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A metageography of port-city relationships

César Ducruet

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Abstract

This chapter is an empirical attempt to identify the nature and regional dimension of port-city relationships on a world scale. Although general processes of such relationships can be identified in the literature, regional variations are still not well understood when dealing with the insertion of port cities in the global transport chain. An analysis of a world sample is proposed using simple characteristics such as geographical coordinates, urban population, logistic activities, port infrastructures, maritime traffic and transport connections. Factors of port hierarchy, land/sea, port/city, and logistic/intermodal oppositions create north-south and east-west patterns. An equilibrate insertion between different functions or networks gives a sustainable position to some port cities within the transport chain. Finally, this chapter serves as an experimental complement to the study of world regionalisation and global-local processes.

Keywords: Containerisation, Globalisation, Port city, Regionalisation, Transport chain

1. Introduction

It is now generally recognized that maritime networks have had an increasing influence on ports and port-city relationships over the last three decades, following the container revolution and the new spatial distribution of industrial activities. Although containerisation has spread globally and homogeneously, it has also encountered a regional diversity of heritages and practices. The responses of port cities to global economic change reveal important differences between world regions, notably in terms of waterfront redevelopment in Europe and America (Hoyle, 2000) and port-city planning in the Northern and Southern hemispheres (Carmona,

2003). Thus, transport players that are willing to insert the port city within the global transport chain must cope with normalised logistic systems which are managed by an ever-reducing number of powerful global companies (e.g., shippers, shipping lines, freight forwarders, logistic agents) and local and regional specificities in terms of economic development and spatial planning. Between global insertion and local impediments, a wide variety of situations can be found.

This chapter seeks to determine whether or not homogenous port regions exist, and, if so, what factors define such regions from arbitrary spatial divisions (Braudel, 1979; Lewis and Wigen, 1997). Studies on the world system and regionalisation have not paid much attention to ports (Lloyd, 1992; Durand et al., 1993; Dollfus et al., 1999); while most studies focus on the world's largest cities when examining transport globalisation (Dogan, 1988; Keeling, 1995). Port geographers have addressed a number of models usually separating developed and developing countries at different periods from colonial cities to global logistics (see Lee et al., 2006 for a synthesis), but their application has remained limited to collections of case studies rather than macro-regional or global analysis (Slack et al., 2000).

In this respect, port cities seem to be an original ground on which to study the local and regional factors affecting globalisation. Important contemporary changes have been widely described by scholars, such as the decline of mutual economic benefits (Benacchio et al., 2001) and the increased spatial separation (Hoyle, 1989) between ports and cities resulting from technological and managerial change in global transportation. In order to verify the linkages between global and local factors affecting port cities, a large-scale analysis is needed. This research analyses the relationships between functional attributes (demographic size, logistic activities, port infrastructures, traffics and land-sea connections) and locational attributes (latitude, longitude), so as to test the hypothesis of a regional coherence underlying the insertion of port cities in the global transport chain. Previous works have been limited in

undertaking such verification without the inclusion of geographical attributes (Ducruet, 2004a; Ducruet and Jeong, 2005). Geographical coordinates appear to be the only objective parameter available to express a regional belonging. It has the advantage of being neutral and unique to every place, and also it avoids the subjective definition of regional entities.

2. Models of port-city relationships

The port city does not refer to a specific scientific category or methodology, because of the diversity of port-city issues and the usual separation of port and urban studies (Broeze, 1989; Reeves, 1989; Chaline, 1994; Morvan, 1999). Thus, it is still an “unidentified real object” (Brunet, 1997) which, without a universally recognised definition, remains only broadly addressed by scholars as a circulation node between land and sea where specific functions develop (Bastié and Dezert, 1980; Brunn, 1983; White and Senior, 1983; Brocard, 1994).

2.1 Urban and port models

In port and maritime geography, the city has been given particular importance dating back to the works of Vigarié (1979). However, urban-related issues are often disregarded in the general literature on ports and transport (Banister, 1995), which is more focused on technical (network and node performance) and/or institutional (transport players and their strategies) issues. Reasons for this focus include the traditional separation between urban geography and transport geography and the contemporary phenomenon of port-city separation which has become a very fertile ground for waterfront-related issues among planners, geographers, and economists.

The city appears to be a constraint to port expansion because of the technological transformations in the maritime world (e.g., the growing size of ships). The outports depicted by Perpillon (1959) and systematised in the anyport (Bird, 1963) and European estuary

(Brocard et al., 1995) models show the shift of port facilities from the upstream city to deep-sea downstream locations. Hoyle (1989) also illustrates the successive stages of port-city spatial separation.

Urban functions are considered secondary factors to explain the strategies of shipping lines, port operators and freight forwarders which focus on cost and time efficiency of transport systems regardless of the location of port infrastructures. Additional issues regarding dry ports and inland multimodal platforms tend to reinforce the idea of the urban constraint within coastal cities. Port models have doubted the local benefits of new port facilities, like in the case of remotely located ports (Stern and Hayuth, 1984).

The port is also poorly represented in urban models. Port function is often considered as disturbing the regularity of the central place theory, due to its effect on the urban system (Bird, 1977). Thus, it has been neglected for a long time, for instance at the local level in urban models (Gleave, 1997). At least port activities confer to the economic structure some specialisation in transport functions, with a higher share of employment in the transport sector than in non-port cities.

For such reasons, port cities have often lower ranking in urban classifications (Hautreux and Rochefort, 1963; Noin, 1974; Pumain and Saint-Julien, 1976). Bird (1973) reacts to this by considering gateway and central place functions as equally important for cities and regions. Such argument was further developed through the idea of multiplier effects, described by Vigarié (1979) as a “reciprocal breed” between ports and cities. Vallega (1983) also developed a theory on the interaction between port growth and local economic diversification, even though port and urban dynamics remain of a different nature. More recent researchers still consider ports as advantageous locations for trade and urban development (Fujita and Mori, 1996; Fujita et al., 1999). The everlasting debate about the direction of the influence between ports and urban systems (Boyer and Vigarié, 1982) raises the problem of causality:

“does the port develop the city and its economic activities, or is the city the engine of port expansion ?” (Verlaque, 1979). Goss (1990) condemns this question, arguing that “it serves no useful purpose to ask which functions came first or are the more important: they go together.”

