regions.

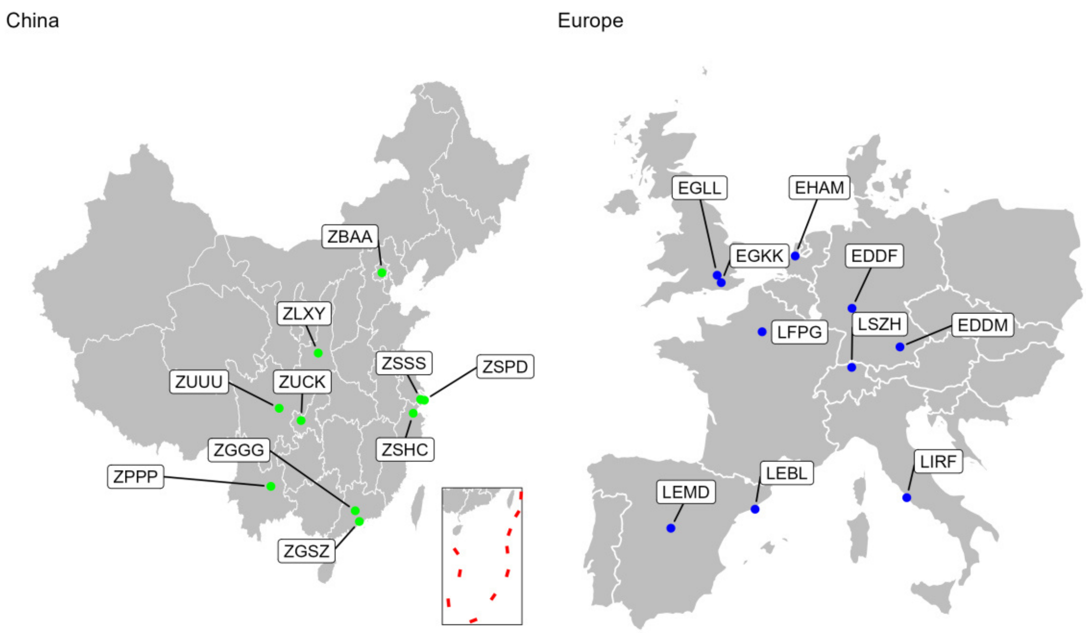


*Figure 1.1: Geographical context of China/Europe Comparison*

### 1.3.2 Temporal Scope

The scope of this report covers the period from January 2019 through June 2021. This allowed for the provision of a pre-COVID baseline by comparing the observed performance before and throughout the pandemic years. In future editions, this baseline will support to assess the recovery in both regions and the associated air navigation system response to the anticipated growth of air traffic.

The reader should note that the data shown for 2021 represents the observed traffic and performance for the first half of 2021. Conclusions drawn from this report need to be seen in this context.

## 1.4 Data Sources

This report builds on comparable data exchanged between both groups.

The nature of the performance indicator requires the collection of data from different sources. CAAC/CAUC/ADCC and PRU investigated the comparability of the data available in both regions to ensure a harmonised set of data for performance comparison purposes.

There are two data sources in China. Traffic data comes from ADCC, and punctuality, delay and taxi data are derived from CAAC's Flight Punctuality Statistics System. For this initial iteration the agreed data has been aggregated on a monthly basis.

Within the European context, PRU has established a variety of performance-related data collection processes. For this report the network level data is extracted from the European Traffic Management System (ETMS) of the Network Manager. These data are augmented with airport operator data to establish a flight-by-flight dataset. The combination of both data streams ensures consistent data for arrivals and departures at the chosen study airports. The data is collected on a monthly basis and typically processed for the regular performance reporting under the EUROCONTROL Performance Review System and the Single European Sky Performance and Charging Scheme.[1]

## 1.5 Structure of the Report

This initial China-Europe operational performance comparison report is organised as follows:

- **Introduction** – overview, purpose and scope of the comparison report, including a short description of data sources used;
- **Air Navigation System Characteristics** – high-level description of the two regional systems, i.e. areas of responsibility, organisation of ANS, and high-level air navigation system characteristics;
- **Traffic Characterisation** – air traffic movements, peak day demand, and fleet composition observed at the study airports;
- **Efficiency** – analysis of unimpeded taxi-out time and additional taxi-out time;
- **Punctuality** – observed arrival and departure punctuality;
- **Conclusions** – summary of this report, associated conclusions and next steps.

[1] The indicators used throughout this report represent a variation of the indicators used within the European context. While the overall trend is ensured, the actual values in this report may differ from the European performance monitoring (c.f. https://ansperformance.eu).

# 2 Air Navigation System Characteristics

In general terms, air navigation services are provided in China and Europe with similar operational concepts and procedures, and supporting technology. However, there exists a series of differences between the two regional systems. This section provides a general background on the characteristics of the Chinese and European air navigation system. These characteristics form an integral part to explain the similarities and differences in the KPIs observed throughout this report.

## 2.1 Organisation of Air Navigation Services

The key difference between the Chinese and European air navigation system can be seen in the organisation of air navigation services (ANS).

In China air navigation services are established through the Civil Aviation Administration, with air traffic services provided by the Air Traffic Management Bureau and the Operation Supervisory Center responsible for the air traffic flow management, flight plan processing, including flight security and emergency management.
In Europe, each member state has assigned the service provision to national or local providers, and thus a variety of service providers exists with cooperation in terms of flow management on European level. The air traffic flow management function is performed by EUROCONTROL's Network Manager.

China's continental airspace covers an area of 9.6 million square kilometers in total, accounting for about 84% of the area covered by Europe. In terms of providing air traffic services, China has only one air traffic service provider, which is responsible for air traffic command of aircraft flying within China's territorial airspace. The airspace in China is structured in 11 flight information regions, respectively located in Beijing, Shanghai, Guangzhou, Wuhan, Lanzhou, Shenyang, Kunming, Urumqi, Sanya, Hong Kong and Taipei. Recently, the central air traffic management platform approved by Civil Aviation Administration of China was officially put into use on June 30, 2021, effectively covering and connecting the three major operating parts: air traffic control centers, airports and airlines, improving the cooperative operation effectiveness and further enhancing the flight efficiency. As for flight plan unified processing, China has established a unified flight plan processing center in Shanghai. Since December 2018, the center began to manage the flight plans of inbound flights in China.

The European airspace spans over an area of 11.5 million square kilometers. As concerns the provision of air traffic services, the European approach results in a high number of service providers, i.e. there are 37 different en-route ANSPs with varying geographical areas of responsibility. Dependent on the size of the member state, the airspace is organised in multiple lower and upper flight information regions. Next to a limited number of cross-border agreements between adjacent airspaces and air traffic service units, air traffic service provision is predominantly organised along state boundaries/FIR borders. Maastricht UAC represents the only multi-national collaboration providing air traffic services in the upper airspace of northern Germany, the Netherlands, Belgium, and Luxembourg. The Integrated Initial Flight Plan Processing System (IFPS) is a centralised service designed to rationalise the reception, initial processing and distribution of flight plan data across the different European air traffic service units. The level of civil-military integration varies from country to country in Europe. Models range from stand-alone to collocated or fully integrated service units. Within the European context, air traffic flow management (ATFM) and airspace management (ASM) are provided/coordinated centrally through the Network Manager. The design of airspace and related procedures is no longer carried out or implemented in isolation in Europe. Inefficiencies in the design and use of the air route network are considered to be a contributing factor towards flight inefficiencies in Europe. Therefore the development of an integrated European Route Network Design is one of the tasks given to the Network Manager under the European Commission's Single European Sky initiative. This is done through a CDM process involving all stakeholders. A further task of the Network Manager is to ensure and coordinate that traffic flows do not exceed what can be safely handled by the air traffic service units while trying to optimise the use of available capacity. For this purpose, the Network Manager Operations Centre (NMOC) monitors the air traffic situation and proposes flow measures coordinated through a CDM process with the respective local authorities. This coordination is typically affected with the local flow management position (FMP) in an area control centre. The NMOC implements then the respective flow management initiative on request of the authority/FMP.

## 2.2 High-Level System Comparison

Table 2.1 summarises the key characteristics of the Chinese and European air navigation system.

The non-oceanic airspace in China spans over 9.6 million $km^2$ and is about 83% in comparison to Europe. Air traffic services are provided by a single ANSP, while in Europe a number of national and local ANSPs assume responsibilities.

*Table 2.1: High-Level System Comparison based on 2019*

| KPA | China | Europe |
|---|---|---|
| geographic area (million $km^2$) | 9.6 (non-oceanic) | 11.5 (non-oceanic) |
| number of en-route ANSPs | 1 (CAAC ATMB) | 37 |
| number of towers | 45 | 400+ |
| number of APP | 46 | 16 (stand alone) |
| number of ACC | 26 | 62 |
| number ATCOs in OPS | 15 001 | 17 563[1] |
| controlled IFR flights (2019) | 5 813 407 | 11 043 815 |

[1]2018, excluding Georgia and Canary Island

Within the en-route environment, there are 37 different ANSPs in Europe compared to a single provider, i.e. ATMB, in China. Europe has a slightly higher number of APP and ACC facilities, i.e. Europe: 78 vs China 72. The number of ATCOs in operations is about 15% lower in China than in Europe. In 2019, China controlled about 53% of the traffic handled in Europe. Both regions have seen a continual growth of air traffic between 2012 and 2020, c.f. Figure 2.1.

Prior to 2019, China observed a steady and significant traffic increase. The traffic volume in 2019 is 1.7 times that of 2013. Traffic in 2020 and the first part of 2021 was significantly reduced due to COVID19 and the associated travel constraints.

Europe saw constant traffic levels in 2013 compared to 2012 and then experienced a period of steady traffic increase between 2013 and 2019. The year 2019 showed a slightly lower trend due to the slowing economic growth and the collapse of several air transport operators. On top, the grounding of the B737Max fleet impacted the overall growth in 2019. On average, the volume of flights in the ECAC area grew by 15.4% - corresponding to 1.5 million additional flights in 2019 - in comparison to 2013 and totalling around 11 million annual flights.

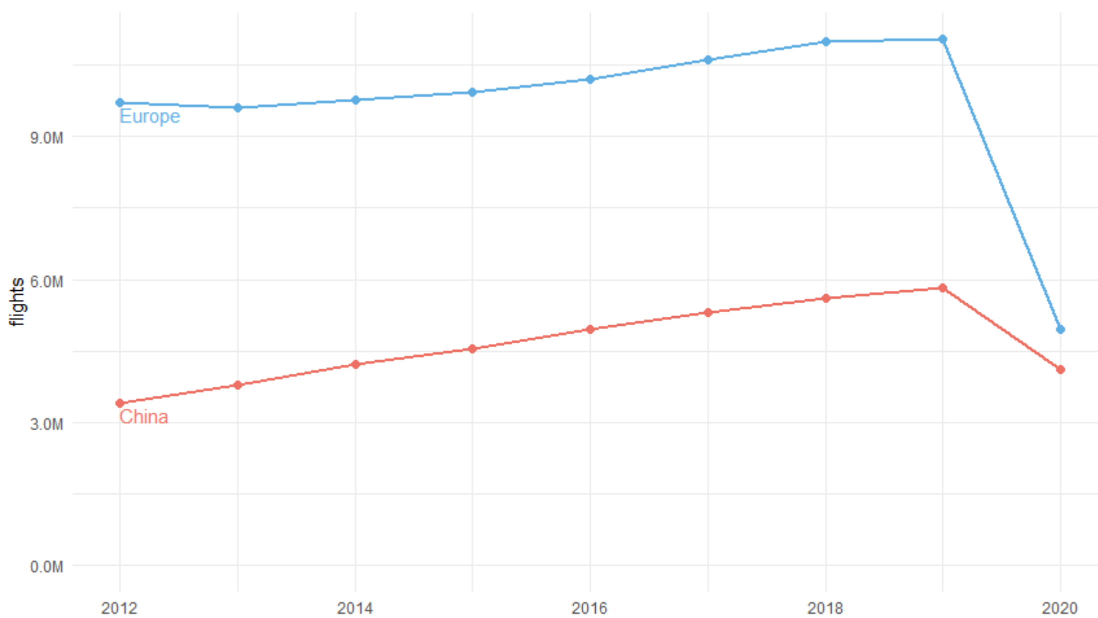


*Figure 2.1: Traffic evolution in China and Europe 2012 - 2020*

Figure 2.1 shows the overall trend in terms of air traffic development in both regions. The Chinese continental airspace is about 17% smaller than the European one. In 2012 traffic levels in China ranged about 35% of the European traffic volume. Air traffic grew stronger in China than in Europe over the period 2012 to 2019. In 2017 China handled about 50% of the European traffic numbers and in 2019 about 53%.

As will be shown throughout the report both regions faced similar challenges responding to the COVID pandemic. The nature of the European air navigation system is characterised by a multitude of countries. This resulted in a mix of policy measures and constraints on air travel as also intra-European traffic was subject to international air traffic restrictions.

The following sections will also show the development of air traffic and the observed performance for the first part of 2021. China and Europe observed similar total annual traffic levels in 2020, i.e. China/4.1 million vs Europe/4.96 million flights. As will be shown, China serviced about 10% more in terms of total traffic by June 2021, i.e. 2.3 million vs. Europe/2.03 million flights. The further development of the traffic demand in the second half of 2021 will reveal to what extent the observed trends continue. To monitor the further developments, CAAC and EUROCONTROL agreed to update this report on a regular basis.

## 2.3 Air Traffic Characterisation

### 2.3.1 Air Traffic Evolution January 2019 Through June 2021

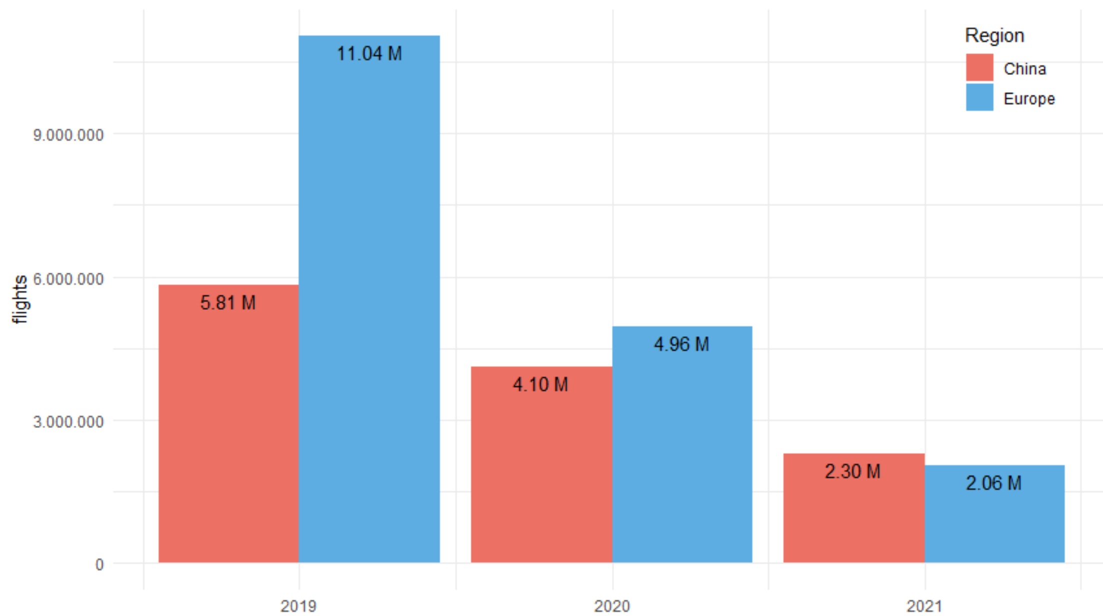


*Figure 2.2: China/Europe - annual traffic volume*

Figure 2.2 shows the annual traffic volume for 2019 and 2020. Data for 2021 captures only the first 6 months of the year, i.e. January through June. Assuming a similar level of air traffic for the second half of 2021, it is anticipated that the total annual traffic reaches a similar level as in 2020.

