Air-sea linkages in European port cities

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Abstract:

This chapter aims at highlighting the relationships between air, maritime & logistic activities of port cities in Europe. Although recent studies have considered sea-air intermodality as a locational advantage for ports and coastal urban centres, they are still few and isolated case studies. Nevertheless, this subject appears to be of growing interest for transport, logistic players and urban planners to improve port performance in a competitive context. However, there is neither an estimation nor a comparative analysis on effective air-sea relations within port city nodes. We propose a valuation of such potentials based on available and comparable data at a European scale, such as air and maritime traffics, urban population, and employment in specific transport activities (freight forwarding, logistics, warehousing, port and airport services). This innovative approach focuses on the level of interdependency between airports, ports and cities. It shows that air-sea linkages within European port cities are still not strongly interdependent.

1. Introduction

Studies of port-city linkages have become more and more numerous over the last twenty years, whereas only a few authors have led both quantitative and comparative approaches on such issues (Wang and Olivier, 2003). In a context of economical and physical port-city dysfunction, geographers and planners have concentrated their efforts on the urban-port interface, taking into consideration that wider levels of organisation of port, urban and maritime systems are acquired knowledge. However, some recent studies of general port-city relationships at global (Ducruet 2004; forthcoming) and continental (Ducruet, 2003; Joly and Martell 2003; IRSIT 2004; Ducruet and Jeong, 2005) levels, have particularly highlighted the importance of international comparison.

Taking inspiration from such works, this article deals with a very specific aspect of port-city combination, namely "air-sea" linkages. The choice of this topic is based on two factors. On the one hand, newly-designed airports exerting efficient air-sea linkages such as Incheon in South Korea (Pentaport), Chep Lap Kok in Hong Kong (Marine Cargo Terminal) and Dubai Airport are interesting experiences for European port cities, where such strategies are still lacking. In fact, the interconnection of air transport is mostly focusing on public transportation like trams, subways and railways. On the other hand, some transport companies have recently appeared on the European scene, such as Damco Air-Sea and ABX Logistics, showing a growing interest in this issue.

A European database including urban, port, maritime and logistic indicators is built as a mean to verify what are the factors influencing air-sea linkages among 58 port cities (Figure 1). The choice of indicators focuses on local characteristics of the nodes, in terms of employment, market size, port and airport activities. It is expected that such indicators can highlight a number of trends underlying the level of interdependency between these functions. A preliminary evaluation is available in Figure 2, with the relative share of air and sea employment. It shows that the European territory can be explained by a centre-periphery pattern with on one side, a ring of peripheral metropolises with important air functions, and on the other side, a second ring of port gateways located close to the heartland. Groupings of European port cities, under homogeneous parameters of various characteristics, are suggested to go beyond such interpretation. Furthermore, the analysis of synthetic expressions such as principal components, resulting from simple (linear) relationships between port cities' air and sea functions, allows to presume some potential air-sea interactions within European port cities.

[INSERT FIGURES 1 and 2 ABOUT HERE]

2. Methodology

Factor Analysis such as Standardized Principal Components Analysis is used to discover hidden structures, and to reach an objectivity which is difficult to attain with classical techniques. The use of principal component analysis depends on a series of mathematical restraints and limitations which are particular to port cities' activities.

2.1 Identification of 13 variables:

The variables are chosen according to their relevance for this study (Table 1). In particular, the measurement of employment has necessitated a specific methodology. The calculation is based on the Kompass database of companies. Because these companies usually exert more than one activity, their total number of employees has been redistributed equally among the different activities, so as to enable a modal sum. Furthermore, companies have been counted at the level of the metropolitan area, what gives more reality than the city centre only.

Notably, many activities tend to locate in suburban areas such as logistic parks, airports and interchange sections at the outskirts of cities.

[INSERT TABLE 1 ABOUT HERE]

2.2 Selection of port cities and data collection

This study restricts the scope of the analysis to a sample of European port cities (Table 2). Port cities have been chosen according to their participation to the "*Trans-European Transportation Network*" (TEN), relative to the ''*TEN Airport Network''*, which distinguishes several components: "*Regional & Accessibility Points*", "*Community Connecting Points*" and "*International Connecting Points*". Such criteria is relevant according to the analysis of air-sea linkages in Europe, because it takes into account a specific aspect of the current European transport policy. Some other port cities have been included in the sample because they are major ports and exert important economic functions: Antwerpen, Genoa, and Copenhagen.

[INSERT TABLE 2 ABOUT HERE]

2.3 Analysing the data

The standardised principal component analysis is here employed to develop comprehensive indexes (i.e. transformed named variables principal components or factors) reflecting the 13 port-city variables and to identify those significant indicators underlying the classification of European port cities. The data for these variables for the 58 respective European port cities are presented in Table 3.

[INSERT TABLE 3 ABOUT HERE]

3. Analysis of variable and factors (principal components)

3.1 Analysis of linear correlations

One objective of the principal component analysis is to find combinations of the 13 active variables, to produce indexes (factors F1 … F13) that are not correlated. The lack of correlation (Table 4) is a useful attribute because it means that the indexes are measuring different dimensions of the same original information.

However, the first analysis of the Bravais-Pearson Correlation Matrix (Figure 3) shows that all r coefficients are positive. It means that all of the 13 variables prove to be less geographically dispersed. Discrimination between the 13 air and sea active variables is relevant according to high (up to 0.8 r max value) or low (from 0.26 r min value) statistically significant values of the r coefficient based on bilateral tests (alpha = 0.05).

