

The Connectivity of Airports

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PhD Thesis: The Connectivity of Airports – A System Dynamics View on An Airport's Competitive Position in the Air Transport Network

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Motivation

Ongoing privatisation and commercialisation of airports

- Airport competition is an issue
- How can growth be achieved?

Two sources for passenger growth at an airport:

- **Landside** catchment (O&D passengers: business travellers, tourists, visitors)
- **Airside** catchment (Transfer passengers) → very dynamic, e.g. Dubai airport

Transfer traffic depends on the airport's position in the air transport network, i.e. the airport's air transport supply structure in comparison to others.

→ **Connectivity = Competitive position of an in airport in the network is a strategic resource that generates transfer traffic**

So far there is no clear understanding of that position.

→ **Research questions:**

- 1. How can the connectivity of an airport be measured if it is meant to be a strategic resource that expresses the airport's competitive position within the network?***
- 2. Why has an airport's connectivity developed in a certain way and what can airport operators do to improve their competitive network position?***

Approach

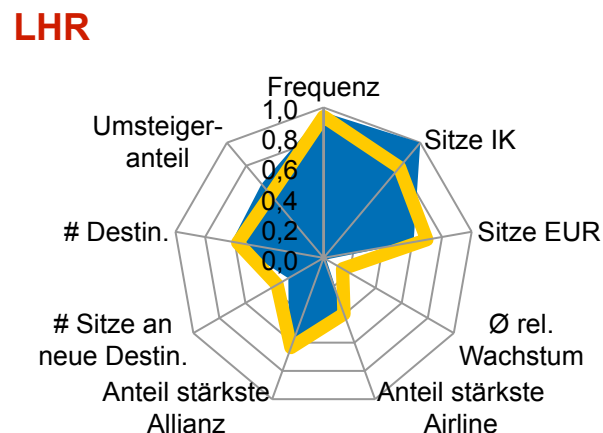
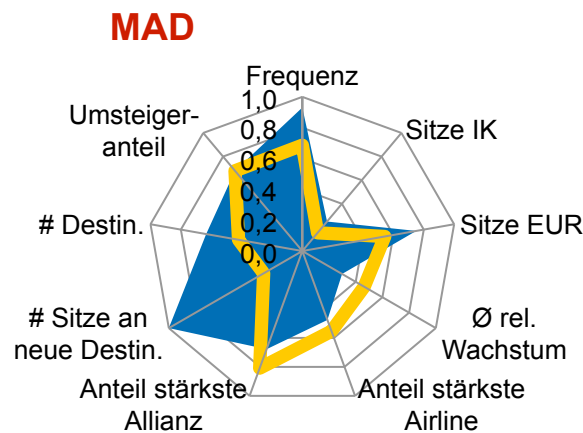
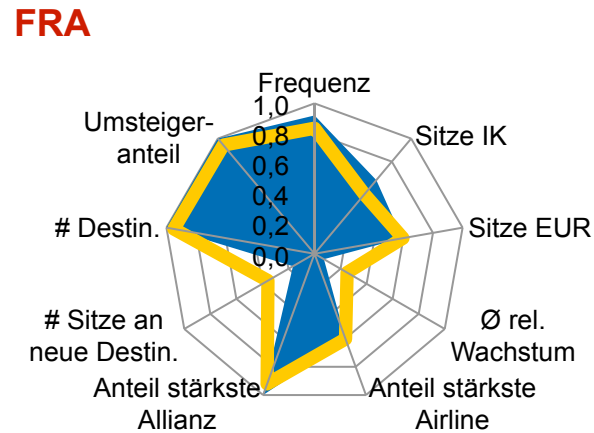
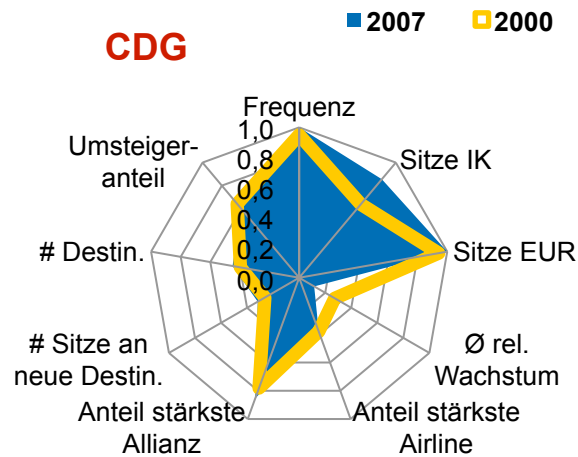
1. Find suitable connectivity measure

