Patterns of ATC capacity insufficiencies in Europe: an exploratory analysis

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Project acronym: **COCTA**

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Motivation for the analysis of capacity insufficiencies

- The COCTA model(s) will be tested using real data
- We want to test the model under different demand/capacity profiles to simulate different situations in the network
- How do we know which days are representative and suitable for testing?
- Are there any “similar” days in the network and how often do they occur?
- What variables can we use to describe different days?
- The motivation behind the analysis of capacity insufficiencies, as a part of the COCTA research, is to identify similar days in the network and choose (a) representative day(s) for model testing

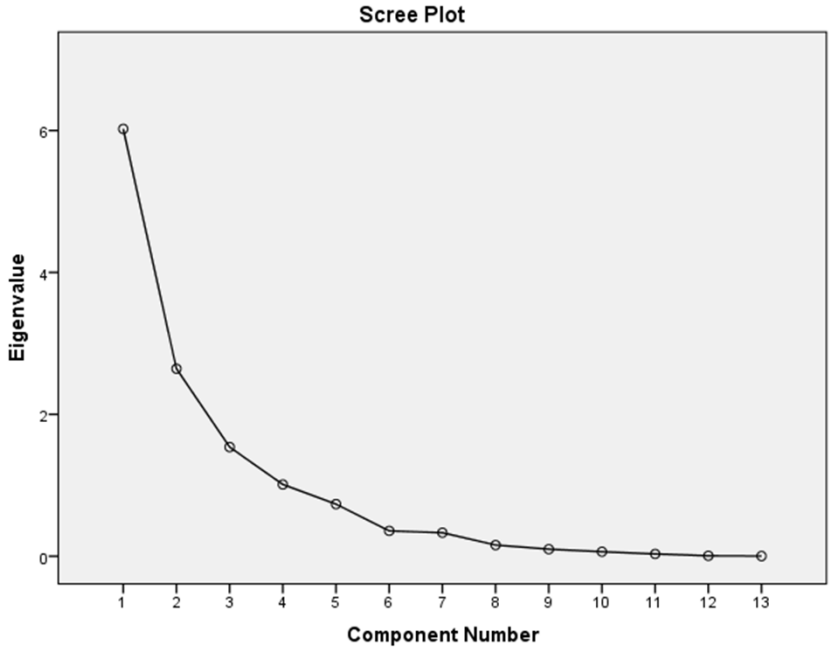
Data & Methodology

- A unique dataset with 21 variables for period 2009-2014 (daily data): *Number_of_flights, Number_of_regulations, Early_cancelled_regulations%, AVG_Regulation_Anticipation_Minutes, Airport_Regulated _Traffic_% , etc.*
- Data pre-processing in SPSS: plotting, descriptive statistics and distribution, correlation between variables…
- After data pre-processing we first excluded 2009-11 from further analysis, so only 2012-2014 was considered.
- From 2012-2014 several days with excessive delay (due to industrial actions mostly) and the period around Christmas were excluded as well.
- In the end the sample counted 1075 days.
- Principle Component Analysis to choose representative variables.
- K-means clustering to find similar groups of days in the network (PCA variables used as an input).

Typical days in European network: PCA & Cluster analysis

Total Variance Explained

Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**6.023**	**46.330**	**46.330**	**6.023**	**46.330**	**46.330**	**4.954**	**38.109**	**38.109**
2	**2.643**	**20.334**	**66.665**	**2.643**	**20.334**	**66.665**	**3.351**	**25.779**	**63.887**
3	**1.539**	**11.837**	**78.501**	**1.539**	**11.837**	**78.501**	**1.646**	**12.662**	**76.550**
4	**1.011**	**7.777**	**86.279**	**1.011**	**7.777**	**86.279**	**1.265**	**9.729**	**86.279**
5	.734	5.649	91.927						
6	.357	2.749	94.676						
7	.332	2.550	97.227						
8	.157	1.211	98.438						
9	.099	.760	99.197						
10	.063	.487	99.685						
11	.032	.248	99.932						
12	.006	.047	99.980						
13	.003	.020	100.000						



Typical days in European network: PCA & Cluster analysis

Rotated Component Matrix[a]

	Component			
	1	2	3	4
Number of Flights ECAC	.385	-.224	-.097	.599
Nb Regulations	**.865**	-.380	-.060	.153
Airport Regulations %	-.276	**.864**	.045	.147
Early Cancelled Regulations %	-.118	-.017	**.886**	-.114
Lately Defined Regulations %	-.028	.123	**.893**	.113
Regulation Active Hours	**.899**	-.267	-.152	-.058
AVG Regulation Anticipation Minutes	-.049	-.266	-.067	**-.855**
MP Regulated Traffic	**.900**	-.291	-.094	.231
MP Airport Regulated Traffic %	-.180	**.951**	.059	-.016
Regulated Traffic	**.903**	-.315	-.068	.181
Airport Regulated Traffic %	-.221	**.942**	.056	.000
Delay Minutes	**.958**	-.046	-.008	.111
Airport Delay Minutes	**.730**	.523	.032	.033