[INSERT TABLE 4 and FIGURE 3 ABOUT HERE]

3.2 Analysis of factors (principal components)

The factors are in such an order that F1 displays the largest amount of variation, F2 the second largest, and so on. Fs are also called principal components (PC). By examining the contribution of each PC to the total variance and excluding the PCs with a variance inferior to 1, represented by the eigen values of the correlation matrix (Table 5), variations in the database can be adequately described by a few PCs: 4 factors explaining almost 70% of the total variance. Thus, some economy in the use of data can be achieved. Furthermore, throughout this analysis we can obtain an appropriate weighting for each variable which can be used in indexing the overall characteristics of European port cities. Of course, these indexes (Fs factors) are used to discriminate European port cities, which is the main objective, i.e. the classification of the port cities into significant groups.

[INSERT TABLE 5 ABOUT HERE]

F1 First principal Factor (30.61 %): ***Air Integration of European port cities***

The first factor represents a mass statistical effect: variables are projected on the same positive side of the axis (Table 5). This first factor has the highest variance and thus shows the structure which differentiates European port cities the most, concentrating 30.61% of the original variables' dispersion (Tables 5 and 6). Four variables (AIRTRAFM, AIRINTEG, POPAGGLO and AGENTSSF) concentrate more than 60% of the PC's formation.

[INSERT TABLE 6 ABOUT HERE]

The first factor means that integration in air networks depends on location of forwarders and metropolitan market size. Thus, *"Air Integration of European Port Cities"* is a combination of airports' activities and the connection with local markets through the specific function of freight forwarding, which connects international and local scales. Port cities' ranking on F1 is here interpreted as a capacity of places to connect their market to air transport networks through the attraction of forwarding agents within the port city and notably in the vicinity of the airport itself.

F2 Second Factor (17.77 %): ***Ferry Ports & Air Traffics***

F2 gives complementary information on relations brought into light by F1 and sums up almost 18% of the original data dispersion (Table 7). A strong opposition is manifested between on one hand, FERRYSERV, SHIPSERV and AIRPSERV (3 variables contributing for 70% of F2's axis formation), and on the other hand AIRINTER, AIRTAFF, AIRTAFM and POPAGGLO.

[INSERT TABLE 7 ABOUT HERE]

F2 shows a statistical opposition between on one side ferry-related employment, basic port and airport activities (daily activity and administration); air traffics and freight forwarding on the other side. This can be interpreted in a way that important ports are opposed to important airports.

F3 Third factor (12.56 %): ***Container & Cruise Ports***

This factor shows an opposition between the couple of variables SEACONNEX (total of direct links to other ports or 'foreland') and AGENTSSF (maritime agents & forwarders) on one side, and CRUISE (number of cruise companies with regular calls in ports) on the other side (Table 8).

[INSERT TABLE 8 ABOUT HERE]

The third factor reflects two types of maritime transport activities: container shipping and cruise lines. It shows an interesting opposition between 2 groups of variables, where air transport is more related to cruise lines and metropolitan population than to the intensity of port activity.

F4 Fourth Factor (8.63 %): ***Logistics & Maritime Activities***

This factor shows an opposition between the couple LOGISTIC and WARESTOR (logistic and warehouse employment) on one side and 3 variables SHIPSERVICES, CRUISE and POPAGGLO (basic port activities, cruise and metropolitan population) on the other side (Table 9). This is the less representative axis among the statistically significant axes (Kaiser criteria). However, it shows also an interesting opposition between marine activities on one side, and logistic activities on the other.

[INSERT TABLE 9 ABOUT HERE]

4. Geographical dimension of the single-cluster analysis

F1 shows that very few city ports enjoy a high integration within air transport networks. Those few are especially located along the Channel – North and Baltic Sea (Dublin, London, Amsterdam, Hamburg, Copenhagen, Oslo, Stockholm and Helsinki), with Barcelona as a Mediterranean exception. This reveals that the relative importance of port and maritime activities doesn't have a significant influence on the air integration of port cities; apart from Barcelona and Hamburg, the major ports (e.g. Rotterdam, Antwerpen, Genoa, Le Havre…) do not appear very well. We also assume that the north-south unbalance may be explained by the strategies of air transport operators to reach inland markets and productive centres.

[INSERT FIGURE 4 ABOUT HERE]

The F2 opposition has also a spatial logic throughout the European territory, with a major western concentration of air services and a minor eastern gathering of ferry ports (e.g. Baltic sea gateway). On the one hand, western cluster forms an Atlantic arc (except Dublin) and a western Mediterranean at the periphery of Europe. On the other hand, ferry ports have the benefit of short maritime distances (e.g. Le Havre – Southampton), with a possible difference between northern and Mediterranean ferryports according to their specialisation: passengers or freight (ro-ro).

[INSERT FIGURE 5 ABOUT HERE]

F3 reinforces the trend observed in F2, with the Mediterranean basin specialised in cruise shipping. One can notice the gathering of a major northern range (Le Havre, Antwerpen, Rotterdam, Bremen Ports and Hamburg) and a Mediterranean range (Marseilles, Barcelona, Valencia and Genoa). Thus, container ports are opposed to the well established northern cruise calling ports such as Southampton, Dublin and Oslo.

[INSERT FIGURE 6 ABOUT HERE]

F4 shows different groupings such as logistic platforms creating added value (Med, Great Britain) on one side, opposed to maritime gateways (northern range, Ireland and French Atlantic city ports). This confirms the complexity of the interpretation of F4 linked to the weak dispersion of original data.

