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Airport capacity constraints: Modelling approach, forecasts and implications for 2032

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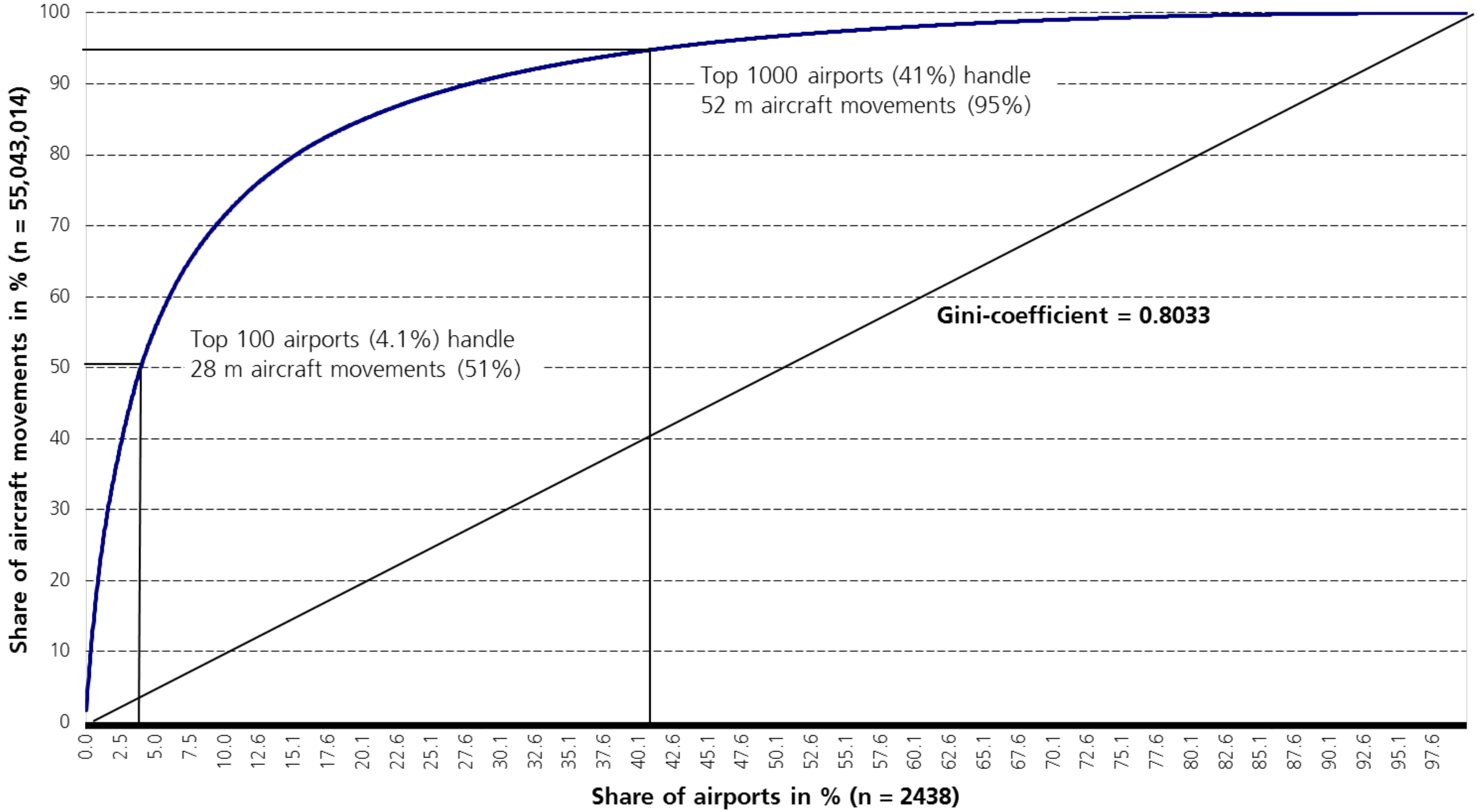
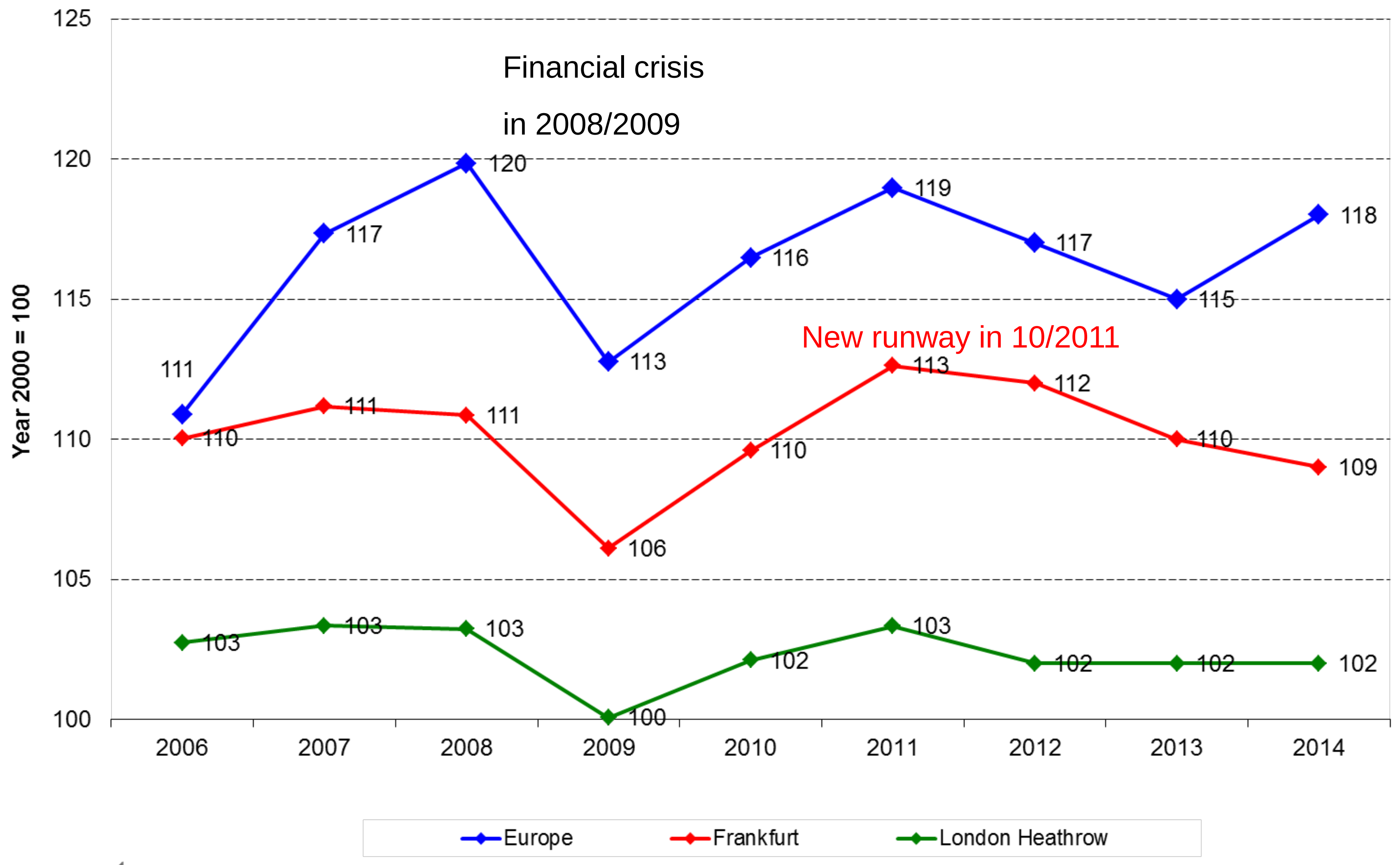
Agenda