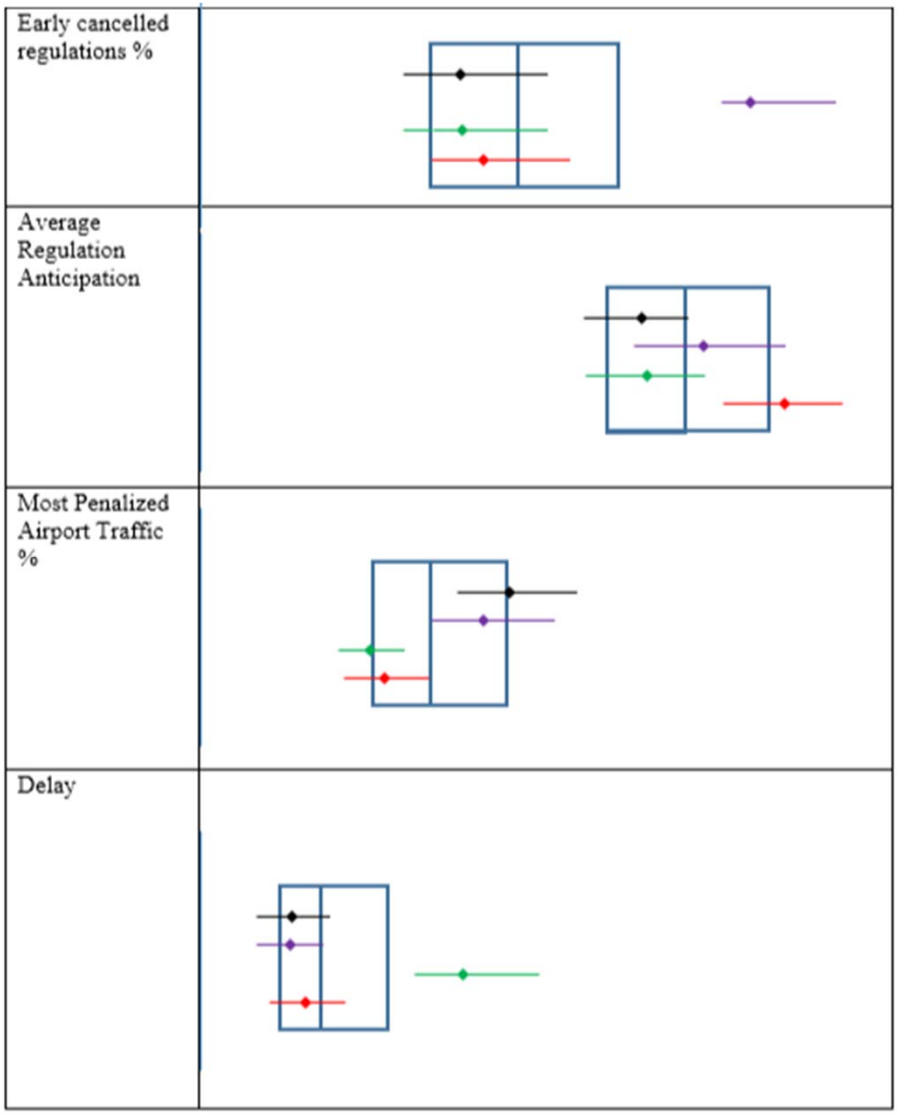
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

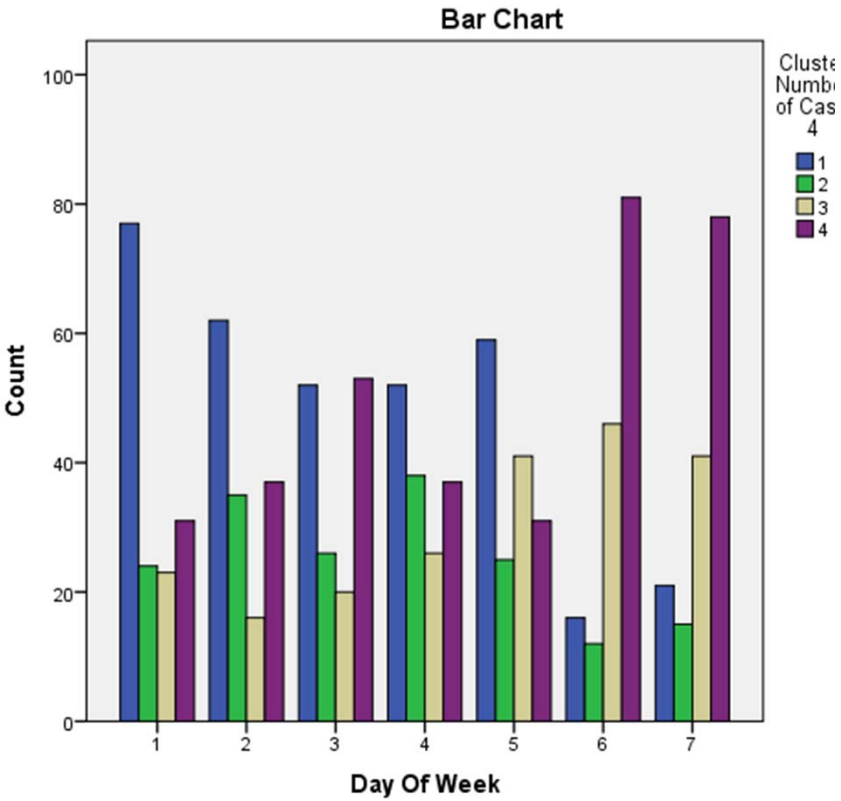
Typical days in European network: Results

