Impact of COVID-19 on Global Air Connectivity, and A Research Agenda

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Economic importance of <u>aviation</u>

- Directly employed 10 million people and generated US$3.0 trillion in value-added output globally (ATAG, 2018).

- Airline industry is vulnerable to various shocks – next page

Shocks of various kinds

- ○ Locally: Convective weathers; Mechanical failures
- ○ Economic and financial disruptions; Wars; "9-11"
- ○ Epidemic and pandemic outbreaks
- ○ COVID-19 can be considered a unique event
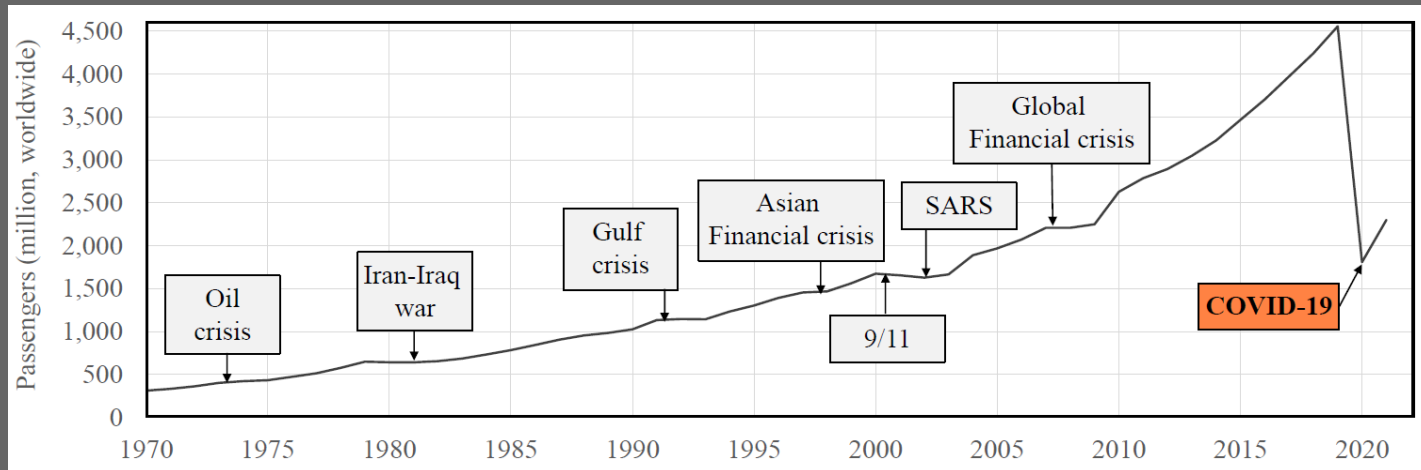
Evolution of global airline passengers (left) and revenue (right), 2019‑2022
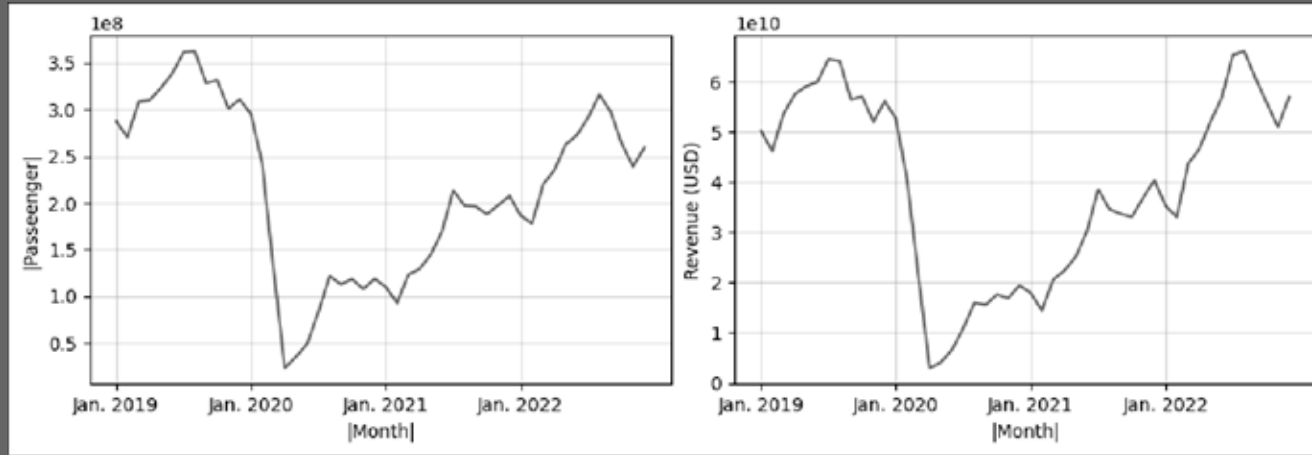
I. Jan‑May 2020: Shock from epidemic outbreak to pandemic