- Why capacity constraints at airports?
- The airport capacity constraints model
- A simple 20 years forecast with airport capacity constraints
- A model of aircraft size development
- Summary & conclusions

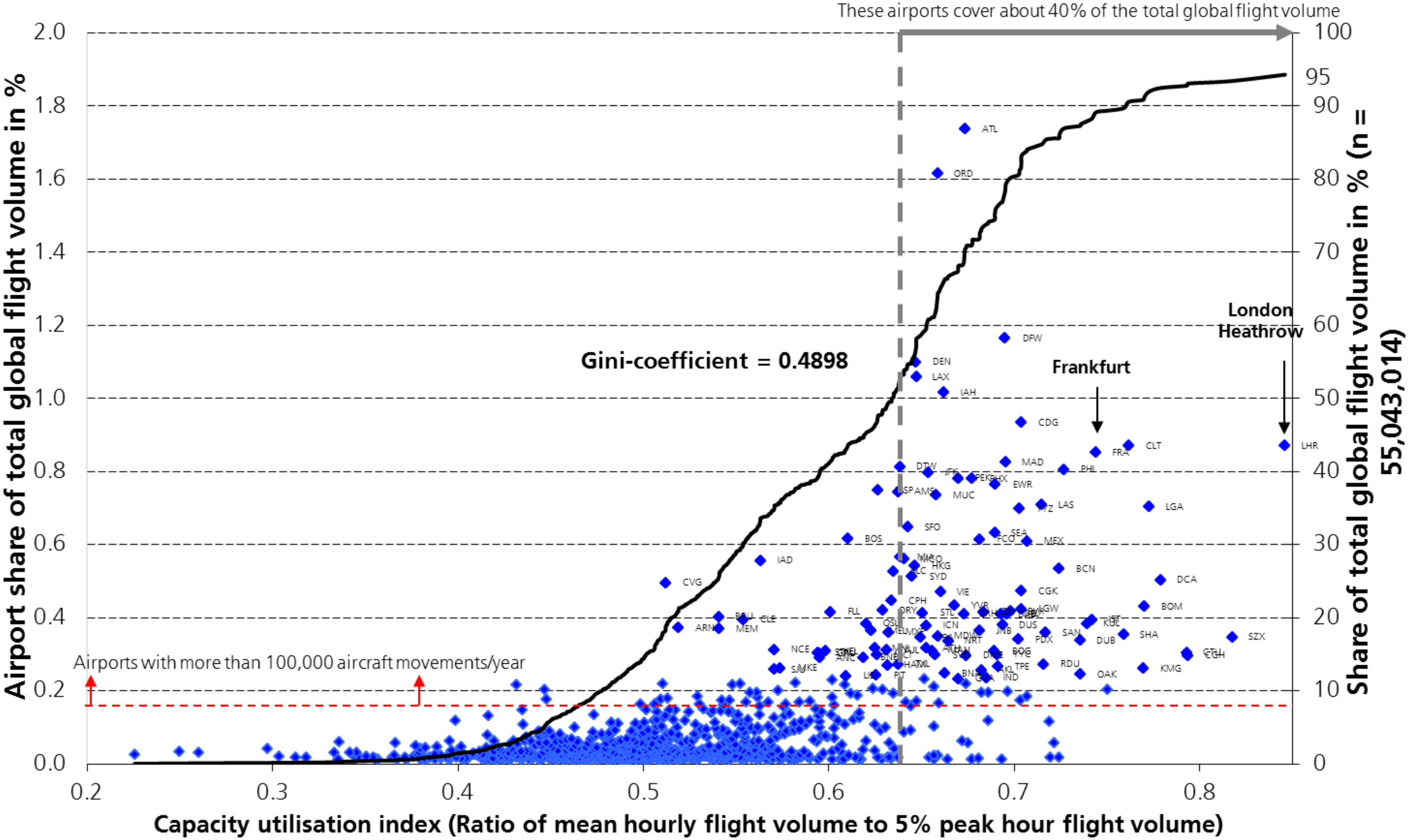
Concentration of global air traffic



Traffic development at LHR, FRA and in Europe between 2000 and 2014



CUI values of the top 1000 airports worldwide



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Factors inflencing airport expansion delays

Attitude of Population towards Air Transport

- Welfare Level –
- Age Structure –
- Tourism +
- ...

↔

Participation Level and social Values

- Democracy –
- Ministry of Environment –
- ...

↕

Location and Size of an Airport

- Noise –
- Number of Flights –
- Airport Category –
- ...

↔

Intermodal Substitution

- Railway Km –
- Country Size +
- ...

⇒ Acceptance & Speed to improve Airport Capacities

+: Positive wrt Improvement
-: Negative wrt Improvement

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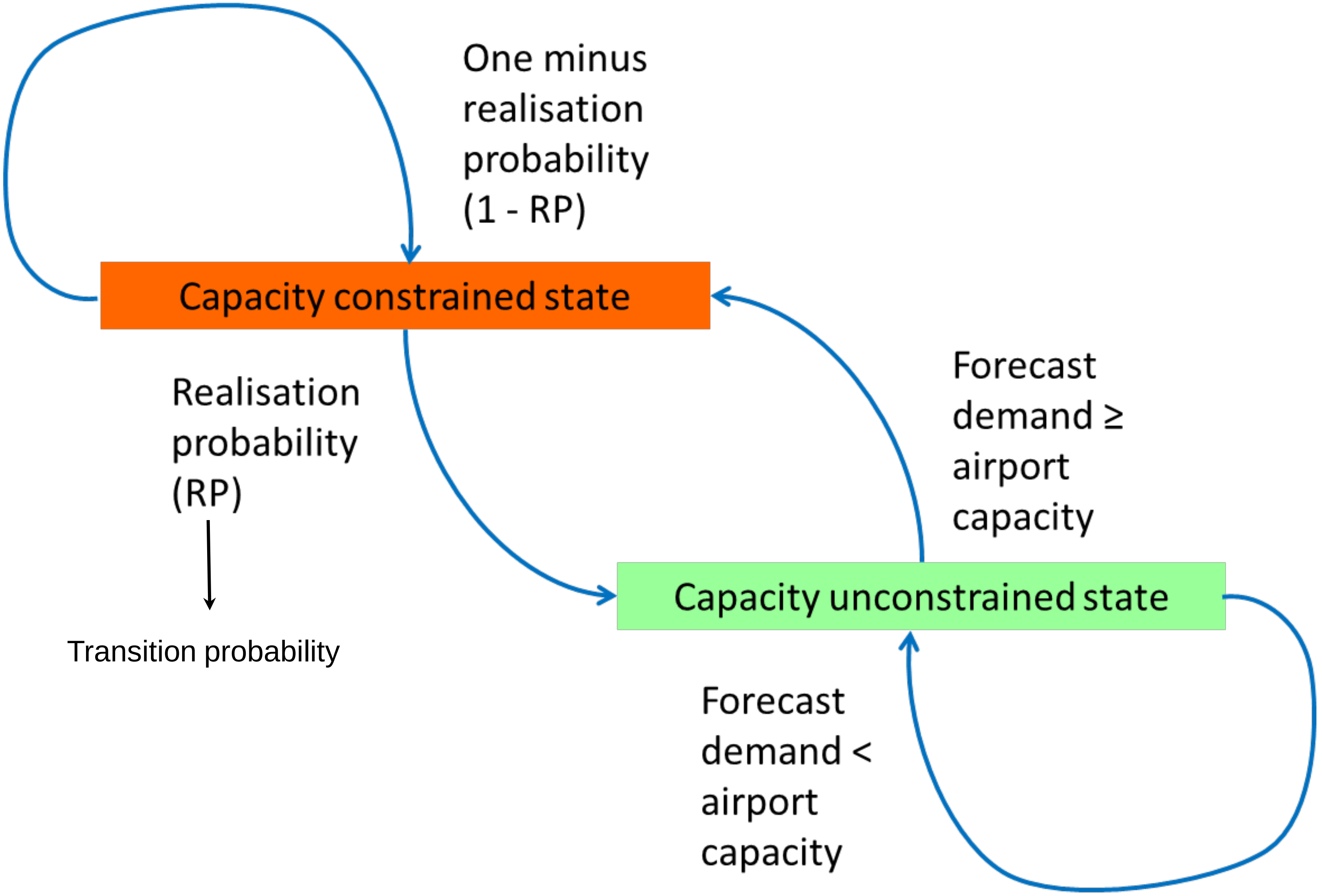
A Markov chain of runway expansions



Discrete choice theory: Modelling Realisation Probability (RP) in the Markov chain

Potential problems in overcoming capacity constraints

→ Explanatory variables: welfare level, ...