[INSERT FIGURE 7 ABOUT HERE]

5. Concluding remarks

This analysis leads to the conclusion that air-sea linkages in European port cities are still not a strong issue. Some explanation of the recurrent air-sea "opposition" might come from the historical formation of the European nodes, where port and air activities followed their own spatial logics (Dienel 2004). Another reason is probably deriving from regional specialisation effects of European policies and spatial concentration. Then, in both functional and spatial terms, air-sea linkages in Europe have still a long way to go before becoming a reality. The sample studied, officially eligible to the "*Trans-European Transportation Network*" (TEN) relative to *TEN Airport Network*, does not yet seem developed for such air-sea strategies. The *TEN network* plan may be directed towards other implications such as the support of peripheral port cities (Morvan 1999) more than air-sea intermodality, even if some private players have a growing interest in this issue. There may be at term a risk in developing air-sea linkages in only a few concentrated places, like existing gateways, at the expense of smaller and/or remotely located city ports.

Authors, of course, are responsible for any errors in this paper.

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Table 1. Presentation of the variables

Code	Description
AGENTSSF*	Total employment in freight forwarding activities, including several transport modes such as air, sea, road, etc.
AIRINTEG**	Logistic and Forwarding Agents located in Airport Areas
AIRPADMI*	Total employment in Airport Administration and operation
AIRPSERV*	Total employment in air services
AIRTRAFF*	Total Airport Cargo Throughput in 2003 (metric tons)
AIRTRAFM*	Total Airport Operations in 2003 (movements)
CRUISE ***	Number of cruise companies having regular services to the port
FERRYSER *	Ferry Services linked to employments
LOGISTIC *	Total employment in logistic activities (distribution, packaging, road transport, etc.)
POPAGGLO****	Number of inhabitants of the metropolitan area, including administrative and suburban population
SEACONNEX *****	Total number of ports connected through seaborne links relative to regular container shipping lines in 1992
SHIPSERVICES *	Total port-related employment, or "port service industry" including port authority, dockers, stevedores, towage & tug services in ports
WARESTOR *	Total employment in warehousing and storage activities

Data Sources:
* KOMPASS
** Journal for International Transport (2005) *International Register of Logistics and Forwarding Agents*. http://195.65.73.10/itz/irflaNeu/e/irfla_suche.asp
*** Cruise Lines (MSC, MED, COSTA)
**** www.world-gazetteer.com
***** Ph. D. Doctorate in Territorial Planning & Transport Geography - O. Joly (1999)

Table 2. Presentation of the 58 selected European port cities

Port Identification	Airport Identification	UNCTAD PORT CODE
AALBORG	Aalborg	AAL
AARHUS	Tirstrup	AAR
ABERDEEN	Aberdeen	ABZ
ALICANTE	Alicante	ALC
AMSTERDAM	Schipol	AMS
ANCONA	Falconara	AOI
ANGRA DO HEROISMO	Terceira Lajes	ADJ
ANTWERPEN	Deurne	ANR
BARCELONA	Prat	BCN
BARI	Palese	BRI
BELFAST	Belfast	BFS
BILBAO	Sondica	BIO
BORDEAUX	Merignac	BOD
BREMEN PORTS	Bremen	BRE
BRISTOL	Spekee	BRS
CATANIA	Fontanarossa	CTA
CONSTANTZA	Kogalnoceanu	CND
COPENHAGEN	Kastrup	CPH
CORK	Cork	ORK
DUBLIN	Dublin	DUB
FORTH PORTS	Edinburgh	EDI
FARO	Faro	FAO
GENOA	Cristoforo Colombo	GOA
CLYDEPORT	Glasgow	CYP
GOTENBURGH	Landvetter	GOT
HAMBURG	Hamburg	HAM
HELSINKI	Vantaa	HEL
SAINT HELIER	S. Jersey	STH
KIEL	Holtenau	KEL
LE HAVRE	Le Havre-Octeville	LEH
LEIXOES - PORTO	Oporto	LEO
LISBON	Lisbon	LIS
LIVERPOOL	Liverpool	LPL
LONDON	Heathrow + Gatwik + Stansted + City	LON
MALMO	Sturup	MMA
MARSEILLES	Marseille-Provence	MRS
NANTES - ST-NAZAIRE	Nantes	SNR
NAPLES	Capodichino	NAP
NICE	Nice	NCE
OSLO	Gardermoen	OSL
OSTENDE	Ostend	OTD
PALERMO	Punta Raisi	PMO
PALMA DE MALLORCA	San Juan	PMI
LAS PALMAS	Palma	LPA
PIRAEUS	Athens	PES
PLYMOUTH	Plymouth	PLH
ROSTOCK	Lagge	RTK
ROTTERDAM-EUROPORT	Schipol	RTM
SANTANDER	Parayas	SDR
SOUTHAMPTON	Southampton	SOU
ST PETERSBURG	Pulkovo	STP
STOCKHOLM	Arlanda	STO
TEES	Tesaide	TES
THESSALONIKI	Thessaloniki	SKG
VALENCIA	Manises	VAL
VENICE	Marco Polo	VCE
VIGO	Vigo	VGO
WATERFORD	Waterford	WAT