China's air traffic volume in 2019 ranged at about 53% of the European traffic levels. The year 2020 was characterised by the impact of COVID-19 in both regions. With a multitude of international and regional travel constraints in Europe, traffic levels in Europe dropped significantly to 4.96 million flights (about -55% when comparing 2019 to 2020). The overall reduction in number of flights was milder in China with a reduction of about 1.7 million flights to 4.1 million (approx. -30% compared to 2019). To overall observed annual traffic in 2020 showed hence only a 17% difference between China and Europe.

For the first half of 2021, the air traffic level in China overtook Europe. Similar to the previous year, COVID-19 related containment measures in the form of air traffic restrictions drove the overall evolution. By the middle of the year, China serviced about 2.3 million flights accounting for 10% more of traffic than Europe.

Later sections of this report will show the differences in both regions regarding the handling the the pandemic and associated air traffic restrictions. On average, these restrictions were significantly lower in China, while Europe suffered from a fragmented approach driven by varying national policies. In that respect China profited from a more central and unified approach regulating travel policies and air traffic demand.

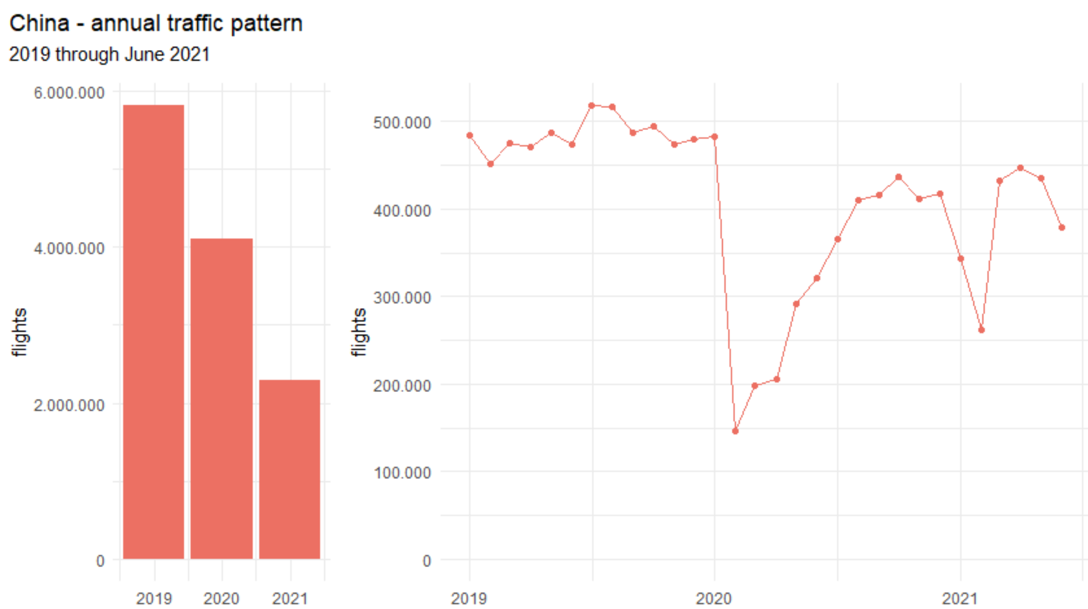


*Figure 2.3: China - annual traffic and monthly timeline*

Figure 2.3 shows the annual distribution of air traffic in China and the evolution of monthly traffic at the network level. On the network level traffic in China is less seasonal and was fairly constant in 2019 with a mild peak for the summer months, i.e. July and August. Throughout 2019 traffic ranged around an average of 484.500 flights on a monthly basis.

The COVID related traffic decline started in January 2020 representing a drop of -69.6% in February. Air traffic in China enjoyed a steady and quick recovery as of March 2020 ranging or exceeding 400.000 monthly flights (~ about 82.6% for the period August through December 2020 compared to the 2019 average). Traffic levels in early 2021 dropped again in January and February with a strong rebound for March, April, and May. June 2021 saw another monthly decline of about 13.1% compared to the previous month.

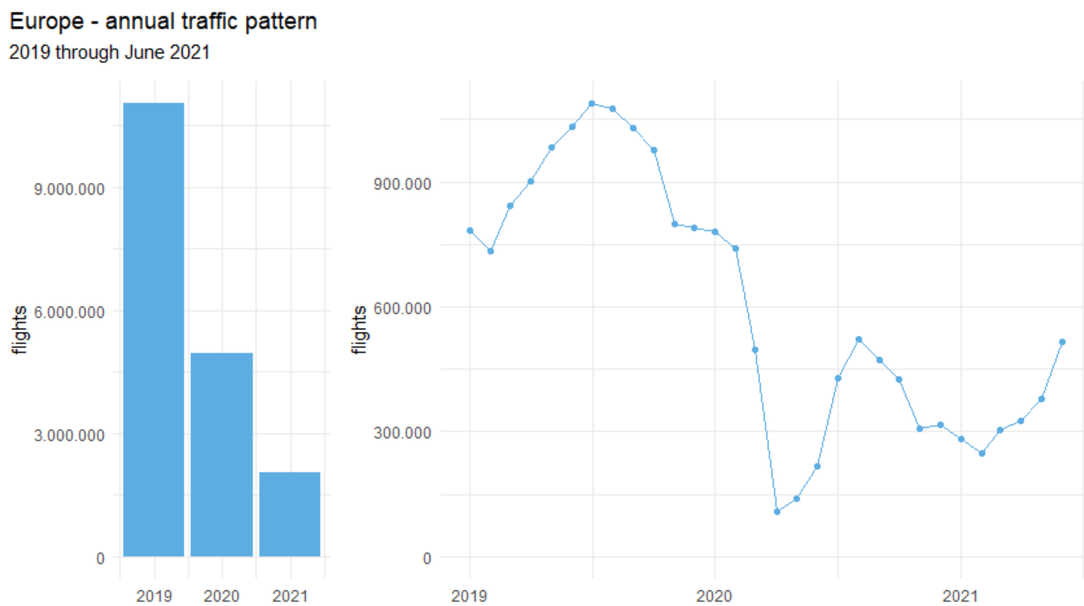


*Figure 2.4: Europe - annual traffic and monthly timeline*

European air traffic showed a pronounced seasonal pattern in 2019 (c.f. Figure 2.4) with traffic above 0.9 million flights on a monthly basis for the period April through October. The winter months plateaued just under 800.000 flights in November 2019 through January 2020.
COVID-19 related travel restrictions kicked in with March 2020 and resulted in an approximate 70% drop of air traffic for April 2019 compared to the beginning of the year. Throughout the second quarter of 2020, an initial recovery of air traffic in Europe was observed with multiple states relaxing their travel constraints in support of the summer months. Following this opening, a second COVID-19 wave struck Europe and resulted in a fragmented approach to COVID, i.e. varying policies and national travel constraints. Air traffic declined in the autumn and winter season 2020 to around 300.000 monthly flights. Beginning of 2021 saw a continual increase in vaccination rates across Europe. As of March 2021 a variety of States lowered travel restrictions and accepted travellers from different countries. Although there is no European-wide agreed policy on regional (i.e. intra-European) travel, air traffic demand continually increased again for the summer season. Traffic levels in June 2021 exceeded for the first time 0.5 million of flights in June. A level comparable to the highest observed traffic in 2020.

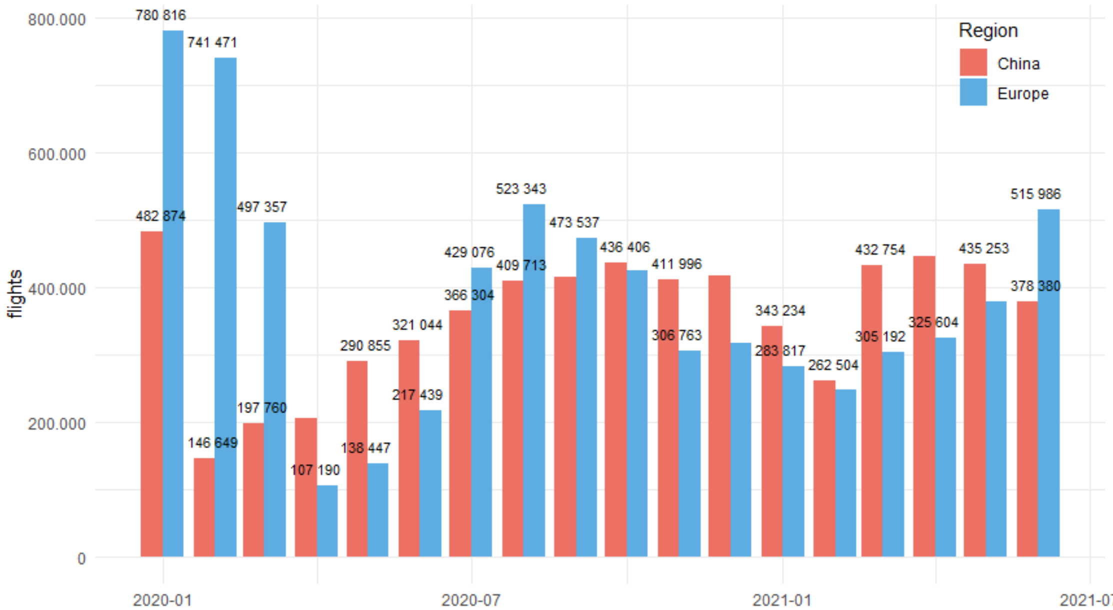


*Figure 2.5: China/Europe - monthly traffic volumne*

Figure 2.5 shows the monthly traffic volume for the period January 2020 through June 2021. Air traffic in China and Europe followed a different monthly pattern in the first quarter for 2020. In February 2020, China's air traffic volume reached rock bottom with 146.649 flights. In Europe COVID-19 related travel restrictions kicked in after the WHO made its pandemic declaration on 11. March 2020. The traffic decline reached its bottom after that date and leveled off. April 2020 showed the lowest monthly traffic levels in Europe.

Both regions experienced an initial recovery for the 2nd quarter in 2020 and the summer months. However, both regions also encountered a phase of higher travel constraints due to surges of COVID-19 cases and associated restrictions on travel.

The pattern for China followed a more linear and steady increase from March through August 2020 and then levelled off for the rest of the year. Early 2021 saw a traffic decrease again in response to another increase in infection cases. With the increase in vaccination rates and success of the travel restrictions, travel demand increased significantly again for March, April, and May 2021. Traffic in June 2021 dropped by about 14% in comparison to the previous month.

Europe observed an increasing recovery rate in May and June 2020 accommodating increased travel demand for the summer holiday season and the initial reduction of travel constraints. However, with increasing infection rates across multiple countries, travel and social distancing restrictions were widely reintroduced resulting in a decline of air traffic in autumn and winter 2020. The lower level of air traffic demand reached into early 2021 (i.e. January and February). As of March 2021 Europe observed a steady recovery with an step-increase of about 25% in June compared to May. Traffic in June 2021 totals just under 516.000 flights, similar to the peak month of 2020 (i.e. August 2020: 523.343 flights).

The number of flights in China has recovered steadily since January, 2021. In February, China's civil aviation industry handled about 260,000 flights, so did Europe. And China's Lunar New Year holiday usually comes in February. So then the business passengers' TWI ( Travel Willingness Index ) was relatively low. But from March 2021, the number of business travelers increased to the same level as the end of 2020. Traffic in China from March to May 2021 surpassed that of Europe. In June, 2021, there appeared some new domestically transmitted COVID-19 cases in Guangzhou. Therefore, the targeted measures were implemented and the number of flights decreased significantly.

On average, traffic levels in Europe were lower than in China for the period November 2020 through May 2021. For the first half of 2021, the total amount of traffic serviced by China ranges about 10% higher than the total movements in Europe.

## 2.4 System-level comparison

### 2.4.1 Normalised Traffic Evolution

The previous section showed the overall traffic development in both regions. Obviously, government policies to restrict the further spread of COVID-19 were a key driver for the observed air traffic demand evolution. With a view to highlight the regional response to COVID-19 and its impact on air travel this section compares the evolution on a normalised basis. To frame the presentation, key dates witin the Chinese and European context are listed in 2.2.

*Table 2.2: Table of key dates in the response to COVID-19*

| Date | Context | Action |
|---|---|---|
| 23 January 2020 | EUR | EUR initial set of airlines stop direct flights to China |
| 11 March 2020 | EUR | US bans entry from EU/Schengen and later complete EU |
| 11 March 2020 | WHO | WHO assesses COVID19 as pandemic |
| 17 March 2020 | EUR | EUR entry ban for non-EU residents |
| 20 March 2020 | CHN | All international passenger flights bound for Beijing will be diverted to the designated first points of entry. |
| 29 March 2020 | CHN | All domestic airlines were allowed to operate only one flight to each country per week, while foreign aviation companies should keep only one air route to China and there should be no more than one flight every week for each of the air route to China, according to the circular. |

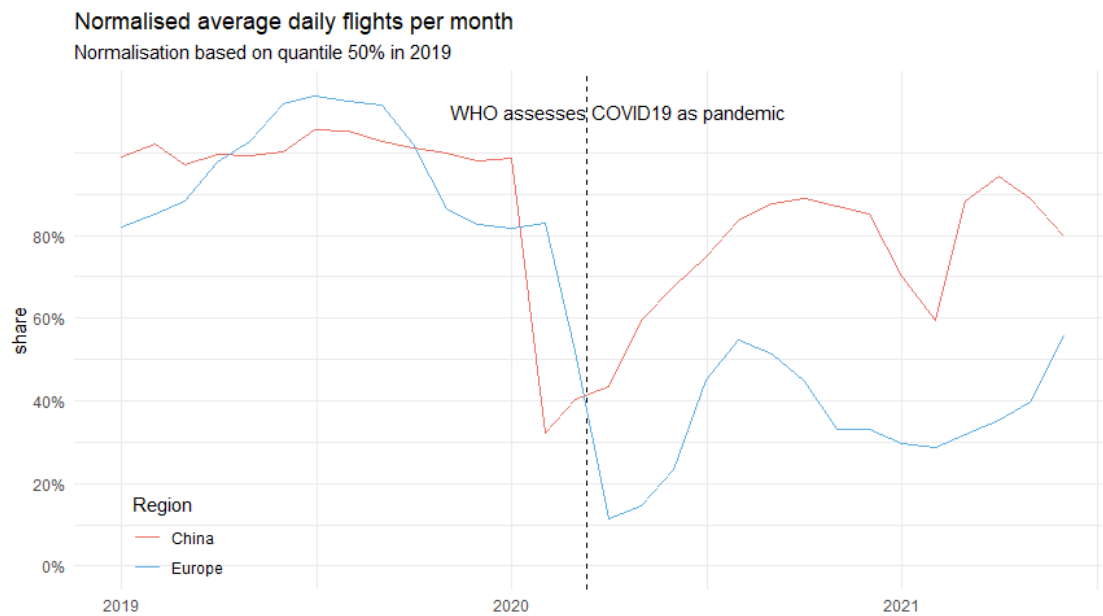


*Figure 2.6: Normalised comparison of traffic development in China and Europe*

Figure 2.5 showed the total of traffic in both regions. With this section Figure 2.6 highlights the different responses in both regions by showing the air traffic volume in a normalised fashion. The normalisation is based on 50th percentile, i.e. median, for the average of daily flights per month.

