

Defining of port gravitational areas as a function of port development

Blanka Kesic

ASSISTANT PROFESSOR OF SHIPPING ECONOMICS AND PORT ECONOMICS AT THE FACULTY OF MARITIME STUDIES - RIJKA

Edna Mrnjavac

PROFESSOR OF TRANSPORT TECHNOLOGY AT THE FACULTY OF MARITIME STUDIES - RIJKA

Introduction

The business operations and development of a port are directly effected by the existence of port gravitational areas, since a port is, for the greatest part a result and reflection of its hinterland which is limited by the range of its gravitational area. A clear analysis of a port gravitational area is a prerequisite for proper functioning and organizing of port systems, for bringing the right business and port policy decisions, as well as being the basic point of departure for making any plan of development, since such an analysis renders insight into whether the port has utilized all its possibilities for attracting cargo, or whether unexploited reserves still exist. To determine and define the gravitational area of a

port means to establish the dimension and limits of a port's hinterland, for whose production of goods intended for overseas exports or for maritime importation of goods to be consumed on that area, the port represents a most suitable point between land and sea transport. In view of this definition, the hinterland that gravitates to a certain port, or respectively, that prefers a specific direction of transport - can be separated into three zones:

- the immediate hinterland adjacent to the coast
- areas that gravitate towards two or more ports within a single country (national market)
- areas abroad which have possibilities to use ports of two or more countries (transit market).

Every port, through adequate measures, strives to strengthen the position of the port in relation to its hinterland, but also to expand the limits of the gravitational areas as much as possible. From the port's viewpoint, the immediate hinterland of a port is the safest and most qualitative gravitational area, since the competition of other ports in relation to the area is least, thus cargoes from and to the area may be counted on and planned with the utmost security. The competitive potentialities of other ports grows with the increase of distance

between the port and business partners in the hinterland, while the positions of the port in relation to more remote hinterland regions declines, therefore necessitating greater effort and caution in business operations and planning in these areas. The national market is a relatively safe area for export and import of commodities via domestic ports, and insight into the state of affairs and development of the national economy is accessible, making it possible to take into account and plan the domestic foreign trade traffic with a relatively high percentage of reliability. But, as far as port traffic is concerned, the domestic substrate is frequently inadequate to employ the installed facilities and create a base for any more significant development of the port.

The transit market is the most flexible, most insecure, but also the most valuable gravitational area of a port system, since transit traffic represents non-commodity exports and produces foreign exchange earnings, on top of attracting considerable quantities of cargo, as a base for further strong development of the port and employment of its capacities. However, in light of the fact that transit partners have, as a rule, possibilities to choose between several directions of transport for the destination of their cargoes, the ports - in view of these gravitational areas - should exert their greatest effort and business efficiency in preserving acquired positions, and respectively, in expanding the activities on the transit market.

1. FACTORS OF RELEVANCE FOR DETERMINING THE DIMENSION OF THE GRAVITATIONAL AREA

The port gravitational area is a changeable dimension that functions through a series of factors which determine the attractiveness of a port to compel the interest of commodity flows, and it is necessary to determine it for each type of commodity separately¹. Here it is important to point out that the limits of a gravitational area are not a single fixed direction on a geographical map, but actually, the limits of a gravitational area are a con-

siderably wide area in which there is a marginal intertwining of influences of particular ports, in other words, of all relevant factors which more or less determine the role and importance of competitive ports in relation to particular cargoes. The elements that influence the dimension of the port gravitational area are numerous, and can be assorted into 3 basic groups:

- the economic (state of) development of the hinterland and land transport infrastructure which links the port to the hinterland
- the development and (state of) equipment of the port
- the foreland of the port.

The possibility of a port to affect the enlarging of its gravitational areas through changes of certain factors are diversiform. Namely, some of these elements are beyond reach of the port itself (economic state of development of the hinterland, land transport routes, existing international and political relations) and the port simply adapts to them, whereas others are within the port's domain (range of capacities, the state of equipment and organization of work) and with the implementation of adequate measures of micrologistic policy the port can affect the enlarging of its gravitational areas.