Table 3. Presentation of the database

PORTCODE	AIRINTEG	AIRTRAFF	AIRTRAFM	AIRPADMI	AIRPSERV	AGENTSSF	CRUISE	FERRYSER	SEACONNEX	SHIPSERVICES	WARESTOR	LOGISTIC	POPAGGLO
AAL	0	1,229	21,822	0	0	192	0	0	6	86	201	346	122
AAR	0	1,961	21,947	0	0	371	1	0	31	286	70	26	226
ABZ	0	3,997	97,603	0	0	180	0	5	3	2,055	286	25	183
ALC	0	5,849	66,577	750	0	8	1	0	9	0	111	135	428
AMS	8	1,353,760	408,300	2,134	817	4,185	2	118	32	1,320	2,364	2844	1,188
AOI	0	5,469	19,320	0	60	198	1	40	14	278	107	24	100
ADJ	0	0	0	0	0	110	0	0	2	0	0	0	12
ANR	0	4,903	63,994	0	210	3,150	0	93	145	3,311	3,484	1106	933
BCN	11	76,173	282,015	750	35	1,838	2	0	72	1,046	3,085	1307	4,973
BRI	0	3,740	22,995	0	120	217	2	0	9	522	52	53	303
BFS	0	42,116	113,265	750	175	496	0	75	11	310	128	0	585
BIO	0	3,826	44,006	0	0	130	0	6	32	474	224	1801	1,120
BOD	3	15,592	65,708	200	0	885	0	13	18	178	618	559	971
BRE	2	2,237	42,789	287	30	1,813	0	83	76	2,625	1,479	1306	1,001
BRS	0	5,279	74,540	0	0	1,109	0	0	6	342	23	114	616
CTA	0	12,354	54,436	0	0	91	2	0	7	16	164	196	852
CND	0	281	1,423	0	0	680	0	8	18	4,707	1,826	0	303
CPH	1	11	90,626	0	17,000	1,255	2	5,512	16	22,523	1,614	724	2,366
ORK	0	7,114	54,277	270	0	711	0	77	5	249	283	1096	188
DUB	0	133,871	177,783	4,040	2,500	3,759	2	3,432	10	3,770	2,757	2247	1,024
EDI	0	53,281	106,205	0	0	17	1	4	30	113	15	410	696
FAO	0	1,834	37,278	0	0	0	0	0	2	0	0	0	41
GOA	0	2,813	29,041	0	461	454	2	617	51	2,534	433	167	692
CYP	0	5,791	104,301	0	20	353	0	3	10	344	842	695	1,379
GOT	0	58,976	60,148	0	0	1,006	2	4,150	30	4,723	678	1179	786
HAM	7	35,968	149,363	11	27	11,045	0	585	101	7,078	3,371	1698	3,278
HEL	3	88,140	218,967	126	17,758	3,746	2	829	31	993	1,118	5460	1,215
STH	0	5,680	74,555	0	0	1	1	0	2	5	1	0	28
KEL	0	0	27,200	42	315	111	0	24	10	131	41	1	235
LEH	0	133	41,621	0	0	2,049	2	42	86	2,895	556	60	254
LEO	0	28,140	43,144	0	0	976	0	0	26	310	212	0	1,218
LIS	3	95,767	117,658	777	7,310	1,552	0	306	60	1,950	324	45	2,613
LPL	0	24,253	84,402	0	37	495	0	826	36	43	135	20	3,562
LON	9	1,736,563	936,551	383	440	3,082	2	108	54	818	1,260	3798	11,327
MMA	0	28,504	42,040	0	0	627	0	351	5	270	199	178	2,366
MRS	3	53,547	111,613	350	253	3,702	2	1,215	91	1,183	761	75	1,573
SNR	2	10,589	63,815	333	151	2,404	1	0	15	355	479	288	765
NAP	0	6,200	65,016	0	792	573	2	1,070	34	1,962	64	20	3,770
NCE	3	15,315	181,303	825	225	238	0	11	0	30	59	6	908
OSL	0	72,688	185,645	1,241	9,598	1,922	3	1,686	19	814	1,045	27147	808
OTD	0	78,066	37,354	0	0	14	0	0	4	118	16	0	69
PMO	0	5,372	42,866	0	135	21	2	0	11	55	4	0	987
PMI	0	22,358	168,977	0	0	0	4	135	7	3	111	111	475
LPA	0	43,307	99,698	411	0	136	0	0	2	360	111	111	621
PES	2	109,741	170,130	698	581	1,840	4	553	64	3,887	915	2135	3,231
PLH	0	68	28,900	88	0	8	1	175	6	100	0	0	247
RTK	0	3,424	4,617	0	0	18	0	0	24	411	107	0	196
RTM	0	230	66,943	33	29	3,163	0	126	172	1,579	3,905	56	3,328
SDR	0	40	11,326	86	0	374	2	0	15	381	100	179	185
SOU	0	322	48,960	0	0	147	4	178	31	675	3	180	764
STP	0	26,045	53,869	0	33	3,898	0	2	30	2,734	1,456	295	4,784
STO	2	131,355	285,781	50	5,800	1,770	0	179	5	394	12,835	3334	1,692
TES	0	943	51,525	0	0	163	1	7	27	67	113	5	675
SKG	0	1,211,639	21,094	0	0	269	3	0	15	681	26	192	829
VAL	0	11,776	65,548	0	0	600	2	6	68	351	245	181	1,740
VCE	2	11,222	76,886	1	585	254	0	2	33	3,376	194	55	259
VGO	0	1,137	13,455	0	0	125	2	0	23	68	151	181	419
WAT	0	0	0	22	0	77	0	20	11	30	71	82	47

