The Impact of Sea-River Ports on Spatial Development of Cities

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Sea-river ports are in most cases the final element of the network of inland waterways - usually, in a situation, where they are located at the river's mouth, the possibility of further shipping of inland vessels ends. Ships, sometimes also ocean-going vessels, may however call for many sea-river ports lying in a large distance from the mouth of rivers (eg Szczecin, Hamburg, Bremen). Due to more central position in the transport network in the region or country, seaports, situated further in the hinterland, are generally preferential. However, they face a number of technical problems connected with maintaining the availability of navigation from the sea. In the case of sea-river ports problems related to: construction, operation, maintenance and management of both seaports, inland ports and waterways are cumulated. While seagoing ships and river barges use very often the same waters and quays, using the same equipment, the land on which they are operated is in the competence of many different institutions and bodies. The functioning of the sea-river ports is also strongly correlated with the existence and development of the other cities in the hinterland, being a part of a system of river routes. Finally, the complex spatial and functional dependencies occurring between modern ports and port cities or metropolitan areas, heavily conditioned the development of both of these structures. The scope of this article is analysis of the functional and spatial relationships between them.
Keywords: sea-river ports, port cities, spatial development, land use

1. SPATIAL LAYOUT OF SEA-RIVER PORT CITIES

The course of the river, the topography of the valley and the river regime are determinants of spatial composition of the city, as well as development and nature of the city's structure (eg building on river terraces, no or temporary constructions on floodplains etc.). Second important factor shaping the spatial and functional arrangement of cities located on rivers is the accessibility to waters. Analyzing the land use plans of chosen Baltic riverside port cities (Lübeck [9], Szczecin [10], Gdańsk [11]) one could distinguish two or three functional zones (I, II, III.) existing along the river. The first two zones are closed and are not accessible to the public.

The first zone (I) is created by spatial objects whose function enforces the waterside location. These are usually: the port terminals, industrial plants, and energy plants, which have to use raw materials and intermediate products delivered by water transport. Mostly, zone I is continuous, and is interrupted only by transport passageways (arterial road, tracks), river crossings (bridgeheads, check ferry), or infrastructure objects (e.g. wastewater treatment plant). If zone I is divided into particular sections, it is usually greenery which separates them. Residential development located directly on the banks of the river is relatively rare outside the downtown.

Zone II is designed to support or to co-operate with the first zone. It usually consist of back-up infrastructure (eg energy facilities, water supply facilities, machine base), transport-logistics objects (such as logistic centers, railway sidings, parking lots for a truck route, container depot etc.) and industrial objects (eg factories providing services for freight). Zone II is more or less parallel to the

first one, and is not fully of continuous nature, due to access lanes going into direction of the river.

A third zone is a mixed use area, bringing together services and institutions working for both transportation and industrial zones (I and II), as well as housing, recreation, and other services. It is discontinuous in form, and fully accessible for the residents of the city.

Since some areas of the port (zones I and II) are closed and not available to the public, they form strictly defined boundaries inhibiting spatial development of the city in a certain direction. Thus, the boundary between port and city structure may be of two types:

- "soft" – it occurs in case of functional diffusion of port and city activities. It usually concerns logistics and services, and takes place in zone III or at the border of zones II and III.
- "sharp" - occurs when adjacent areas are characterized by extremely different scales of development (eg, heavily built-up downtown contra extensively used port storage area), and when the port area is closed and strictly separated from a city tissue by barriers of different kind.

Thus, spatial isolation of cities from the port area may be due to the existence of:

- functional barrier (e.g. busy urban thoroughfares, railways tracks, river channel, port waters, marshland etc.)
- spatial barrier - vertical (wall, fence, string of buildings) or horizontal (protective zones, extensively used large areas, green-protected zones, harbor docks etc.)

The boundary of a positive nature can be a water body (river channel), allowing for visually attractive and collision-free separation of port and industrial activities from residential areas [8]. A high potential barrier are extensively used areas located between port and city, in functional and visual terms not being a part of any of these two structures, often called "no man's land". A good examples of such spaces are sites situated between embankments in riverside cities, administered by RZGW[1]. Reshaping of "no man's land" in many cities allowed to create their new, positive image.

In each case, the land use and the landscape value of city-port contact zone effect significantly on ground rent of adjacent sites. This factor should, at least in theory, enforce cooperation of city authorities and many different institutions and bodies using riversides sites and lead to a consistent land management.

