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APPLICATION OF MULTIPLE CRITERIA DECISION AID METHODS IN LOGISTIC SYSTEMS

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ABSTRACT. The paper presents the application of different multiple criteria decision aid (MCDA) methods in two logistic systems. One of them is the Polish system, while the second is a worldwide one operating also in Poland. Based on their precise analysis strengths and weaknesses are identified. They lead to the construction of different alternatives - development scenarios of the two considered logistic systems. The alternatives are designed heuristically and evaluated by two different sets of criteria. In both cases, selection of the most desirable solution is required. The decision problem is formulated as a multiple criteria ranking problem, thus all the considered development scenarios are ranked from the best to the worst. The methodology of MCDA is applied. The authors present selected MCDA ranking methods, including: Electre III and AHP. Those methods fit the best to the two considered decision problems of logistic systems. The computational experiments are carried out and their results are presented. The authors discuss the results generated by two MCDA methods and draw final conclusions regarding their suitability for the analyzed decision problems.

Key words: Redesign of logistic systems, location problem, MCDA methodology, Electre III and AHP methods.

INTRODUCTION

The general definition of logistic presented by many authors [Coyle et al. 1996, Tarkowski et al. 1995] states that this is the activity based on the flow of products from points of origin to points of destination i.e. final customers. Its aim is to optimize the coordination of the flow of raw materials and goods, warehousing, goods loading and unloading, transporting, packing and managing. Council of Logistics Management [1985] formulates more complex definition. Logistic is the process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.

Taking into account many definitions the authors of this paper consider the logistic system as a set of such elements as: logistic infrastructure, human resources, transportation fleet, business processes and organizational rules that provide coordination and control over the above mentioned components. Those components should match together to assure the efficiency and effectiveness of the whole logistic system and a coordinated flow of materials (products), information and cash. That is why the design and redesign of the logistic system is a very complex task.

The redesign of the logistic system [Coyle et al. 1996] may be carried out either in a heuristic manner or in a more rigid conceptual form, based on a mathematical formulation of the redesign process. In the first case different development scenarios of the logistic system are designed

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intuitively, based on the expert knowledge. The second approach consists in finding the optimal structure of the system, based on the mathematical programming formulation of the decision problem. In the literature several combined approaches are also presented to the redesign of the logistic systems, such as: optimization and simulation methods [Wegryn, Siprelle 2001], MCDA methods and optimization [Korpela, Lehmusvaara 1999], MCDA methods and simulation [Wlodarczak et al. 2003] etc.

This paper focuses on the first of the above mentioned approaches, in which the development scenarios of the two considered logistic systems are constructed intuitively. They are evaluated by a set of criteria with an application of a selected MCDA method. The authors of this paper present the results of their research focused on selection and application of the most appropriate ranking method for the multiple criteria evaluation of the development scenarios of the two real-world logistic systems.

The paper is composed of 4 sections. The first one presents the introduction to the problem. In the second section the characteristic of MCDA is presented, selected MCDA methods i.e. AHP [Saaty 1980] and Electre III [Roy 1985, Vincke 1992] are characterized and finally the methodology of solving multicriteria decision problems is described. In the next section two different decision problems are formulated. The characteristic of logistic systems and their alternative development scenarios are presented, evaluation criteria and decision maker's (DM's) preferences are defined. The computational experiments carried out with an application of AHP and Electre III methods and their results are presented, as well. The fourth section presents conclusions and further research directions.

THE METHODOLOGICAL BACKGROUND OF MCDA

Multiple criteria decision aid is a field, which aims at giving the DM some tools in order to enable him/her to solve a complex decision problem where several points of view must be taken into account [Vincke 1992]. MCDA concentrates on suggesting "compromise solutions", taking into consideration the trade-offs between criteria and the DM's preferences. In many decision situations are involved decision maker, stakeholders and analyst. The DM is a person, who has a great impact on the decision making process. He/she expresses preferences, evaluates the situation, considers different solutions and approves final results. Stakeholders are parties involved in the considered decision situation and interested in finding a solution for the problem considered. Their opinions should be taken into account by the DM. B. Roy [1985] emphasises the role of the analyst in the decision making process, who supports the DM in finding the most desirable solutions taking into account his preferences and the set of criteria. An analyst is an expert responsible for recognition of the decision problematic, construction of the decision model of the situation considered, explanation of consequences of decisions and selection of the appropriate decision aiding methods and tools.

Decision aiding methods and tools support the DM and the analyst in solving multiple criteria decision problems. They can be divided into three major groups [Roy 1985, Vincke 1992]:

- choice (optimization) methods, providing optimal solution of the decision problem;
- sorting methods, providing the allocation of alternatives into predefined classes;
- ranking methods, providing the rank/ hierarchy of alternatives from the best to the worst.

Many authors [Guitouni, Martel 1998, Roy 1985, Vincke 1992] distinguish two major streams of MCDA methods i.e.: the American school based on multiatribute utility theory and the European school based on the outranking relation. Well-known representatives of those streams are: AHP [Saaty 1980], UTA [Jacquet-Lagreze, Siskos 1982] methods, and Electre [Roy 1985, Vincke 1992], Promethee [Brans, Vincke, Mareschal 1986] methods, respectively. The authors of this paper concentrate on two MCDA methods, i.e. Electre III and AHP.