2.2 The port-city matrix

The absence of a universal definition or model of port-city relationships is balanced by several typologies, of which the port-city matrix is a synthesis. In Figure 1, an upper left – lower right diagonal illustrates the hierarchical combination of centrality¹ and intermediacy (Fleming and Hayuth, 1994) while the lower left – upper right one marks their opposition. The cityport, as defined by Hoyle and Pinder (1981, 1992) is a state of equilibrium between the coastal town and the global port city in terms of size and between the hub and the general city in terms of function. This underlines the fact that, in reality, few port cities might be considered cityports because of the recurrent disequilibria between these two main orientations.

[INSERT FIGURE 1 ABOUT HERE]

3. A global approach

Most port studies on a world scale are limited to port traffics (Marcadon, 1995; Brocard et al., 1995), while others use original methodologies such as the application of graph theory to maritime systems (Joly, 1999), and the calculation of a weekly containerised transport capacity from the main shipping lines’ services (Frémont and Soppé, 2003). Port-city

¹ Centrality is defined as a local / regional trade generation power (endogenous) while intermediacy is defined by external player’s election of a place for serving their networks (exogenous).

relationships are more developed in regional studies but few of them have a methodological framework.

3.1 Regional studies

Regional-based studies have allowed us to understand Asian (Basu, 1985; Broeze, 1989, 1997), Atlantic (Knight and Liss, 1991; Konvitz, 1994), and European (Konvitz, 1978; Hoyle and Pinder, 1992; Lawton and Lee, 2002) trends. In particular, some authors have valued the unique combinations of global and local trends taking place within port regions, notably in Asia, through particular land patterns (Mc Gee, 1967) and hinterlands (Banga, 1992), the effects of dense urban environments on port activities (Ness and Tanigawa, 1992), the urban-oriented policies of Asian port cities (Okuno, 2000), the evolution of the port-city interface in hub port cities (Lee, 2005), and the new trend of port back-up area development (Lee et al., 2005). A comparison of main port regions is shown in Figure 2, to illustrate the varying importance of inland and coastal hinterlands in terms of market centrality (Lee et al., 2006).

[INSERT FIGURE 2 ABOUT HERE]

Studies at a national level provide very different results. In India, for example, the linear correlation between demographic size and total port throughput has diminished dramatically between 1911 and 1981 (Kidwai, 1989) due to the emergence of specialised ports from big cities (e.g. New Mangalore, Paradip). Inversely, in Canada (Slack, 1989) and Australia (O'Connor, 1989), city size and port throughput are strongly correlated with transport activities. The French case (Steck, 1995) does not show any correlation between urban and port growth during the 1975 to 1990 period. In addition, the growth rates in Europe of added value were identical between port cities and non-port cities between 1975 and 1985, but

became stronger for non-port cities between 1985 and 1996 (Lever, 1994), illustrating the economic advantage of inland location in the European central place system (IRSIT, 2004). In China, although new ports are distant from inner cities, they become industrial growth poles while port activity is still important for inner ports (Wang and Olivier, 2003).

3.2 Measuring port-city relationships

The lack of relevant sources for measuring these relationships through international comparisons (Ducruet, 2003) has restrained the quantitative approach to “approximate measures of economic benefits deriving from port activities” (Wang and Olivier, 2003). In fact, port-city relationships are more of a qualitative issue but a number of authors have proposed some indicators to allow a comparative approach.

The relative concentration index is proposed by Vallega (1976) to compare Mediterranean regions, by simply dividing the regional share of throughput by the regional share of population. Similar index are used by Vigarié (1968) to measure maritime dependence (number of merchant marine tons per inhabitant) and Kenyon (1974) to measure the relative importance of transit function and urban magnitude amongst US port cities (number of general cargo tons per inhabitant).

The works of Witherick (1981) and Gripaios (1995) remain based on specific data collected from national censuses. Recent works on port-related employment in British travel-to-work areas (Gripaios and Gripaios, 1999), air-sea employment in European port cities (Ducruet et al., 2005), the port-city interface in Europe and Asia (Ducruet and Jeong, 2005), and global-local forces affecting global hub port cities in Asia (Lee, 2005) have provided useful outcomes motivating the pursuit of a global approach.

4. Application to a world sample

4.1 Global analysis

As a result of data collection on a world scale, the sample covers approximately 96 percent of container throughput, 60 percent of port tonnage, and 53 percent of coastal urban population (Table 1).

[INSERT TABLE 1 ABOUT HERE]

The criteria used to select ports is their participation to regular container services of the world's major shipping lines, regardless of a demographic or traffic size (Frémont and Soppé, 2003). This criteria has the advantage of assessing the participation of the port city to the global logistic chain. Moreover, containerisation implies a higher value of the goods transported, a potential intermodality, and a set of logistic functions which are not common with ports specialised in bulk or oil products. The resulting sample consists of 348 ports located throughout the world.

Available data have been selected through their relevancy: geographical coordinates (Lloyd's Maritime Atlas, 2005), urban population (Helders, 2006; Lahmeyer, 2006; Brinkhoff, 2006), container-related businesses (Containerisation International Online, 2006), freight forwarders and logistic agents (International Transport Journal, 2006), highway and railway connections (Microsoft, 2006), container throughput, maritime connections, nautical accessibility and total length of the container terminals (Containerisation International, 2006). Although other indicators exist at a global scale, they have not been included to avoid redundant values (e.g. ton traffic, total quayage, administrative and suburban population, surface of the metropolitan urbanised area, and shipowners' headquarters).

The original values are transformed into logarithms to lower extreme values, except for geographical coordinates, which contain negative numbers. In Table 2, eigenvalues and

cumulated variance show the results of the factor analysis with four main factors, accounting for 76% of the original information.

[INSERT TABLE 2 ABOUT HERE]

The first factor (F1) is the concentration of the transport chain, based on logistic activities, port throughputs and infrastructures. In this hierarchy, geographical coordinates do not play an important role. Then F1 can be defined as a gradient of insertion in the global transport chain.