It is apparent that China responded earlier to COVID-19 than Europe (about 2 months). Home quarantines were applied already in January 2020 in China. In Europe, a set of airlines stopped operating flights to China as of end January 2020. This was broadly masked by the overall reduced traffic beginning of the year (seasonal winter traffic). The WHO assessed COVID19 as a pandemic on 11. March 2020. On the same day, the US banned entry from EU/Schengen flights and non-US citizens. Equally, European states introduced inner-European travel restrictions. This lead to a traffic decline by about 85% in March 2020 for the average daily traffic.

Figure 2.6 highlights the the temporal offset in terms of COVID related air traffic restrictions and the overall impact in both regions. The overall magnitude of the impact based on the average daily flights per month ranged about 5-10% lower in China than in Europe. Initial recovery in China started in early 2020. Europe showed a similar, but delayed behaviour with the aforementioned policy decision and related travel constraints kicking in as of mid March and with little change in April 2020. Traffic increased with April/May again in Europe.

The recovery rate - based on the monthly average of daily flights - in both regions is similar. However it continued for China into the autumn season, while Europe experienced a second wave in terms of COVID infection rates.

For the European region, this resulted in the re-introduction of increased social distancing measures and travel restrictions. Accordingly, air traffic declined as of August 2020 in

Europe. The winter season November 2020 through March 2021 ranged about -65% of the traffic levels observed in 2019.

China showed a fairly stable traffic for the summer and autumn season in 2020 ranging about -15% under the 2019 traffic.The number of new domestically transmitted COVID-19 cases in China considerably increased in December, 2020, comparing with November. So in accordance with the requirements for joint prevention and control of COVID-19 cases, the government suggested people to reduce unnecessary movement beginning December 2020 to January 2021. During this period, the number of flights decreased.

Increased vaccination rates and reduced number of infections and critical hospital admissions resulted in more permissible travel requirements among European states. Traffic continuously increased for the second quarter of 2021 reaching a value of approximately -40% to the 2019 base level of average daily flights per month.

As the conditions turned for the better in March, 2021, the number of flights in China has continued to grow due to the expanded business travel market, and it has basically recovered to the level of the end of 2020 from March to June.

While there is a temporal difference between both regions, policy reaction to curb the further spread of COVID19 resulted in a similar behaviour. Following the harsh decline of travel in the early stage, both regions evidenced an initial increase of air traffic based on the success of the travel constraints. Overall, the impact in terms of loss of average daily flights per month was milder for China (approx. 5-10%). The initial recovery phase is further pronounced for China levelling off for the summer autumn season at -10-15% compared to the base level in 2019. Europe faced a second wave of COVID-19 with the end of the summer vacation period resulting in a drop of air traffic to levels of -65% versus the 2019 base level. As of March 2021 a second recovery period started. Traffic in China for the period March to May 2021 surpassed that of Europe. However, in June, 2021, due to the local transmitted COVID-19 cases in Guangzhou, the number of flights decreased significantly.

With a view to follow the further developments, it is planned to update this report on a regular basis. This will allow to monitor the success of policy action (e.g. travel constraint relaxation vs long-term traffic growth) in both regions.

### 2.4.2 Market Segments

The overall traffic analysis revealed intersting trends in both regions. The following takes a closer look in how different market segments evolved throughout this period.

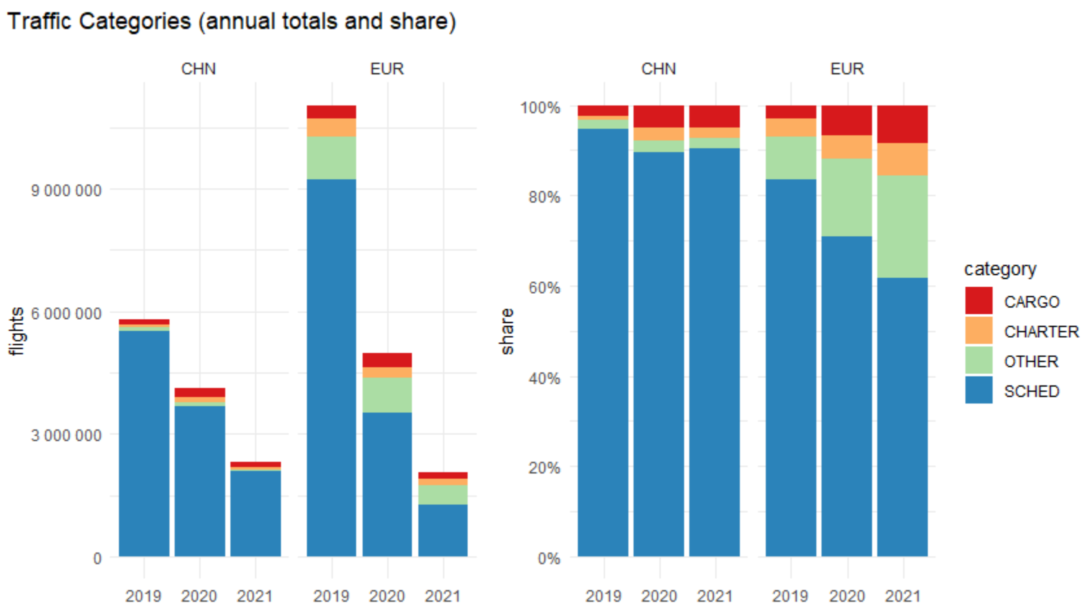


*Figure 2.7: Comparison of market segments in both regions*

Figure 2.7 breaks down the annual traffic volumes (c.f. Figure 2.2) for 2019 and 2020. Flights in 2021 cover the first six month, i.e. January through June.

In general, the pre-dominant traffic category in both regions is scheduled passenger air traffic. Charter flights complement the passenger flights on a shallow level. The share of scheduled passenger traffic within the Chinese region accounted for over 95% in 2019 and ranged at and above 90% in 2020 and - for the first six months - in 2021. The overall ratio of the market segments in 2020 and 2021 is fairly constant in China.

Europe showed a varied picture. Cargo flights in Europe account for a comparatively small share of the total flights. In 2019, the share of cargo flights was comparable with the share observed in China. The response to COVID increased the need for goods and equipment to fight the pandemic. This resulted in an increased number of cargo operations in 2020. An increased share of cargo flight operations is identifiable for the first half of 2021. Scheduled passenger traffic accounted for the largest share of traffic in Europe (~80% in 2019). This segment was heavily affected by measures implemented by the countries to contain the pandemic and as a result the number of flights and its share decreased in 2020 and the first half of 2021. There is a discernible share of other operations in Europe, including business aviation. Although the total number of these operations declined in 2020 and 2021, its overall share increased. This suggests that this market segment is more flexible to account for the travel constraints and decreased by much less than the regular passenger traffic.

It appears that the annual share of the different operations is more stable in China. Scheduled passenger operations are the pre-dominant air traffic type in China. Passenger transportation accounts for the main part of market demand in China's civil aviation industry. And in China, water carriage, railway, highway and other modes are more used in cargo transportation. For the first 6 months of 2021, China and Europe have serviced a similar total number of movements. The proportion of scheduled passenger flights in China is higher than that in Europe. However, there is a higher share of Cargo, Charter, and Other air traffic in Europe than in China.

### 2.4.3 Passenger Traffic

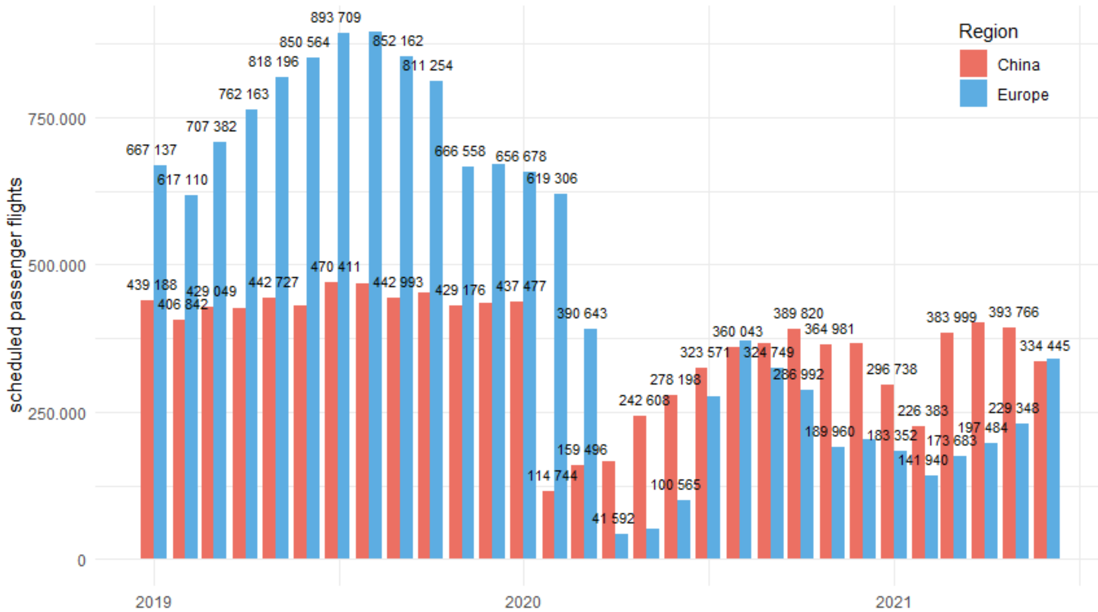


*Figure 2.8: China/Europe - monthly traffic volume of passenger flights*

As presented above, passenger flights are the predominant traffic category in China and Europe. This reflects the relevance of air transportation in terms of regional (and international) connectivity and public mobility. Figure 2.8 depicts the monthly number of passenger flights in both regions. This also shows a characteristic difference between both regions. Traffic and connectivity in China was fairly stable across 2020. The passenger traffic pattern in Europe showed a strong seasonal pattern peaking during the summer month, i.e. July and August. On a monthly basis the difference between the lower winter season and the summer period  accounted for a difference of approximately 25% in 2019. In China the overall monthly difference in 2019 between ranged around 9%.

As mentioned before, COVID-19 related flight restrictions resulted in a decline in traffic in China about 2 month earlier than in Europe. Interestingly, the level of passenger traffic during the the summer and second half of 2020 ranged around the level of traffic observed in Europe during the peak month August 2020 (~ 360.000 flights). With June 2021, passenger traffic in Europe rebounced to this level.

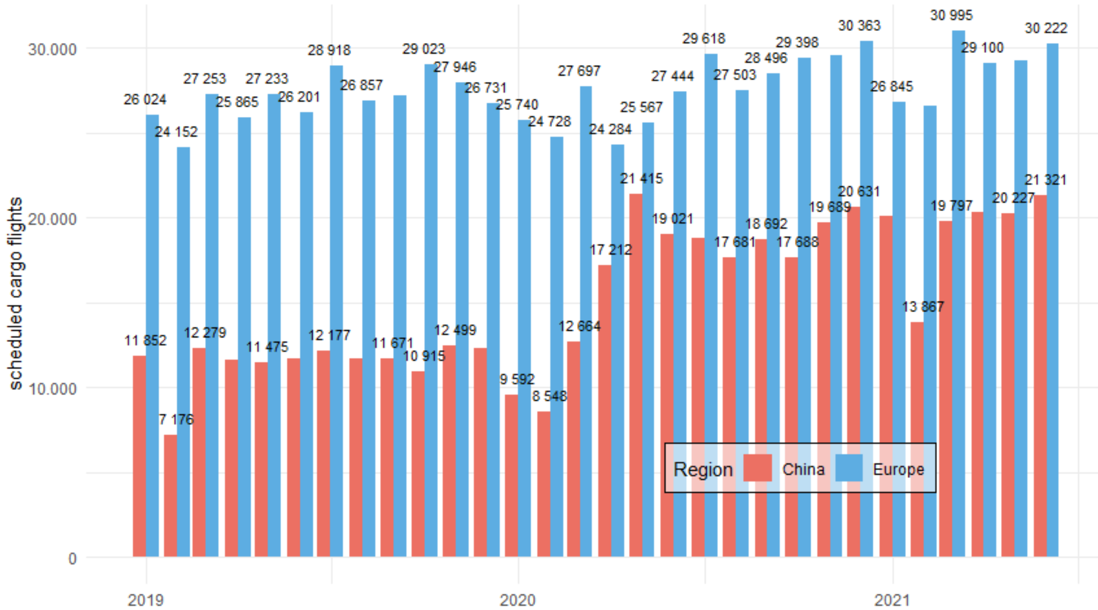


*Figure 2.9: China/Europe - monthly traffic volume of cargo*

Figure 2.9 shows the monthly totals of cargo flight operations. In 2019, the total number of cargo operations in Europe is about 55% higher than comparable traffic within China. This ratio changed considerably in 2020. While there is a slight increase in total cargo flights in Europe, cargo operations increased significantly in China. On average, the monthly difference reduced by approximately 20%-points with the Chinese cargo traffic volume ranging around 34% of cargo traffic observed in Europe.

This pattern and spread continued in the first half of 2021. With the exemption of February during which China introduced renewed travel restrictions, a higher base level of cargo operations in observed in China comparable to the demand levels in 2020. Cargo operations show the same reaction to higher constraints in early 2021.. Over the whole period, cargo operations increased showing a mild seasonal behaviour.

The monthly aggregation of flight totals might mask changes of the logistical air network connectivity. This offers a candidate for expanding the analysis in future editions of this report.

# 3 Airport Level Comparison

This chapter compares the performance observed at the top 10 airports within the Chinese and European airspace. The overarching objective of air traffic services is the provision of safe, orderly, and efficient flow of air traffic. Accordingly, operational system performance is linked to the actual and serviced demand (i.e. air traffic). For operational comparisons, it is therefore important to have a good understanding of the level and composition of the air traffic at the study airports.

## 3.1 Air Traffic at Airports

### 3.1.1 Traffic Development

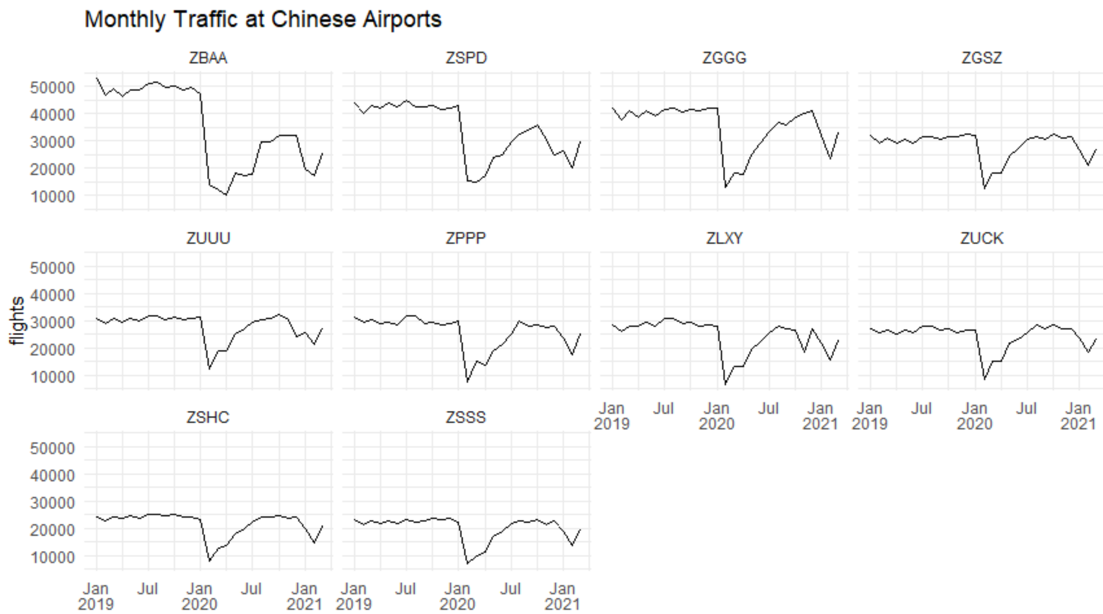


*Figure 3.1: Monthly evolution of air traffic at Chinese airports.*

Figure 3.1 depicts the evolution of monthly traffic counts at Chinese airports. As shown above, traffic across all airports followed a schedule characterised by little monthly variation. National travel constraints impacted mobility in January 2020. For the initial recovery in 2020 an interesting pattern emerged across the airports in China. With the exception of Beijing (ZBAA) and Shanghai Pudong (ZSPD) traffic levels bounced back to pre-COVID levels. This suggests that outside the aforementioned airports, air traffic at the other 8 airports is pre-dominantly domestic (inner-China) air traffic. Thus, travel restriction for international traffic did not affect these airports.