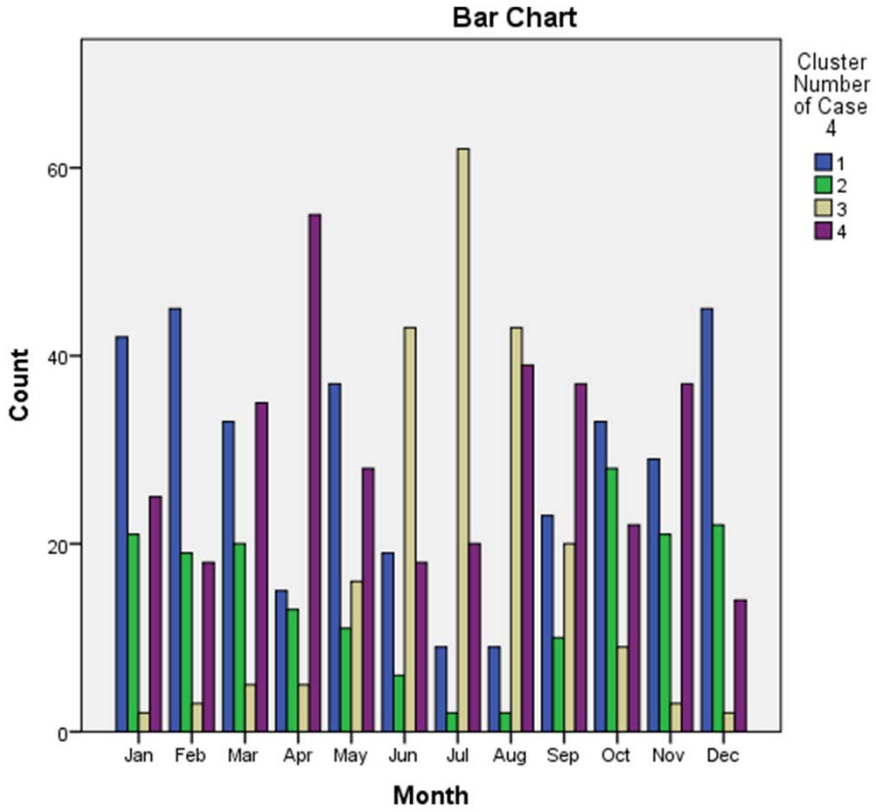
Final Cluster Centers				
	Cluster			
	1 (339)	2 (175)	3 (213)	4 (348)
Zscore: Early Cancelled Regulations %	-.38384	1.61932	-.35597	-.22252
Zscore: AVG Regulation Anticipation Minutes	-.69014	.19563	-.41434	.82751
Zscore: MP Airport Regulated Traffic %	.75284	.50258	-.71643	-.54760
Zscore: Delay Minutes	-.28409	-.47204	1.43260	-.36273

Typical days in European network: Results



Typical days in European network: Results





Conclusions and further steps

- We identified different cluster in the network, with good similarity within the cluster and good distinction between clusters (silhouette~0.5)
- To select the representative days from these clusters, we will further perform a second-stage analysis
- Within cluster discrimination based on the regulation type, to distinguish between inherent ATM/C system inefficiencies (e.g. regulations due to staffing) and inefficiencies out of the scope of the ATM system (e.g. weather related regulations)
- Data sample 2012-2016 (individual regulation data – disaggregated)
- Categorize data/variables and include a more specific geographical reference (e.g. FABs)

Invitation to COCTA Stakeholder Workshop

- **September, 27, 2017 (Wednesday)**

  House of Logistics and Mobility (HOLM)

  Frankfurt airport, Germany

- More information on project and news: www.cocta-project.eu

COCTA - Patterns of ATC capacity insufficiencies in Europe: an exploratory analysis

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