Table 4. Bravais-Pearson correlation matrix in lower triangular form

	AIRINTEG	AIRTRAFF	AIRTRAFM	AIRPADMI	AIRPSERV	AGENTSSF	CRUISE	FERRYSER	SEACONNEX	SHIPSERVICES	WARESTOR	LOGISTIC	POPAGGLO
AIRINTEG	1												
AIRTRAFF	**0.53**	1											
AIRTRAFM	**0.73**	**0.74**	1										
AIRPADMI	**0.27**	**0.26**	**0.33**	1									
AIRPSERV	0.11	-0.01	0.18	0.13	1								
AGENTSSF	**0.56**	0.22	**0.36**	**0.29**	0.19	1							
CRUISE	0.11	**0.26**	0.22	0.19	0.18	0.01	1						
FERRYSER	-0.03	-0.04	0.06	**0.32**	**0.55**	0.19	**0.28**	1					
SEACONNEX	**0.30**	0.04	0.13	-0.04	-0.04	**0.55**	0.04	0.00	1				
SHIPSERVICES	0.11	-0.04	0.02	0.04	**0.54**	**0.31**	0.12	**0.75**	0.18	1			
WARESTOR	**0.30**	0.10	**0.32**	0.16	0.23	**0.42**	-0.11	0.11	**0.28**	0.17	1		
LOGISTIC	0.10	0.13	**0.28**	**0.30**	**0.45**	0.20	**0.27**	0.22	0.00	0.01	0.16	1	
POPAGGLO	**0.61**	**0.52**	**0.75**	0.07	0.08	**0.42**	0.12	0.10	**0.37**	0.16	**0.30**	0.15	1

Table 5: Factorial Analysis Results

Eigenvalues of the correlation matrix

Factors	F1	F2	F3	F4
Eigen Values	3.98	2.31	1.63	1.12
% variance	30.61	17.77	12.56	8.63
% Cumulative	30.61	48.38	60.93	69.57

Eigen Vectors

Variables/Factors	F1	F2	F3	F4
AIRINTEG	0.39	-0.23	0.04	-0.03
AIRTRAFF	0.31	-0.27	-0.31	-0.20
AIRTRAFM	0.42	-0.22	-0.21	-0.04
AIRPADMI	0.22	0.09	-0.29	0.36
AIRPSERV	0.20	0.46	-0.06	0.08
AGENTSSF	0.35	0.00	0.35	0.18
CRUISE	0.15	0.14	-0.40	-0.30
FERRYSER	0.18	0.53	-0.03	-0.20
SEACONNEX	0.20	-0.08	0.50	-0.05
SHIPSERVICES	0.19	0.46	0.24	-0.36
WARESTOR	0.24	0.03	0.30	0.45
LOGISTIC	0.19	0.20	-0.30	0.48
POPAGGLO	0.37	-0.21	0.07	-0.30

Variable Contributions to Factors %

Variables/Factors	F1	F2	F3	F4
AIRINTEG	15.10	5.46	0.19	0.11
AIRTRAFF	9.71	7.33	9.44	3.93
AIRTRAFM	17.27	5.00	4.39	0.19
AIRPADMI	4.91	0.82	8.37	13.30
AIRPSERV	4.08	20.77	0.40	0.71
AGENTSSF	12.25	0.00	12.19	3.36
CRUISE	2.30	1.93	15.66	8.86
FERRYSER	3.28	28.38	0.10	4.08
SEACONNEX	4.15	0.66	24.91	0.27
SHIPSERVICES	3.52	21.41	5.82	13.04
WARESTOR	5.84	0.07	8.96	19.88
LOGISTIC	3.76	3.81	9.09	23.41
POPAGGLO	13.82	4.35	0.46	8.85

Table 6: F1 First Factor-Description with the help of 3 active variables

Variable	Coordinates	Contribution (%)
Non Significative Central Zone	This zone contains 10 remaining variables	
POPAGGLO	0.37	13.82
AIRINTEG	0.39	15.10
AIRTRAFM	0.42	17.27

Table 7: F2 Second Factor- Description with the help of 6 active variables

Variable	Coordinate	Contribution (%)
AIRTRAFF	-0.27	7.33
AIRINTEG	-0.23	5.46
AIRTRAFM	-0.22	5.00
Non Significative Central Zone	This zone contains 7 remaining variables	
AIRPSERV	0.46	20.77
SHIPSERVICES	0.46	21.41
FERRYSER	0.53	28.38

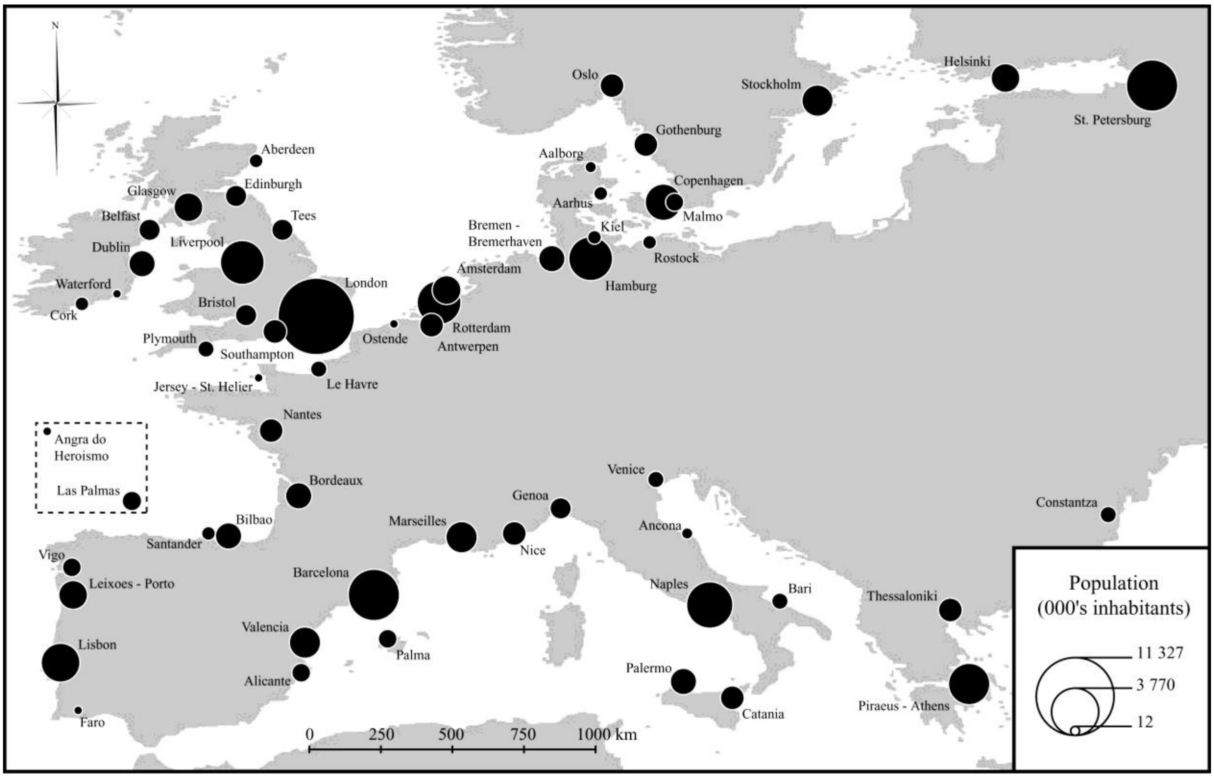
Table 8: F3 Third Factor-Description with the help of 6 active variables