The second factor (F2) is an opposition between two trends. On one side, maritime connections and maximum depth of the container terminals are related to longitude (east-west maritime gradient), while on the other side, inland connections are related to latitude (north-south landside gradient). This opposition is recurrent in port geography, as it refers to the “port triptych” model (Vigarié, 1968) where foreland and hinterland are two major components of the transport chain, along with the port itself; few ports embrace a dominant position on both sides of the triptych. Aside these two major factors which account together for almost 60% of the analysis, two other ones worth attention.

The third factor (F3) brings a complementary opposition: on one side is the interplay of demographic size and longitude (east-west urban gradient), and on the other side is the one between container infrastructures and latitude (north-south port gradient). The opposition between city size and port performance is a recurrent issue as stated previously. It means that the efficiency of port operation contradicts the importance of the urban centre, because of growing congestion at the port-city interface. Although coastal location has been an advantage in attracting population and industries close to ports for economic reasons, the spatial effects of such concentration have increasingly led to diseconomies of scale and of agglomeration. It

also confirms in some way the opposition between the hub port, dominated by maritime shipments, and the coastal city or metropolis, dominated by central place functions (Figure 1). The north-south port gradient also recalls the works of Zohil and Prijon (1999) and Boske (2003) on the interdependence of transshipment volumes and distance to major sea lanes. Port planning on a world scale is highly influenced by the shortest path used by bigger ships, linking the three main economic poles of the world: ports located away from the circumterrestrial artery cause a deviation and are used as feeder ports instead of as direct ports of calls for mother vessels.

The fourth factor (F4) opposes two different trends: the interplay of logistic activities, population and latitude (north-south logistic gradient) and the combination of nautical, inland accessibility with longitude (east-west intermodal gradient). Urban economies are important for logistic activities, because urban systems remain the *raison d'être* of production and consumption activities. If the local relationship between ports and port cities undergoes growing pains (McCalla, 1999), ports and transport players cannot ignore the markets they serve and nor their location patterns. The opposition to an intermodal potential means that the efficiency of transport systems has its own logic but, in the end, transport players are more likely to follow the urban hierarchy.

The absence of a gradient of port-city interdependence shows that on a world scale, there is more of an opposition than a combination of urban and port functions.

4.2 Regional analysis

The spatial distribution of the gradient of transport chain concentration (F1) reveals the three dominant economic regions: North America, Europe and East Asia (Figure 3a). The cores of the world economy are also in the south: Callao-Lima, Buenos Aires, Rio de Janeiro, Abidjan, Capetown, Durban, Australian cities, Auckland, and the important metropolises of the Middle

East (Jeddah, Dubai) and South Asia (Karachi, Mumbai, Colombo, Visakhapatnam). These port cities are the most connected to the global transport chain although the principles of their insertion differ in terms of market centrality and urban systems (as shown in Figure 2). Thus, unsurprisingly, the organisation of global logistics corresponds to the world pattern of economic wealth and port concentration, dividing the world into two distinct hemispheres.

[INSERT FIGURE 3 ABOUT HERE]

[INSERT FIGURE 4 ABOUT HERE]

The first opposition (F2) reveals the contemporary shift of maritime and port activities to the East, the new gravity centre of the world economy (Figure 3b). Thus, the concentration of shipping lines and modern port infrastructures follows an east-west gradient, with most important scores located in East Asia. It also indicates the lack of inland connections, a main characteristic of Asian ports resulting from the extraversion of port activities and the coastal concentration of markets (Figure 2). Inversely, for the Western (Atlantic) world, the concentration of shipping lines is lower and the importance of inland connections is higher. This is particularly true for North America as well as for Europe, where ongoing regional integration is mostly based on the interaction between EU member countries within the continent. It also confirms that North America and Europe are more continental while Asia is more maritime.

The second opposition (F3) shows a complementary reality (Figure 4a). The east-west gradient shows the importance of city size in South and Southeast Asia (from Karachi to Manila), Oceania, Western and Southern Africa, and to a lesser extent in Northeast Asia and South America. In other regions, city size is relatively less important than port functions; this indirectly indicates the fact that Western urban economies have also developed inland,

especially in Europe where the heartland of the continent is the core of the regional economy. Thus, European port cities compete to sustain their accessibility and welcome the highest cargo volumes for serving overlapping hinterlands.

The third opposition (F4) has a more complex spatial distribution (Figure 4b). Broadly speaking, the east-west intermodal gradient concentrates on port cities along the circumterrestrial trunk line: Caribbean, West and North Africa, East Mediterranean, and South and East Asia. The north-south logistic gradient lies north or south of this trunk line with South America, Northeast America, Western Europe, Japan and Oceania. Although the two gradients exclude each other, the importance of logistic activities in Europe does not mean a lack of intermodal potential. This trend can be explained by the historical importance of logistic activities in Europe, alike Japan and Northeast America. In other regions sharing this trend, the lack of intermodal potential is probably the main explanation. Thus, the remoteness to major shipping lines lowers the need for intermodal operations but accentuates the importance of local economies and logistics.

4.3 Exceptions

According to the east-west maritime gradient (F2), any port city located westbound of the Greenwich meridian should indicate a relatively lesser concentration of shipping lines compared to the level of its landside connections. This is not true for some port cities of the Caribbean (Kingston, Puerto Cabello, Cartagena, Colon) and South America (Rio Grande, Paranagua, Sao Francisco do Sul, Santos, Sepetiba, Suape). In Europe, port cities located close to the heartland also contradict the trend, like those of the Northern range (Le Havre, Zeebrugge, Rotterdam, Tilbury, Felixstowe), northern Italy (Genoa, La Spezia, Venice, but also Koper in Slovenia) and the Mediterranean hubs (Algeciras, Gioia Tauro, Marsaxlokk, Piraeus, Limassol). Their direct connection to the global economy through the world's major

shipping lines overwhelms the importance – or accentuates the lack - of inland connections. In contrast, some port cities located eastbound of the Greenwich meridian have a lower concentration of shipping lines compared to the importance of their inland connections, such as Japanese and South Asian port cities (e.g., Bangkok, Chittagong, Yangon, Visakhapatnam, Batangas). For Japan, this can be explained by the absence of one unique load centre and to its Western character due to earlier industrialisation than other Asian countries.