- Different measures for an airport's connectivity are assessed to find one that can best explain an airport's volume of transfer traffic
- Commonly used: Local-based measures, e.g. number of passengers, destinations, movements
- Needed: Network-related measure to capture the airport's position in the network

3. Model influences on connectivity

- System Dynamics model to investigate the influences on connectivity
- The methodology is chosen because it allows to capture the complex multiple feedback relationships between the different influencing factors and to include soft variables, such as passengers' satisfaction, into the quantitative simulations
- Simulations will help to **identify policies to improve the airport's connectivity**

Strategic Airport Profiles

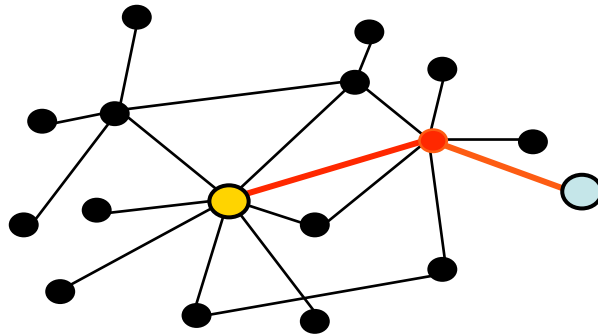


- **FRA** is the group leader in terms of transfer share and destinations offered
- **LHR** offers more intercontinental traffic
- **CDG** is comparably strong in European traffic
- **MAD** has hub characteristics but so far less intercontinental traffic; new destinations are being opened

Data source: primary OAG

Methodology: Network Topology Analysis

Analysis based on shortest paths



What is a “shortest path”?

- The minimum number of flights needed to get from airport **A** to airport **B**
- E.g. direct flight length = 1

Suggested connectivity measure: Centrality

Number of shortest path within the network that run over an airport



- **The measures account for onward connections based on the whole network**
- **Thus they reflect the airport’s position within the air transport network!**

Centrality in the European Network

Airport			2006	2003	2000	1997	1994
DME	Moscow (Domodedovo)	Russia	1	5	29	45	2
CPH	Copenhagen	Danmark	2	1	2	1	5
OSL	Oslo (Gardermoen)	Norway	3	2	1	4*	6*
SVO	Moscow (Sheremetyevo)	Russia	4	8	3	7	8
STN	London (Stansted)	UK	5	6	5	58	40
ARN	Stockholm (Arlanda)	Sweden	6	7	8	3	7
LED	St. Petersburg (Pulkovo)	Russia	7	10	12	10	1
ORY	Paris (Orly)	France	8	3	6	6	4
FRA	Frankfurt	Germany	9	4	4	2	9
IST	Istanbul	Turkey	10	14	7	9	22
MUC	Munich	Germany	11	13	11	14	17
AMS	Amsterdam	Netherlands	13	11	10	5	11
CDG	Paris (Ch. de Gaulle)	France	20	15	13	12	13
LHR	London (Heathrow)	UK	38	27	23	8	10