2. THE DYNAMICS OF DEVELOPMENT OF PORT CITIES LOCATED IN ESTUARIES

A special case of riverside port cities are these located directly at the river mouths (in estuaries). Their functional structure, in relation to European port cities, has been described in detail by C. Ducruet and S. W. Lee [3]. In turn, phases of spatial evolution of the ports located in the estuary were presented in the J. Bird model, named by the author of "Anyport" [1]. According to the model port facilities representing successive stages of technological development are always localized below the existing ones (port centers are moving down the river). In addition, the surface of port terminals is normally larger than the old investment. The specificity of this process is the result of the increasing draughts of next generation of ships. Similar argument, this time in relation to port cities, presents a model "Bottenhamn", constructed by I. Layton [6], according to which next to new terminals "wandering" downstream the new urban settlements appear. Searching for a more general theory explaining the process of historical simultaneous development of ports and port cities, one could find that due to technological leaps occurring in shipping, ports always work in a dual arrangement – an old and a new port – and technically obsolete post-port areas undergo the process of urban recycling [4]. The logic of location of new port facilities is described at table 1, and presented at figure 1.

In retrospect, the process of development of port, as well as transportation and industrial areas, as opposed to the development of the city, rarely takes place as spatially continuous. As a result of technological evolution the spatial structure of the riverside belt (zones I and II) is not uniform – it is

[1] RZGW (Regionalny Zarząd Gospodarki Wodnej) – Regional Water Management Board in Poland

made up of several areas with different land-use intensity, width and size (the area's width and surface increases clearly in direction downstream). More over, the closer to the river mouth the particular areas are, the higher (more modern) stage of technological development they represent.

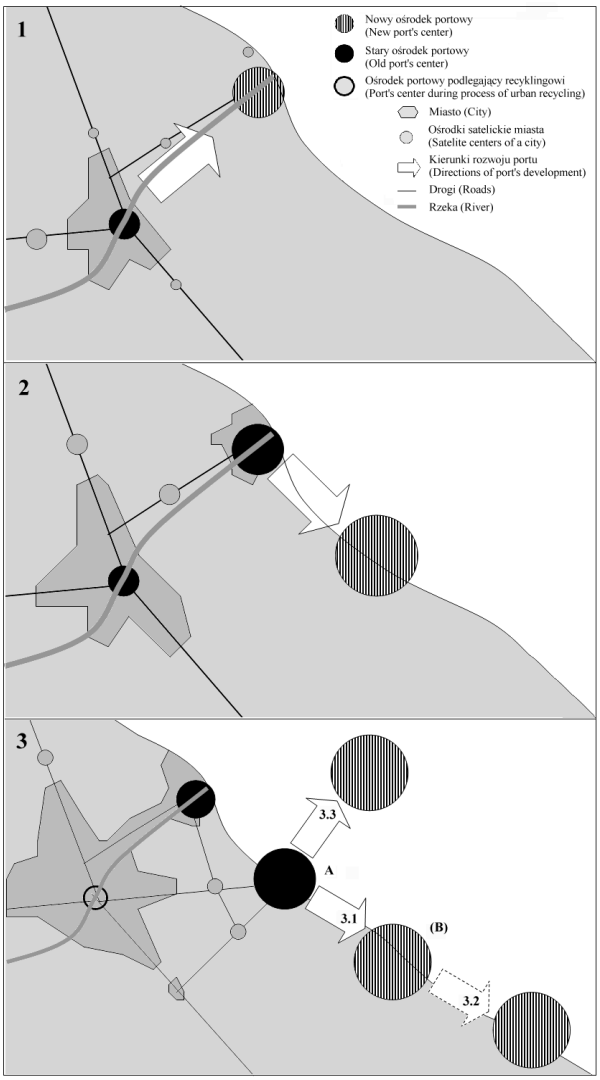

Figure 1. The evolution of the spatial layout of ports and port cities. Source: author's own

New port terminals, transport-logistics centers and industrial plants building zones I and II, due to their large surface and hazard and nuisance which their work may pose to the housing (e.g. storage of dangerous goods, dust load, reek, noise, vibration, etc.) are generally spatially separated from the purely residential areas and located in a far distance from the city center.

The areas of zone I and II, which are technologically obsolete but still in use, do not yet have the value of a "monument" and are often visually unattractive for residential and services.