Similarly, the north-south landside gradient is not matched by several south American port cities (Paíta, Ilo, Chanaral, Caldera, Coquimbo, Buenos Aires, San Lorenzo, Montevideo, Rio de Janeiro, Ilheus, Recife, Fortaleza, Belem, Georgetown, Degrad-des-Cannes, Guanta, Maracaibo). Such exceptions are not found in Oceania, despite the distance to major shipping lines, because of the insular character of the port cities.

According to the east-west urban gradient (F3), port cities located westbound of the Greenwich meridian should see their city size less important than their port functions. Again, South America has several exceptions (most Brazilian cities, Talcahuano, and Coquimbo). Some Eastern cities show a lesser importance of city size as compared to their port functions (Laem Chabang, Jawaharlal Nehru, Port Mohammad Bin Qasim); these ports were recently created to reduce the congestion problems in their older neighbours (Bangkok, Mumbai, Karachi).

The distribution of the north-south port gradient (F3) is contradicted by several UK (Cardiff, Belfast, Glasgow, Edinburgh, Tyne, Hull, London) and Baltic (Copenhagen, Malmo, Rostock, Szczecin, Stockholm, Gdansk, Riga, Klaipeda, Saint-Petersburg) port cities, as well as in the south (Bordeaux, Sevilla, Malaga, Alicante, Algiers, Tunis, Messina, Bari, Volos, Thessaloniki, Izmir, Istanbul, Varna). Economic diversification, remoteness to major shipping lines, and congestion at the port-urban interface are main factors which explain the precedence taken by urban functions over port functions.

The last factor (F4) shows the spatial division of Europe, with logistic importance in the west and intermodal potential in the east. The logistic importance may correspond to the strategies of operators, to concentrate on few dominant ports to serve the continent.

5. Policy implications: strengths and weaknesses of port cities

Although the factor analysis shows the different oppositions of variables and regions, an important question remains: how do port cities integrate land and sea networks? Port and urban functions? Logistic activities and intermodal potentials? Because the particularity and efficiency of a port city is more to combine different elements of the transport chain in a single place, a complementary approach is needed. The lower the contribution of a port city to an opposition between two trends, the higher its participation to both opposing trends will be. Port cities having less than 0.1 per cent contribution to a factor are considered more equilibrate within different functions and networks. A selection is proposed in Table 3, with (+) for contributions under 0.1 percent (equilibrium) and (-) for contributions above 0.1 percent (disequilibria). Results are interpreted as strengths or weaknesses regarding the insertion of port cities in the transport chain, with Figure 5 as a framework.

[INSERT FIGURE 5 ABOUT HERE]

Port-city integration in Europe is observed only for places located away from the heartland (Amsterdam, Liverpool, Dublin, Glasgow, Gothenburg, Oslo, Lisbon, Leixoes, Naples, Piraeus, Thessaloniki). European gateways are more efficient for triptych and intermodal integration (Rotterdam, Hamburg, Aarhus, Dunkirk, Southampton, Trieste, Genoa, Valencia, Leghorn). This confirms that the closer that ports are close to the heartland, the less their port-

city equilibrium will be realised, given the concentration of flows and the indirect dependence on inland markets, which accentuates port specialisation.

Elsewhere, port-city integration reveals the specificity of Asian hub port cities (Hong Kong, Singapore, Port Klang) combined with intermodal logistics (Busan, Incheon, Qingdao, Kaohsiung, Colombo). Such cities manage to keep a profitable equilibrium between urban and port functions by overcoming the risk of congestion at the port-city interface but suffer from the lack of hinterland. Except for hub port cities, Asian places are mostly concerned with port triptych integration (Osaka, Nagoya, Hakata), which combines with intermodal logistics in the case of south-eastern metropolises (Bangkok, Jakarta, Chennai) but cannot maintain a sustainable port-city equilibrium.

In North America, 13 port cities among 17 integrate logistics and intermodality, except for Halifax, New York, Boston and Philadelphia. Similar to European gateways, North American port cities have grown into powerful integrators of transport networks, allowing the formation of land bridge strategies across the continent. However, the absence of port-city integration stems from the diversity and size of local economies.

Finally, the integration of all three factors is quite rare and spatially restrained. In fact, this profile is seen only in the south European-Middle Eastern area, except for Abidjan. Lisbon, Bilbao, Barcelona, Marseilles, Izmir, Beirut, Haifa, Dammam are the only port cities to maintain a total equilibrium. Thus, they can be attributed the identity of cityports. Inversely, the total absence of integration does not have a specific geographical logic. It is more of a functional matter, like the absence of consistent local economy, inland connections and intermodal logistics (Le Havre, Zeebrugge, Felixstowe, Limassol, Keelung, Xiamen, Santos), or the dominance of urban functions combined with the lack of space (London, Tokyo, New York, Shanghai, Bremen, Brisbane, Melbourne, Sydney, Istanbul, Kitakyushu, Karachi).

These cities cannot be cityports because their situation in the transport chain gives advantage to only one of the elements of the system at a time.

[INSERT TABLE 3 ABOUT HERE]

6. Concluding remarks: the transport chain is not ubiquitous

Starting from the hypothesis that a world regionalisation underlies port-city relationships, this research has overcome the difficulty of gathering relevant data from a vast sample of port cities throughout the world. Another difficulty of such an approach is the systematic measurement of a complex phenomenon which is not well defined in the literature; port-city relationships are often hampered by the institutional and physical separation between urban and port authorities, transport modes, and operators. Far from ignoring this reality, the focus was placed on a geographical rather than on an economical perspective. Arguing that the combination of different variables in every place is not unique, this chapter searched for wider levels of organisation, where port cities face a number of common challenges inherited from similar stages of development (e.g., colonial period, first industrial revolution), physical constraints (e.g., islands and continents, distance to trunk lines) and settlement patterns (e.g., types of urban systems), defined as long-term factors.

The first part of the results verifies the respective weight of long-term and short-term factors, the latter being the strategies for inserting port cities in the global transport chain (Robinson, 2002). Unsurprisingly, long-term factors have a strong influence on the distribution of port and urban variables, which are in line with east-west and north-south patterns. This confirms the recurrent separation between port and urban functions, but this separation does not have the same meaning according to macro-regions. There are important distortions of regional

patterns, caused by recent strategies of port concentration, new port construction and hub-feeder networks.