Database: OAG



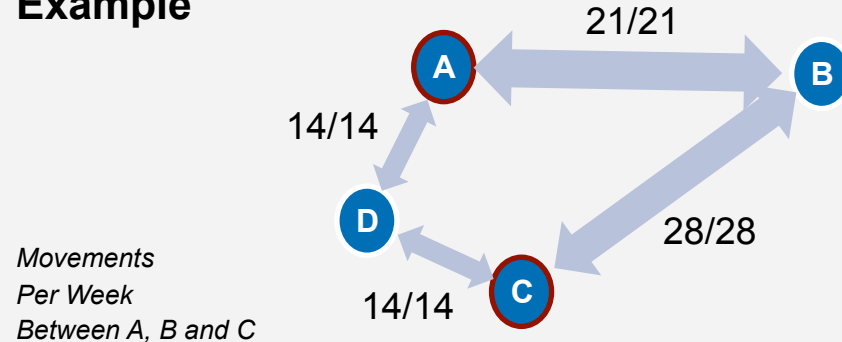
- Frankfurt is today the only international hub in the top 10
- Since 1994 Munich and Frankfurt persistently hold their strong importance in the European air traffic network
- Multi airport systems: European traffic shifts from Heathrow to Stansted
- Russia dominates the top 10 (Moscow links plenty of fairly connected airports)

Which Connections do Passengers Actually Fly?

From *shortest* to *fastest* paths

- Interpretation problem in shortest path computation: Data is dichotomised → Results depend on threshold used
- Shortest Path analysis understands “short” in terms of the number of flights needed for the connection → Actual arrival, departure and travel times are not considered. Is that realistic?

Example



Shortest Way from A to C

- So far: ADC and ABC
- Pure traffic weights: ABC
- With space/time dimension: ADC



Relevant for passengers is the *fastest* path!

- How many fastest paths run over an airport?
- How many of these are offered by an airline/ an alliance?

Example: Fastest Paths in the European Network

Airports' competitive position measured by fastest path centrality

(Ø number of fastest connections per hour from 6-24h)

Airport		In alliances (A)	Whole network (G)	Share (A/G)
Frankfurt	FRA	1 425	2 310	62 %
Munich	MUC	1 306	2 662	49 %
Paris Ch. de Gaulle	CDG	1 007	2 520	40 %
Madrid	MAD	927	2 540	36 %
Amsterdam Schipol	AMS	821	2 262	36 %
London Heathrow	LHR	743	1 867	40 %
MilanMalpensa	MPX	389	748	52 %
Rom Fiumicino	FCO	372	1 403	26 %
Barcelona	BCN	348	1 392	25 %
Stockholm Arlanda	ARN	258	1 123	23 %
Helsinki Vantaa	HEL	165	588	28 %
London Stansted	STN	-	319	0 %
European Network		11 288	33 345	34 %

Number of fastest paths in on average per hour (from 6:00h to 24:00h).
 MCT = 1h, maximum waiting time = 2h, distance threshold = 100km.