↓ Binary logit model

Realisation probability (RP)

→ e.g. 10% RP

↓ Markov chain

Expected delay of runway expansion plans

→ e.g. 9 Years = (100% / 10% RP) - 1

$$RP_{ij} = \frac{1}{1+e^{V_{ij}}}$$

$$V_{ij} = \sum_k \beta_{kj} * x_{kij}$$

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Some remarks on the estimation method

- Model estimation with time series data is very difficult because of data availability and rather few airport expansions due to capacity constraints in the past (not enough for econometric estimation)
- Therefore we have used a cross-sectional data approach
- Basis for model estimation is the share of constrained airports in the estimation data set and their attributes, e.g. flights, population etc.
- Airports were randomly drawn by region and size

Model estimation and realisation probability (RP)

- For reasons of simplicity, all airports are equal and are always operating at their capacity limit
- RP = 1/3; x = “constrained”, o = “unconstrained” → average delay = 2 periods

Period	Airport 1	Airport 2	Airport 3
1	x	x	o
2	o	x	x
3	x	o	x
4	x	x	o
5	o	x	x
...	x	o	x

Random Permutation 1

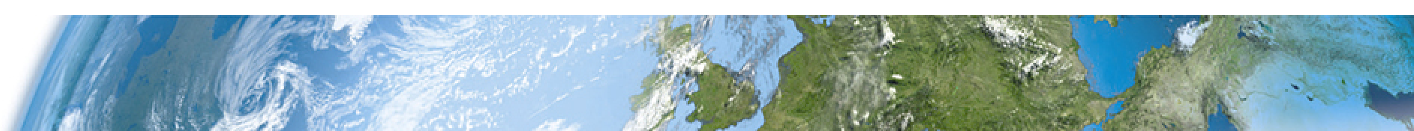
1	x	x	o
2	x	o	x
3	o	x	x
4	x	x	o
5	x	o	x
...	o	x	x