Following the horizontal analysis, based on the search for a bi-dimensional coherence of port-city relationships, the second part of the results is more a vertical one. Although port and urban variables are systematically opposed (land/maritime, port/city, logistics/intermodality), there are several cases for which these functions are articulated. This is a useful qualitative complement to usual port rankings based on sole traffics. The synthetic expression of strengths and weaknesses of port cities addresses several policy implications. In the end, it provides some evidence about the relativity of universal issues, such as the transport chain, which are far from being ubiquitous. Results can also be a tool for port and urban players to position themselves in the world system.

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Table 1: Sample representativity.

	Container throughput (2000)		Total tonnage (2000)		Coastal urban population (1990)	
	TEUs	%	Metric tons	%	No inhab.	%
Sample studied	215,915,760	95.83	7,248,765,716	59.84	452,306,000	53.59
World total	225,300,000	100.00	12,113,000,000	100.00	844,000,000	100.00

Sources: Containerisation International, ISL Statistical Yearbook, Journal de la Marine Marchande, Moriconi-Ebrard 1994, World Gazetteer, Citypopulation, Populstat, UNCTAD 2002, Noin 2000

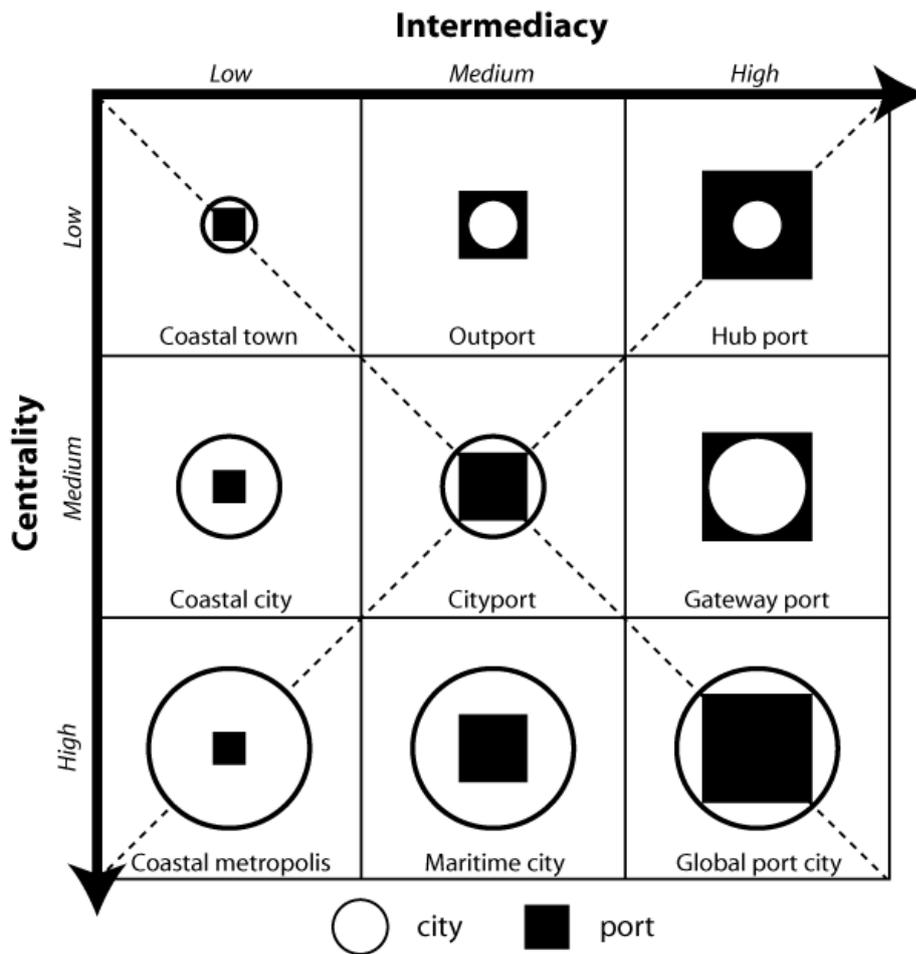
Table 2: Main characteristics of the principal components

	F1	F2	F3	F4
Eigen values	5.2	1.3	1.0	0.8
Cumulated variance (%)	47.2	59.1	68.3	76.0
<i>Contribution of the indicators to the factors (%)</i>				
	<i>Transport chain concentration</i>	<i>North-south landside gradient</i>	<i>East-west urban gradient</i>	<i>North-south logistic gradient</i>
Coordinates > 0	Logistic Activities (14%)	Rail Connections (19%)	Longitude (51%)	Logistic Activities (10%)
	Container Throughput (13%)	Road Connections (18%)	Urban Population (14%)	Urban Population (7%)
	Container Terminals (12%)	Latitude (15%)	Logistic Activities (3%)	Latitude (3%)
	Freight Forwarders (12%)	Urban Population (3%)	Rail Connections (1%)	Freight Forwarders (3%)
Coordinates < 0	-	Container Throughput (6%)	Container Throughput (2%)	Longitude (10%)
	-	Maximum Depth (11%)	Container Terminals (5%)	Rail Connections (15%)
	-	Maritime Connections (11%)	Latitude (7%)	Road Connections (17%)
	-	Longitude (13%)	Maximum Depth (13%)	Maximum Depth (30%)
		<i>East-west maritime gradient</i>	<i>North-south port gradient</i>	<i>East-west intermodal gradient</i>

Table 3: Types of transport chain integration at the world's main 100 port cities