Variable	Coordinate	Contribution (%)
CRUISE	-0.40	15.66
AIRTRAFF	-0.31	9.44
POPAGGLO	-0.30	9.09
Non Significative Central Zone	This zone contains 7 remaining variables	
WARESTOR	0.30	8.96
AGENTSSF	0.35	12.19
SEACONNEX	0.50	24.91

Table 9: F4 Fourth Factor-Description with the help of 5 active variables

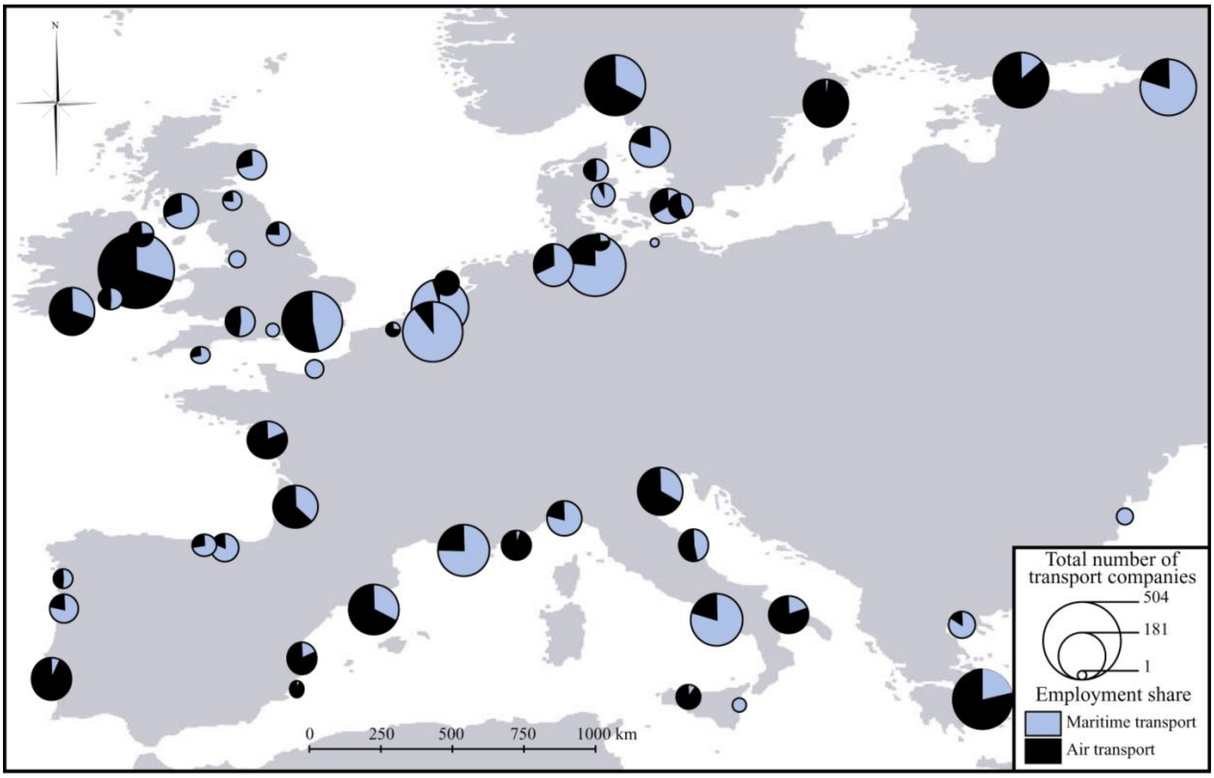
Variable	Coordinates	Contribution (%)
SHIPSERVICES	-0.36	15.66
CRUISE	-0.30	8.86
POPAGGLO	-0.30	8.85
Non Significative Central Zone	This zone contains 8 remaining variables	
WARESTOR	0.45	19.88
LOGISTIC	0.48	23.41

