ORGANIZATION OF CROATIAN COUNTY SEAPORT MANAGEMENT SYSTEM

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Making appropriate decisions is one of the essential prerequisites for achieving desired effects in management and decision-making with any economic entity. Most of the tasks and problems in analyzing, planning and management of a port have very complex goals, with different scenarios and alternative solutions, as well as evaluation criteria and restrictions, which result in the inability of their uniform solution. In this paper, one of the processes of multi-criteria decision-making via a computer program based on the process of different scenarios ranking was used for decision-making and the development of a model of county ports system management. Also, the problem of managing the system of the county ports of Croatia was firstly considered as a whole, i.e. a system, and then its components are analyzed, followed by a synthesis, employing the multi-criteria analysis. As to acquire actual solutions and develop a new model of county ports system management, the Primorsko-goranska County is analyzed, by using the multi-criteria analysis PROMETHEE procedure, with a corresponding computer program for multi-criteria decision-making.

1. INTRODUCTION

A port system consists of more subsystems, which make a unique port network with the goal of connecting all relevant subjects at regional, national and international levels. The individual development of ports within such a

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system influences economic development (and vice versa). As a result, port system development and its design are of national interest. A country, by using economic and legal measures, can influence the port system development. Establishment of port authorities is such a measure, which should create an economic, legal and theoretic basis for the development of a port system and individual ports within the system; whether of national, county or local importance.

The analysis of seaports of national importance, including the analysis of business and financial reports of port authorities indicate that existing county ports management approach has more drawbacks than advantages. This approach is diverse and of questionable efficiency, thus it is unlikely that it can be upgraded, as to create a completely new port management system. Namely, it can be stated that, currently, there is no optimal and purposeful organization or adequate systematic approach. Therefore, we propose that:

H1. Research on county seaports and multi-criteria decision-making methods helps to create presuppositions for creating, designing, operating and controlling the rational management of county ports in the Republic of Croatia.

This study focuses on three research objects: county seaports, seaport systems and the Republic of Croatia. The paper presents an analysis of the possibility to use a multi-criteria decision-making method in the organization of the county seaport management system.

2. REVIEW OF PREVIOUS STUDIES

Analysis of relevant materials on county port management and port authorities in Croatia indicates a modest number of existing scientific papers. Among the significant papers on managing ports of county importance, the one by Vrus (2002) stands out. Although this study focus on the similar topics as this one, the previous research results were based on the outdated regulations, chaged by the current *Law on Maritime Property and Seaports,* which came into effect in 2003. However, Jugović (2007) points out problems in county seaport management system operations from a more recent perspective. By taking into account the number of large and small ports in Croatia, their natural dispersion, and different conditions and amount of business, this study demonstrated the necessity of implementing decentralization of the county seaport system management.

The application of the multi-criteria decision-making (i.e. optimization) has been already applied in the field of port management, transport planning, traffic and port capacity management. The following specific problems have already been already analyzed in previous studies: optimal location selection, multiple business decision selection, logistic networks planning, transport network design and traffic and transportation planning. It is important to note that this has not been done with the issue of seaport management system design

Studies by Brans, Mareschal & Vincke (1986), Saaty (1994), Karleuša, Deluka-Tibljaš & Benigar (2003) and Poletan Jugović Jugović & Zelenika (2007) analyze the application of multi-criteria optimization methods in business decision-making and transport planning. However, there are other studies, applying the multi-criteria decision-making (optimization) approach, but they do not address the specific issue of multi-criteria decision-making in creating, designing and implementing new models (solutions) of seaports and seaport system management.

3. ORGANIZATION ELEMENTS OF COUNTY PORT BUSINESS IN THE REPUBLIC OF CROATIA

Research and design of the county seaport management model are not possible without previous analysis of port authorities' operations and discussion of legal regulations, which represent a framework for the implementation of port management.

3.1. Institutional framework for national port management

With adequate legal measures and development programs, national port system development can be influenced. Establishment of port authorities is such a measure, which should create economic, legal and theoretic preconditions for development of both the port system and the individual ports, whether of national, county or local importance. As to design a new county seaport system management model, it is necessary to analyze and compare relevant legal provisions.

In Croatia, on the basis of the *Law on Maritime Property and Seaports* (Narodne novine, 2003, 158), counties are obliged to establish a port authority, for the purpose of managing public ports of county and local importance. Establishment, organization and operation of port authority is based on the stipulations of the mentioned regulations, as well as on the *Law on Institutions* (Narodne novine, 1993, article 76), which required that a port authority should

be established as a public institution (including the provisions for defining the port area, port activities, assignment of port authority bodies, administrative council and director, setting the headquarters, etc).

Stipulations of the Law on Maritime Property and Seaports state that the local authorities are obliged to establish a seaport authority for all ports located in the county, as well as separate port authority for some of the ports. Such a possibility can be used by lower levels of local government, who may suggest the establishment of a port authority in their area.