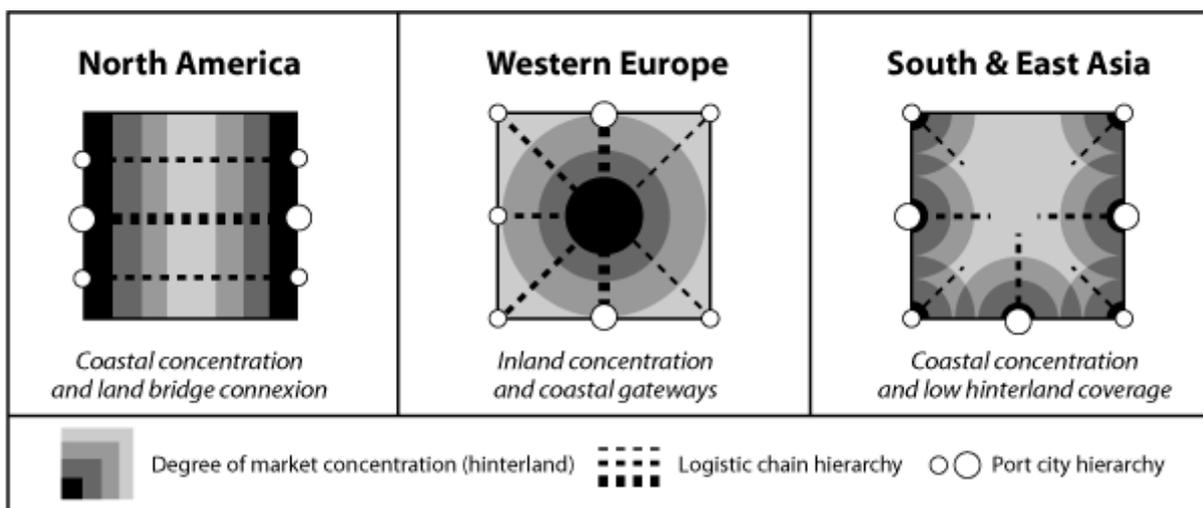
Rank on F1	PORT CITY	Integration type			Rank on F1	PORT CITY	Integration type		
		Sea-land	Port-city	Logistic-intermodal			Sea-land	Port-city	Logistic-intermodal
1	Tokyo-Yokohama	-	-	-	51	Durban	-	-	+
2	Osaka-Kobe	+	-	-	52	Rio de Janeiro	-	+	-
3	Rotterdam-Europoort	+	-	+	53	Saint-Petersburg	-	-	+
4	Hamburg	+	-	+	54	Dublin	-	+	-
5	New York-New Jersey	-	-	-	55	Philadelphia	-	+	-
6	London	-	-	-	56	Southampton	+	-	-
7	Antwerp	+	-	-	57	Brisbane	-	-	-
8	Los Angeles-Long Beach	-	-	+	58	Leixoes-Porto	-	+	+
9	Hong Kong	-	+	-	59	Copenhagen	-	-	+
10	Barcelona	+	+	+	60	Felixstowe	-	-	-
11	Miami-Port Everglades	-	-	+	61	Beirut	+	+	+
12	Busan	-	+	+	62	Savannah	+	-	+
13	Singapore	-	+	-	63	Mumbai (Bombay)	+	-	-
14	Shanghai	-	-	-	64	Portland OR	-	-	+
15	Bremen-Bremerhaven	-	-	-	65	Callao-Lima	+	+	-
16	Valencia	+	-	+	66	Chennai (Madras)	+	-	+
17	Genoa	+	-	+	67	Jacksonville	-	-	+
18	Nagoya	+	-	-	68	Fremantle-Perth	+	-	-
19	Seattle-Tacoma	+	-	+	69	Incheon-Seoul	-	+	+
20	Houston	-	+	+	70	Qingdao	-	+	+
21	Manila	-	-	+	71	Cape Town	-	-	+
22	Montreal	-	+	+	72	Abidjan	+	+	+
23	Bangkok	+	-	+	73	Trieste	+	-	-
24	Melbourne	-	-	-	74	Leghorn (Livorno)	+	-	+
25	Buenos Aires	-	-	+	75	Tanjung Perak-Surabaya	+	-	-
26	Vancouver BC	-	-	+	76	Ho Chi Minh City	+	-	-
27	Piraeus-Athens	-	+	+	77	Dalian	-	-	+
28	Marseilles	+	+	+	78	Haifa	+	+	+
29	Kaohsiung	-	+	+	79	Casablanca	+	+	-
30	Tanjung Priok-Jakarta	+	-	+	80	Boston MA	-	+	-
31	Baltimore	-	-	+	81	Izmir	+	+	+
32	Le Havre	-	-	-	82	Taichung	-	-	+
33	Lisbon	+	+	+	83	Zeebrugge	-	-	-
34	Port Klang-Kuala Lumpur	-	+	-	84	Auckland	-	-	+
35	Sydney-Port Botany	-	-	-	85	Algeciras	-	-	+
36	Gothenburg	-	+	+	86	Keelung-Taipei	-	-	-
37	Oslo	-	+	+	87	Hakata-Fukuoka	+	-	-
38	Helsinki	-	+	-	88	Thessaloniki	-	+	+
39	Dubai	-	+	-	89	Dammam	+	+	+
40	Bilbao	+	+	+	90	Aarhus	+	-	+
41	Oakland-San Francisco	-	-	+	91	Halifax	+	-	-
42	Charleston	+	-	+	92	Kitakyushu	-	-	-
43	Tianjin	+	-	+	93	Karachi	-	-	-
44	Colombo	-	+	+	94	Santos	-	-	-
45	New Orleans	-	-	+	95	Port Said	-	-	+
46	Jeddah	-	+	+	96	Lagos-Apapa	+	-	-
47	Amsterdam	-	+	-	97	Dunkirk	+	-	+
48	Haydarpasa-Istanbul	-	-	-	98	Limassol	-	-	-
49	Naples	-	+	+	99	Glasgow	-	+	-
50	Liverpool	-	+	-	100	Xiamen	-	-	-

Figure 1: A matrix of port-city relationships



Source: adapted from Ducruet, 2004b

Figure 2: Regional models of port-urban organisation



Source: Lee, Song and Ducruet, 2006

Figure 3: Spatial distribution of the results (1)