However, there is an interaction between the objective and subjective factors that are of relevance for the dimension and strength of a gravitational area, and the state of development of a port. On the one hand - the magnitude of traffic gravitating toward a port has an effect on the expansion of capacities and modernization of the port, and on the other hand - the installed capacities of a port add to the attractiveness of the port - in relationship to the commodity flows from the broader gravitational areas. The state of development of a port and the economic strength of the port's hinterland are likewise in direct correlation, since - as much as the extent of structure and strength of a port's hinterland affects the degree of its development, so does the existence of the port with the services it can render affect the activating of economic development of the hinterland. Such a port, in view of its hinterland, is particularly significant for the development of underdeveloped regions, since the existence of a port near such a region incites industrial development and building of land traffic routes, which are basic prerequisites for regional progress. The betterment of quality, and quantity respectively, of particular elements inside or outside of the port, which affect the magnitude of the gravitational areas, directly influence change in the trends of commodity flows, and expansion of limits of port gravitational areas for particular cargoes. The basic measures in view of these positive tendencies are²:

- building of new transport routes,
- introduction of new technological processes,
- modern specialized port infrastructure or superstructure capacities,
- development of the degree of port's commercialization,

– enhancement of international relations.

On occasion of investigating and determining the gravitational area of a port, it is necessary to analyze the relevant elements of a particular port, its degree of development and possibilities for improvement, but it is also indispensable to analyze all the relevant factors and happenings in the competitive ports, for it is obvious that any bigger change - in any of them - will have a certain bigger or smaller impact on the trend of commodity flows and on the change of limits of gravitational areas in neighboring ports.

2. METHODS OF DETERMINING THE DIMENSION OF GRAVITATIONAL AREAS

Determining which area in the hinterland of a port gravitates to a particular port, in other words, the defining of a port gravitational area, is a complex and responsible assignment. It is a complex assignment because the port gravitational area is a changeable dimension which depends on a whole succession of variables that determine its limits and they all need to be analyzed and permanently followed, among other reasons because each gravitational area has to be determined for each cargo separately. The responsibility of this assignment is in the importance and dimension of the gravitational area in relation to the possibilities of business transactions and the development of each port system, since the existence and development of a port is directly conditioned with the existence of a gravitational area. If for any reasons whatsoever, a port finds itself isolated from all of its gravitational areas, its basic transportation function will cease and not only will its development be brought into question, but its survival.

As regards the choice of method for determining port gravitational areas, several methods are employed, each with its advantages and drawbacks. These methods are³:

1. Geographical-Geometrical Method
2. Land Tariff Method
3. Method based on actual cost of transport on land traffic routes
4. Method based on total cost of transport

These known and practiced methods are primarily based on analysis of costs of the transport route, namely, on evaluation of geographical distance between the port and its hinterland. The other important logistic factors that determine the relations between the port and its hinterland are not taken into account, and that would be the basic drawback of the quoted methods.

3. METHOD OF EVALUATION OF LOGISTIC ELEMENTS FOR DETERMINING THE DIMENSION OF GRAVITATIONAL AREAS

The logistic aspect for defining port gravitational areas and analysis of the gravitational areas of certain ports deserves to be far more all-inclusive and sophisticated so as to adequately evaluate all the relevant elements which are important for choosing the traffic direction for the destination of a particular commodity via a particular port. The methods used so far only valorized the proximity of the hinterland in relation to the port, and transport costs respectively. These elements are certainly essential. However, under conditions of traffic nowadays they are not the only ones, nor are they always the decisive ones, since a short and cheap transport route does not necessarily have to be optimal. By accepting and evaluating other elements, which are of importance for determining port gravitational areas, the results achieved are that two physically different distances become economically equal, or that two broader and economically different distances become logistically equal, and this then, essentially changes the picture regarding the limits of port gravitational areas⁴.

Under today's traffic conditions and the demands required by the world transport market, besides the price of transport, speed of transport is the most important factor when it comes to choosing transport services and commodity destinations. In order for the port, or port system respectively, to fit into these tendencies and to win the attribute of being considered "a fast port", it is necessary to satisfy a whole series of criteria. First of all, the port itself, within the port system, must optimally fulfill required assignments, which means that it is sufficiently equipped with modern infrastructure and superstructure capacities adaptable to the magnitude and type of traffic, and that the organization of work in the port conforms to demands of contemporary transport technologies. Only a well equipped and well organized port can achieve high transshipment performance, rendering services to ships in an optimal period of time, thereby shortening the ship's stay in port as much as possible and thus satisfying the ship operator, and forwarding the cargo as soonest possible, thus satisfying the shipper.