Random Permutation 2

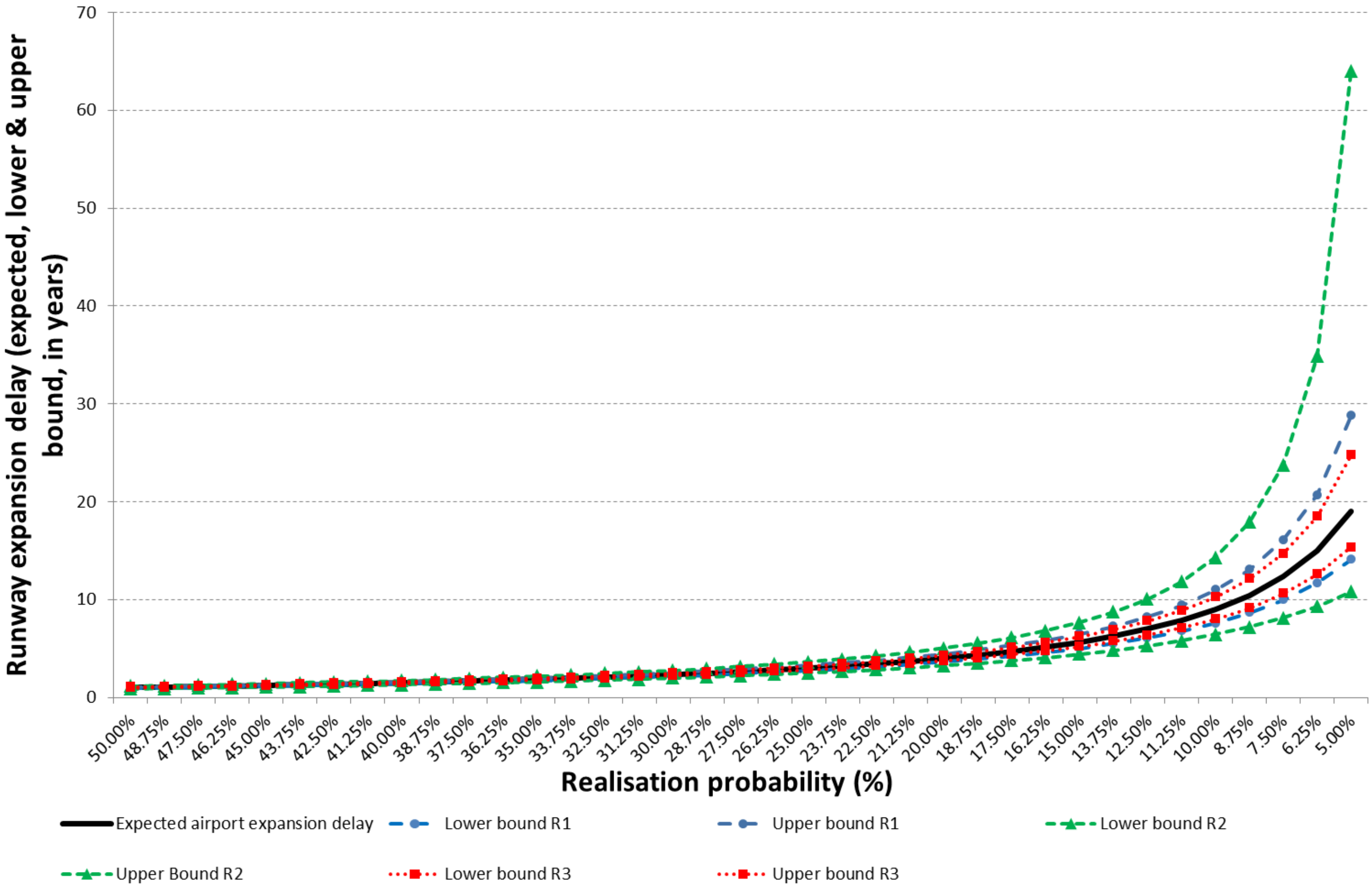
Estimation Results

Model	Variable	Coefficient		Pseudo R-squared	# of obs.
R1	AP1	-5.24534	***	57.84%	259
	AP2	-1.67711	***		
	POP10KM	1.5472E-06	***		
	ATM	3.6565E-06	***		
	BROAD	3.7298E-06	***		
R2	AP1	-6.63962	***	61.25%	97
	POP10KM	1.0389E-06	***		
	ATM	3.4042E-06	***		
	GGDP	-105.829	***		
	BROAD	0.00010021	***		
	TOUR	-0.340495	***		
	RAILKM	24.1668	***		
R3	AP1	-8.93214	***	51.67%	235
	AP2	-6.53189	***		
	POP10KM	8.909E-08	***		
	ATM	2.4019E-06	***		
	BROAD	4.942E-05	***		
	PART	5.38518	***		
*** Significant at the <=1% level				∑	591

- Region 1 (R1): Europe
- Region 2 (R2): North/Central America, Australia, New Zealand, Oceania, Japan, South Korea, Taiwan & Singapore
- Region 3 (R3): Others