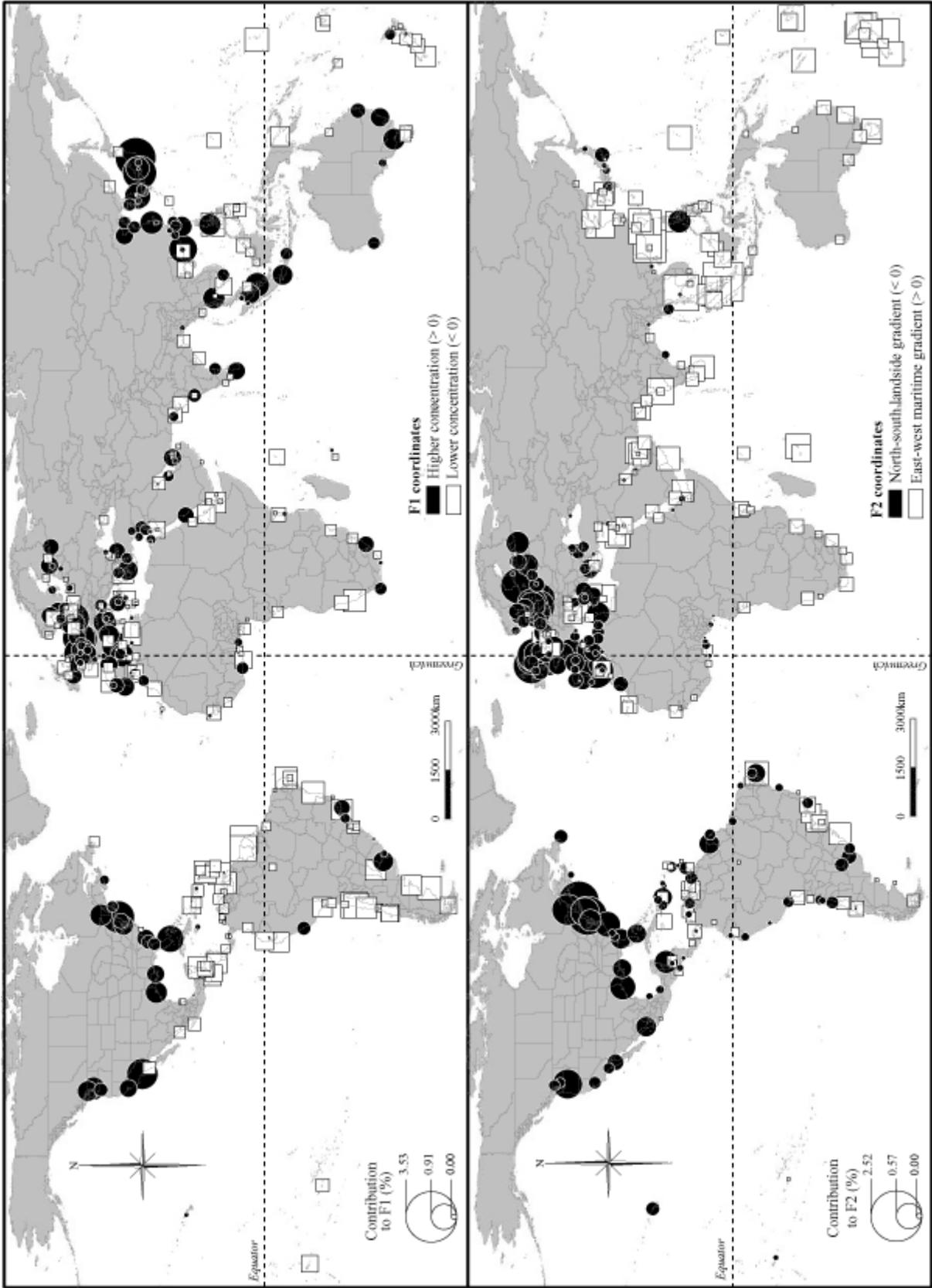


Figure 4: Spatial distribution of the results (2)

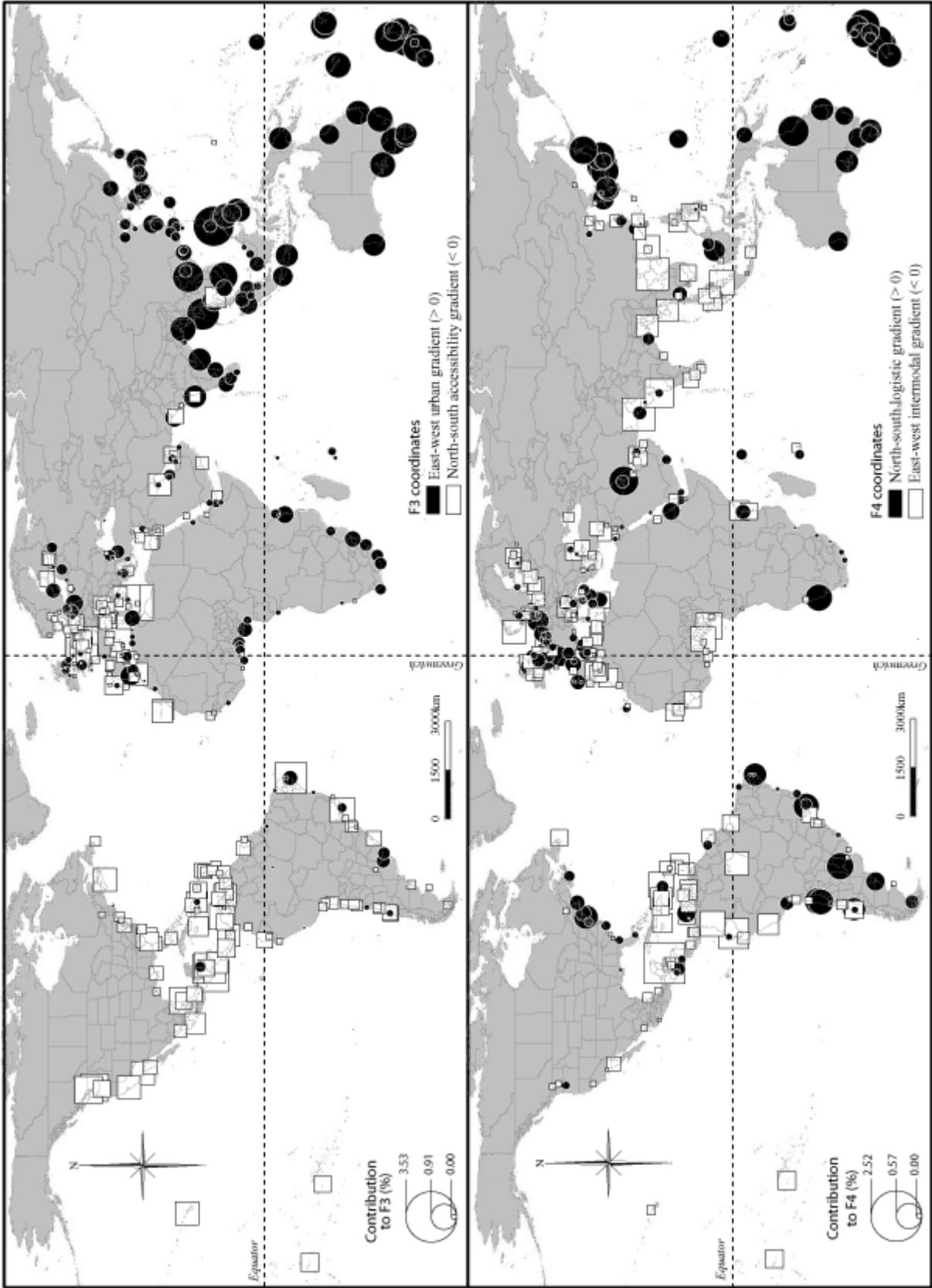
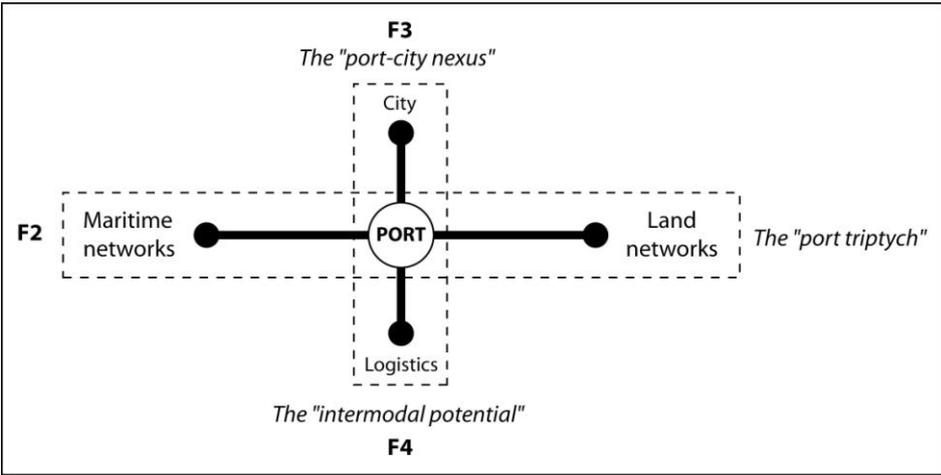