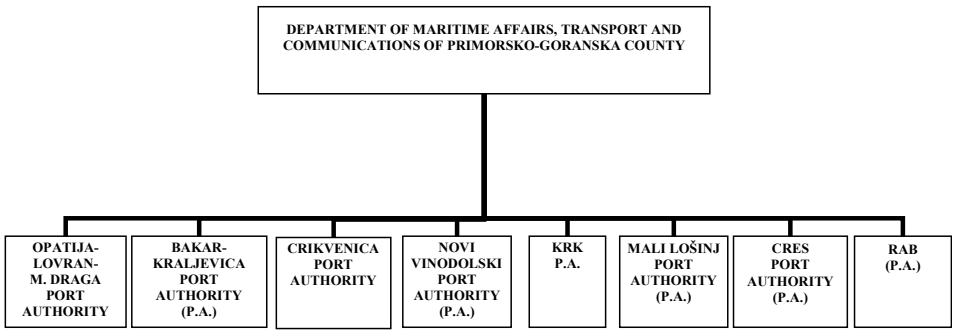
The general attitude of the government on (de)centralization of county port authorities is that centralization produces financial and political rationalization, but also creates a lack of democracy. On the other hand, decentralization brings management closer to the area which it should manage and problems it should solve.

Existing models of the management of seaports of county importance in the Croatia are based on decentralization, i.e. there may be several independent port authorities in a single county. This is enabled by the Article 75, Paragraph 1 of the *Law on Maritime Property and Seaports: "For the purposes of management, construction and use of publicly open seaports of county and local importance, more than one port authority can be formed on the request of the municipal or city council; in which case, the demand applicants are co-founders".*

In Paragraph 2 of the same Article, it is stated that the founder of the port authority from Paragraph 1 of this Article is the county, and the decision on its formation is made by the county assembly. Since port authorities are independent organizations, in accordance with the *Law on Seaports* and the *Law on Institutions,* its Administrative Council is formed and the Director is nominated.

Figure 1 presents the organization of port authorities in Primorsko-goranska County, which is also the model used in the majority of counties in the Republic of Croatia. The only difference in the organization of county port authorities is found in the exact number of established port authorities (for example, there are three port authorities in the area of the County of Istria and eight in Primorsko-goranska County).

Figure 1. Organizational structure of port authorities in Primorsko-goranska County



3.2. Comparative analysis of county port authorities' management

Comparative analysis of county port authorities' management and their operations from establishment until the present is conducted on the basis of official data and reports of port authorities and relevant county and state institutions. Data, presented in Table 1, were used to select a county, in which the suggested model of county port system management is to be tested. The 2007 data were used, as they were available at the time of writing this study. There may be several reasons for newer data not being available, including: port authorities' inconsistency in managing their financial indicators; even though being public institutions, port authorities are often not willing to publish their data; in addition, there are changes in the number of port authorities per county In addition, one of the biggest port authorities' customers – the national ferry liner *Jadrolinija*, often does not cover the port fees and taxes on time, which also influences the decision to publish financial data.

Data shows that counties with the largest number of berths (County of Istria and County of Zadar) do not necessarily have to have the largest income from their own business activities, because a large number of berths are intended for local residents who pay symbolic or significantly lower fees for those berths.

Port authorities' costs structure shows that counties (County of Istria and Primorsko-goranska County) with a larger number of port authorities have bigger costs for salaries and other services (book-keeping, legal advice, traveling costs and alike), which is proportional to the number of employees Although there is a lower number of port authorities in the County of Istria than in Primorsko-goranska County (which is translated to six to seven employees

and three port authority administrative councils less), their total amount of salary costs for 2007 is 25% higher. This is especially significant, if one takes into account that the County of Istria and Šibensko-kninska County have the smallest number of ports under their jurisdiction (County of Istria six county ports and 21 local ones, while Šibensko-kninska County has one county port and 21 local ones).

Table 1. Comparative analysis of county port authorities management by counties

Port / Authorities	County of Istria	Primorsko -goranska County	Ličko-senjska County**	County of Zadar	Šibensko-kninska County	Splitsko-dalmatinska County	Dubrovačko-neretvanska County***
Sea and coast area (in km^2)	-	3,582	597	3,632	2,939	9,473	7,489
Coastline length (in km)	539	1.065	200	1.300	806	875	-
Number of ports							
of county importance	6	5	7	10	1	6	6
of local importance	26	55	14	44	21	45	74
Number of port authorities	5	8	2	1	1	1	4
Number of berths	3,752	3,281	-	3,403	2,836	1.458	759
Port authorities' revenues for 2007 (in 000 KN)							
total	22,871	37,892	7,911	15,197	8,619	41,500	17,097
own	18,632	19,452	4,811	4,245	6,569	17,500	8,597
from budget	4,238	18,440	3,100	10,952	2,050	24,000	8,500
Port authorities' costs in 2007 (in 000 KN)							
total	19,178	37,892	7,408	15,195	8,793	41,500	15,260
investments	5,648	26,394	5,847	12,043	0	30,000	11,059
maintenance	5,057	-	300	605	6,726	6,000	853
documents	1,679	-	158	1,541	1,304	1,400	150
salaries	2,784	2,111	322	640	664	1,400	1,258
other*	4,008	9,386	781	366	99	2,700	1,940

Notes: * The item *other* in the costs of the Primorsko-goranska County represents the sum of financial and material costs, while the items *maintenance* and *documents* are part of the item *investments.*

** Data for 2007 for Ličko-senjska County are compiled from two separate sources because the Senj port authority was not willing to publish data. Author used the date delivered by the relevant ministry.

*** Financial data for the Dubrovačko-neretvanska County are based on the plan for 2007. In 2007, three new port authorities were established. Taking into account the short period of their activity, author would not have been able to make valid conclusions about their operations.

