

AIRPORT CLASSIFICATION AND FUNCTIONALITY WITHIN THE EUROPEAN NETWORK

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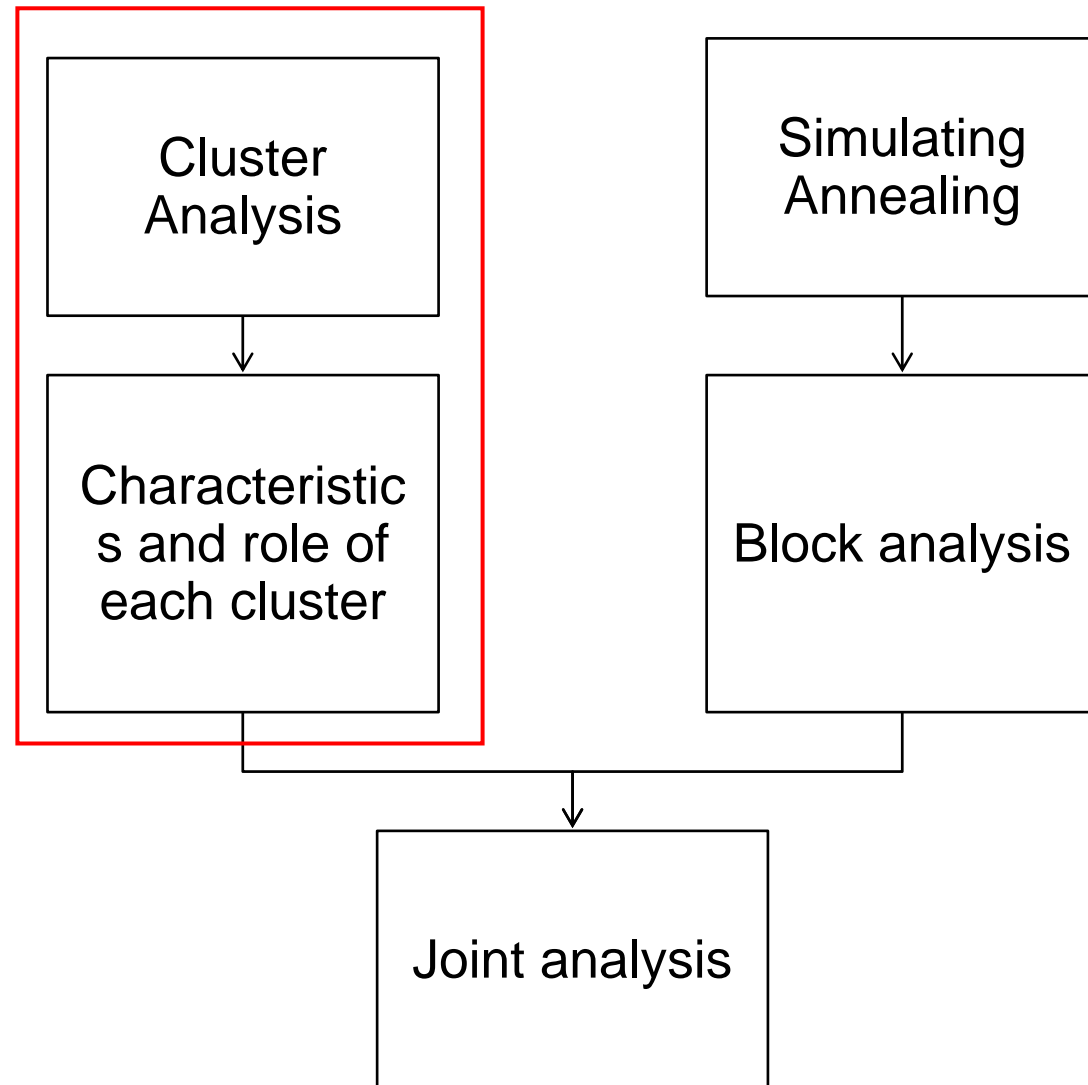
- Pre liberalization era
 - *National Hub*
 - ✓ Airports with international/intercontinental connections
 - ✓ Dominated by the "flag carrier"
 - Relevant international airports
 - ✓ Few international routes (mostly within Europe)
 - Minor airports
 - ✓ Feeding routes to the national hubs served by the flag carriers or by Regional airlines

- ... Post liberalization era?
 - National vs. supra-national hubs?
 - Which role for rapid growth airports?
 - Which competitive structure?
 - Which role for flag carriers?