However, in order for a port to be an optimal point for cargo destinations in the macrologistical chain of transporting goods from sender to receiver, other elements must also be satisfied, not only the degree of a port's development. In light of the port's role in the transport chain, as a place where means of land or river transport meet with means of maritime transport, this means that there must be good road, railway or river (canal) connections of the port with the hinterland - on the one part, and a well developed harbor foreland, on the other part.

The quality of the inland infrastructure, traffic flow rate and transportation potentiality of road and railway rou-

tes, organized multimodal transport between port and commodity distribution centers or economic centers of the hinterland, to a great extent contribute to the attractiveness of such a transport route since the land transport to or from the port is cheaper and faster. The building or modernizing of a land transport route to a particular port will in a great degree change the trend of commodity flows in the broader gravitational area and will have an impact on changing the limits of port gravitational areas of competitive ports in the region. For example, the completion of building of the canal between Bamberg and Regensburg which will connect the Rhein-Main-Danube rivers basins into a united European river & canal system and directly link the ports of Western Europe and the Baltic with the ports of the Black Sea, will bring about the transmission of Central European cargo from the Adriatic transportation route, which will cause a diminishing of gravitation areas of Adriatic ports on the European continent⁵.

A further element that determines the attractiveness of a transport route through a particular port is the state of development of the foreland of that port, and respectively, the average number of monthly liner departures. It is a tendency of every port to have a well developed foreland since it enables faster dispatching of cargo from the port, increases the circulation of port capacities, curtails the stay of ships in the port, and in fact, a developed foreland brings multifarious advantages from the viewpoint of shipowners and shippers and forwarders and the port. The port with a developed foreland is a "fast" port for shipper and ship operator, and this advantage is taken into account when choosing the destination for commodities.

From the viewpoint of logistics there is still a number of factors which influence the dimension of gravitational areas of a particular port and they need to be analyzed and evaluated. These are customs and customs formalities in ports, tariff systems and tariffing policies, political relations, the state's influence, and the measures of port policy. Each of the mentioned elements can at a particular time have a positive or negative influence on a potential gravitational area to a particular port or port system. For instance, the political actualities and armed conflicts in Croatia have completely changed the gravitational areas of Croatian ports, not only at present, but also in the future. The domestic gravitational areas of the main ports of Croatia will be smaller than in previous analysis, since up to now the area of all of former Yugoslavia was considered a domestic gravitational area, and in the future it will only be the territory of Croatia. It is also realistic to assume that in the forthcoming period, cargoes from Serbia that had previously, in import and export, used the services of Croatian ports, can no longer be counted on. In view of this, future possibilities of expanding the gravitational areas of Croatian ports should be searched for on the transit

market.

Taking into account all the mentioned facts, a new method of determining the dimension of port gravitational areas for a particular cargo is proposed, by means of tables which include the relevant factors that determine the dimension and potentialities of port gravitational areas. These factors are listed according to their priority and importance on occasion of choosing of a particular port for importing, exporting or transit of a particular commodity. For each port, or respectively each type of commodity for which a transport route is being determined, every relevant element is categorized with a grade from 1 to 10, and the grade is then pondered with the number with which a particular element is ranked in the table. By adding the pondered grades we obtain an index on the advantages of one port in relationship to some other port for transportation of a particular cargo from the potential gravitational area. The forthcoming table shows an abstract example of determining a gravitational area by means of this method, according to the author's subjective evaluation. This example estimates 11 relevant factors which are of importance for cargo destination through two ports. The suitability of these ports for multimodal transport was taken as the most important factor, thus the estimated grade of that factor for a particular port will be multiplied by number 11. In this example, political relations were taken as the least important of the 11 factors, thus this factor will be multiplied by the lowest number 1.

From the example in the illustrated table it is visible that port Y is more suitable for transporting of goods A from the area of Z than the port X, chiefly because Y is better organized for application of facilities of multimodal transport, and is better connected by railway line with location Z and has more frequent liner connections with the port of destination. In this example it is precisely these logistical elements that were decisive in

choosing the transport route via port Y.

In this way, as a rule, it is possible to determine gravitational areas for each port and separately for each kind of cargo, providing that each concrete case requires previous determination of priorities for each particular logistical factor in light of its significance within a particular transport. For example, in the transport of commodities via Croatian ports today, political relations would take first place because, in light of the conditions of warfare, they could be the decisive and limiting factor for cargo destination through any of the ports within the Croatian port system.