Realisation probability, runway expansion delay and 80% confidence interval



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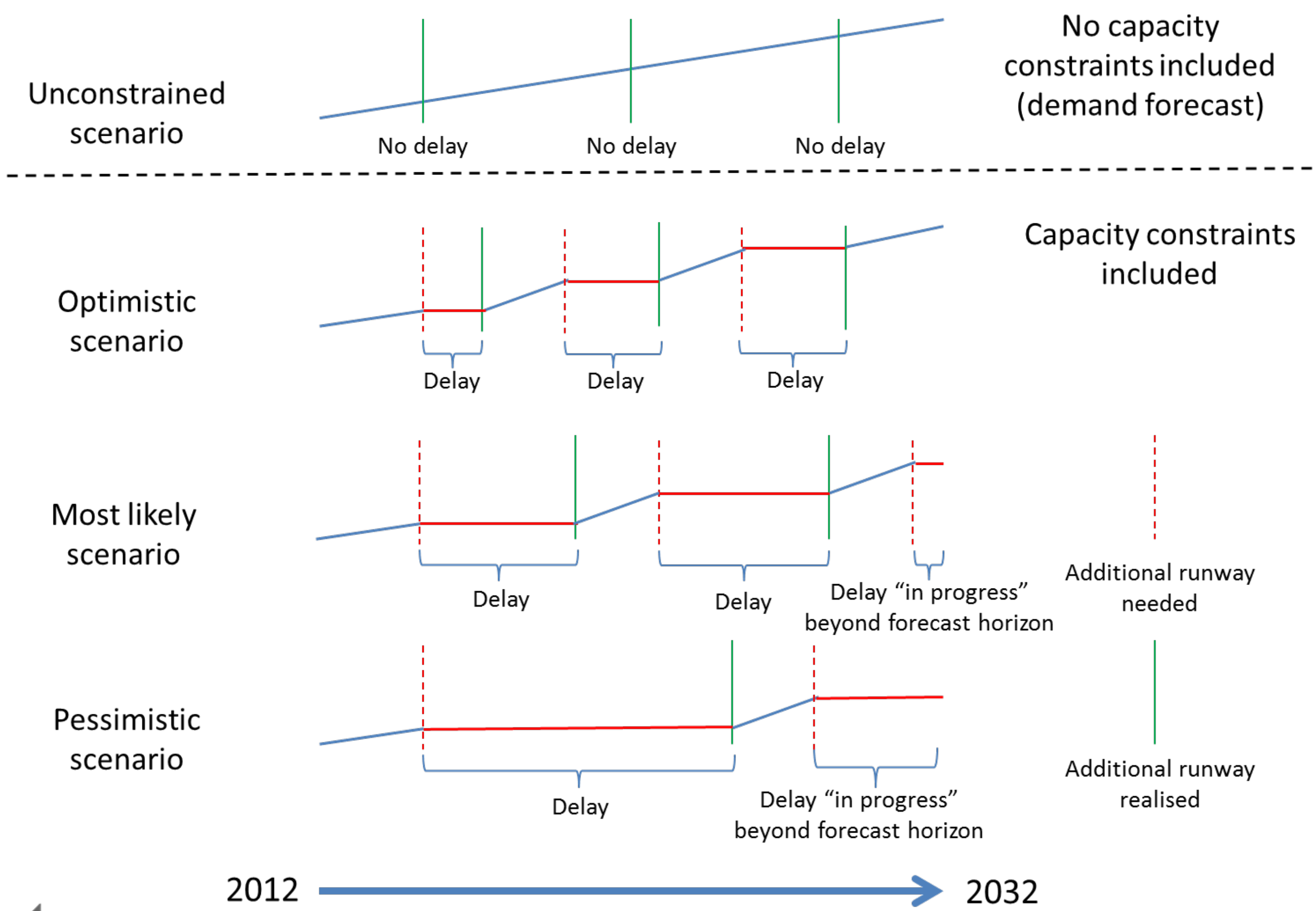
Schematic illustration of runway expansion delays in different scenarios



Global model results of the three runway capacity constraints scenarios (unrestricted CAGR 3.5%)

Scenario	# of new runways	Capacity gap	CAGR (20 years)
Unconstrained	107	0.00%	3.50%
Optimistic	76	1.88%	3.40%
Most likely	70	2.49%	3.37%
Pessimistic	65	2.90%	3.35%

Problem: There is a high variation in the level unaccommodated flights between airports. For the global top 10 constrained airports, the share of unaccommodated flights lies between **15% and 49%** compared to an unconstrained forecast. Runways that can be realised until 2032 are already included.