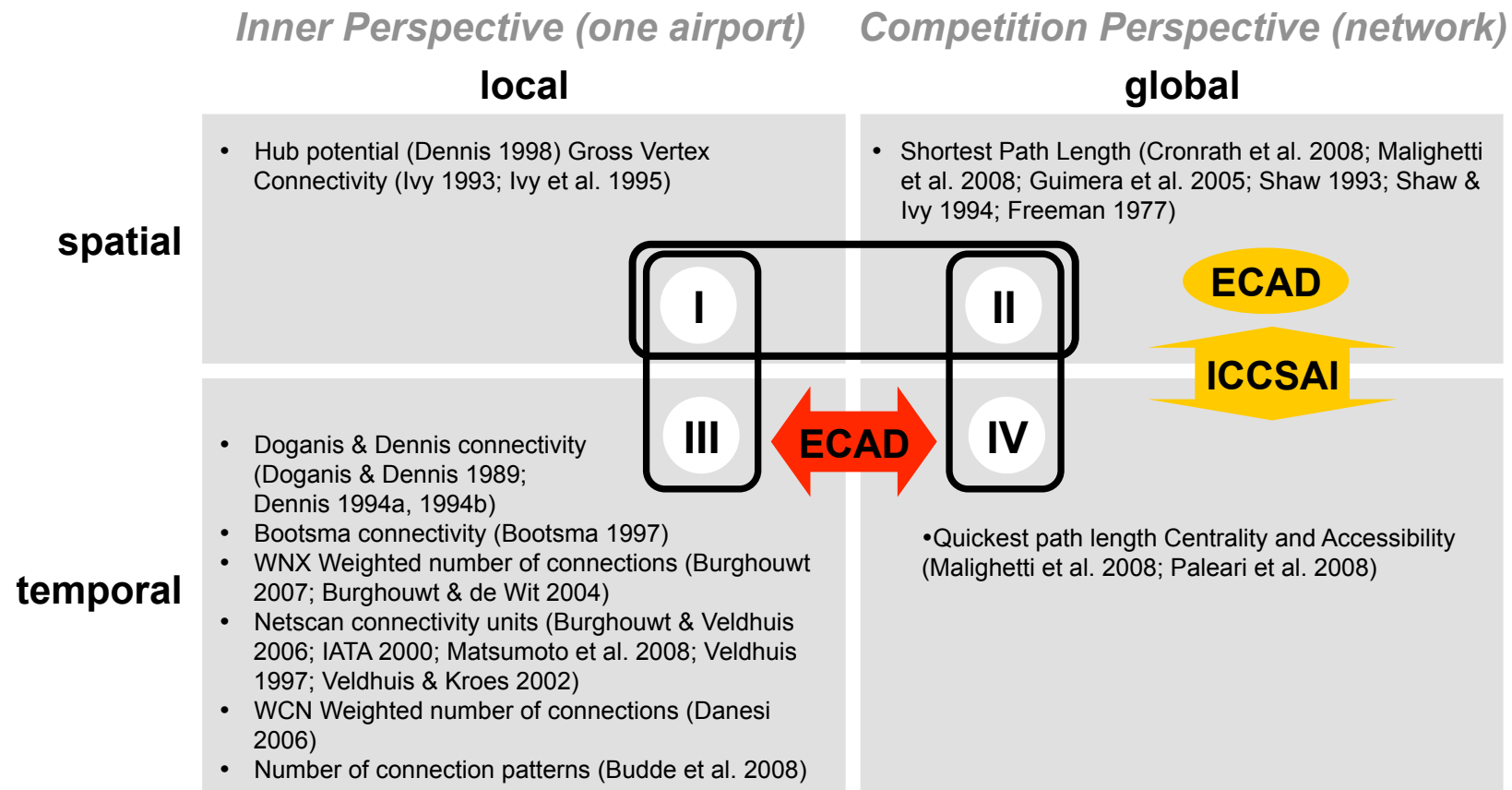


Potential: 2/3 of all possible fastest connections within the European network are not offered by alliances!

Source: P. Malighetti et al., ICCSAI, 2008.

How Can an Airport's Network Position Be Measured?

Approaches in the literature



Example: Inner Perspective

Local view on one airport: Frankfurt FRA

- Data source : OAG Flight Schedules
- Analysierter Tag: Thursday, 03.07.2008
- MCT: 45 minutes
- Distance coefficient: 1,25