Figure 5: A system of port city integration in the transport chain



Annex: Most representative port cities

(+)	<i>North-south landside gradient</i>	<i>East-west urban gradient</i>	<i>North-south logistic gradient</i>
↑	Boston	Auckland	Nagoya
	Philadelphia	Ho Chi Minh City	Yokkaichi
	Glasgow	Wellington	Tokyo-Yokohama
	Stockholm	Melbourne	Osaka-Kobe
	Montreal	Sydney-Port Botany	Philadelphia
	Portland OR	Adelaide	Hakata-Fukuoka
	New York-New Jersey	Chittagong	Adelaide
	Bristol	Brisbane	Brisbane
	Bordeaux	Cebu	Buenos Aires
	London	Bangkok	Bremen-Bremerhaven
	Copenhagen	Tanjung Perak-Surabaya	Kitakyushu
	Houston	Fremantle-Perth	Gwangyang
	Liverpool	Mumbai (Bombay)	Fremantle-Perth
	Nantes	Tanjung Priok-Jakarta	Nantes
	St. Petersburg	Tokyo-Yokohama	Melbourne
	Belfast	Belawan-Medan	Glasgow
	Teesport	Karachi	Sydney-Port Botany
	Tunis	Shanghai	Wellington
	Baltimore	Dar-es-Salaam	London
	Riga	Hakata-Fukuoka	Shimizu
	Jacksonville	Kitakyushu	Amsterdam
	Amsterdam	Chennai (Madras)	Vigo
	Miami-Port Everglades	Tunis	Boston
	New Orleans	Stockholm	Trieste
	Rouen	Penang	New York-New Jersey
	Gothenburg	Osaka-Kobe	Liverpool
	Leixoes-Porto	Ningbo	Southampton
	Alicante	Buenos Aires	Shuwaikh
	Dublin	Haydarpasa-Istanbul	Gioia Tauro
	Oslo	Nagoya	Bordeaux
	↓	Zeebrugge	Southampton
Belawan-Medan		Aarhus	Mina Zayed
Incheon-Seoul		Jacksonville	Limassol
Puerto Cabello		Port Said	Tunis
Dalian		Veracruz	Haydarpasa-Istanbul
Algeciras		Rio Grande	Penang
Taichung		Portland OR	Santos
La Spezia		Rotterdam-Europoort	Puerto Cabello
Limassol		Vigo	Ravenna
Santos		Trieste	Cadiz
Gioia Tauro		Antwerp	Felixstowe
Dubai		La Spezia	Cebu
Manila		Bremen-Bremerhaven	Dubai
Busan		Le Havre	Ho Chi Minh City
Keelung-Taipei		Kingston	Dar-es-Salaam
Penang		Savannah	Belawan-Medan
Auckland		Charleston	Dakar
Rio Grande		Santa Cruz de Tenerife	Mombasa
Wellington		Tilbury	Kingston
Colombo		Puerto Cabello	Venice
Port Said		Oakland-San Francisco	Casablanca
Chiwan (Shenzhen)		Algeciras	Callao-Lima
Xiamen		Halifax	Chittagong
Port Louis		Los Angeles-Long Beach	Hong Kong
Felixstowe		Honolulu	Singapore
Kaohsiung		Felixstowe	San Juan
Qingdao		Gioia Tauro	Lagos-Apapa
Port Klang-Kuala Lumpur		Vancouver BC	Mumbai (Bombay)
Hong Kong		Seattle-Tacoma	Guayaquil
Singapore		Zeebrugge	Karachi
(-)		<i>East-west maritime gradient</i>	<i>North-south port gradient</i>