The comparative characteristics and conclusions on county port authorities' management and operations are obtained by analyses of port operations in individual counties and their port authorities. However, the complete information (income and costs, achieved goals and tasks reports, implemented investments, etc.) has not been presented entirely because of the size limitations. It is also available in a paper by Jugović (2008). Taking into account the existing diversity in the financial operations of individual port authorities and the fact that port authorities have different principles in their book-keeping, we should be somewhat reserved with the obtained comparative financial results.

3.3. County port management evaluation and problems

On the basis of previous research and analyzed annual reports on operations of county port authorities, certain conclusions can be made. They indicate more drawbacks than advantages of the decentralized model of public port management in the Republic of Croatia. Those include (Jugović, 2007):

- *Diversity of subjects managing port, their social and legal status, and particularly their economic interests.* Subjects managing county and local ports are: towns, municipalities, publicly owned companies (town and municipal communal companies), as well as private companies. It is understandable that the interests of those subjects are very different, so a large portion of discrepancies in county port management is derived from differences in those interests;
- *Discrepancy in methods and criteria for charging port fees and other revenues, which should serve to finance maintenance and improvement of ports' infrastructure.* In some ports, there are no fees, while in others, fees are charged in advance at fixed rates. However, some ports

charge for each docking, in accordance with the ship's length, with the amount per meter of the docked vessel significantly differs from port to port. In other ports, port fees are charged per passenger, and some ports also have differentiated prices for foreign and domestic ships. Ferry ports, as a rule, charge port fees with specific amounts per passenger and per vehicle, with rates and fee amounts also differing from port to port. Subjects managing ferry ports charge ship-owners, who add a port fee to the transportation price and charge it to the passengers. In ports where different non-line ships dock, it is not possible to do this kind of charging, so managing subjects cope in different ways;

- *The risk of spending the funds for other purpose than provided by the law.* Given the diversity of subjects managing public ports in the previous period and the lack of funds for financing other functions than maintenance of infrastructure, the existing management system does not ensure the compliance in spending the collected fees;
- *The issue of local government investing funds into public port improvement and not retrieving those funds by charging port fees.* As opposed to the previously mentioned, there are several cases of tourist towns and municipalities, which invested into the enhancement of port infrastructure and did not arrange charges/fees, as to refund the invested funds. (However, these subjects have may have refunded the funds indirectly, because of indirect economic benefits).
- *Nonexistence of a systematic approach in setting priorities and directing investment into individual ports.* Financial reports show that, in some port authorities, there is a shortage of funds for development, renovation and maintenance of port infrastructure. This happens in ports with smaller revenues from their own operations, i.e. in cases where port fees are the most important aspect of the total port's income. This is a consequence of traffic patterns, which is especially obvious in the case of port authorities managing ferry ports, which have a large amount of ferry traffic. From this aspect, the question of investment priorities arises, as well as the question of a systematic approach, which would enable smaller ports with an opportunity to improve their infrastructure, services, etc.

4. POSSIBLE COUNTY PORT MANAGEMENT MODELS IN THE REPUBLIC OF CROATIA

In addition to the existing decentralized models of public port management in Croatia, the *Law on Maritime Property and Seaports*, which defines the port management (including ports of county and local importance) and the *Law on*

Institutions provide for some other possible solutions for port management systems. Specifically, the legal provision is as follows: *"for the purpose of management, construction and use of public seaports of county and local importance, more than one port authority can be established on the request of the municipal or city council, in which case, the demand applicants are co-founders".*

The cited legal provision shows that the regular approach to organizing systems of managing ports of county importance would imply a unique port authority for all ports in the county. However, legislator, anticipating the possibility of exceptions to that rule, left flexibility for different solutions, including the one implying that ports in a single county can be managed by several port authorities. The latter solution could be established by the county assembly, if all municipal and city assemblies, on whose territory the ports of county importance are located, previously agree to the exception to the rule.

From the aspect of territorial organization, a solution that involves the establishment of more decentralized port authorities can be proposed. A system of port management based on one port authority for the entire county can, in accordance with the *Law on Institutions* (Article 9), be enhanced with the establishment of branches (departments, centers) outside the port authority headquarters. This promotes the location of certain functions related to the port management on the islands and the coast, being far away from the port authority headquarters.

A system based on several individual port authorities may be organized in a way that a smaller amount of funds needed for functioning of the entire system is deducted from all fees. There would be no need for each of the port authorities to have its own legal department (or other shared service departments). E.g., the shared legal department would conduct trials and perform other complex tasks of legal nature for all port authorities. Also, there would be no need for hiring private experts to prepare documentation for tenders and carry out supervision of work on maintenance, renovation, reconstruction and expansion of ports' infrastructure. Additional operational, financial and other tasks could also be performed more economically and efficiently if they are centralized and not dispersed in many small institutions. However, If any city or municipality, which has any of the ports in their area, or the county assembly is reluctant to establish a system based on the territorial principle, such an option would be impossible to implement.

A port management system based on one port authority for the entire county can, in accordance with the *Law on Institutions,* Article 9, be enhanced with the establishment of subsidiaries (branches, centers) outside the main port authority headquarters. The model with a centralized county port authority and a number of branches would change operations in a way that operations can be performed by branches, while the system of decision-making would not be changed at all.

Namely, if referred to Article 7 of the Croatian *Law on Trade Associations,* it is evident that the branches are not legal persons. Thus, the rights and obligations that arise as a result of their work are legally bound to the port authority, which means that the centralized system of decision-making is retained, while benefits of both a centralized and decentralized management system are obtained.