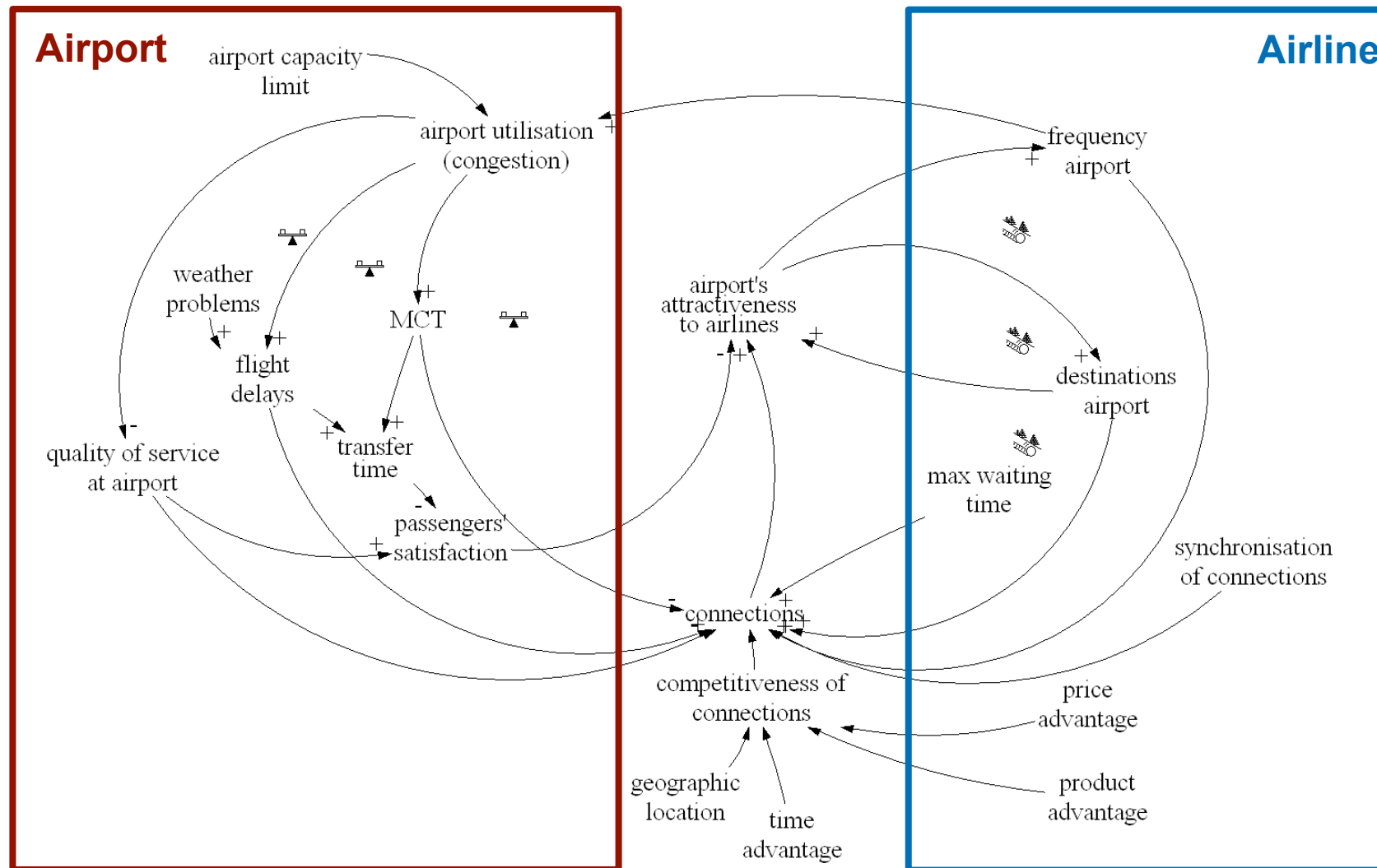
FRA's connection Profile

Max. waiting time (after MCT)	1h	2h	3h	4h
All possible transfer connections	14.000	27.500	40.200	51.500
- Guided connections	9.000	7.000	23.350	29.250
- Non-guided connections	5.000	10.500	16.850	22.250
Additional destinations in time window	4.000	8.000	12.250	15.500
Competitive connections (<i>fictitious</i>)			20.000	
- Guided			16.000	
- non-guided			4.000	



Research Question 2: Why has an airport's connectivity developed in a certain way and what can airport operators do to improve their competitive network position?

Basic System Dynamics Model



Summary

Transfer traffic depends on the airport's position in the air transport network, i.e. the airport's air transport supply structure in comparison to others.



Connectivity = Competitive position of an in airport in the network is a strategic resource that generates transfer traffic

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Research questions

1. How can the connectivity of an airport be measured if it is meant to be a strategic resource that expresses the airport's competitive position within the network?

→ *Fastest path method*

2. Why has an airport's connectivity developed in a certain way and what can airport operators do to improve their competitive network position?

→ *System Dynamics model for scenario simulation*

Next Steps

- Validate fastest path algorithm
- Calibrate the System Dynamics model for a hub airport and an O&D airport

Thank you very much for your attention!

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