Besides the positive fact that all logistics relevant for choosing transport routes via a particular port are graded through the application of this method, a further advantage is that it also estimates the situation of the

EVALUATION OF PORTS X AND Y FOR THE DEFINITION OF GOODS A FROM REGION Z

Factors of importance for determining port gravitational areas	Port X	Port Y	Ponderation	Pondered evaluations	
				Port X	Port Y
1. Suitability for multimodal transport	3	6	11	33	66
2. State of development of land routes with Z	5	8	10	50	80
3. State of development of foreland of port	7	9	9	63	81
4. Port capacities	10	7	8	80	56
5. Depth of harbor's aquatic basin	8	5	7	56	35
6. Organization of work in the port	2	4	6	12	24
7. State of development of port's trading functions	2	3	5	10	15
8. Customs tariff system in port	4	6	4	16	24
9. Railway tariffs	5	8	3	15	24
10. Port fees	3	4	2	6	8
11. Political relations	8	7	1	8	7
TOTALE				349	420

Source: A subjective evaluation of the author.

competitive direction of transport. The difference between competitive ports is evident immediately, emphasizing the advantages or drawbacks of a port in comparison to one or more other ports.

The work gives a brief demonstration and theoretical example of a new method for determining port gravitational areas. In further research the proposed method will be applied to concrete examples. Attempts will be made to evaluate relevant logistical elements of various competitive ports and determine their gravitational areas for particular cargoes. The drawback of this method is the subjective presence of the researcher. This subjectivity mainly comes to the surface on occasion of ranking the chosen logistical factors that are to be graded. The possibility of eliminating this basic drawback is to work out a corresponding mathematical model and employ its simulation. In that way we could accomplish the defining of gravitational areas of particular ports, or more exactly of particular terminals as sub-systems of a complete port system. The results obtained would also give a vivid description of a particular port in comparison to competitive ports on the same, or on adjacent directions of transport.

4. CONCLUSION

To determine and define the limits of port gravitational areas is a complex and responsible assignment due to the port's dependence on the existence and dimension of its gravitational area. This is a changeable dimension which depends on a series of variables, and the change of any of the variables has a positive or negative impact on the dimension of the hinterland that gravitates to a particular port. The business operations and development of every port or of a port system should be based on detailed analysis and permanent follow-up of its gravitational areas.

In literature and practice, a number of methods are used for determining the limits of port gravitational areas: the geographical and geometrical method, the mainland-tariff method, the actual mainland transport cost method, and the total transport cost method. The basic drawback of these methods is that in determining the port gravitational areas, only the geographical distance of the port from the mainland industrial centers, or the transportation costs, are taken into account, whereas all other logistical elements which could be crucial under prevailing transport conditions for the choice of the direction of transport are neglected.

This paper proposes a new method for determining the limits of port gravitational areas in such a way as to take into account all logistical elements which are of consequence for determining the gravitational area of a port. Affecting the trend of commodity flows through a particular port system, besides transportation costs and physical distance from centers of economy in the hinterland, one must also take into account: the state of

equipment of the port, degree of development of the overland infrastructure network, the development of the foreland of the port, the degree of port's commercialization, measures of port tariffing and customs formalities, political relations, measures of port policy and the influence of the state. All these elements need to be estimated for competitive ports on occasion of destination of a particular cargo in order to learn the optimal direction of transport, in other words, to define which port is best suited as a solution for import, export or transit of that cargo from the continental hinterland.

NOTES:

¹ KESIĆ BLANKA, *Ekonomika i organizacija luke, Pomorski fakultet u Rijeci*, Rijeka 1992, str. 12 (Economics and Organization of the Port, Faculty of Maritime Studies, Rijeka 1992, p. 12).

² KESIĆ BLANKA, *Ekonomika i organizacija luke, Pomorski fakultet u Rijeci*, Rijeka 1992, str. 25 (Economics and Organization of the Port, Faculty of Maritime Studies, Rijeka 1992, p. 25).

³ Z. JELINOVIĆ, "Ekonomika saobraćaja" ("Economics of Transport"), Informator, Zagreb, 1968, p. 257.

⁴ D. POŽAR, "Teorija i praksa (transporta in) logistike, Založba obzorja", Maribor, 1985 "Theory and Practice of (Transport and) Logistics".

⁵ B. MAROLD, "Prometna izoliranost jadranskih luka", *Logistika*, 7-8, Beograd, 1990.