Therefore, in accordance with legal regulations, the system of managing ports of county importance in the Republic of Croatia can be organized as follows:

- One centralized county port authority with headquarters in the capital of the county: i.e. one port authority for all ports in a particular county,
- one county port authority with several branches,
- modified current models with several port authorities, with the County Department of Maritime Affairs, Transport and Communications of the counties providing professional services (legal, financial and book-keeping),
- several decentralized port authorities,
- other possible models, including one island and one mainland port authority, one mainland and several island port authorities, or one county port authority (for ferry ports) and one local port authority (for all other ports).

All these models have legal grounds in the legislation of the Republic of Croatia.

5. DESIGN OF THE COUNTY PORT MANAGEMENT SYSTEM

This section discusses the application of multi-criteria decision-making to choosing a county seaport management system model. Procedures and methodologies of multi-criteria decision-making are also presented. In addition, application of multi-criteria decision-making and the relevant procedures are

discussed in the case of multi-objective ranking of possible scenarios in Primorsko-goranska County.

5.1. Application of multi-criteria decision-making in designing the county port management system

In order to successfully design the county port management system by using multi-criteria decision-making, it is necessary to discuss the basic characteristics of multi-criteria decision-making, applicability of multi-criteria decision-making to designing a new model of county port system management, the design methodology, methods and processes of multi-criteria decision-making, generation of possible scenarios of county port system management and selection of relevant criteria for the establishment of such a system.

5.1.1. Basic characteristics of multi-criteria decision-making

The task of multi-criteria decision-making (optimization) is to select the best scenario (alternative, solution) from several possible in terms of the adopted criteria. The criterion defines quality and represents a measure for comparison when choosing the best scenario. The criterion is expressed with the criteria (goal) function for the best scenario (variant, solution) which should reach a global extreme, taking into account the constraints that represent the possibility of achieving the goal. Given that this kind of procedure minimizes or maximizes a given goal (criterion function), the expression of multi-criteria optimization is also used. The theory of optimization includes a quantitative study of the optimum and methods for its determination.

Optimization, in mathematical terms, is reduced to searching extremes of the criterion function under certain conditions and restrictions. For optimization, one can use different methods, depending on the type of relations in the mathematical model, the criterion function and restrictions. The most common criterion for optimization is the economic one, because it is considered that a higher income or profit will lead to expanded reproduction and general welfare. The result is that the previous development did not care much about the human and natural environment in general. The quality of air and water has deteriorated, and even climate changes have occurred. This has caused the need to do the optimization not only based on one criterion, usually economic, but to proceed to the optimization according to different criteria. Thus, multi-criteria decision-making (optimization) was developed.

Decision-making, especially the multi-criteria one, is a complex process of making the relevant decision. General characteristics of a multi-criteria problem (Nikolić & Borović, 1996), unlike the single-criterion one, are the following (Jugović et al., 2007):

- multiple criteria (goal function, criteria function) for decision-making,
- multiple scenarios (variants, solutions) for selection,
- a separate process of selecting one final scenario, i.e. one final solution.

In the field of *multi-criteria decision-making*, there are two types of multi-criteria problems from the point of view of describing them via a mathematical model (Nikolić & Borović, 1996):

- *multi-goal decision-making* – the presence of criteria is defined by the objectives and criteria, the goal is explicit, attributes (criteria) are implicit, restrictions are active, possibilities (scenarios, solutions, actions, or variants) are infinite in number, and model application, i.e. solving applies to designing (finding solutions and selection);
- *multi-attribute decision-making* – the presence of criteria is defined solely by attributes (criteria), the goal is implicit, attributes (criteria) are explicit, restrictions are inactive, possibilities (scenarios, solutions, activities or variants) are final in number, and model application, i.e. solutions are known, i.e. relating to the selection.

For the purpose of this study, the author applied multi-attribute decision-making, because the attributes, i.e. criteria are set only by criteria and not by constraints (goals). Similarly, the number of scenarios (solutions, variants) is given and the preferred solutions are related to the selection of the best scenario in terms of analyzed criteria, which is not the case with the multi-goal decision-making.

Multi-attribute decision-making has the following general mathematical setting:

$max \{ f_1(x), f_2(x), \quad n \geq 2 \}$, with the following restrictions:

$x \in A = [a_1, a_2, ..., a_m]$, where:

n - number of criteria (attributes), $j = 1, 2, ..., n$
m - number of scenarios (solutions, variants, alternatives), $i = 1, 2, ..., m$
f_j - criteria (attributes), $j = 1, 2, ..., n$

a_i - scenarios (variants, alternatives) for consideration, i = 1, 2, ..., m
A - the set of all scenarios (variants, alternatives).

The problem of selecting the optimal solution (Karleuša et al., 2003) becomes complicated, if there are multiple criteria, which can be used to select the optimal solution. Such problems can be solved by multi-criteria optimization processes. The optimal solution selection, with respect to different criteria, is performed by determining the vector criterion function, which is composed of *n* criterion functions, whose extreme represents the best solution. Most often, it is impossible to find a solution that has an extreme in all criterion functions, so it is necessary to find a satisfactory, non-inferior solution. A solution is non-inferior if there is no other solution among the variants, that is also better by all the criteria. For the problem of multi-criteria decision-making, it is characteristic that the increase of satisfying solutions on one criterion function generally reduces the degree of satisfying solutions on one or more other criterion functions.