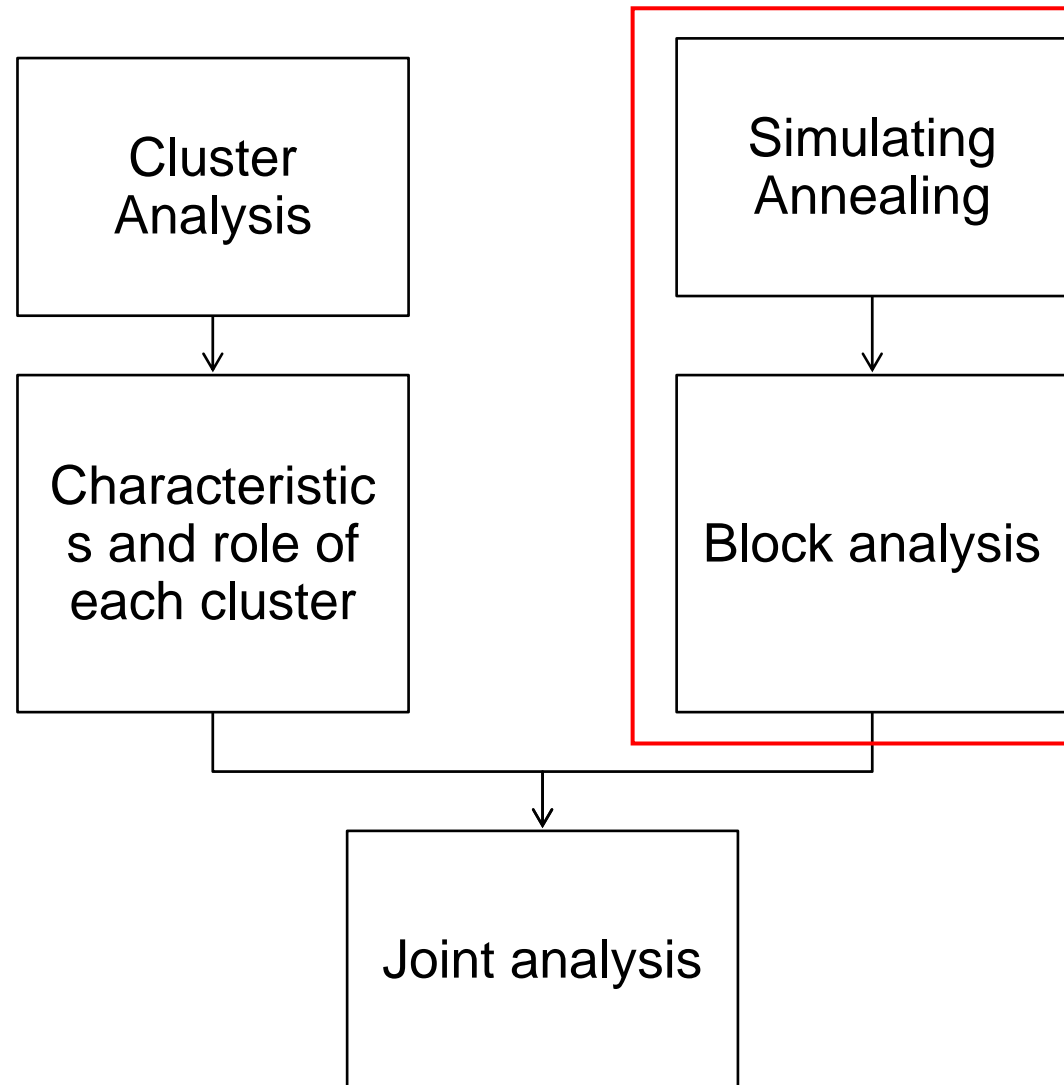
- Policy makers
 - To evaluate cohesion of the airport system
 - Framework to evaluate airport competition
 - ✓ Airport compete both i) on a geographical base and ii) with airports playing a similar role within the network
 - Competition within sub-networks vs. competition between networks

- Airport operators
 - Which role and in which network?
 - Understand growth potentiality
 - Individuate benchmark groups

- Steps:
 - Cluster of airports with homogeneous network features
 - Role of each cluster in the network



- Steps:
 - Cluster of airports with homogeneous network features
 - Role of each cluster in the network
 - Analysis of the connections strength and definition of sub-networks or modules
 - Features of each sub-networks



- **Simulated Annealing**: method described by Kirkpatrick et. al. in 1983, adaption of a **Monte Carlo method**, employed to maximize complex multidimensional function
 - Individuation of sub-network modules. Each airport is assigned to one and only one module. The optimal number of modules is also determined.