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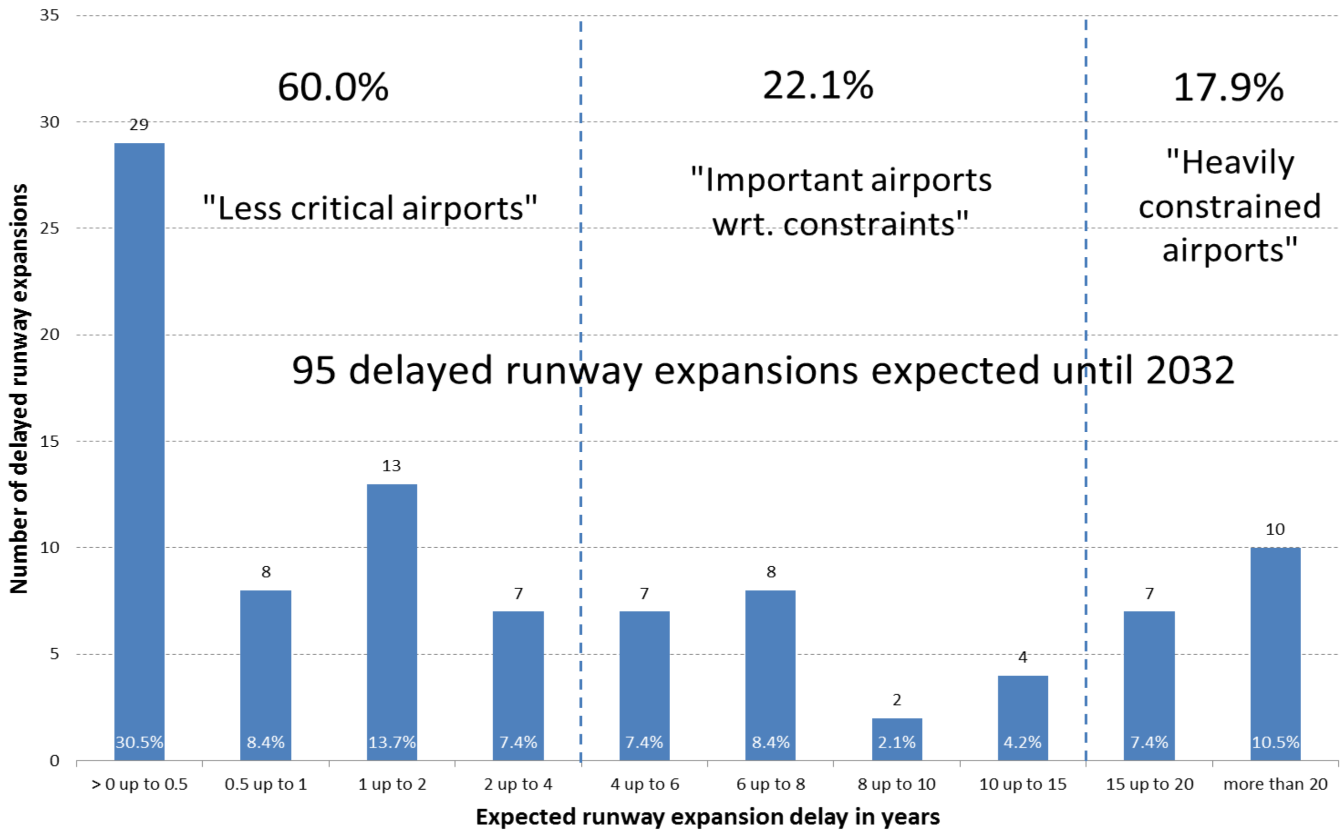
Global Distribution of delayed runway expansions (most likely scenario) until 2032 (unrestricted CAGR 3.5%)



The majority of expansion delays of more than 15 years can be found at important European and Asian hub airports (e.g. LHR, AMS, HND, ...), however on a global level, short-term delays are more common

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Model results of the three runway capacity constraints scenarios for Europe (unrestricted CAGR 3.5%)

Scenario	# of new runways	Capacity gap	CAGR (20 years)
Unconstrained	23	0.00%	3.50%
Optimistic	11	3.58%	3.31%
Most likely	10	3.76%	3.30%
Pessimistic	8	4.41%	3.27%

On the European level, there is again a high variation in the level unaccommodated flights between airports. For the “big 3”, the share of unaccommodated flights lies between **24% and 49%** compared to an unconstrained forecast. Runways that can be realised until 2032 are already included.