II. June 2020‑End of 2021: Bumpy recovery

III. Jan 2022‑: Back to (new) normal? (Summer 2022)

     - Higher price in recovery process

Global Airport Connectivity Index (GACI)

Cheung, T.K., Wong, C.W., & Zhang, A. (2020). The evolution of aviation network: Global airport connectivity index 2006–2016. Transportation Research Part E: Logistics and Transportation Review.

Global Airport Connectivity Index (GACI)

▮ Classify airports at <u>global</u> level

▮ Tracking (evolution for a given airport).

▮ **Benchmarking, on <u>connectivity</u>.**

▮ Identify the relevant forces driving rankings: this part is still at an early stage (to be discussed later).

▮ Combine **five** centrality indicators (incl. volume-adjusted).

Five network centrality indicators

- Degree

- Closeness (measuring "accessibility" of airport)

- Volumetric-based flow betweenness ("hubbing")

- Eigenvector ("onward connections")

- Regional importance ("importance in a subnetwork")

Top-20 Hubs: GACI 2006-2019 (pre-pandemic)

Ranking	2006	GACI	2011	GACI	2016	GACI	2019	GACI
1	FRA	3.275	FRA	3.286	PEK	3.392	PEK	3.626
2	LAX	3.239	LAX	3.168	CDG	3.225	FRA	3.314
3	ATL	3.023	ATL	3.167	FRA	3.131	LAX	3.308
4	ORD	2.950	CDG	3.083	LAX	3.116	CDG	3.258
5	CDG	2.942	AMS	3.031	DXB	3.008	ORD	3.145
6	JFK	2.905	PEK	2.996	AMS	2.982	PVG	3.141
7	AMS	2.779	SIN	2.862	PVG	2.912	DXB	3.065
8	YYZ	2.766	ORD	2.860	IST	2.908	AMS	3.051
9	LHR	2.751	DEN	2.714	ORD	2.906	SIN	3.024
10	EWR	2.649	JFK	2.679	ATL	2.865	IST	3.009
11	DFW	2.552	YYZ	2.652	JFK	2.763	ATL	2.952
12	BKK	2.522	DFW	2.648	SIN	2.748	LHR	2.920
13	IAH	2.503	LHR	2.640	HKG	2.730	CAN	2.919
14	DEN	2.485	SFO	2.609	LHR	2.721	YYZ	2.872
15	SIN	2.470	BKK	2.599	YYZ	2.674	HKG	2.871
16	BOS	2.399	DXB	2.581	SFO	2.656	DFW	2.820
17	IAD	2.399	EWR	2.569	ICN	2.606	JFK	2.792
18	HKG	2.391	HKG	2.466	CAN	2.603	ICN	2.693
19	PEK	2.386	IAD	2.452	EWR	2.547	DEN	2.643
20	SFO	2.321	SEA	2.447	DFW	2.522	BKK	2.631