On the other hand, the international hubs(ZBAA and ZSPD) observed less traffc. As Beijing Daxing Airport opened on September 25, 2019, and all international passenger flights bound for Beijing were redirected, the number of airplanes taking off and landing from Beijing Capital International Airport ( IATA: PEK, ICAO: ZBAA ) reduced. Shanghai Pudong International Airport ( IATA: PVG, ICAO: ZSPD ) mainly carries out international passenger and cargo flights to/from Shanghai. In 2019, international and regional passenger flights of

Shanghai Pudong International Airport accounted for 42.75% of all flights. During the coronavirus epidemic, the number of global international flights decreased sharply, so the number of flights of Pudong Airport failed to increase to the same level of 2019. All airports showed the impact of the 2nd wave in the beginning of 2021.

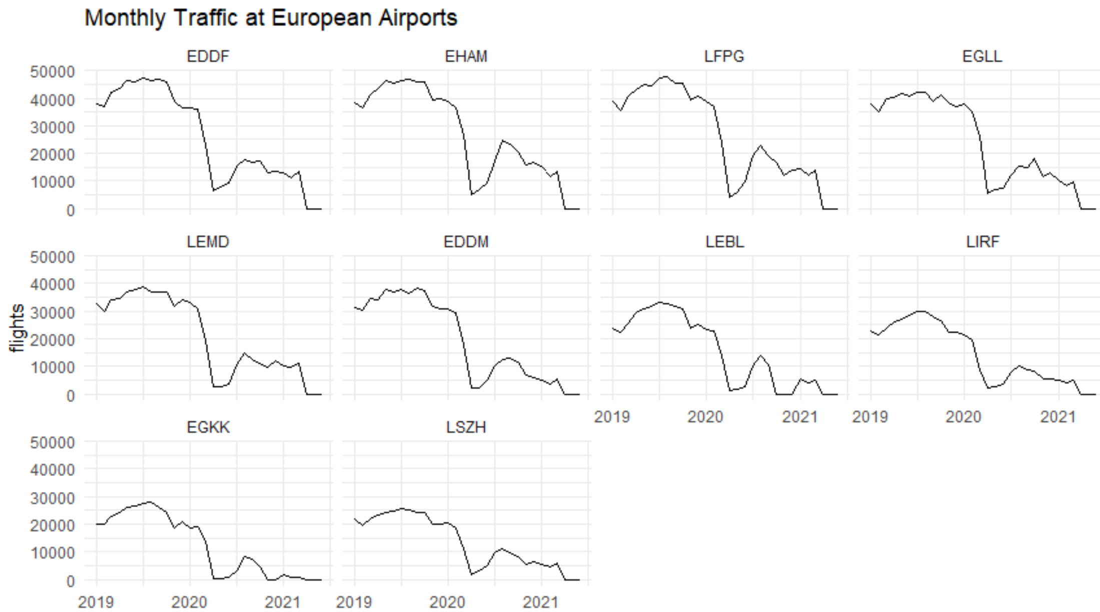


*Figure 3.2: Monthly evolution of air traffic at European airports.*

Figure 3.2 shows the monthly traffic evolution at European airports. All airports showed a pronounced seasonality of the local air traffic in 2019. Amsterdam Schiphol (EHAM), Paris Charles de Gaulle (LFPG), Frankfurt Rhine/Main (EDDF), and London Heathrow (EGLL) ranked as the top 4 airports in Europe and monthly number of 40.000 or more fligths. While the overall pattern across the airports shows similar behaviour, there are differences in terms of local or national response to the COVID crisis. The top-10 airports in Europe represent major national hubs with a strong share of pan-regional and international traffic. With the initial shutdown of flights to Asia of major airlines (e.g. KLM, British Airways, Air France, and Lufthansa), there is already a shallow decrease of air traffic in January and Februay 2020. European states reacted to the pandemic declaration of WHO by introducing wide-ranging travel constraints. The introduction of national social distancing and travel restrictions on air travel lead then to a sharp decline of air traffic in March and April 2020 at all airports in Europe. The role of the airport within the domestic network and to what extent national carriers contracted operations to a sub-set of national airports was witnessed in the level of initial recovery and the decrease gradient or plateauing in the autum season of 2020.

In line with the overall trend in Europe in the second quarter of 2021 increasing levels of air traffic were observed at all European airports of this study.

### 3.1.2 Peak Day Operations

While the annual traffic provides insights in the total air traffic volume and associated demand served at an airport, it does not provide insights on the upper bound of achievable daily movement numbers. Next to the traffic levels (i.e. demand), the latter depends on operational procedures and constraints, and the use of the runway system infrastructure. The peak day traffic is determined as the 99th percentile of the total number of daily movements (arrivals and departures). This measure represents such an upper bound for comparison purposes.

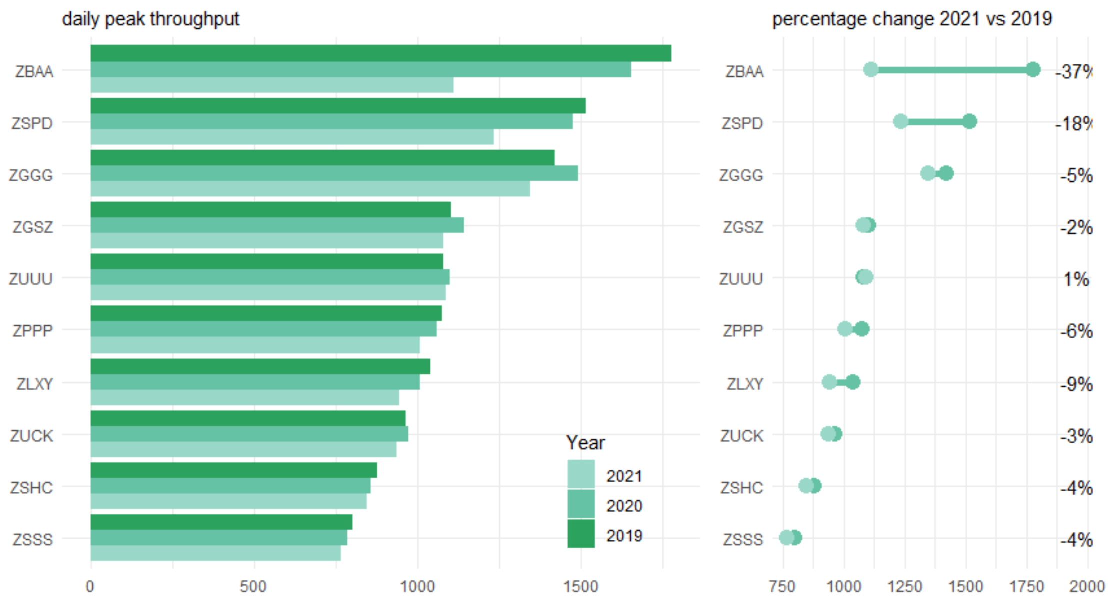


*Figure 3.3: Peak day traffic observed at Chinese airports - annual evolution and recent change.*

For the majority of Chinese airports the daily peak operations changed marginally for the years 2020 and the first six months of 2021 as can be seen in Figure 3.3. This indicates that the overall pressure during peak hours did not substantially decline over time with a high stability of movements/connections. For the major hubs, i.e. Beijing (ZBAA) and Shanghai Pudong (ZPSD), have seen a strong decline in the peak behaviour due to the traffic reduction. The traffic reduction is primarily linked to the loss of international connections.

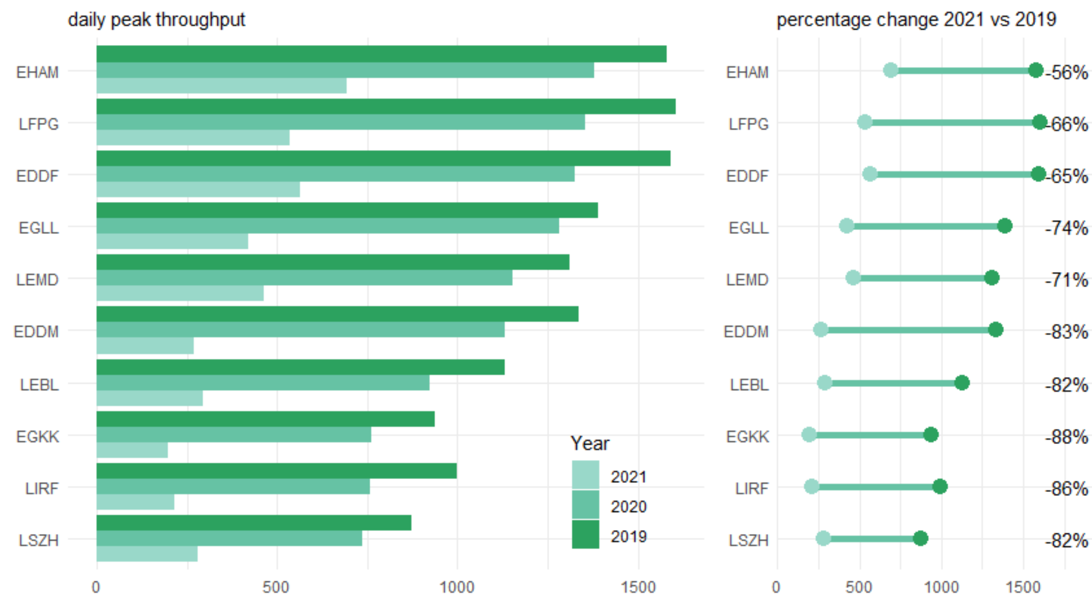


*Figure 3.4: Peak day traffic observed at European airports - annual evolution and recent change.*

Traffic levels in 2020 and the first half of 2021 are heavily reduced due to the prevailing national COVID-19 constraints. With the general increase in traffic in the second quarter of 2021 airspace users reestablished routes (domestic and pan-European aerodrome pairs). Higher levels of traffic are associated with higher airport utilisation including banks of feeder flights. However, across the top 10 European airports the daily peak throughput is significantly lower in comparison to the pre-COVID year 2019.

## 3.2 Domestic/ Regional Connectivity

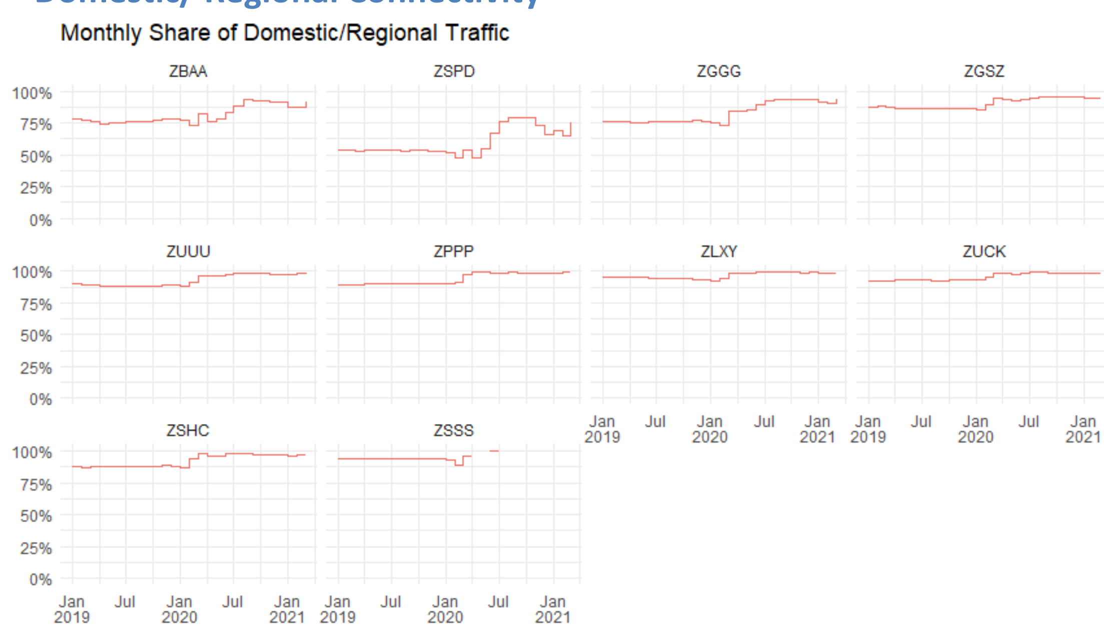


*Figure 3.5: Share of domestic air traffic at Chinese airports*

Due to the international traffic constraints in response to the COVID pandemic, the domestic share of traffic at Chinese airports increased. For the majority of airport the regional traffic share accounted for 95% or more of air traffic (c.f. Figure 3.5. A distinct picture can be seen at ZSPD with a significant higher domestic traffic share of 20-35% over the past year. Shanghai Pudong International Airport mainly carries out international passenger and cargo flights to/from Shanghai. In 2019, international and regional passenger flights of Shanghai Pudong International Airport accounted for 42.75% of all flights. During the coronavirus epidemic, the number of international passenger flights decreased and the domestic market was comparatively stable, Pudong Airport increased the number of domestic flights, filling the spare operating hours. By doing this, it achieved a phased growth of the number of domestic flights in 2021.

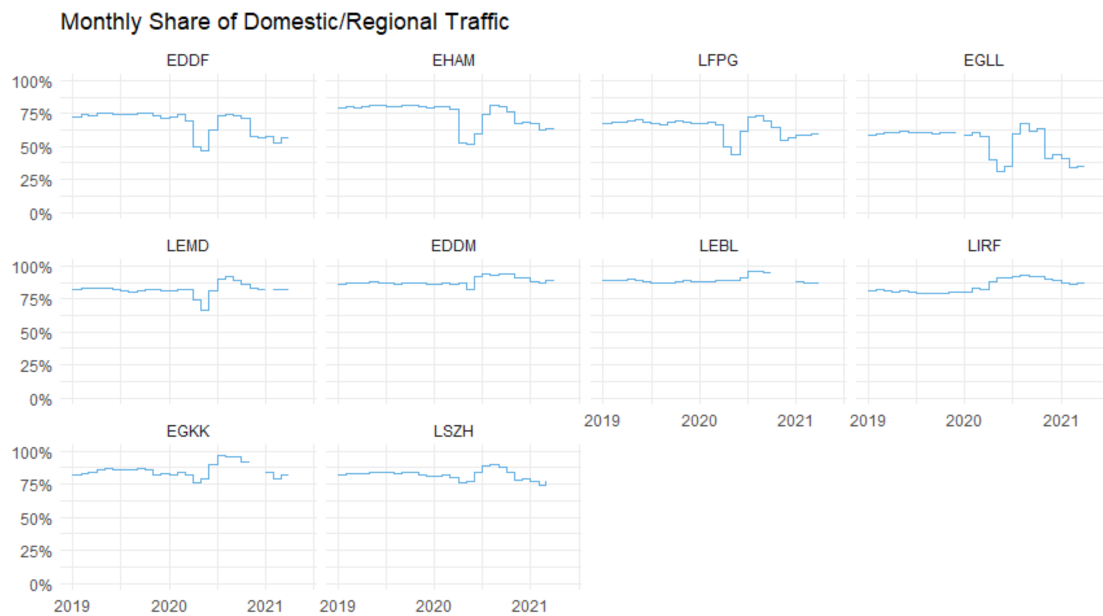


*Figure 3.6: Share of regional (intra-European) air traffic at European airports*

Figure 3.6 shows a higher variety of regarding the regional (intra-European) flights. Due to the nature of the European air navigation system with services typically organised on the national level, travel constraints amongst the different European countries resulted also in change of the share. The level of regional traffic is lower at the major European hubs, i.e. Amsterdam Schiphol (EHAM), Frankfurt (EDDF), Paris Charles de Gaulle (LFPG), and London Heathrow (EGLL). These airports saw in 2019 a share of about 20-25% of international traffic, and EGLL even accounted for approx. 40%. Interestingly, the share of regional connection at these hubs reached the same levels during the initial recovery in summer 2020. At the secondary hubs, the pattern shifted. These airports observed a higher share of domestic/regional traffic in during the initial recovery. While the number of intra-European flights decreased overall, there was an almost complete loss of international traffic amplifying the domestic and partial intra-European traffic. The overall share at these secondary hubs decreased during end 2020 and beginning of 2021. With traffic numbers still significantly below the 2019 values (c.f. above), the overall share of reemergence of international traffic pushed the ratio towards the pre-pandemic levels.