General (global) optimization criterion may be formulated as a vector criterion function incorporating individual criterion functions, which enables introduction of a preference structure. The preference structure contains information on comparing relations between possible solutions and criterion functions.

The quality of procedure of selecting the best scenario and the accuracy of the final decision depends on the quality of criteria and determination of measures, in relation to which the optimization process is performed. Generating variants is performed by analyzing all the possible solutions to the problem, from which, before the implementation of multi-criteria optimization, one select a reasonable set, or the number of scenarios. Out of those, the final scenario is selected. The previous scenario selection can eliminate scenarios which initially do not meet specific criteria relevant to the final scenario selection.

In the process of multi-criteria decision-making and defining the quality of scenarios, criteria and measures, the crucial role is played by the decision-maker. As the person responsible for making the final decision (i.e. adopting the final solution), the basic role of the decision-maker is to define the criteria and preference structure, as well as to select the final solution. Complexity of the decision-making process is also dependent on the decision-maker's preferences, based on economic, technological, social, technical, political, and other criteria.

Those can be known before the optimization, or can be changed after certain steps have been made.

5.1.2. Application of multi-criteria decision-making in designing a new model of county port system management in Republic of Croatia

Applying multi-criteria decision-making (optimization) in transport planning involves the systematic analysis of the problem. Systematic analysis, as a rational process of decision-making, based on efficient organization and analysis of available information, can be used for analyzing and solving various complex problems. It consists of the following elements, i.e. steps (Karleuša et al., 2003):

- problem identification and orientation,
- defining the problem (goals, criteria, measures, boundaries and work plan),
- analysis of the contingencies related to the problem,
- generation of scenarios (variants) and selection of the best scenario (variant),
- design and implementation of solutions and
- development of problem-solving procedures.

Basic requirements for quality implementation of procedures in multi-criteria scenarios (variants) ranking are:

- definition of all scenarios (variants) at the same level, or same level of data (criteria) processing for all scenarios, which enables the mutual comparison of scenarios in relation to satisfying certain criteria;
- careful defining of criteria and objective assessment of the individual criteria impact;
- evaluation of all scenarios according to the adopted criteria.

5.1.3. The PROMETHEE method

In this paper, the PROMETHEE method is used, as to create the model. It is a process of multi-criteria variant ranking, used for obtaining partial (PROMETHEE I) and complete (PROMETHEE II) ranking variants. Basic principles underlying the procedures of a 'higher level', and therefore the PROMETHEE procedure are:

5.1.3.1. Expanding the criteria concept

This is based on the introduction of the preference function that gives preference of the decision- maker for variant 'a' in relation to variant 'b'. Associated function of preference $P(a,b)$, from *(a)* to *(b),* is defined according to the following expression:

$$P(a,b)=\begin{cases}0 & ;\text{if } g(a)\le g(b)\\ p[g(a),g(b)]; & \text{if } g(a)>g(b)\end{cases} \quad (1).$$

In particular cases, it seems reasonable to choose the *p* function of the following type:

$$p[g(a),g(b)]=p[g(a)-g(b)] \quad (2),$$

depending on value differences *g(a)* and *g(b)*.

To clearly show the area of indifference around *g(b)*, it is marked:

$$x=g(a)-g(b) \quad (3),$$

and the function *H(x)* is defined as follows:

$$H(x)=\begin{cases}P(a,b) & x\ge 0\\ P(b,a) & x\le 0\end{cases} \quad (4).$$

The preference function is defined for each criterion separately, with its value being between 0 and 1. The smaller the value of the preference function, the greater the indifference of the decision-makers and vice versa: the closer the value of the function is to 1, the greater its preference is. In the case of strict preference, the function value is equal to 1.

5.1.3.2. 'Higher level' relation assessment

It is conducted in a way that for each couple $a,b\in A$, the preference index is defined for *a* in relation to b_i in order for all the criteria. It is assumed that each criterion is identified as one of the six observed types of criteria so that the

functions of preference $P_i(a,b)$ are defined for each $i = 1,...,n$. The preference index is defined with the expression:

$$\pi(a,b) = \frac{1}{n}\sum_{i=1}^{n} P_i(a,b) \quad (5).$$

It is clear that this index gives a measure of preference a over b for all the criteria so that the closer the index is to the unit, the greater the preference is.

5.1.3.3. Using the 'higher level' relation

Application of criteria established in the previous mode allows the construction (use) of the estimated relation (graph) of the 'higher level'. The use of such a graph achieves a partial (PROMETHEE I) or complete (PROMETHEE II) variant solutions ranking.

If the estimated graph of the higher level is defined, for each core *a*, the output stream is as follows:

$$\phi^{+}(a) = \sum_{x \in A} \pi(a,x), \quad (6)$$

and the input stream is:

$$\phi^{-}(a) = \sum_{x \in A} \pi(x,a) \quad (7).$$

The decision-maker may require a complete order, or a complete ranking (PROMETHEE II) without incomparability. In other words, such a ranking of variants may be required, that each variant is in its rank and that there is no possibility that two or more variants are equally ranked. In this case, for any solution $a \in A$, a clean stream is observed:

$$\phi(a) = \phi^{+}(a) - \phi^{-}(a) \quad (8).$$

This can be easily used in solution ranking:

- *a* has a higher rank than *b* $\left(aP^{(2)}b\right)$ if $\phi(a) > \phi(b)$ (9),
- or *a* is indifferent to *b* $\left(aI^{(2)}b\right)$ if $\phi(a) = \phi(b)$.