Table 1. The evolution of spatial layout of ports and port cities

1. Sea-river port away from the mouth of the river The port is developing on the riverbank. In its surroundings, unbalanced against the river, the city is growing. Around the city, along the main roads, smaller satellite centers are formed. The only possible way for further development of the port is the creation of new port facilities in the direction downstream the estuary, or immediately at the river's mouth.
2. Seaport at the mouth of the river Simultaneously the new and the old port are working. The old port is tightly surrounded by residential buildings, which leads to a continuous functional conflicts. As a result of construction of infrastructure serving the new port (road network), in its neighborhoods the process of creation of new residential and mixed use areas begins. The only logical direction for further development of the port activity is building a new port's center at the seacoast.
3. Port A at the seacoast Simultaneously the new port A and the port in the river's mouth are active. The old sea-river port undergo the process of urban recycling. Slowly, the development of urban centers around the harbor at the river's mouth leads to surrounding it by buildings and the occurrence of functional conflicts. In turns, new roads serving port A contributes indirectly to creation of new residential districts in its vicinity. Further development of the port may run optionally: **3.1** - along the coastline, with the piers overlooking the sea **3.2** - in the case of functional and physiographical constraints the distant relocation of some port facilities (or the entire port) is possible. In such a case so called "a farm" of an existing port arises. **3.3** - in the absence of other possibilities a variant of relocation of a port on the sea is realized. It can be achieved through construction of a deepwater port built on an artificial island or peninsula. After creation of port B seaport in the river's mouth (2) will undergo the process of urban recycling.

Source: own

In addition, these sites, usually due to a functional barrier, are inaccessible to the public,

what causes the location of adjacent buildings "back" to them, the consequence is to create a “sharp” boundary between the port function and a city.

The oldest obsolete port areas, released by transport and industrial functions are situated in the vicinity of downtown are of relatively small surface, and many post-industrial buildings and facilities located there have a historical character. These factors makes urban recycling and renewal of these areas easier and more effective. Thanks to new investments, realized usually in compliance with the existing port heritage (eg. Hamburg – Hafencity, Hamburg - Harburg[2], Lübeck etc.) the new urban tissue gradually "blends" into the existing urban fabric. This kind of activity fully fits in the area of investment interest of city authorities and other developers. Very important issue in this case, however, is the response time of authorities and residents of the city following the functional changes in the abandoned port/industrial area. The longer a given area post-port/postindustrial site remains unused, the more intense is the process of its degradation and its regeneration become more difficult.

3. THE IMPACT OF OPERATIONAL ACTIVITIES OF A PORT ON THE SPECIFICITY OF THE PORT CITY

Functional structure and physiognomy of port-city is greatly affected by profile of cargo operations in terms of both cargo spectrum and amount of cargo handled by port. Together, these two factors allow to distinguish situations, in which cities are formed together with:

- specialized bulk ports, in which there is a small number (usually one to four) highly specialized terminals, each of which is adapted to use only one load (often in only one relationship - the import or export). Annual turnover of the port is usually tens of millions of tons per year of dry bulk (coal, iron ore, chemicals, etc.) or liquid bulk (oil, fuel, gas, etc..).
- passenger ports, equipped for tourists traveling by ferry and cruse traffic.
- universal ports, allowing transshipment of almost any type of cargo (conventional general cargo, ro-ro and containerized cargo, bulk, etc.), transferred in any direction, in one of many terminals specialized in a specific range of cargo handling.

Further, in Table 2, functional and spatial structure of the port cities emerging from a specific profile in terms of port activity were characterized. The analysis took into account amongst others: type of port-supporting industries in the city, use of land on port-city contact zone, a typical layout of the transport network, the economic potential created by the port to the city.

Table 2a Functional and spatial structure of port cities characteristic for a particular profile of port activity.

Profile of port’s activity	**Specialized bulk port with high volume of cargo**
Type of port supporting industries	- developed heavy industry in ports importing bulk cargoes (fuel and energy, metallurgy, chemical, food industry) - lack of industry in ports exporting goods (possible mining industry)
Impact on local technological chains	- cargo passing through the port mainly in transit (rarely fully processed on the spot), thus technological lines in the city and region are poorly developed
Land use of port-city contact zone	- large spaces are extensively used (due to huge protection zones) - port and port supporting activities are spatially isolated from the city structure
Transport network	- developed rail and/or pipeline network
Economic potential of the port	- due to the low cargo diversification economic ties between port and city/region depend directly on the demand for the cargo

Source: author’sown

[2] An extremely interesting example of revitalization of inland-port area is Harburg [2]. Construction works connected with planned building exhibition (IBA 2013) show a deep respect for the historical port buildings and facilities.

Table 2b Functional and spatial structure of port cities characteristic for a particular profile of port activity.

Profile of port's activity	**Passenger port**
Type of port supporting industries	- the city and partially the region is basing mainly on the tourist service sector and recreational functions
Impact on local technological chains	- functional lines are developed exclusively within the industry and services working for tourism
Land use of port-city contact zone	- port tourist infrastructure is easily accessible from the city - port functionally and visually connected to the city
Transport network	- developed public and road transport network
Economic potential of the port	- city/region dependant on tourist market situation and climate seasons

Source: author's own

Table 2c. Functional and spatial structure of port cities characteristic for a particular profile of port activity.