Maximization of M(P) function

$$M(P) = \sum_{s=1}^{N_m} \left[\frac{l_s}{L} - \left(\frac{d_s}{2L} \right)^2 \right]$$

Cohesion of
the modules

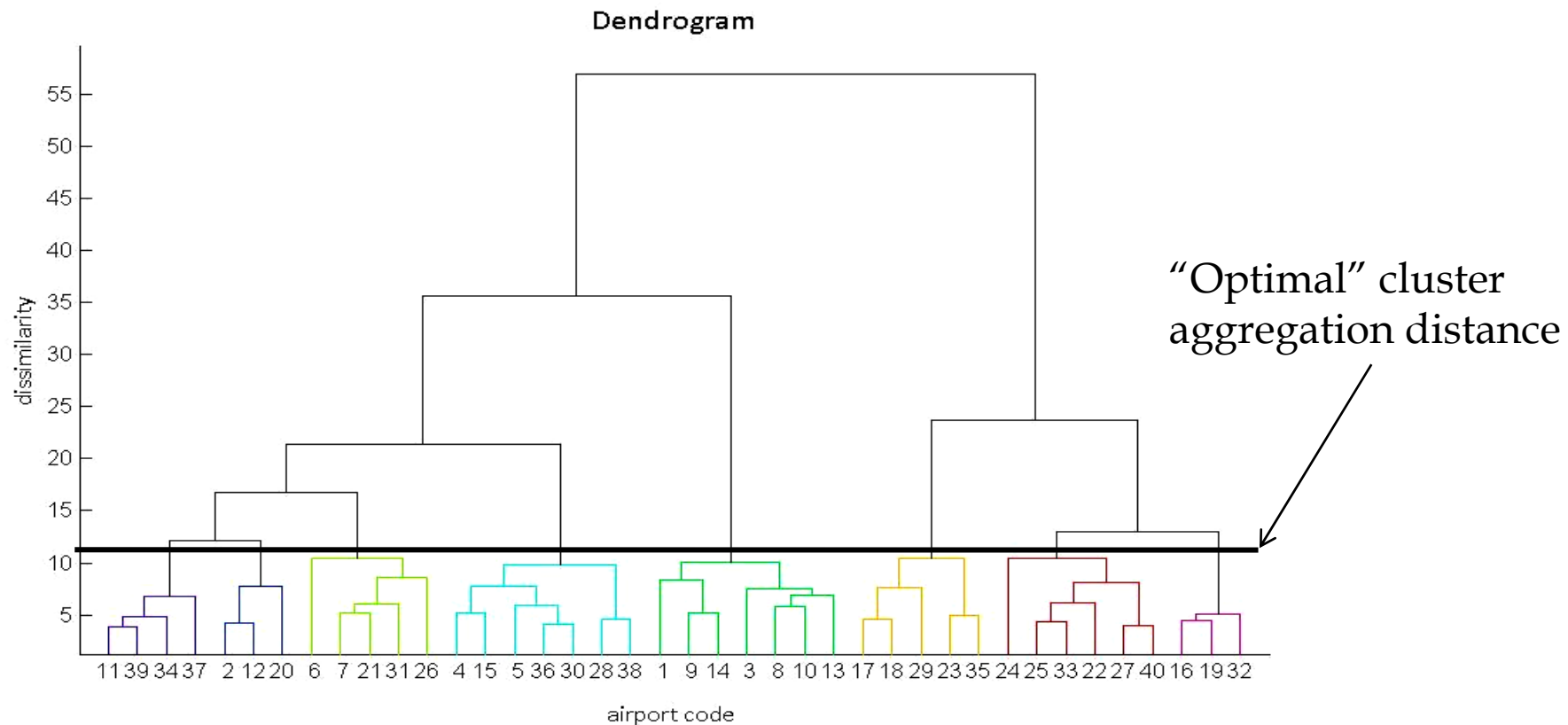
Dimension
of the
modules

- N_m is the number of modules
- L is the number of connections of the whole European network (or number of seats)
- l_s is the number of connections (or seats) between airports belonging to the same module s
- d_s is the sum of degree (number of connections or of seats) of the airports in the modules.

- **Cluster Analysis**: aggregation of objects with similar features based on a dissimilarity matrix
- Variables employed (1/2)
 - Size and density
 - ✓ Number of daily seats offered (seats)
 - ✓ Number of daily flights (flighth)
 - ✓ Number of destinations (n° dest)
 - Destination
 - ✓ Percentage of EU destination (% dest in EU)
 - ✓ Percentage of domestic routes (% dest dom)
 - ✓ Polarization: HHI index based on the seats share on each destination divided by the HHI index in the case of equal number of seats offered on each destination (it equals 1 when there is no polarization; the higher the index the higher the polarization)

- Cluster Analysis – variables employed (2/2)
 - Connectivity offered
 - ✓ Betweenness (betw) : number of European shortest paths between any couple of airports for which the shortest path passes through the airport
 - ✓ Essential Betweenness (%essBetw): number of shortest paths through the airport with no alternatives with the same number of steps.
 - Type of service
 - ✓ Share of seats offered by low cost carriers
 - ✓ Number of carriers for which the airports is the most important in term of ASK