Figure 1. Demographic size of the metropolitan areas



Source: World Gazetteer, 2005

Figure 2. Relative importance of sea and air transport employment



Source: Kompass, 2005

Figure 3. Bravais – Pearson linear correlation graph

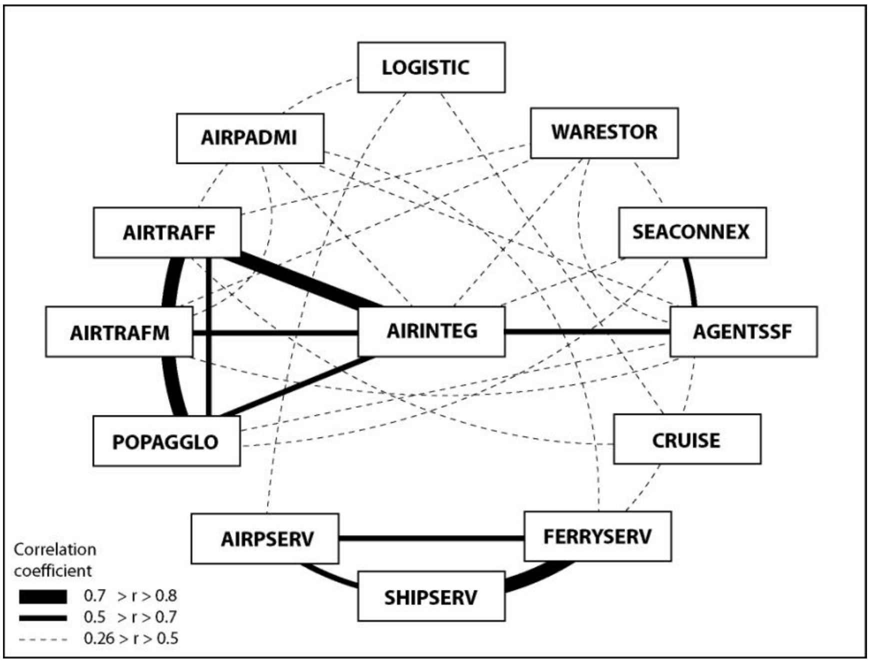


Figure 4. Air integration of European port cities (30.61% of total variance)

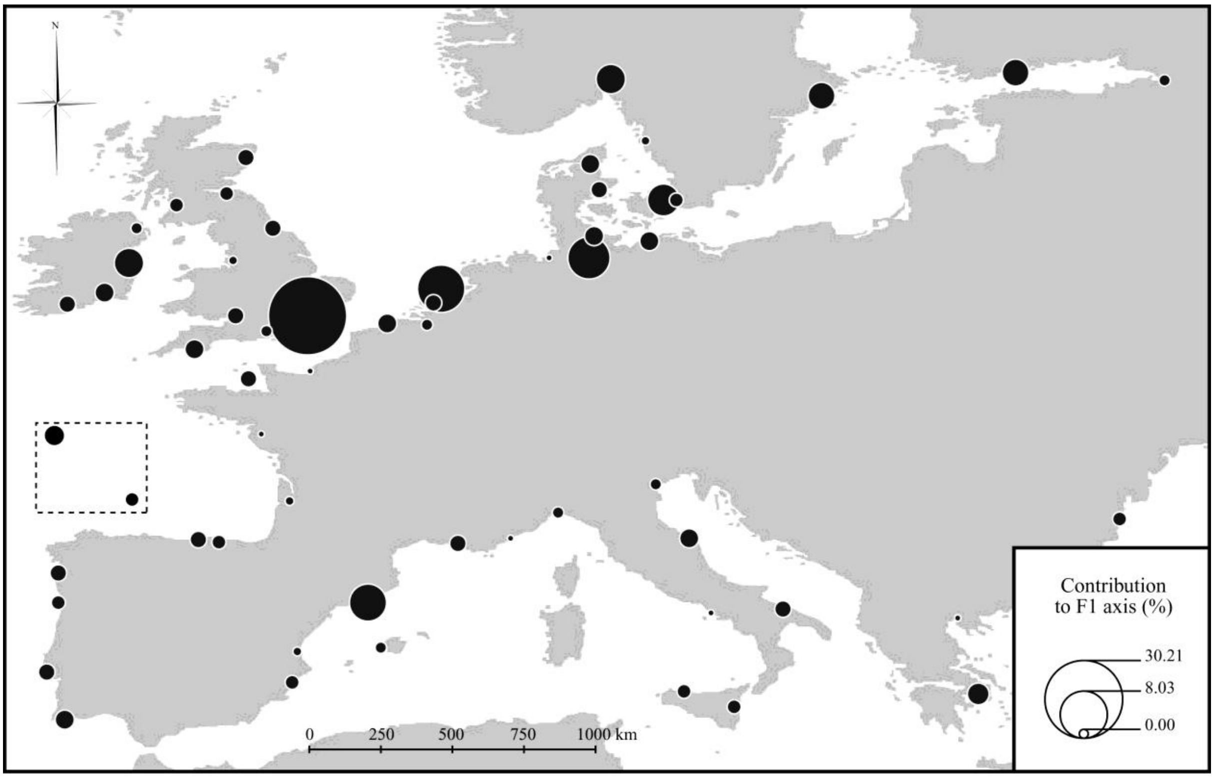


Figure 5. Ferryports and air services (17.77% of total variance)