## 3.3 Fleet Composition

Operational performance is also affected by the variation of the fleet composition as sequencing and traffic synchronisation impact the traffic flow. Traffic synchronisation influences therefore the capacity and observed (and realisable) throughput at airports. In particular, a highly varied mix including a larger proportions of heavy aircraft may result in lower throughout due to the larger wake turbulence separations. The locally defined capacity values may therefore differ based on the predominant fleet mix and operational characteristics. This can ultimately result in different observed throughput numbers, higher sequencing times in the terminal airspace, or additional times during surface movement.

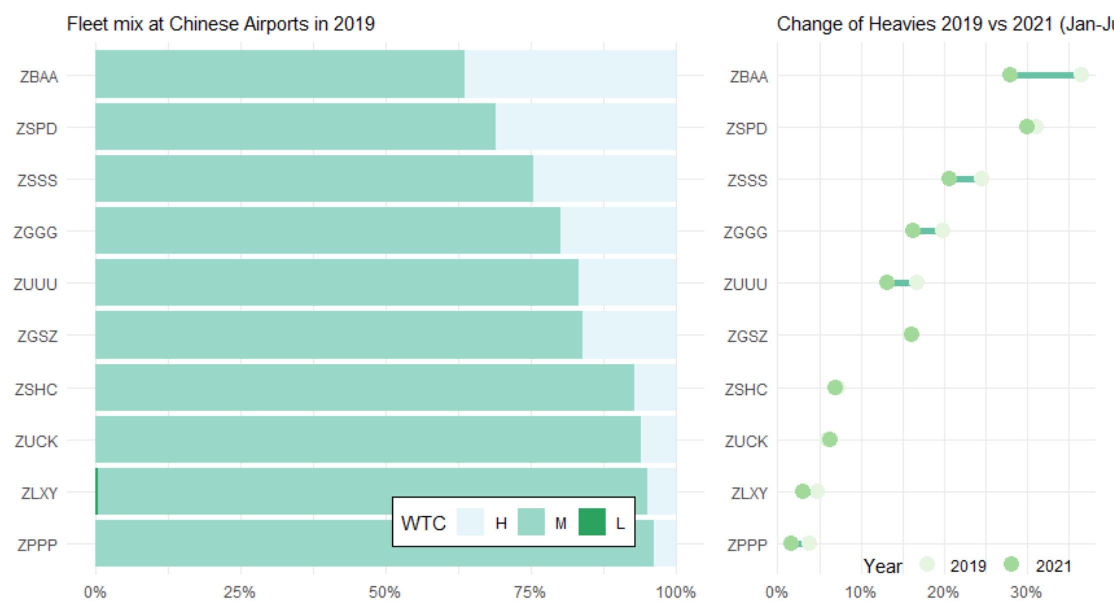


*Figure 3.7: Fleet mix observed at Chinese airports*

Figure 3.7 shows the fleet mix at the Chinese study airports in 2019. Across Chinese airports the share of light types is negligible and Medium aircraft are the predominant fleet aircraft. In 2019, a share of Heavy aircraft of 25% or more was observed at ZBAA, ZSPD, and ZSSS. However, there is also a considerable share of Heavy aircraft across the other airports. There was a varied picture for the reduction in Heavy aircraft comparing 2021 to 2019 levels. Beijing (ZBAA) saw a drop by almost 10% which widely coincides with the drop of international long-range traffic. However, the share of Heavies reduced only marginal at Pudong (ZPSD) when comparing the first months of 2021 with pre-pandemic levels. International connections accounting for a significant share of Heavies appeared to be more centralised.

There is an interesting higher share of Hs at ZSSS, ZGGG, ZUUU, ZGSZ. These four airports are China's major hub airports. These airports' flight schedules are more valuable which makes the airlines are more willing to choose wide-body planes to carry out the flight plans. While those airports located in northwest China, like ZUCK, ZLXY and ZPPP, can not provide services for large aircrafts, only available for regional ones. As for ZSHC, it serve more domestic cargo flights. In China, the cargo airlines usually use middle-size airplanes to carry out domestic cargo flights.

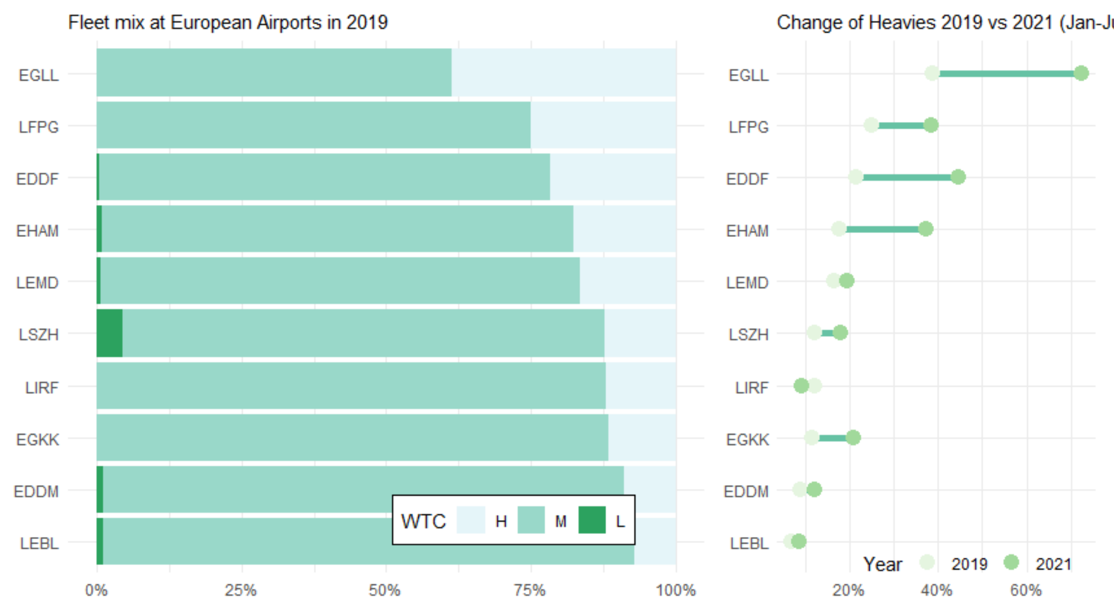


*Figure 3.8: Fleet mix observed at European airports*

Figure 3.8 depicts the fleet mix observed at European airports in 2019 and the respective change of the share of Heavies between 2019 and the first half of 2021. The fleet composition in Europe in 2019 showed a discernible share of Light aircraft for a number of airports. In particular, at Zurich (LSZH) light types accounted for over 5% of he traffic. On average, the share of Heavies is comparable between China and Europe at the top-10 airports. Heathrow (EGLL) observed a similar high share of Heavies than Beijing. Across the bottom part of the top 10, airports in Europe observed a higher share of Heavies in 2019. All of these airports have a considerable part of international long-range traffic showing the more spread connectivity across Europe. Between 2019 and the first 6 months of 2021, the change in fleet composition varies widely across European airports. There is a significant reduction in Heavies at the major hubs. Heathrow (EGLL) with a high number of international long-range connections observed a 30% lower share of wide-body aircraft in the first half of 2021 compared to 2019. LFPG, EDDF, and EHAM saw a reduction of Heavy movements of 10-15% which is alos closely linked with the stop of the international operations in light of the COVID travel restrictions.

# 4 Efficiency

Operational efficiency is a critical component in assessing the management and execution of operations during the arrival and departure phase of flight. Air navigation services play a vital role in enabling an efficient flow of air traffic, both on the ground and in the air, in particular by applying associated separation and synchronisation activities. Inefficiencies can have an impact on user operations in terms of experiencing delays or excessive fuel burn.

For this report, operational efficiency is assessed for the surface operations (i.e. taxi-in and taxi-out) and during the arrival phase. Conceptually, the measures reported in this study are based on the observed aircraft travel time. These travel times are compared with an associated reference time based on similar characteristic operations. The determined difference (i.e. additional times) measures the level of inefficiency during the operations. It must be noted that high performant operations will still yield a certain share of measured additional times. Operational efficiency is therefore aiming at the minimisation of these additional times across the population of flights.

## 4.1 Additional taxi-out time

The additional taxi-out time compares the actual taxi-out duration from the aircraft parking position to take-off with a reference time for the same type of operation. From an efficiency perspective, these reference times shall be comparable to traffic situation during which no congestion occurs (i.e. unimpeded time). Monitoring of the unimpeded times could support the identification of bottlenecks or seasonal specifics that can inform standard operating procedures.

For this report, taxi-operations at airports in China are grouped on the airport level. Standard taxi-out reference times are caculated using the same algorithm with Europe. The 20th percentile of the actual taxi-out time of the airport is the unimpeded taxi-out time of the airport. Each airport has a reference taxi time per month.

For the European data the ICAO GANP algorithm is applied and the reference taxi-out times are determined for each parking position and runway combination. To account for operational variation, e.g. operations during peak vs low traffic periods, varying weather conditions, the respective reference times are set as the 20th percentile of all observed combinations for the year. Note that for this report, the reference times are determined for each year. This is to account for the significant change of traffic patterns at the different airports (pre-COVID and COVID constraints).

### 4.1.1 Unimpeded standard taxi-out time of Chinese Top10 airports


*Figure 4.1: Reference taxi-out times observed at Chinese airports in 2019*

Figure 4.1 depicts the calculated reference times on a monthly level in 2019. For the majority of airports, the standard taxi-out times represent a constant value over a series of months. For example, the standard taxi-out time is determined as 10 minutes at Xi'an Xianyang International Airport (ZLXY). TO account for local specifics, the standard taxi-out time is modulated.

Shanghai Pudong (ZSPD) is the only airport with a highly varied standard taxi-out time. Shanghai Pudong was built near the sea shore, which makes it is easily affected by advection fog and low clouds in winter. Then it turns out that the aircraft taxiing time will be longer in this season.


*Figure 4.2: Reference taxi-out times observed at European airports in 2019*

Figure 4.2 shows the calculated reference times on a monthly level in 2019. For the majority of the airports in Europe, the 20th percentile approach provided a fairly constant monthly reference taxi-out time. Based on the algorithm, this suggests a fairly stable and regular schedule, and similar operating conditions. A higher level of variance is only observed at Amsterdam (EHAM). EHAM is the only European airport with 6 runways. Given its location (close to Dutch coast) and variable weather conditions, a multitude of runway system configurations are used on a month-to-month basis. The variation of combination leads to the observed variability of the aggregated monthly reference times in 2019.

### 4.1.2 Additional taxi-out time

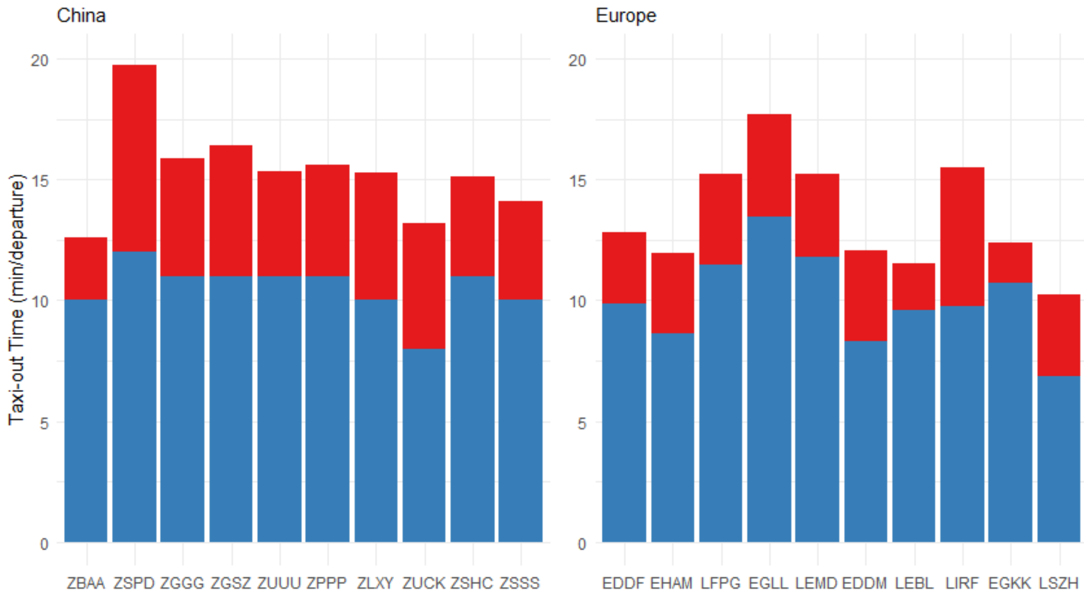


*Figure 4.3: Taxi-out times observed in China and Europe in 2021*

According to Figure 4.3 taxi-out times in 2021 vary across the airports in both regions. On average, the average additioanl taxi-out time is lower in Europe in comparison to China. However, the additional taxi-out time is not associated with the ranking of the airports. With the exemption of Beijng Capital (ZBAA) and Chongqing Jiangbei (ZUCK) there exists a moderate linear relation with the overall traffic and rank for the Chinese airports. Europe shows a variable pattern. London Heathrow (EGLL) accrued the highest aggregated reference time of all airports in Europe. In comparison to the other European hubs, EGLL is a 2-runway airport (EDDF/4, EHAM/6, LFPG/4). Accordingly, there is a significant pressure on the surface infrastructure in terms of taxi operations. This suggests that the 20th percentile approach applied for EGLL may contain already a discernible share of congested flights. Amongst the European airports, Rome Fiumicino (LIRF) accrued the highest average additional taxi-out time.