Profile of port's activity	**Universal port**
Type of port supporting industries	- developed port supporting light industry plus logistic and services associated with refining of cargo, located mainly in the city and its suburbs (metropolitan area)
Impact on local technological chains	- cooperation of various branches of industry (development of technological lines) - cooperation of maritime industry with scientific and research centers (sea clusters) - creation of special economic conditions for the development of maritime economy (special economic zones)
Land use of port-city contact zone	- fragmented land use structure of port allows for neighborhood of a mosaic of urban functions - areas of port, industry and port supporting services activity merge spatially - competition for the most valuable location in the port area (the waterfront) leads to the intensive development of the area and thus eliminate features that do not require access to water (dry ports)
Transport network	- highly developed network of road transport, well-developed rail network
Economic potential of the port	- diversification of activities and well-developed technological chains lead to the creation of maritime clusters, which stabilize the economic in metropolitan area - industry around port and administrative functions of the port generate employment (city development character).

Source: author's own

4. THE ECONOMIC IMPORTANCE OF PORTS FOR CITIES

Size (width and depth) and the regime of rivers affects the technical feasibility of their use for transportation purposes. Thus, the importance of trade and transport of the river to the city is primarily a result of the class of the river (the size and condition of technical infrastructure of the river as a waterway), the size and technical infrastructure of the river port located in the city, and the connections of the city to other inland port cities. It should be noted that the economic importance of the river is much broader than its commercial and transport importance, as it also includes water and sewage management, energy economy of the city, sometimes also tourism and housing. These issues were omitted in this paper.

In modern sea-river ports, in addition to the traditional activities of cargo handling, transport and production, as described earlier, a logistics and developer-investment functions were introduced. In such a spectrum of activities the competitiveness of ports largely depends on the quality of the cooperation between port and city authorities, especially in monitoring and planning development of both structures. Spatial policy conducted by the port authorities and municipalities may lead either to cooperation and thus consistency of spatial and functional development, or to isolation and inhibition of the growth of both structures. In order to produce multifaceted cooperation between port and city the following joint actions are possible amongst other:

- planning of investment projects and creation of documentation on the port and the city

development (city development strategy, port development strategy, study of developments conditions of the city, the local zoning plan) [3]
- solving the functional problems in the contact zone between port and city and co-financing of investments (amongst others: in the subject of transport infrastructure)
- land use management and shaping of ground rent,
- co-operation in environmental protection (reduction of the nuisance of port for the city: stench, noise, vibration, dust, pollution of coastal waters, monitoring brought to the area by means of transport and in cargo)
- shaping the labor market,
- taking into account the historical, cultural, social, and landscape conditions.

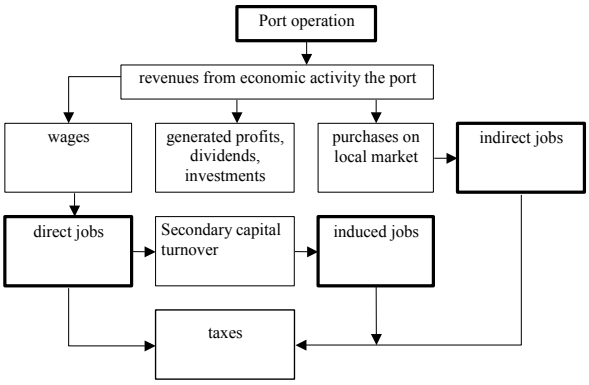

Table 3. Port economic impact on the market of the metropolitan area [5]

Functional spectrum of port's activity directly affects the labor market in the port city. Quantifying the economic importance of the port for the city and region is a major problem however. For this purpose the coefficient of jobs directly and indirectly related to the maritime economy is used (see tab. 3).

Port generates direct employment (employed at the port), intermediate (employed in the maritime sector) and induced employment (employed in services, industry that supports workers employed directly in the port). The strength of this interaction in turn sets the so-called a multiplier effect, which is defined as the ratio of revenues generated directly from the port operations to the income of the working population in industry and services around the port. Assuming that income is 100% direct, indirect revenues of ports can be estimated within the limits of 200%-300% [7].

[3] Polish names of the above mentioned documents are: Strategia rozwoju miasta, Strategia rozwoju portu, Studium uwarunkowań i kierunków rozwoju miasta, Miejscowy plan zagospodarowania przestrzennego.

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