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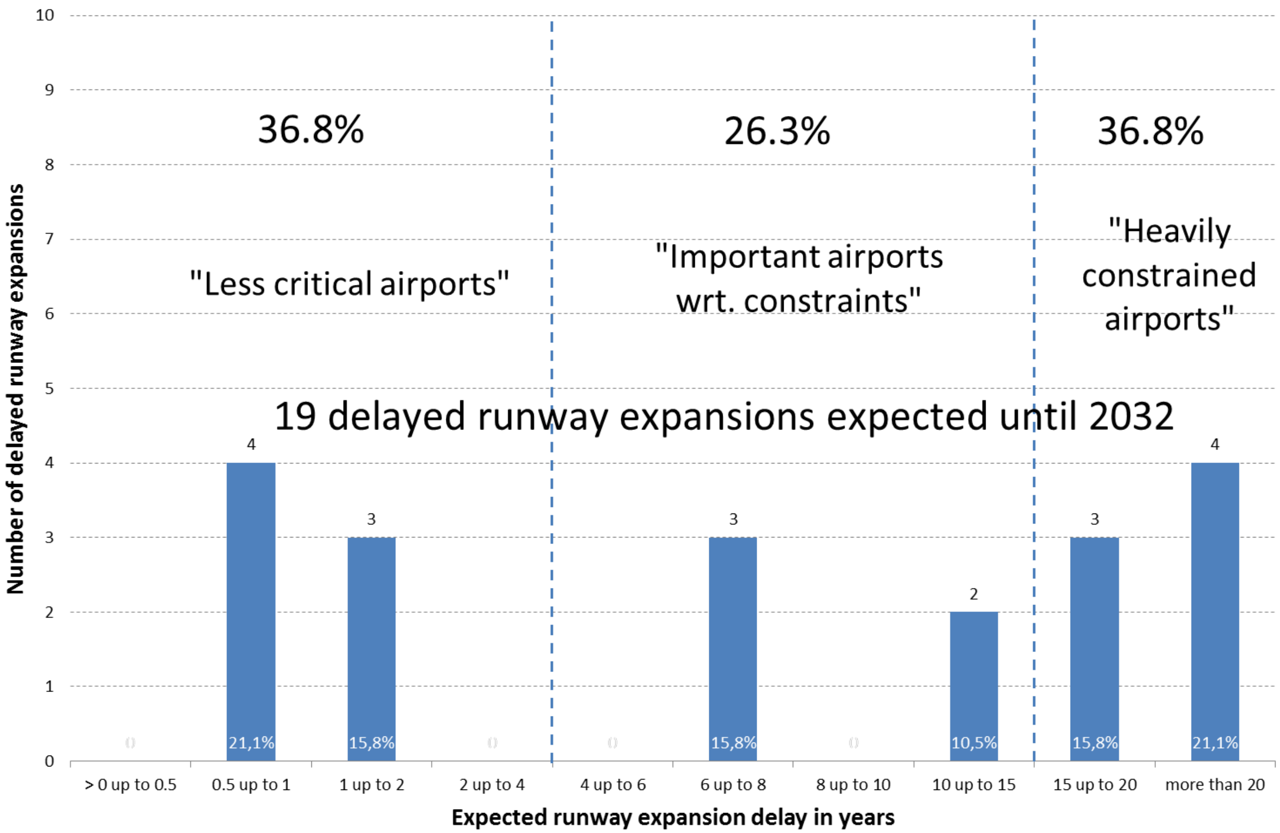
Distribution of delayed runway expansions in Europe (most likely scenario) until 2032 (unrestricted CAGR 3.5%)



Problem: Hubs like AMS, MAD, FRA, CDG & LHR have expansion delays of more than 15 years for their next runway, short-term delays are more common at smaller airports

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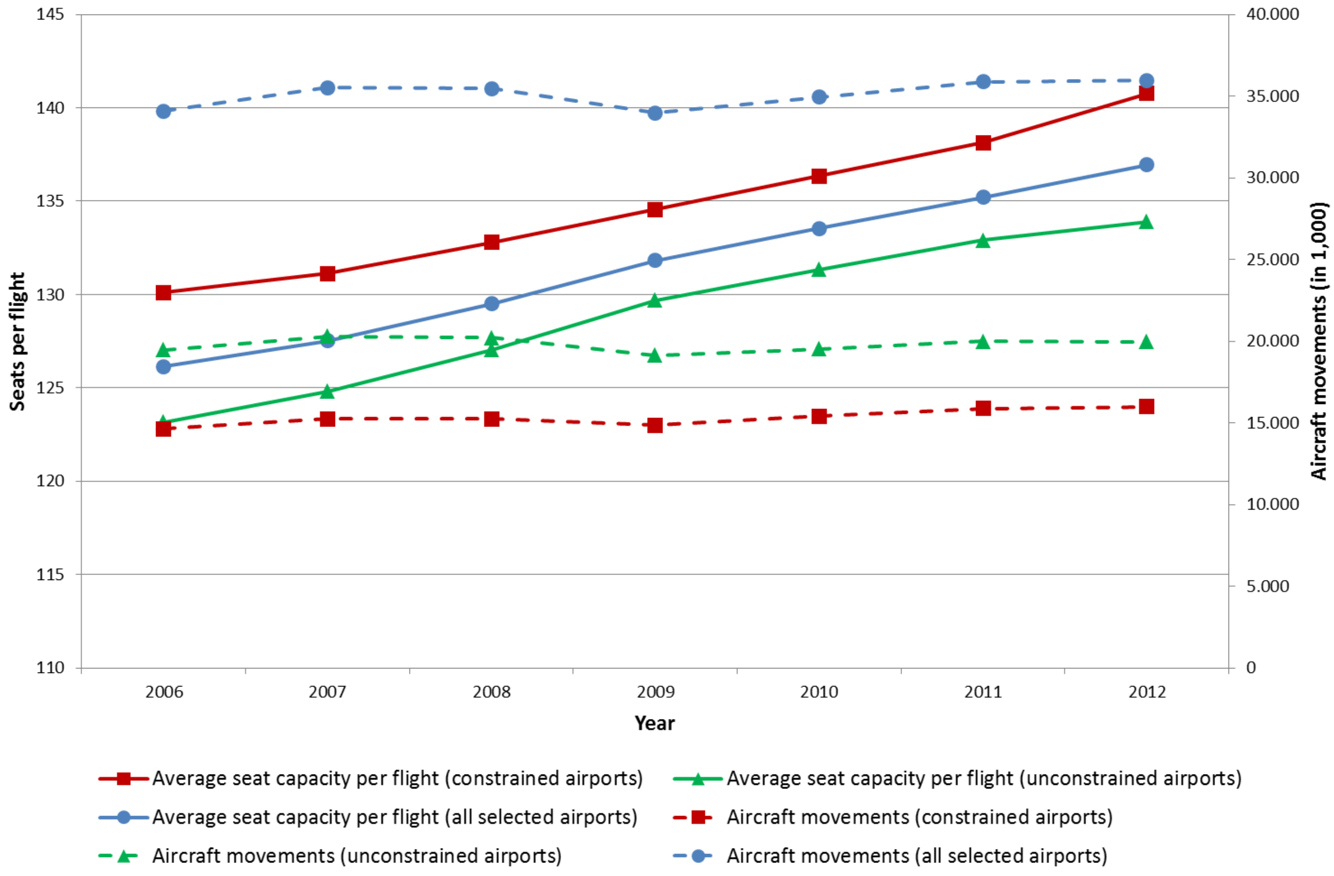
Implications for reference assessments