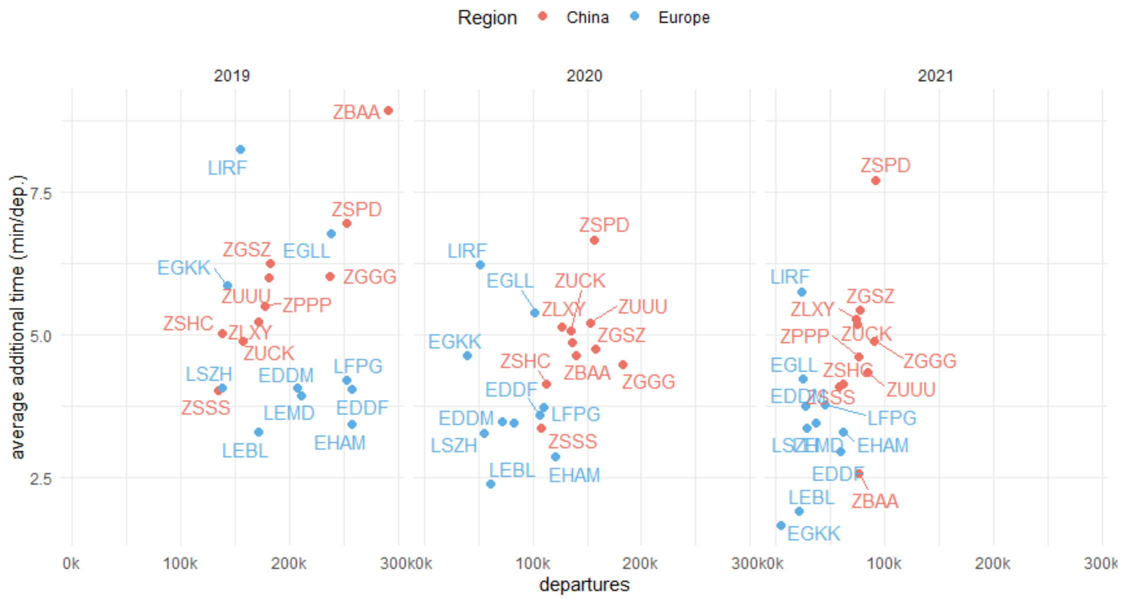


*Figure 4.4: Comparison of additional taxi-out time in China and Europe*

The overall evolution of the departure traffic and associated average additional taxi-out time is shown in Figure 4.4. In 2019, departure traffic levels at ZSPD and ZGGG are comparable with the traffic observed at the major European hubs (EGLL, LFPG, EDDF, and EHAM). Beijing Capital (ZBAA) was the busiest airport of all study airports in 2019. It also accrued the highest average additional taxi-out time of 8.94 minutes per departure. Interestingly, ZBAA accrued the lowest additional taxi-out time during the first half of 2021. And it is closely related to the decrease of the number of departure flights. On average, the average additional taxi-out time is positively associated with lower air traffic. The reduced number of movements relaxes the pressure on the surface movements and is reflected in a lower average additional taxi-out time for all European airports. A similar pattern is observed for the Chinese airports.. Data for 2021 represents the first 6 months. Departure traffic at the majority of airports in China experienced an average additional time of 5 minutes per departure or more in 2019. With the exemption of EGLL, EGKK, and LIRF, these times are higher than observed at the other European airports. Taxi-out performance remained fairly constant for ZPSD despite lower traffic and even increased for the first half of 2021.

# 5 Flight Punctuality

Predictability in the system affects operations in many ways. During the strategic phase when airlines set their schedules and during the operating phase when air navigation service providers and stakeholders balance demand and capacity.

Within that context, punctuality is a widely used measure for the aviation industry. It provides a measure for passenger satisfaction, helps airlines to check the achievability of the set schedule, and supports the further analysis of delay drivers or systematic causes.

Punctuality can be measured in multiple ways. This chapter builds on

- the on-time-performance (OTP) metric considering flights that departed/arrived less than or equal to 15 minutes past the published scheduled departure/arrival time; and
- a set of punctuality intervals based on the ICAO GANP performance measures.

## 5.1 On-Time Flight Punctuality Comparison of 2019 -mid 2021

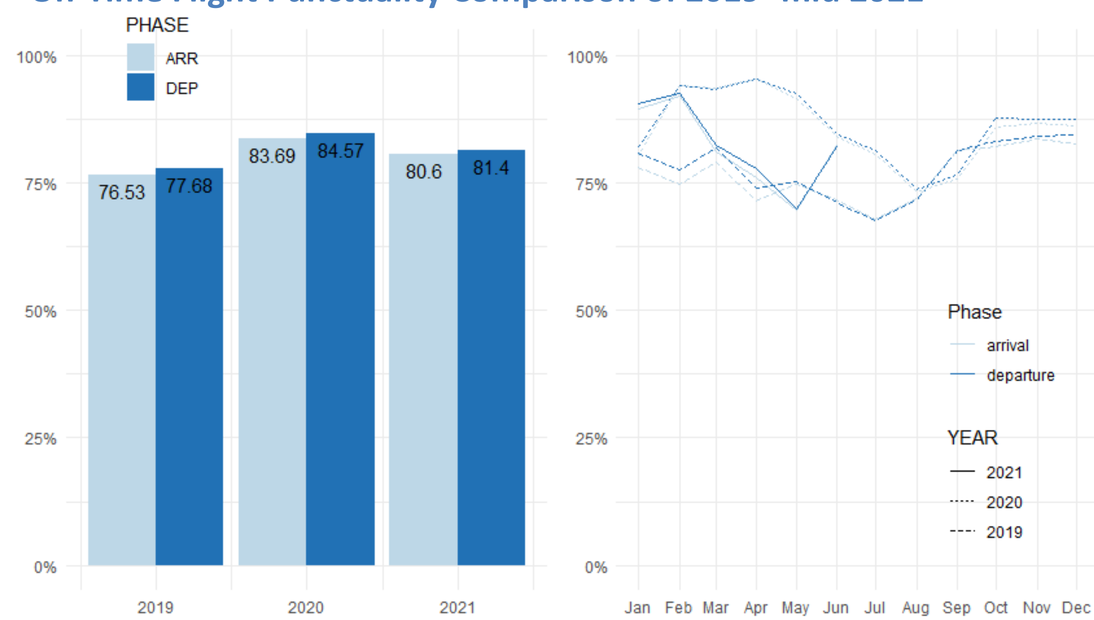


*Figure 5.1: On-time performance in China*

It's shown that from 2019 to 2020, China's OTP measure increased by 7%, and the rate decreased slightly in the first half of 2021. There existed a certain negative correlation between OTP measure and flight volume in China. In 2020, the COVID-19 led to a significant reduction of flight volume. While the flight volume reduced, the OTP value improved. In the first half of 2021, the number of flights in China recovered to about 80% of the same period in 2019, and the OTP performance decreased accordingly. The peak of China's flight volume usually occurs in July and August in summer. Coupled with thunderstorms in summer, the OTP value correspondingly is low.

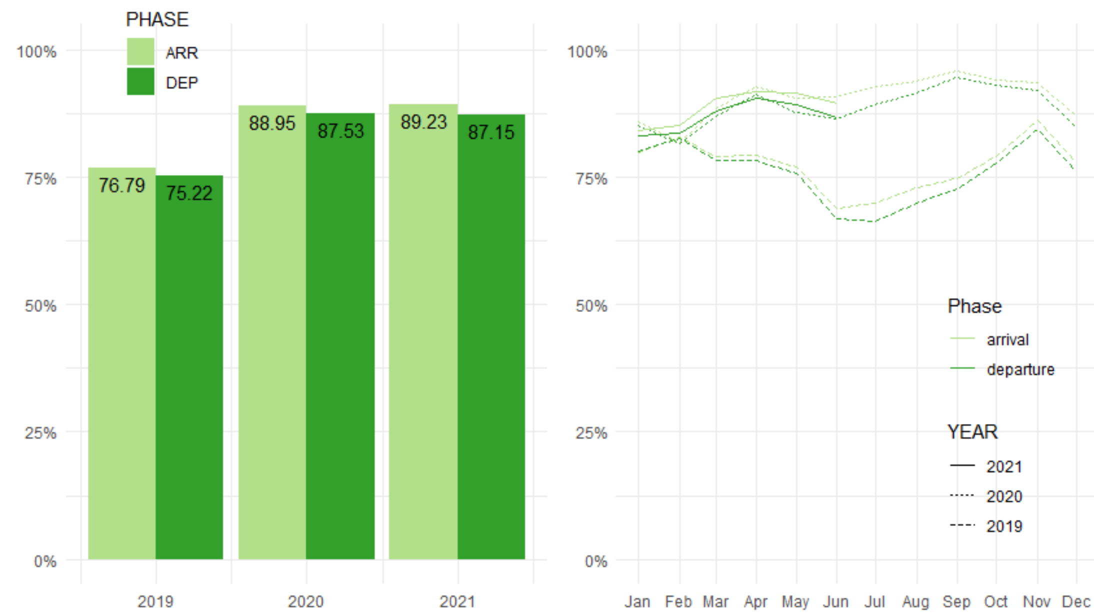


*Figure 5.2: On-time performance in Europe*

Within Europe the OTP measure increased by more than 10 percentage points from 2019 to 2020. In 2018 and 2019 Europe experienced a high level of ATFM delay due to limited airspace capacity. In 2019, the increased level of ground holding negatively affected the overall OTP performance ranging around 75% for both arrivals and departures. On-time performance in 2020 and the first half of 2021 show the same overall level on an annual basis. The higher level of OTP performance in 2020 and the first half of 2021 is also facilitated by significantly lower traffic levels due to the COVID related travel constraints.

Traffic in Europe shows a seasonal pattern peaking during the summer season. This combined with the observed capacity shortfalls lead to a lower monthly OTP performance for the months May through September in 2019 with OTP values below 75%. Traffic during the year 2020 and first half of 2021 experienced lesser constraints and a higher OTP performance is observed on the network level.

## 5.2 Punctuality at Top 10 Airport

The following analysis shows the OTP measure for each of the top-10 airports in each region.

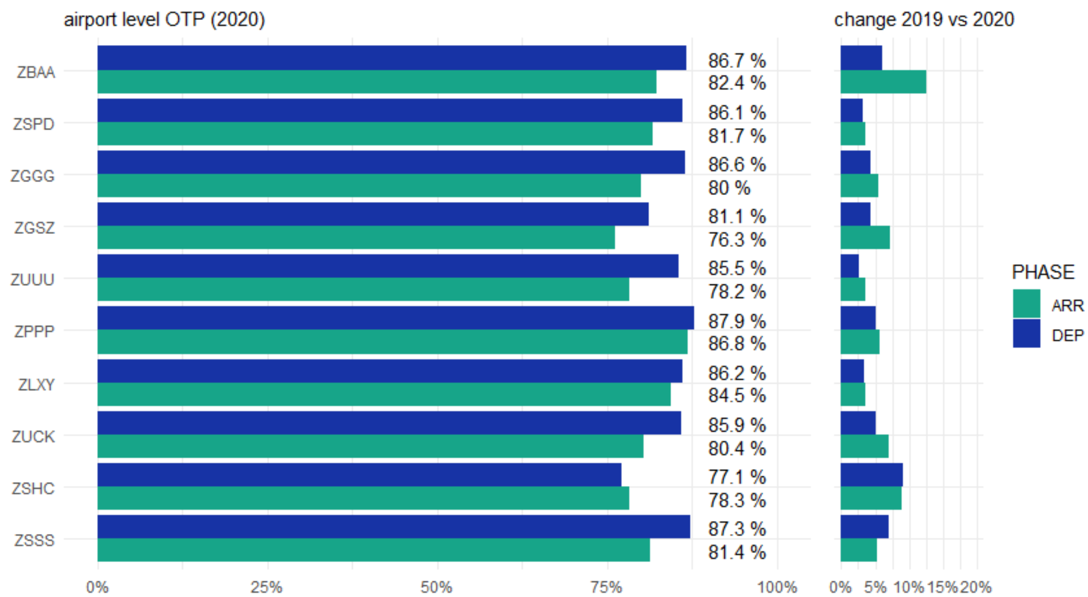


*Figure 5.3: On-time performance at top10 airports in China*

Compared with 2019, the OTP performance of China's top 10 airports increased by about 5% in 2020. This was due to a reduction in travel demand during the COVID-19 pandemic period. The flight volume dropped sharply, and the pressure of airport's operation lightened with an improvement in operational quality. In particular, the OTP value of inbound flights of Beijing Capital International Airport has increased by more than 10% in 2020. The opening of Beijing Daxing International Airport and the significant reduction of international passenger flights have effectively alleviated the operation pressure of Beijing Capital Airport.

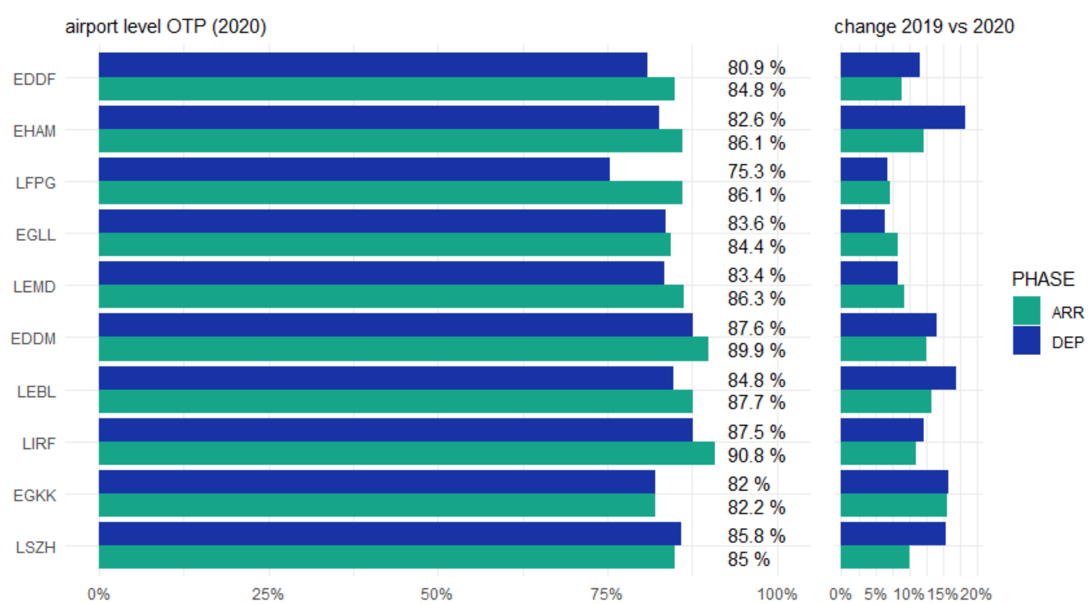


*Figure 5.4: On-time performance at top10 airports in Europe*

The airport level OTP performance follows the network level behaviour. For each of the European airports, the OTP performance increased in percentage points in 2020 compared to 2019. There is a strong variation across the European airports. The percentage point changes range between 7% - 20%. Since the OTP measure is strongly depended on the scheduled times these changes and absolute values need to be understood within the on-going context of COVID. Travel and turnaround times may benefit from the lower traffic levels, and ultimately result in a higher share of OTP arrivals/departures.