For the needs of the simulation model, the software packages PROMCALC & GIAIA V.3.2. for MS DOS was used.

5.2. Relevant criteria selection for county port management system establishment in Croatia

Establishment of the county seaport management system in the Republic of Croatia is a complex economic phenomenon, which involves numerous criteria. Therefore, establishment of such a system requires that criteria and standards are defined on and the solution assessment conducted, as to select the best one. It should be emphasized that the port authorities have been established within the existing port system, which includes governance structures.

The criteria used are the positions for evaluating certain solutions via standards for fulfillment. However, because of the need to conduct a comprehensive study, one needs an approach that is not limited to the analysis of certain types of criteria, but takes into account the simultaneous influence of different criteria, such as the multi-criteria decision-making.

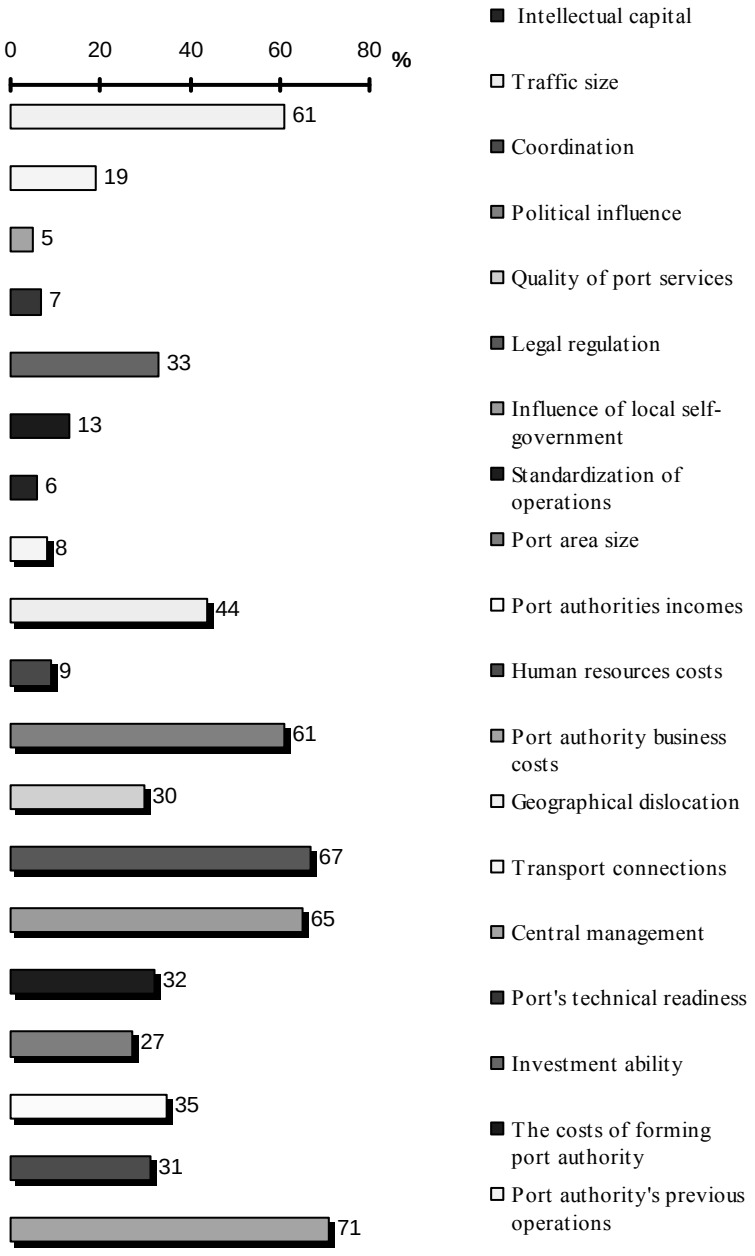
In the legislation, analyzed literature and business practice, there are no defined criteria for the establishment of port authorities, serving as a governance structure for county ports.

Thus, the authors have selected the relevant criteria for establishment of the county port management systems by surveying experts. Since each of the selected criteria does not have the same impact, the experts evaluate the relevant criteria with respect to their importance or impact on the establishment of county port management systems.

It should be noted that the questionnaire used for the expert survey suggested some criteria, which were believed to be essential for the purpose. In order to avoid or eliminate epistemological difficulties, the expert sample consists of respondents with a similar level of education.

Figure 2. illustrates the results of the experts survey, in order to determine the relevant criteria for the establishment of a county port management system. The length of horizontal rectangles indicates the importance of each criterion in the establishment of port authorities, i.e. the percentage of experts who selected a certain criterion as relevant for the purpose of this paper.

Figure 2. Results of the survey of experts on the selection of criteria for the establishment of county port management systems



Therefore, the criteria and their sub-criteria for the formation of a county port management system are:

- *economic and organizational criteria with sub-criteria:* business costs, human resources costs and income;
- *socio-natural criteria with sub-criteria:* legal regulation, influence of local self-government, port area size and geographical dislocation;
- *technological and technical criteria with sub-criteria:* investment in port infrastructure, standardization of payment methods and criteria, and quality of port services.