COVID-19 Impact: GACI 2020-2022

Ranking	2006	GACI	2011	GACI	2016	GACI	2019	GACI	2020	GACI	2021	GACI	2022	GACI
1	FRA	3.28	FRA	3.29	PEK	3.39	PEK	3.63	PEK	2.88	FRA	2.80	FRA	3.20
2	LAX	3.24	LAX	3.17	CDG	3.23	FRA	3.31	PVG	2.85	IST	2.79	ORD	3.09
3	ATL	3.02	ATL	3.17	FRA	3.13	LAX	3.31	FRA	2.82	AMS	2.72	DXB	3.06
4	ORD	2.95	CDG	3.08	LAX	3.12	CDG	3.26	CAN	2.77	DXB	2.7	IST	3.01
5	CDG	2.94	AMS	3.03	DXB	3.01	ORD	3.15	CDG	2.77	CAN	2.67	DFW	2.98
6	JFK	2.91	PEK	3	AMS	2.98	PVG	3.14	AMS	2.71	CDG	2.62	CDG	2.98
7	AMS	2.78	SIN	2.86	PVG	2.91	DXB	3.07	IST	2.69	ORD	2.62	LAX	2.92
8	YYZ	2.77	ORD	2.86	IST	2.91	AMS	3.05	CTU	2.63	DFW	2.54	AMS	2.92
9	LHR	2.75	DEN	2.71	ORD	2.91	SIN	3.02	DXB	2.59	LAX	2.46	LHR	2.9
10	EWR	2.65	JFK	2.68	ATL	2.87	IST	3.01	ORD	2.58	LHR	2.46	ATL	2.78
11	DFW	2.55	YYZ	2.65	JFK	2.76	ATL	2.95	LHR	2.56	PEK	2.42	MIA	2.71
12	BKK	2.52	DFW	2.65	SIN	2.75	LHR	2.92	SZX	2.48	PVG	2.4	JFK	2.69
13	IAH	2.5	LHR	2.64	HKG	2.73	CAN	2.92	YYZ	2.46	CTU	2.32	DEN	2.67
14	DEN	2.49	SFO	2.61	LHR	2.72	YYZ	2.87	LAX	2.42	ATL	2.3	IAH	2.55
15	SIN	2.47	BKK	2.6	YYZ	2.67	HKG	2.87	DFW	2.4	MIA	2.26	EWR	2.53
16	BOS	2.4	DXB	2.58	SFO	2.66	DFW	2.82	XIY	2.36	SVO	2.26	YYZ	2.5
17	IAD	2.4	EWR	2.57	ICN	2.61	JFK	2.79	ATL	2.33	IAH	2.25	SFO	2.48
18	HKG	2.39	HKG	2.47	CAN	2.6	ICN	2.69	SVO	2.28	DOH	2.22	CAN	2.47
19	PEK	2.39	IAD	2.45	EWR	2.55	DEN	2.64	IAH	2.28	YYZ	2.18	SIN	2.46
20	SFO	2.32	SEA	2.45	DFW	2.52	BKK	2.63	CKG	2.22	DEN	2.17	MAD	2.45

The pandemic and airport fortunes

- Evolution of Chinese hub airports, 2006-2022

- "Flow betweeness": HKG falling vs. Mainland China's connecting gateways: PEK, PVG, CAN (despite HKG's resilient air cargo business)

- HKG vs. SIN (Singapore)

- Rise of DXB (Dubai) and IST (Istanbul)

- Indian airports recovered rather well, under influence of increased domestic traffic; so did African airports (increased intra-Africa region)

Implications for the recovery

- The pandemic: Devastating impact on aviation (airlines, airports),

  - World's airlines lost about $700 billion in 2020/2021.