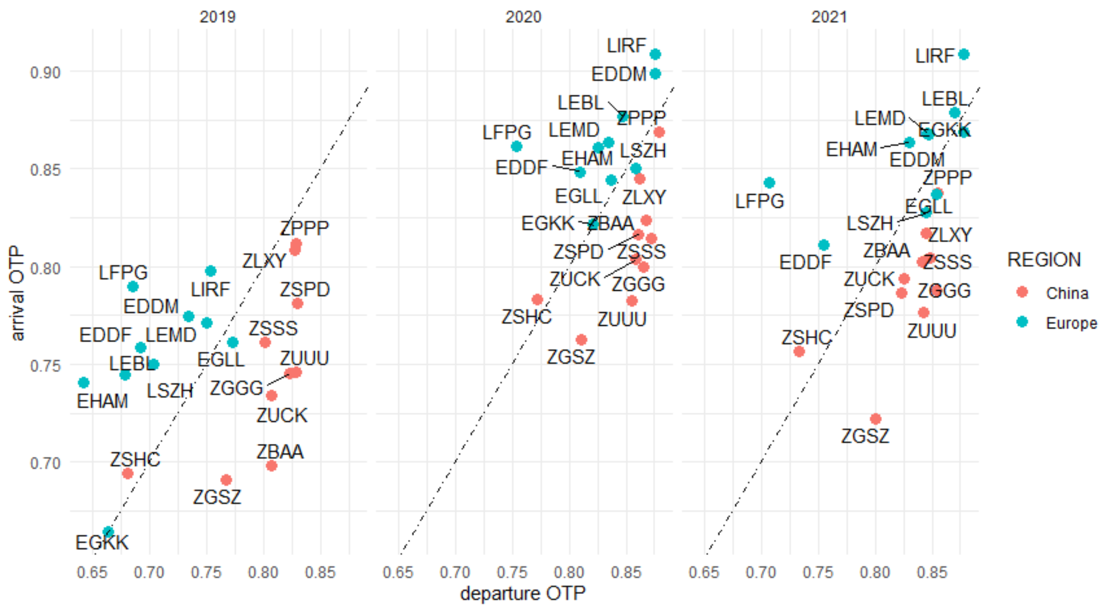


*Figure 5.5: On-time performance at top 10 airports in China and Europe*

Figure 5.5 depicts the relationship between arrival and departure on-time performance. In 2019, on average, airports in China showed a higher departure OTP performance that the European airports. The European airports accrued higher levels of arrival OTP performance. With reduced traffic levels in 2020 and 2021, the OTP performance at all airports increased. However, the overall pattern of China showing a higher level of departure OTP performance and Europe higher levels of arrival OTP.

## 5.3 Punctuality

The on-time performation measure accounts also for early arrival and departures. The level of flights outside the expected arrival or departure window can pose challenges to air navigation as traffic patterns shift and may exceed the available capacity or require additional sequencing within the arrival and departure airspace or during the taxi-phase of flight.

### 5.3.1 Arrival Punctuality

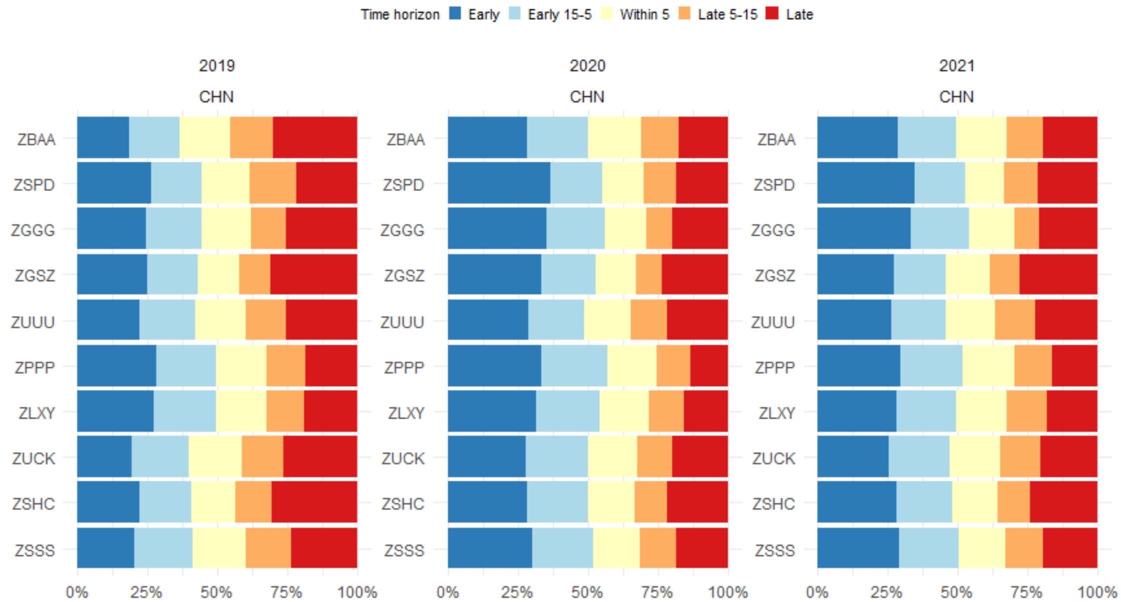


*Figure 5.6: Evolution of arrival punctuality at top10 airports in China*

Figure 5.6 shows the change of arrival punctuality of China's top 10 airports from January 2019 to June 2021. In 2020 and the first half of 2021, these airports' arrival punctuality has increased, especially that of Beijing Capital International Airport (the reasons have been mentioned above). In addition, the proportion of flights arriving more than 15 minutes earlier than the scheduled arrival time has increased, which may be due to the reduction of flight demand, smoother air traffic and shorter flying time.

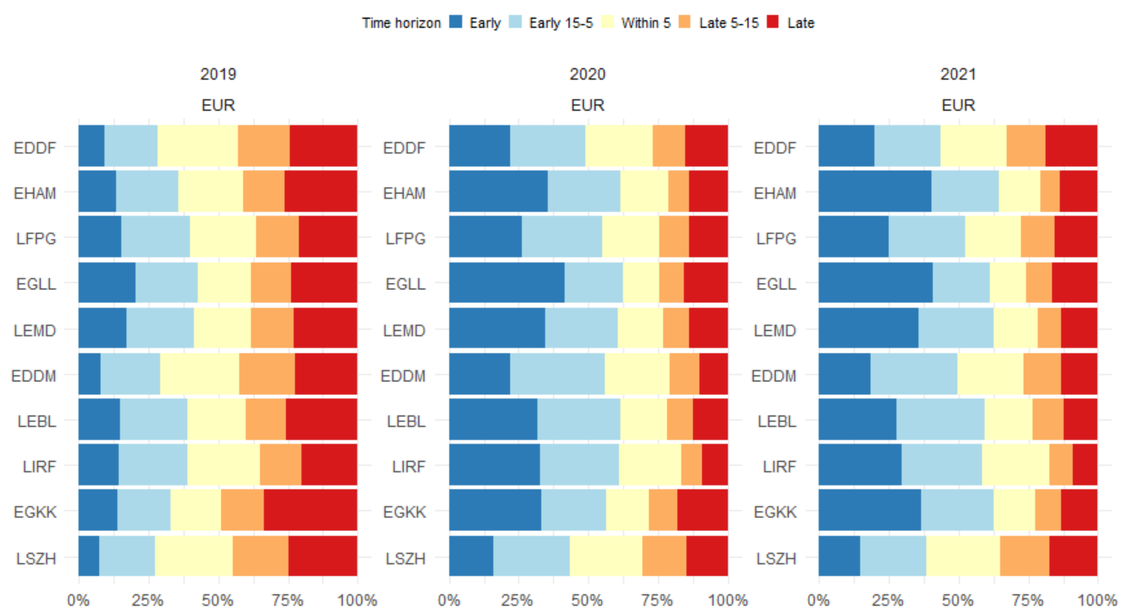


*Figure 5.7: Evolution of arrival punctuality at top10 airports in Europe*

Figure 5.7 shows the annual aggregated arrival punctuality for the period from January 2019 through June 2021. On average, arrival punctuality at the European airports has increased in 2020 and the first half of 2021. Across all airports the flights arriving earlier than 15 minutes before the scheduled arrival time increased. This suggests that the lower levels of air traffic reduce the overall travel time. Potentially air transport operators are operating slots or apply conservative scheduling.

### 5.3.2 Departure Punctuality

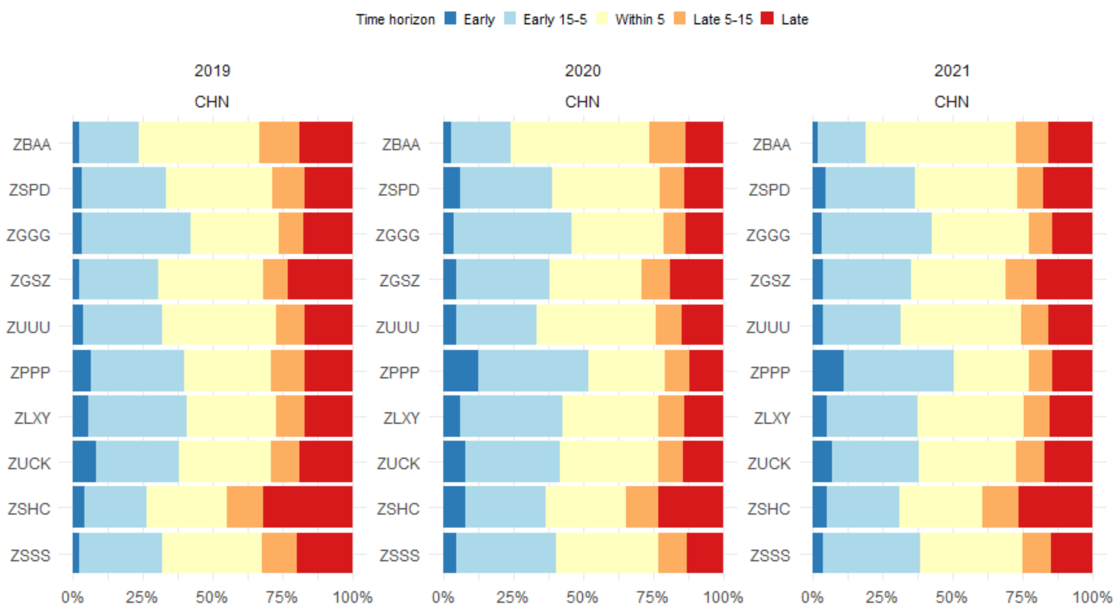


*Figure 5.8: Evolution of departure punctuality at top10 airports in China*

Figure 5.8 shows the change of departure punctuality of China's top 10 airports from January 2019 to June 2021. In 2020 and the first half of 2021, the departure punctuality of these airports has increased. Compared with Figure 5.6 and 5.8, it is noticed that the proportion of departing flights more than 15 minutes in advance is lower, but the proportion of arriving more than 15 minutes in advance is higher. It may be because the airlines are more conservative in formulating flight plans and the operation time in planned flight segments is longer.

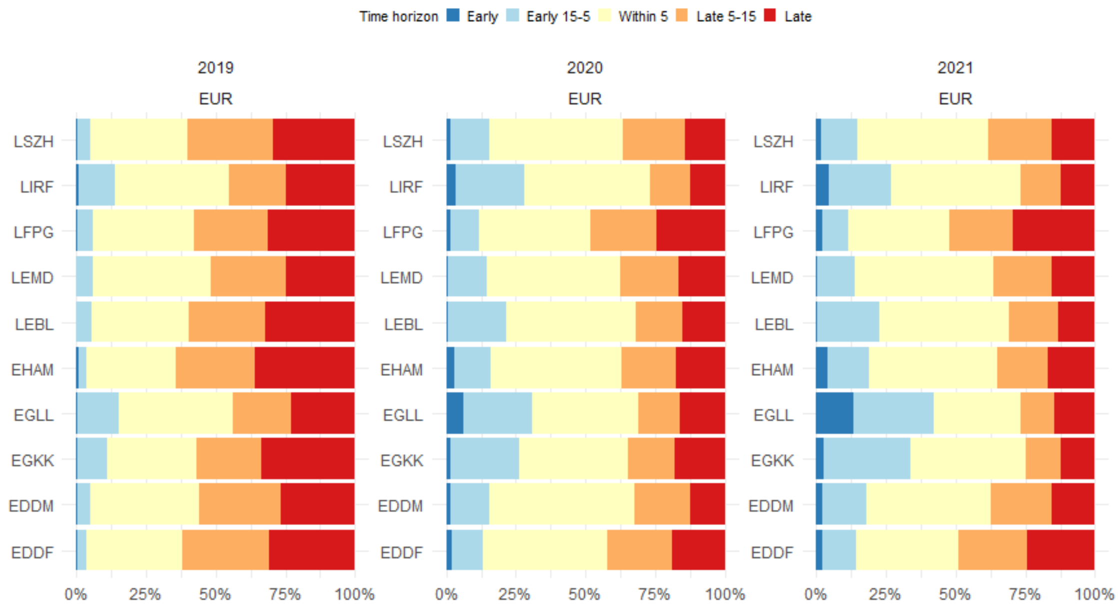


*Figure 5.9: Evolution of departure punctuality at top10 airports in Europe*

Figure 5.9 depicts the annual aggregation of the departure punctuality at European airports. On average, departure punctuality during 2020 and the first half of 2021 increased. Across all airports, flight departing within -/+ 5 minute of their scheduled time increased. Interestingly, Paris Charles de Gaulle (LFPG) and Frankfurt (EDDF) showed a lower reduction in delayed departures (i.e. 15 minutes of more after the scheduled departure time) in comparison to other airports. London Heathrow (EGLL) showed in 2020 and the first half of 2021 a higher share of early departures. Particularly, for flights departing 15 or minutes ahead of their schedule it is assumed that the schedule times and associated airport slots are not fully aligned with the operated schedule.

## 5.4 Main Causes of Delay

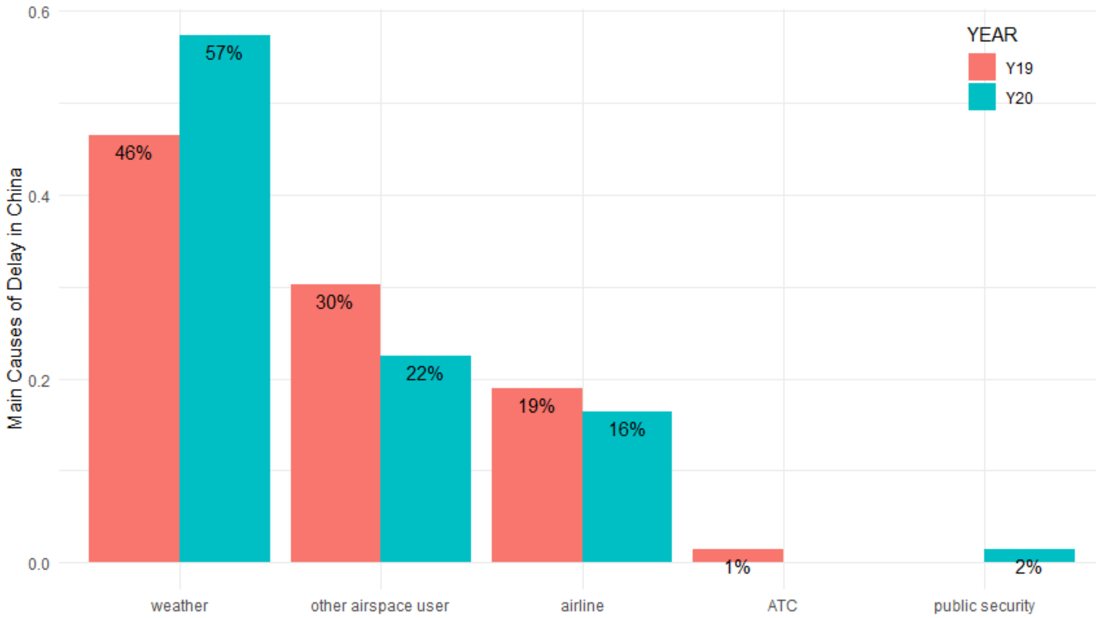


*Figure 5.10: Main Causes of Delay in China*

In China, the delay of each flight is ultimately attributed to one main reason. Therefore, the percentage in the figure refers to the percentage of delayed flights. From 2019 to 2020, the main reasons for flight delays in China are weather and other airspace users. Airlines account for about 20% delayed flights, and air traffic control accounts for a relatively small proportion. In 2020, due to the impact of the epidemic, the number of delayed flights accounted for public safety considerations increased significantly and flights were cancelled or delayed due to some public health events.