5.3. Generation of possible scenarios for the county port management system in Primorsko-goranska county

For the purpose of generating scenarios, the analysis of possible models of a county port management system was conducted in previous sections. The resulting conclusions were basic starting points for the generation (definition) of scenarios (solutions, variants), and possible models of the county seaport system management. The other possible models (one island port authority and one land port authority, one land port authority and four island port authorities, one port authority for all ferry ports and one port authority for all other ports) were excluded.

Namely, they were not acceptable even during field testing, i.e. local government bodies that have the right to establish county port authorities consider these models unacceptable. In many ways, these models stand out from the current situation in the county port system in the Republic of Croatia. Therefore, the following have been selected as the possible models of the county port management system:

- model of coordinated decentralized management, i.e. multiple port authorities united by shared professional services,
- model of decentralized management, i.e. multiple port authorities,
- model of a single port authority management and several business units,
- model of centralized management, i.e. a single, centralized port authority.

Provided that the Primorsko-goranska County is selected for testing (application) of possible models, a modification of the management models (generated scenarios), was performed. The above shows that the system of

managing ports of county importance in the Primorsko-goranska County can be arranged in the following ways:

- *Eight port authorities with shared 'corporate' functions*: Mali Lošinj port authority, Cres port authority, Opatija-Lovran-Mošćenička Draga port authority, Rab port authority, Krk port authority, Bakar-Kraljevica port authority, Crikvenica port authority, Novi Vinodolski port authority;
- *Five decentralized port authorities*: Mali Lošinj and Cres port authority, Opatija-Lovran-Mošćenička Draga port authority, Rab port authority, Krk port authority, Bakar-Kraljevica-Crikvenica-Novi Vinodolski port authority;
- *One county port authority with five branches*, organized in the following way:
  - Primorje port branch: Bakar-Kraljevica, Crikvenica and Novi Vinodolski
  - Liburnija port branch: Opatija-Lovran-Mošćenička Draga
  - Rab port branch: Rab
  - Lošinj-Cres port branch: Mali Lošinj and Cres
  - Krk port branch: Krk.
- *One centralized county port authority with headquarters in Rijeka*, i.e. a single port authority for all county ports.

Scenarios are divided into four groups (1, 2, 3 and 4), because the evaluation of certain scenarios was conducted for each group in order to note which model (scenario) of the county port system management is the most acceptable, with respect to defined criteria and the research hypothesis.

5.4. Overview of scenario evaluation on selected criteria

Evaluation of scenarios, based on selected criteria, was the basic precondition for application of the process of multi-criteria decision-making (ranking), by using the PROMETHEE procedure. Depending on the criterion, some evaluation criteria are expressed quantitatively, or in specific data (costs - HRK, size - km^2 and geographical dislocation - km). Other criteria were subject to qualitative evaluation or the scenarios (proposed models), according to specific criteria (incomes, influence of local self-government, legal regulations), were evaluated with subjective, but scientifically reasoned evaluations (see Table 2). Data listed in Table 2 also represent the input data required for computer programs PROMCALC & GAIA v.3.2., which were used for multi-criteria ranking of scenarios (solutions, variants).

Table 2. Overview of scenario evaluation on selected criteria and values of individual criteria (min. and max.)

CRITE--RION		SUB-CRITERION				SCENARIO			
Abbrev.	Full name	Mark	Full name	Unit	min/ max	1	2	3	4
C 1	ECONOMIC AND FINANCIAL	BC	Business costs	000 Kn	min.	12.057	8.025	9.171	5.762
		HRC	Human resource costs	000 Kn	min.	2.920	1.775	1.745	1.490
		I	Revenues	000 Kn	max.	6.5	4	5.75	3
C 2	SOCIOLOGICAL AND ECOLOGICAL	LR	Legal regulation	grade	min.	0.75	1	2	1.75
		ILS	Influence of local self-government	grade	min.	2	3	1.5	1
		PAS	Port area size	000 km^2	min.	268	429	429	2.143
		GD	Geographical dislocation	km	min.	10	20.22	20.22	79.58
C 3	TECHNOLOGICAL AND TECHNICAL	PII	Port infrastructure investment	grade	max.	2	1	3	4
		SPMC	Standardization of payment methods and criteria	grade	max.	1.6	1.3	4.6	4
		PSQ	Port service quality	grade	max.	3.5	3	4.25	2.5

5.5. Multi-criteria decision-making model results

In accordance with the purpose of research, the rank of variants (from the aspect of analyzed criteria) represents the main output data, which can be used by a decision-maker or a county assembly, as to choose among the models of

county port system management. Ranking model variants was carried out in relation to the influence of the following criteria (see Table 3):

- economic and financial,
- sociological and ecological,
- economic-financial and sociological and ecological,
- economic-financial and technological (technical) criteria,
- economic-financial, sociological and ecological and technological (technical).

Table 3. Ranking of scenarios according to a certain criterion and different combinations of criteria

PROMETHEE II		RANKING OF SCENARIOS ACCORDING TO CRITERIA				
		Economic-financial	Sociological and ecological	Economic-financial and sociological & ecological	Economic-financial and technological (technical)	Economic-financial, sociological & ecological and technological (technical)
		EF	SN	EF-SN	EF-TT	EF-SN-TT
RANK	1.	4	1	4	3	3
	2.	3	2	1	4	4
	3.	2	4	2	1	1
	4.	1	3	3	2	2

Source: Processed by the authors in accordance with the data obtained by using PROMCALC & GAIA v.3.2. - PROMETHEE II procedure

The resulting ranks can be commented as follows:

- Scenario 4 is better than scenario 3, which dominates scenario 1.
- Scenario 2 is better than scenario 1.
- Scenarios 4 and 3 dominate scenario 2, etc.