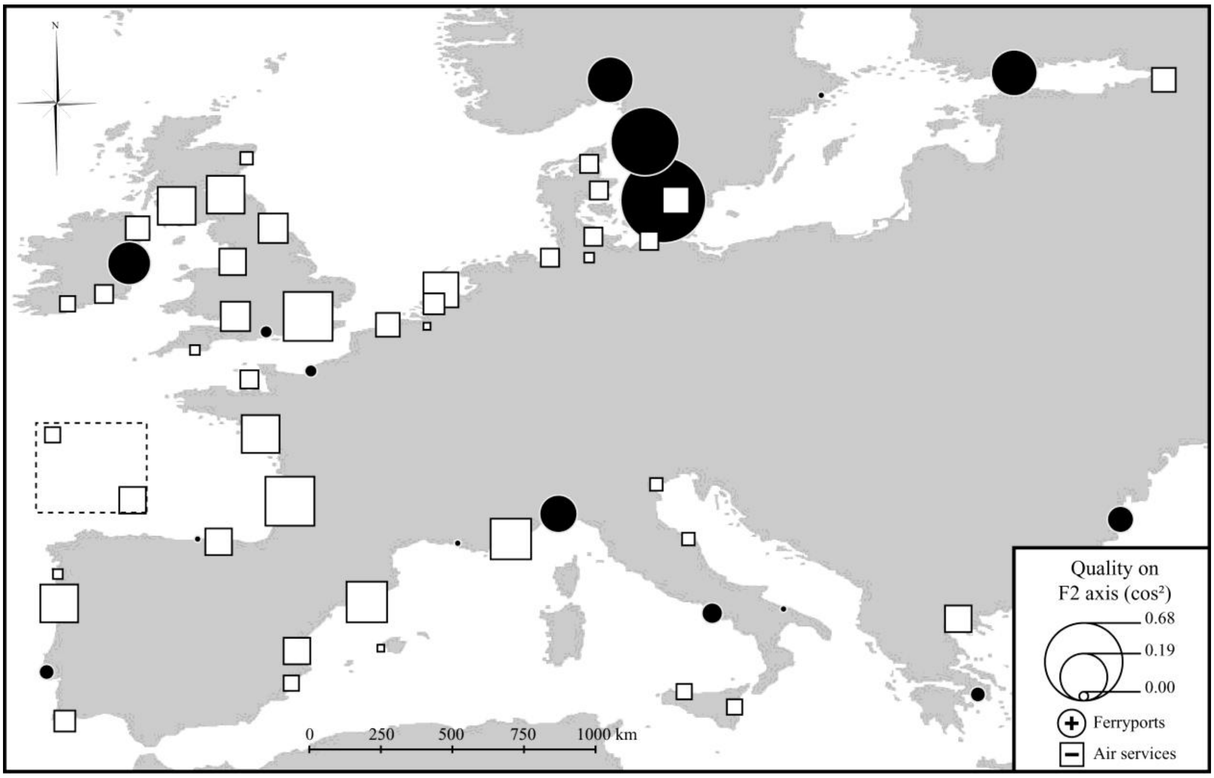


Figure 6. Container and cruise ports (12.56% of total variance)

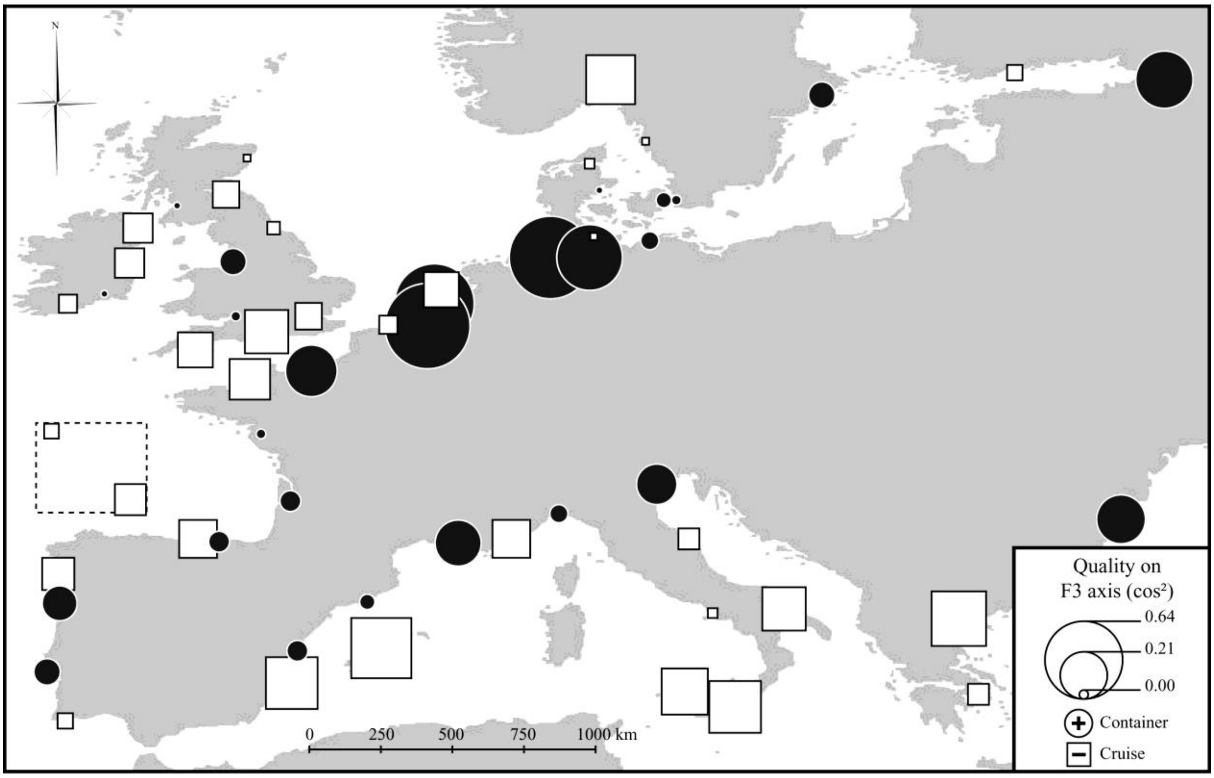


Figure 7. Logistic and maritime activities (8.63% of total variance)