Delay attribution in Europe permits to identify a series of delay causes. Practices across the airspace users vary in terms of the number of cause identification/attribution and it reporting. The respective delay reporting standard accounts for a maximum of five different causes and a split of the observed overall delay to this causes. On average, the majority of the airspace users report 2-3 causes, if applicable.

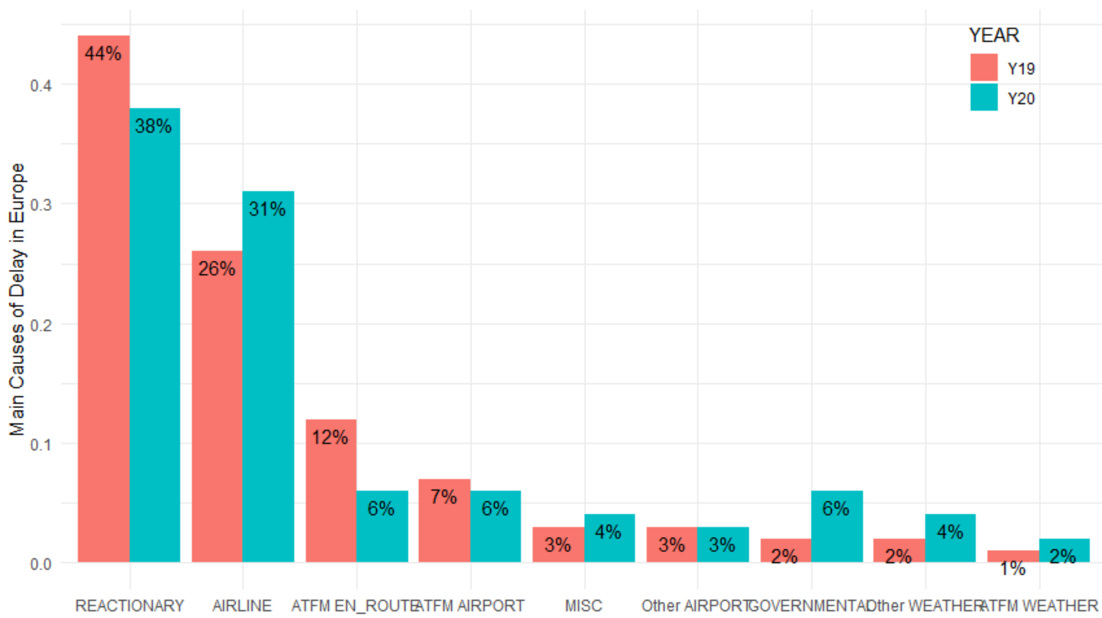


*Figure 5.11: Main Causes of Delay in Europe*

The classification and statistical methods of flight delay causes in Europe are different from those in China. The flight delay causes in Europe mainly include late arrival of previous flights (i.e. reactionary delay), airlines' factor, airports' factor, air route congestion, government factor and weather.

The time proportion of each flight delay is attributed to different reasons. Therefore, the delay percentage in the figure refers to the percentage of each cause of delay in the overall experienced delay. From 2019 to 2020, there are three main delay causes in Europe: the first is the late arrival of the previous flight and late delivery of passengers'/cabin crew's baggage, the second is the airline operations attributable factors, and the third is the volume of air traffic en-route traffic management flow restrictions.

More research is needed to elaborate the identified differences in delay cause attribution and evaluation methods in both regions. This may include a

## 5.5 Turnaround - DDI Analysis

For this study the groups agreed to investigate the delay aborption at the selected airports. For this the Delay Difference Indicator was determined for each flight arriving at an airport and its successive departure.

The following graph shows the average daily DDI per month for each of the airports covering the period January 2019 through June 2021.

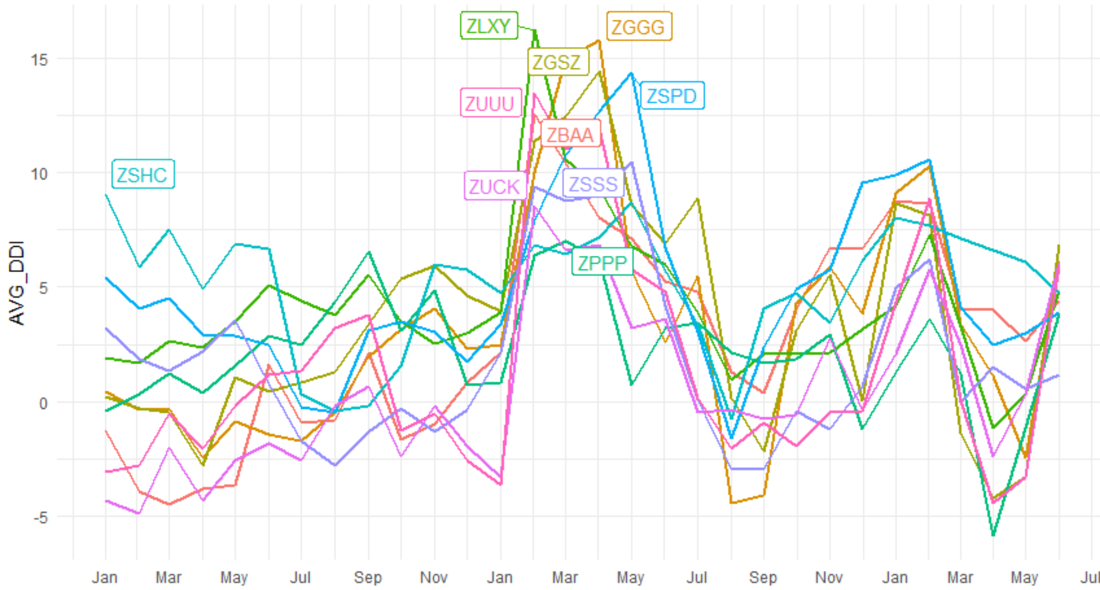


*Figure 5.12: Evolution of Delay Difference Indicator(DDI) at top10 airports in China*

Generally speaking, the top 10 airports in China have a certain delay absorption capacity, that is, they can absorb a certain amount of delay during the turnaround process of the airport, so as to reduce the delay chance of the next flight leg. This index reflects the transit support capacity of the airport. However, it is obvious that the delay absorption rate of each airport has increased significantly from February to June 2020 and from January to March 2021, that is, the delay of subsequent flights has increased by 10-15 minutes compared with the delay of previous flights, which is due to the longer transit time caused by more stringent epidemic prevention and control measures at these airports.

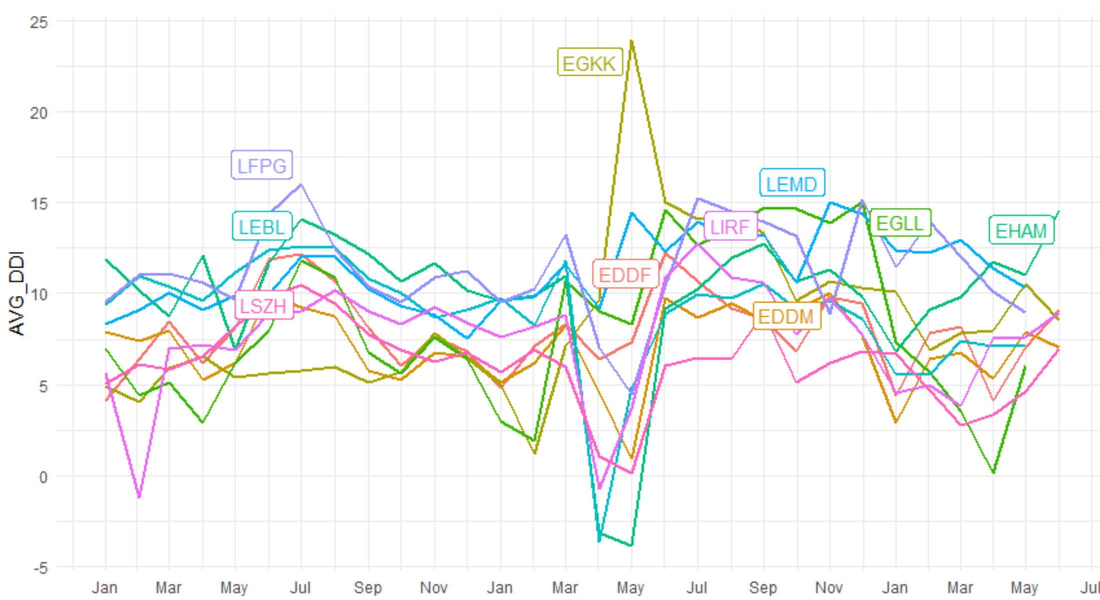


*Figure 5.13: Evolution of Delay Difference Indicator(DDI) at top10 airports in Europe*

For the European airports, the average daily DDI was generally positive throughout the study period and ranged between 5 to 15 minutes per turnaround. On average, flights arriving late will not be able to absorb the experienced arrival delay and depart slightly late. The general trend is broken for March and April 2020. In March 2020 the European traffic declined due to the imposed travel restrictions and was floored throughout April. As of May 2020 an initial rebound was observed (c.f. above). The distortion in these 2 months resulted in a reduction of the average daily DDI, and in some cases a negative DDI (i.e. off-block delay smaller than arrival delay) was observed.

# 6 Participants

This report is jointly produced by OSC of CAAC, CAUC, ADCC and PRU. The main participants are as follows:

*Table 6.1: Main Participants*

| Name | Organization |
|---|---|
| Shaohua Sun | CAAC |
| Yuhang Wang | CAAC |
| Fengfeng Liu | CAAC |
| Wei Zhou | CAAC |
| Qixuan Wang | CAAC |
| Lingling Ma | CAUC |
| Kaiyan Jin | ADCC |
| Di Zuo | ADCC |
| Rainer Koelle | PRU |
| Fabio Carneiro Barbosa | PRU |

# 7 Conclusion

This report marks the first China-Europe comparison of operational air navigation system performance. It has been jointly developed by CAAC/CAUC/ADCC and PRU on the basis of a harmonised set of comparable data prepared by both groups. The collaboration built on existing performance measures in both regions and the ICAO Global Air Navigation Plan. Accordingly a coordinated and harmonised set of performance measures and their parameterisation are presented throughout this report.

The comparison shows similarities and differences in terms of the handled air traffic and the observed performance in both regions. This opens the door for future research and further use-case analyses to study the underlying causes. The future work will also be useful to further develop and complement the performance measurement framework.

This report focuses on time period January 2019 through June 2021. The year 2019 serves as a pre-pandemic baseline to study air traffic developments and air navigation system performance in both regions. As shown throughout this report, both regions went through 2 major COVID-19 waves and associated constraints on air transportation. The report supports therefore to also study the influence of the unprecedented constraints on air transportation on operational performance measures during the COVID-19 pandemic and to what extent air traffic and system performance recovered. The latter encourages regular updates of this report to provide a continual monitoring.

The first part of this report examined commonalities and differences in terms of the organisation of air navigation and performance influencing factors, such as air traffic demand and fleet composition. These factors can have a large influence on the observed performance. Overall, the continental airpace of China covers an area of about 84% of the European area. Air navigation service provision is more fragmented in Europe with a high number of local/national ANSPs and their respective control units. Air traffic in China is serviced by one provider.

On the network level China's air traffic volume in 2019 ranged at about 53% of the European traffic levels. Due to the differences in the response to COVID-19, China's overall air traffic ranged on a similar level in 2020 and overtook Europe in the first part of 2021.

Among the 10 Chinese airports only Beijing (ZBAA) and Shanghai Pudong (ZSPD) "bundle" international air traffic. The other airports recovered after impact to pre-pandemic levels. This pattern is different in Europe with all airports seeing larger variations of the traffic levels and distinct waves. Across all European airports the peak day traffic fell significantly in 2020 and the first half of 2021 when compared to 2019. In China, only ZBAA and SZPD observed a significant drop in peak day throughput in the first half of 2021 compared to 2019 levels. However, the decline is still milder than the peak throughput variation observed across Europe.

On average the share of domestic (or regional) traffic is higher at Chinese airports with Beijing, Shanghai Pudon, and Guangzhou Baiyun showing a higher share of international traffic pre-pandemic and higher variation throughout 2020 and 2021 with an increasing ratio for domestic traffic. For the European airports the reduction of air traffic also included intra-European connections. This resulted in the strong reduction of traffic and associated drop in domestic/international traffic ratio during the COVID peak in early 2020. The second COVID wave in Europe and its impact on the share of intra-European and long-haul traffic is more prominent for the major hubs in Europe, i.e. Frankfurt (EDDF), Amsterdam Schiphol (EHAM), Paris Charles de Gaulle (LFPG), and London Heathrow (EGLL). Other European airports seemed to have suffered less from the loss of long-haul international traffic. Variations were mostly due to the general decline of traffic and in particular the intra-European traffic based on the varying national travel and COVID measures.

This report focusses on the operational effiency in the taxi-out phase. Across the studies airports, the associated reference times for taxi-out operations are similar in both regions. On average, the European airports show a slightly higher variation due to seasonal changes, mostly in terms of weather. On average additional taxi-out times are higher in China than in Europe. With the exemption of Beijing Capital (ZBAA) a more linear relationship between the observed total taxi-out times were observed. This suggests that travel times are associated with airport size in China. In Europe there is more variation across the airports showing a higher dependency on the local conditions (airport dimensions, runway/taxiway system and terminal configuration). The additional taxi-out times show a contracting behaviour in association with the reduced traffic levels in both regions.

On the network level, the annual on-time punctuality values for 2019 were similar in China and Europe. On average Europe observed slightly higher on-time punctuality levels in 2020 and the first half of 2021 with a comparable seasonal development in Europe across the study period. For the studied airports the on-time punctuality values range on average well above 80% and are comparable across the top 10 airports in both regions. On average, punctuality changes were higher in Europe than in China when comparing 2020 and 2019 showing a tighter associated between on-time performance and traffic levels at the airports (stronger overall reduction at European airports). When comparing the relationship between arrival and departure on-time performance, a stronger focus on the arrival phase was observed in Europe in 2019 and on the departure phase in China. Though, the overall pattern emerged in 2020 and for the period January through June in 2021, the spread between arrival and departure on-time performance reduced in both regions with the performance generally increasing to higher percentage points. Punctuality patterns in China vary less than in Europe across the airports and the studied time horizon. Airports in both regions showed similar levels of punctuality in the band of -/+ 5 minutes compared to the scheduled arrival and departure times. However, there exists a discernible share of early arrivals in China and Europe.

Delay reporting in China and Europe differs and this report provides an initial analysis. A key difference can be seen in the attribution of delay causes. Reporting standards in Europe permit multiple causes while in China a main cause is attributed to the observed delay. Weather related causes appear to be the main driver in China while in Europe reactionary delay, airline operations related factors, and ATFM delay account for the top three reasons of delay. Future work could include a deeper analysis of these delay patterns in both regions.

This initial China/Europe comparison of operational ANS performance showed interesting trends in terms of similarities and differences in both regions. The impact of COVID, but also the different approaches to handle the pandemic and its impact on air transportation, is clearly identifiable throughout the report. It will be interesting to study the further development and recovery of both systems and expand on the analyses of the operational performance associated with the demand levels in China and Europe. This report identified areas for future work and further joint research. Both groups agreed to update this report on a regular basis and it is hoped that the findings and observations will help other interested parties to explore the benefit of regional performance benchmarking exercises.

This initial report will be updated throughout the coming years under the umbrella nucleus for a regular updated online report in support of a future edition of the bi-regional comparison. Future editions will also enable to complement data time series and support the development of further use-case analyses.

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