- With government bail-out programs, liberalization would hold back

- Higher ticket prices
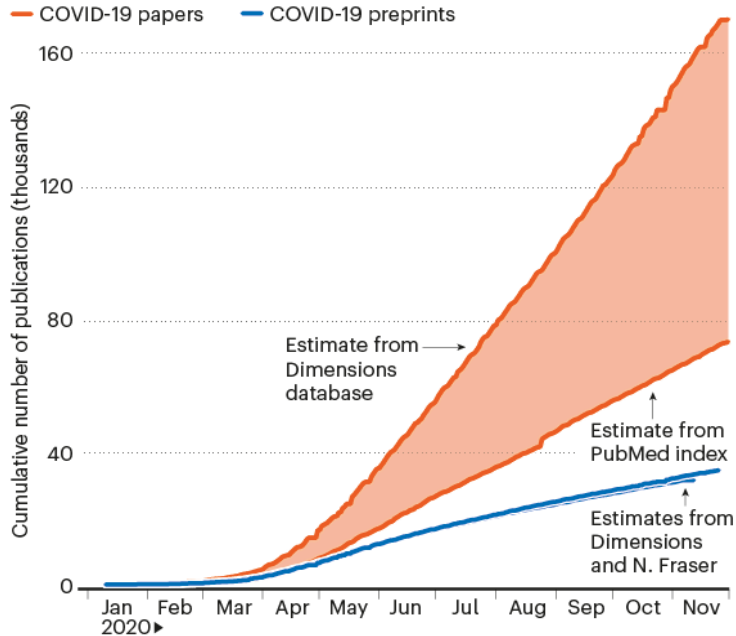
- **Resilient aviation needed**

Further Research: A Research Agenda

1. Resilience

2. Environmental factor

3. Multi-modal

4. Land-side accessibility

5. Evolution and drivers

6. Connectivity and economic performance

7. Connectivity in cargo

8. Other transport modes

The academic COVID-19 "pandemic"

CORONAVIRUS CASCADE
One estimate suggests that more than 200,000 coronavirus-related journal articles and preprints had been published by early December.

— COVID-19 papers   — COVID-19 preprints

Cumulative number of publications (thousands)

160

120

80

40

0

Estimate from Dimensions database

Estimate from PubMed index

Estimates from Dimensions and N. Fraser

Jan 2020 ▶ Feb Mar Apr May Jun Jul Aug Sep Oct Nov

*Estimates differ depending on search terms, database coverage, and definitions of what counts as a scientific article; some preprints were posted on multiple sites online.

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https://www.nature.com/articles/d41586-020-03564-y

- Almost at the same time as the outbreak of the COVID-19 health pandemic, a parallel pandemic started to develop in the academic literature!

- Until the end of 2020, an estimated number of almost 200,000 papers had been published with related keywords.

Aviation is no exception here!

- The reasons for the abundant number of studies on aviation and COVID are various:
  - Aviation plays a major role in epidemic spreading: While aviation is a victim of COVID-19 ramifications, the effectivity of the system enabled the spread of the virus to farthest places on our planet
  - Aviation is probably among the hardest hit industries. Many stakeholders downstream are affected by the pandemic

[Sun, Wandelt, Zheng and Zhang. COVID-19 pandemic and air transportation: Successfully navigating the paper hurricane. Journal of Air Transport Management 94, 102062, 2021]
[Sun, Wandelt, and Zhang. COVID-19 pandemic and air transportation: Summary of recent research, policy consideration and future research directions," Transportation Research Interdisciplinary Perspectives 16, 100718, 2022]

Keywords being used in aviation (e.g. ATRS)

Efficiency
Optimization
Minimization of costs
Revenue maximization
Competition / Market
power
Accessibility /
Connectivity
Economies / tourism
...

Sustainability
Green aviation
Carbon footprint
Clean fuels
'Flight shame'
Social responsibility
...

Vulnerability to shocks
Resilience
Risks
'Circuit breaker'
Coopetition
...

1. Resilience

- GACI $\rightarrow$ "GARI" (Global Airport Resilience Index)

- Less vulnerable, and if hit by a shock, the recovery is faster

- Factors under managerial/policy control; other factors more or less given for a given airport