- There is a huge variation in the duration of airport delays, ranging from minor delays that can be neglected to airports that practically cannot be enlarged any further. Unfortunately, the larger and more important hubs tend to have the longest expansion delays.

- As a consequence, there is also a large difference (up to 100%) between the number of flights in unconstrained and constrained forecasts at airports with capacity constraints. Again the larger and more important hub airports are more affected than smaller airports.

- As a result, assessments have to consider the constraints situation at airports to be meaningful, as a the quantity structure changes significantly because of the constraints.

Average seat capacity and number of aircraft movements in the global network of 178 selected (43 constrained & 135 unconstrained) airports 2006-2012



Berster, P., Gelhausen, M.C., Wilken, D. (2015), Journal of Air Transport Management 46, pp. 40-48.

Model results and model analysis

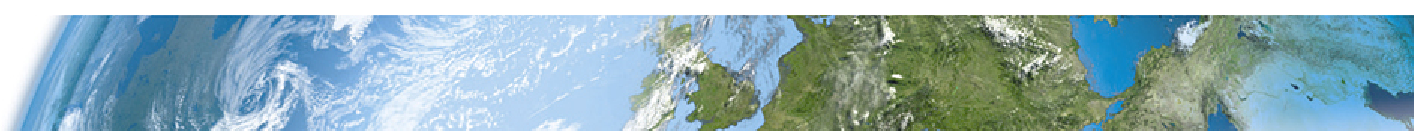
Variable	Coefficient		R^2	# of obs.
CONST	57.6845812	***	75.82%	224
CUI	61.8579267	***		
AVGFL	0.02539032	***		
NA	-23.9042594	***		
EUR	9.89872101	**		
ASIA	30.4363804	***		
MEAST	37.6541034	***		

*** Significant at the <=1% level

** Significant at the <=5% level

Model #	Model name	R^2	Log-Likelihood
1	CUI	12.22%	-1124.478
2	AVGFL	31.86%	-1096.118
3	CUI + AVGFL	37.69%	-1086.086
4	REGIONS	52.08%	-1056.693
5	REGIONS + CUI	56.34%	-1046.253
6	REGIONS + AVGFL	74.32%	-986.802
7	FINAL MODEL	75.82%	-980.061

Berster, P., Gelhausen, M.C., Wilken, D. (2015), Journal of Air Transport Management 46, pp. 40-48.



Summary & conclusions (I)

- Compared to the interview approach (e.g. EUROCONTROL), the econometric model approach seems to be better suited for long-term capacity constraints analysis (>10 years) and to result in more reproducible results after a number of years.

- Comparisons with different approaches (e.g. EUROCONTROL) show very similar overall results, but a slight variation on the airport level.

- Airport capacity constraints dampen the number of flights at certain airports, resulting in lower growth rates (and lower noise & emissions) compared to unconstrained forecasts. However, there is a large difference between constrained and unconstrained forecasts for airports with capacity constraints, so that assessments are only meaningful for unconstrained airports, if the underlying forecast is unconstrained.

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Summary & conclusions (II)

- On a global level, the majority of airport capacity constraints are short- (<4 years) to medium-term (<15 years), however in Europe there is more emphasis (37%) on long-term (>15 years) capacity constraints.

- Over a period of 20 years we see a capacity gap of about 2.5%, or even 3.8% in Europe (of which 1.4 percentage points are long-term).

- Because of the trend to larger and more efficient aircraft we see a reduction of noise & emissions that is above average with regard to the capacity gap compared to unconstrained forecasts. Depending on aircraft technology developments, we see a global CO_2 reduction due to airlines reaction on constraints by using bigger aircraft of about >2.5%, but there is a great variation among capacity constrained airports (up to >15% to even >50% in some cases).

Thank you for your attention!

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