Analysis of the obtained results indicates that, in all combinations of criteria, (simultaneous and individual), the best solution for the county port system management of Primorsko-goranska County are scenarios 3 and 4, i.e. the model of management via a single port authority and five branch offices and the model of one centralized port authority. The exception is the ranking of scenarios according to the sociological and ecological criteria, for which the

best management model emphasizes the model of eight port authorities with shared 'corporate' functions (scenario 1), followed by the model of five port authorities (scenario 2).

Such a result is not surprising, because it is the case of individual influence of a single criterion (sociological & ecological). One could expect that these models are characterized by a high degree of decentralization (criteria of port area size and geographical dislocation), a large influence in local self-government in management, significant political influence in administrative councils, and compliance with the current legislation. However, in the simultaneous influence of two or more criteria (economic-financial, sociological & ecological and technological, i.e. technical), or in the case of exclusion of sociological & ecological criteria (simultaneous influence of economic-financial and technological, i.e. technical criteria), the aforementioned models take the last place in the ranking.

In other words, the mentioned model is considered to be the best (optimal), because it takes into account the simultaneous influence of all three criteria and it represents the optimal direction for successful rationalization of county seaport management.

6. CONCLUSION

In this study, multi-criteria decision-making methods have been applied to the problem of establishing the basic model of county port system management, suitable for all counties in the Republic of Croatia. The obtained results indicate the complexity of decisions that should be defined by the state, or a county, as legal entities responsible for the successful operation of the port system. In other words, this involves analysis of all selected scenarios for the establishment of the county port system management (number and location of port authorities, number of profit centers or business units, the introduction of clusters, etc.), including an in-depth analysis of all the selected economic and qualitative relevant criteria.

The suggested model is designed in accordance with the fundamental principles of multi-criteria decision-making, which represents a procedure of multi-criteria variants ranking. Among different procedures of multi-criteria optimization, the author used the PROMETHEE procedures and the computer programs for multi-criteria programming Promcalc and Gaia v.3.2.

Analysis of the results obtained by means of multi-criteria decision-making indicates that, in all combinations of criteria (simultaneous and individual), the best county port system management solution for Primorsko-goranska County is the model of management by one port authority and five branches and the model of one centralized port authority. The results demonstrate that only scientific organization and management, as well as the involvement of all relevant stakeholders make it is possible to design a management systems, which enables public county seaports in the Republic of Croatia to operate as profitable organizations.

In addition to the definition of a model, this study provides an application of the methodology of multi-criteria decision-making to transport planning in general, and particularly in organizing the management within an individual port system. The proposed model opens additional topics for further research:

- *a larger number of scenarios* - thereby the obtained rankings could be even more precise and concrete,
- *a larger number of criteria* - in this way, one could also analyze possible scenarios from the aspect of various other criteria (e.g., environmental, sustainable development, institutional, cultural, tourist, social criteria, etc.),
- *different combinations of criteria impacts* - beside obtaining the optimal scenario, different combinations of criteria impacts could be used for examining the sensitivity of the ranking list in cases of changes in criteria impact. The results could be compared and analyzed in relation to different combinations of criteria impacts, because some criteria have a positive impact on port operations from one hand, and a negative impact, from another hand.
- *Verification of the obtained results by using other methods and programs for multi-criteria decision-making (AHP, ELECTRE, Decision Lab and EXPERT CHOICE)*, which would be a way to compare and verify the obtained results.
- *Testing the new management model in all coastal counties of the Republic of Croatia using multi-criteria decision-making and their comparison.* In this case, the previously defined criteria and impacts would remain the same, but because of the diversity of the individual counties, the value of each criterion would change. Such an approach could make it possible to compare the results obtained by multi-criteria decision-making in individual counties and to conclude if the same model of county port system management is optimal (best ranked) for other coastal counties.

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ORGANIZACIJA HRVATSKOG NACIONALNOG SUSTAVA UPRAVLJANJA MORSKIM LUKAMA

Sažetak

Donošenje odgovarajućih odluka je jedan od ključnih preduvjeta za postizanje željenih efekata u upravljanju bilo kojim gospodarskim entitetom. Većina zadataka i problema u analizi, planiranju i upravljanju lukom ima vrlo složene ciljeve, pri čemu se izdvajaju i različiti scenariji te potencijalna rješenja problema, kao i raznorodni kriteriji evaluacije te ograničenja rješenja, što ne omogućava dolazak do uniformnih rješenja. U ovom se radu, korištenjem računalno podržanog multikriterijalnog odlučivanja, na temelju rangiranja različitih scenarija, modelira nacionalni sustav upravljanja morskim lukama. Pritom se problem upravljanja nacionalnim hrvatskim lukama prvo analizira kao cjelina, odnosno sustav, nakon čega se pristupa analizi pojedinih komponenata i sintezi, utemeljenoj na multikriterijalnoj analizi. Kako bi se razvila konkretna rješenja i razvio novi model nacionalnog sustava upravljanja morskim lukama, analizira se Primorsko-goranska županija, pri čemu se koristi procedura multikriterijalnog odlučivanja PROMETHEE, uz pomoć odgovarajućeg računalnog softvera za multikriterijalno odlučivanje