2. Environmental factor

- E.g., more emissions from greater connectivity → change the ranking

- Modify GACI by incorporating environmental impact

3. Multi-modal

- Opportunities for multi-modal connections
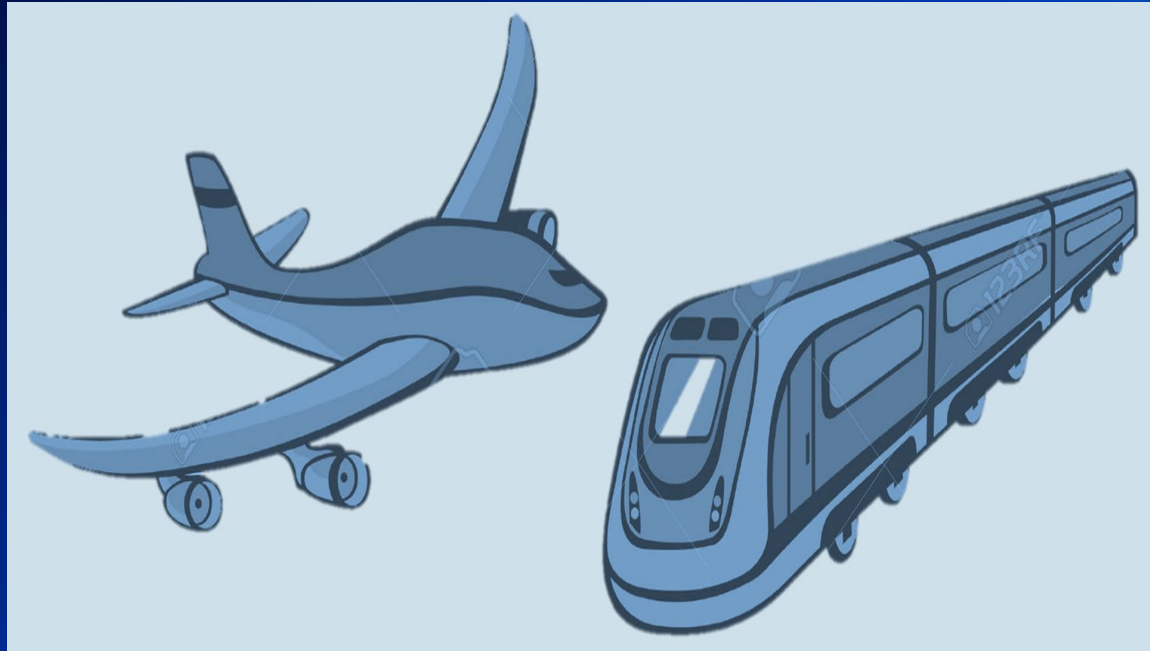
"Connectivity of intercity passenger transportation in China: A multimodal and network approach," Zhu, Zhang and Zhang (2018, J of Trans. Geography)

- Zhu et al. (2018) show that with high-speed rail, airport connectivity ranking may change

- "Airport" connectivity index (GACI) can also be extended to "Link (city pair)" connectivity index

4. Land-side accessibility

■ An MAR phenomenon: "hub bypassing" may happen for a hub airport with another airport of the same "city"

■ But the effective competition may also come from airports closely located in "neighbour cities"

■ Also, when you add a new airport, its importance to the network depends on its land-side accessibility

How to incorporate the land-side accessibility into air connectivity measures?

Need to better measure land-side accessibility

The catchment area of an airport is often defined by travel distance from the airport (e.g. 150 km)

Sun, Wandelt, and Zhang (2021): accessibility based on "travel time" – made possible now with (open source) Big Data

Sun et al. (2021): "Comparative accessibility of Chinese airports and high-speed railway stations: A high-resolution, yet scalable framework based on open data," Journal of Air Transport Management

◼ Combine several Open Data sets, including:

- Gridded Population of the World (GPW:) population data at grid cells with a high resolution (< 1 sq. km)

- Openstreetmap (OSM:) public transport, road network

- Open Source Routing Machine (ORSM:) driving distance

◼ Compute free-flow road travel time, as well as the public transit time, from grid cells to an airport

◼ Apply to China more than 10 million grid cells with population and accessibility data

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5. Evolution and drivers

Drivers:

How contextual factors such as the particularities of the urban, economic and institutional system (including policy) shape transportation system outcomes – in this case, connectivity?

6. Connectivity and economic performance

- Economic performance (e.g. Tourism, high-tech sectors): Important policy questions

- Joint together with Gravity models: 1) City; 2) Link

- Issue of endogeneity

7. Connectivity in cargo

- Air cargo

- Expressdelivery

- More generally, "Logistics performance index"

8. Other transport modes

- Maritime: ports, links

- High-speed rail

- Subway: bike sharing and last-mile problem?

- Urban road

- International trade

- Social network

- ……

Thankyou very much again!