

# TOWARDS THE UNIFIED THEORY OF THE PORT GRAVITATIONAL AREAS INTRODUCING INFORMATION CENTRALITY FACTORS

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## **SUMMARY:**

*A number of methods are available for determining the limits of port gravitational areas, geographic, geometrical, mainland-tariff method or total transport cost method. The basic drawback of this methods is that they take in the account either cost or geographical elements*

*Unified theory of the port gravitational areas, under development at Maritime faculty Rijeka, takes into account other logistic elements which in today's transport conditions can be crucial in choosing the direction of the goods.*

*This paper introduces information centrality factors used to identify communication levels between ports and their gravitational areas, and to define the levels of coordination in the logistic supply chain.*

## **1. 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.

## **2. 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 separately<sup>1</sup>. 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 considerably wide area in which there is a marginal intermingling 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 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. When 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.

## **3. 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

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<sup>1</sup> Kesic Blanka, *Ekonomika i organizacija luke*, Pomorski fakultet u Rijeci, Rijeka 1992, str..

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 are<sup>2</sup>:

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.

#### **4. COMPUTER BASED COMMUNICATION NETWORKS**

With the recent advent of computer-based communication technologies, communication networks have become an important factor in global interaction. The world in the information age may be described as being connected by a lattice of networks. Telephones, for example, provide the basic connection for social interaction between individuals, and the linkages both within and among nations, producing what Deutsch has called "a web of nations." This is first time in history that humans beings are able to realize the prospect of communication networks which link everyone in the world . In fact, information technologies now provide the basic infrastructure for an interdependent world, leading theorists to characterize the world as a "global village" .

The ongoing information revolution involving data storage, processing, transmitting and retrieval obviously affects all aspects of social, political and economic life.

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<sup>2</sup> Z. Jelinoviæ "Ekonomika saobraćaja"  
("Economics of Transport") , Informator,  
Zagreb, 1968, p. 257

There are two major characteristics of the information age or post-industrial society: the information economy and transborder communication. While industrial society was based on the production of goods, the information society is built on the creation and distribution of information. The emergence of the information economy has led the expansion of the service sector as compared to the manufacturing sector. Statistics about the information economy are striking. According to Bell (1973), a total of 39.5% of the workers were in the service sectors (e.g., transport, trade, insurance, banking, public administration, personal service) in the 1960s. The proportion had increased to 47.6% by 1973. Porat (1977) also described the emergence of the information economy noting that by the 1970s,

Globalization, the other major characteristic of the information age, is the process of strengthening the worldwide social relations which link distant localities in such a way that local events are shaped by circumstances at other places in the world .The increase in transborder communication has led to the rapid global diffusion of values, ideas, opinions, and technologies. Transborder communication has changed our concepts of time and space . Technologies have eliminated national boundaries and geographic separation and created a global community (Cherry, 1977; Pool, 1990; Frederick, 1993).

#### **5. TOWARDS THE UNIFIED THEORY OF THE PORT GRAVITATIONAL AREAS**

The theory of the unification of the port gravitational areas is based on integration of following data:

- prices
  - costs
  - speed of transport
  - distance
  - frequency of transport
  - quantity of transported goods
- and
- logistic commodities

The gravitational areas represent attraction field which can be shown as:

$$Pd(f) = \sum_{i=1}^n (a(i) + b(i) + c(i) + d(i) + e(i) + f(i))$$

Where n is total number of ports and i represents the port number, a(i) is price factor, b(i) is costs factor, c(i) is speed factor, d(i) is frequency factor, e(i) is quantity factor and f(i) is logistic factor, and f represents current geographic place originating the transport.

Each of this factors is a separately defined with other factors, for example the prices factor for a particular port i, from the geographic place f is defined as:

$$a(f) = \frac{\sum_k p_k}{\sum_{i=1}^n \sum_k p_k}$$

where  $p_k$  represents transport price, k represents the transport mode, and i represents the port number.

Logistic factor is namely the most critical factor, because it has to represent a large quantity of logistic criteria. Therefore logistic factor f(i) represents the sum of the different factors concerning the logistic functions.

In this paper we will introduce measures of centrality as a factors included in the calculation of the logistic factor f(i).

### 6. CENTRALITY FACTORS

Point centrality measures how centrally a point is located in a given graph. Usually the point at the center of a star or the hub of a wheel is the most central possible position. There are few approaches to measuring the point centrality:

1) Point centrality based on the degree: the point with the largest degree is the most central point in the graph.

count of the degree or number of adjacencies, for a point  $p_k$ :

$$C_D(p_k) = \sum_{i=1}^n a(p_k p_i)$$

where n = number of points

$a(p_i, p_k) = 1$  if and only if  $p_i$  and  $p_k$  are connected by a line 0 otherwise

If we control the size of the graph by dividing  $C_D(p_k)$  by n-1, which is the maximum degree of  $p_k$  in any graph, and make the measurement comparable between graph, we get a "relative centrality" for  $p_k$ ,  $C'_D(p_k)$ .

2) Point centrality based on betweenness: the point which falls on the largest numbers of geodesic paths (that is, the shortest path link a given pair, say,  $p_i$  and  $p_j$ ) between pairs is the most central point in the graph.

where  $g_{ij}$  = the number of geodesics linking  $p_i$

$$C_D(p_k) = \sum_{i=1}^n \sum_{j=1}^n \frac{g_{ij}(p_k)}{g_{ij}}$$

and  $p_j$ .  $g_{ij}(p_k)$  = the number of geodesics linking  $p_i$  and  $p_j$  that contain  $p_k$ .

Like the centrality based on the degree, we divide  $C_B(p_k)$  by the maximum value in any graph,  $(n-2)(n-1)/2 = (n^2-3n+2)/2$ , to get a "relative centrality" based on betweenness for  $p_k$ ,  $C'_B(p_k)$ .

Defining the communication between the a set of European countries as a function of their geographic situation, and calculating the centrality we obtain following:

	Degree	NrmDegree
P	2.00	12.50
SP	3.00	18.75
F	6.00	37.50
B	4.00	25.00
NL	3.00	18.75
D	8.00	50.00
CZ	5.00	31.25
PL	4.00	25.00
SL	5.00	31.25
H	4.00	25.00
HR	4.00	25.00
BH	2.00	12.50
I	5.00	31.25
A	8.00	50.00
CH	5.00	31.25
SI	3.00	18.75

As can be seen the biggest centrality have Germany and Austria, but for our investigation of the port gravitational areas the normalized centrality factor is of interest. Thus ports in Germany have centrality of 50% , and then ports in France have centrality of 37,5% and Italy 31,25% .

Mean centrality of complete network is 23,33% with standard deviation of 11,30. This means that European transport network has little centrality and that no country or port by the position has the central position.

### 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.

In the work we have presented a part of the emerging theory of port attraction field, defined the factors concerning the port

gravitational areas, and introduced the centrality measures as a part of logistic factor.

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