- Dendrogram with the “Ward linkage” aggregation method
- Number of optimal clusters: 8 (individuate by Duda/Hart index).



	n° airports	n° dest	Daily seats	Daily flights	% EU destinat	% dom. destin.	Polarization	betweeness	% essntial betw.	% low cost	n° base
cluster 1- global hub	8	178	44,701	281	54.40%	11.80%	2.6	1,696	58%	10%	2.3
cluster 2 - EU hub	16	116	19,041	143	71.10%	13.10%	2.5	1,087	67%	27%	2.4
cluster 3 – secondary gate	11	72	7,812	67.6	73.20%	17.00%	2.9	356	81%	30%	1.6
cluster 4 – EU low-cost	33	47	5,523	41.8	91.40%	15.20%	2.2	90	63%	75%	0.3
cluster 5 – EU no low-cost	46	28	3,884	35	97.00%	44.60%	3.8	129	67%	25%	0.4
cluster 6 – Regional	44	13	1,000	10.7	82.60%	28.20%	1.7	18	46%	19%	0.3
cluster 7 – minor low-cost	71	9.9	976	7.8	99.10%	21.80%	1.5	7	48%	76%	-
cluster 8 - local	238	3.2	233	3.7	100.00%	93.90%	1.4	9	40%	6%	0.1

Modules	N° Airports	Bigger airport	Airport with more connections within module	% of connections within module	HHI airport	HHI country	1 st country
1	128	London Heathrow	Dublin	64.1%	289	3,119	UK
2	48	Paris Orly	Paris Orly	56.8%	1,491	9,968	France
3	48	Oslo	Oslo	74.1%	1,710	9,972	Norway
4	46	Frankfurt	Palma De Mallorca	55.8%	716	5,284	Germany
5	33	Stockholm-Arlanda	Stockholm-Arlanda	57.8%	1,822	9,730	Sweden
6	31	Athens Eleftherios	Athens Eleftherios	49.0%	2,350	8,354	Greece
7	31	Paris CDG	Rome Fiumicino	45.8%	1,127	8,505	Italy
8	30	Madrid Barajas	Madrid Barajas	47.7%	1,137	10,000	Spain
9	20	Helsinki-Vantaa	Helsinki-Vantaa	44.5%	2,761	10,000	Finland
10	17	Brussels	Prague-Ruzyne	15.2%	1,627	1,948	Czech Rep
11	16	Lisbon	Lisbon	34.5%	1,678	9,366	Portugal
12	12	Copenhagen	Copenhagen	20.8%	3,002	7,939	Denmark
13	7	Reykjavik Dom.	Reykjavik Dom	100%	3,201	10,000	Iceland

- Comments:
 - Most modules present high cohesion
 - Presence of national modules
 - The biggest module contains both the English airports and the main European low cost airports
 - The “Italian” module includes the Paris Charles de Gaulle airport as the major airport. However, Rome Fiumicino is the airport which contributes more to the module (in terms of scheduled passengers)

Cluster Module	1) Global hub	2) Hub	3) Secondary gate	4) EU low cost	5) EU no low cost	6) Regional	7) Minor low cost	8) local
1) UK/low cost	25%	25%	18%	70%	11%	18%	70%	14%
2) France/Orly	-	6%	18%	-	9%	23%	4%	12%
3) Norway/Oslo	-	6%	-	-	11%	0%	0%	18%
4) Germany/Frankfurt	25%	19%	18%	24%	11%	9%	13%	5%
5) Sweden/Stockholm	-	6%	-	-	7%	2%	-	12%
6) Greece/Athens	-	6%	9%	-	7%	2%	-	11%
7) Italy/Paris CDG	25%	6%	9%	-	15%	18%	-	5%
8) Spain/Madrid	25%	-	-	-	28%	-	4%	5%
9) Finland/Helsinki	-	6%	-	-	-	-	4%	7%
10) East-West	-	13%	18%	3%	-	9%	3%	3%
11) Portugal	-	-	9%	3%	2%	5%	-	5%
12) Denmark	-	6%	-	-	-	9%	1%	3%
13) Iceland	-	-	-	-	-	5%	-	2%
	100%	100%	100%	100%	100%	100%	100%	100%

- At least one "big" airport per module
- The first module includes both "low-cost" network and "traditional" UK network. Is it the more "evolutionary" module?
- Existence of strong national modules. Low cost airports tend to be separated from these networks.
- Some modules can be seen as integration of ex national modules and reflect consolidation or "conquer" by some carriers, as Air France in Italy and Lufthansa in Austria and Switzerland