In the first step of Electre III method [Roy 1985] the set of alternatives A construction and the set of consistent family of criteria *F* definition. The definition of DM preferences is based on the modeling of indifference *q*, preference *p* and veto *v* thresholds for each criterion. DM also defines weight for each criterion.

The ranking of alternatives is based on two classification algorithms: descending and ascending distillations. They provide the ranking of alternatives from the best to the worst. In the descending distillation the best alternative is placed on top of the ranking, while in the ascending distillation at the bottom. The next place in the ranking is occupied by the best alternative in the remaining set A. The procedure is repeated until the set of alternatives is emptied. At the end of the algorithm based on the two distillations the final ranking is formulated. The final ranking of alternatives may include the indifference *I*, preference *P* and incomparability *R* relations between alternatives.

In the first step of the computational algorithm of AHP method [Saaty 1980] the information is decomposed into a hierarchy with the 0, 1 and 2 levels. On the 0 level the aim of the decision process is defined e.g. final hierarchy of alternatives from the best to the worst. On the next level the criteria and subcriteria are described. Finally, the alternatives are defined - 2nd level. In the next step the DM and stakeholders give the preference information as the relative weights. This information is presented as pairwise comparison judgments between criteria, and between alternatives with regard to each criterion, quantified on the standard "one - to - nine" measurement scale: 1 - equally preferred; 3 - weakly preferred; 5 - strongly preferred; 7 - very strongly preferred; 9 - absolutely preferred. The intermediate judgments like: 2, 4, 6, 8 can be also used. The values have compensational character, which means that the less important judgement between two compared elements is presented as a reciprocal value of the more preferred element. Thus, the exemplary values 1/2, 1/5, 1/9 are assigned to less important criteria or subcriteria or alternatives. The vectors of normalized absolute weights are calculated. The final result of AHP method is ranking of alternatives based on the order of computed values of additive utility function U_i of alternatives from the best to the worst.

The selected MCDA methods AHP and Electre III are also applied to rank alternatives of two different logistic systems. In both cases, presented in the next section, the following methodology of solving multicriteria decision problems is utilized [Zak 2005]:

- identification of the decision problem and its verbal characteristic,
- construction of the mathematical decision model,
- analysis and selection of the methods and algorithms to solve decision problem,
- computational experiments,
- analysis and evaluation of the results, choice of the most satisfactory, compromise solution.

SOLUTION OF THE REAL LOGISTIC DECISION PROBLEMS

SITE LOCATION PROBLEM

The decision problem considered in the first case is formulated as the ranking of alternatives of Logistic Center (LC) site location. This LC is going to be placed in Poland. The main role in the decision process of the considered problem plays a local government, which represents public sector and the operator of LC, representing private sector. Local government creates opportunities to locate center i.e. accepts site development plan, helps to formalize the investment, etc. However, the final decision of the LC location makes the operator, thus he acts as the decision maker (DM). The location problem is divided into two stages. The first one is a macro analysis and is based on a detailed analysis of the regions in which LC should be created. Then the best region, which meets expectations of the DM is chosen. In the second stage micro analysis is carried out. Three cities in selected region are analyzed. Based on DM's preferences and computational experiments, the final location of LC is selected (see figure 1).

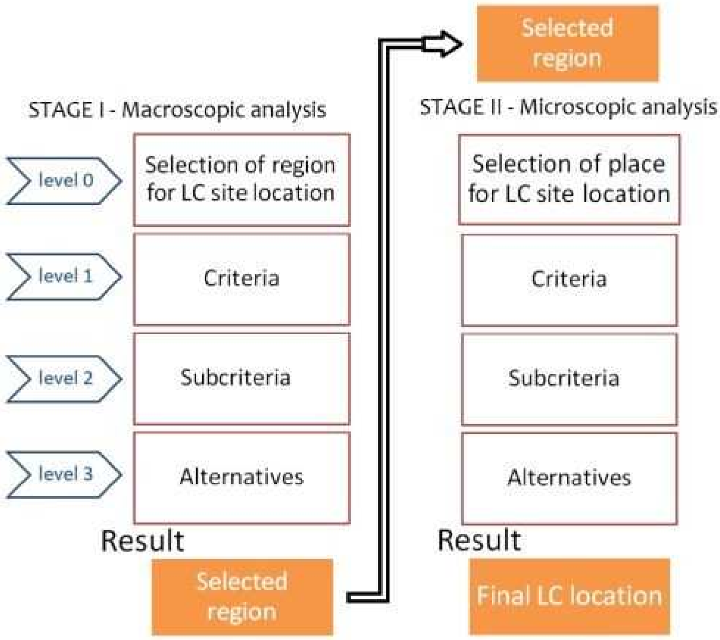

Fig. 1. Structure of the decision problem of LC location
Rys. 1. Struktura problemu decyzyjnego dla problemu lokalizacji CL (centrum logistycznego)

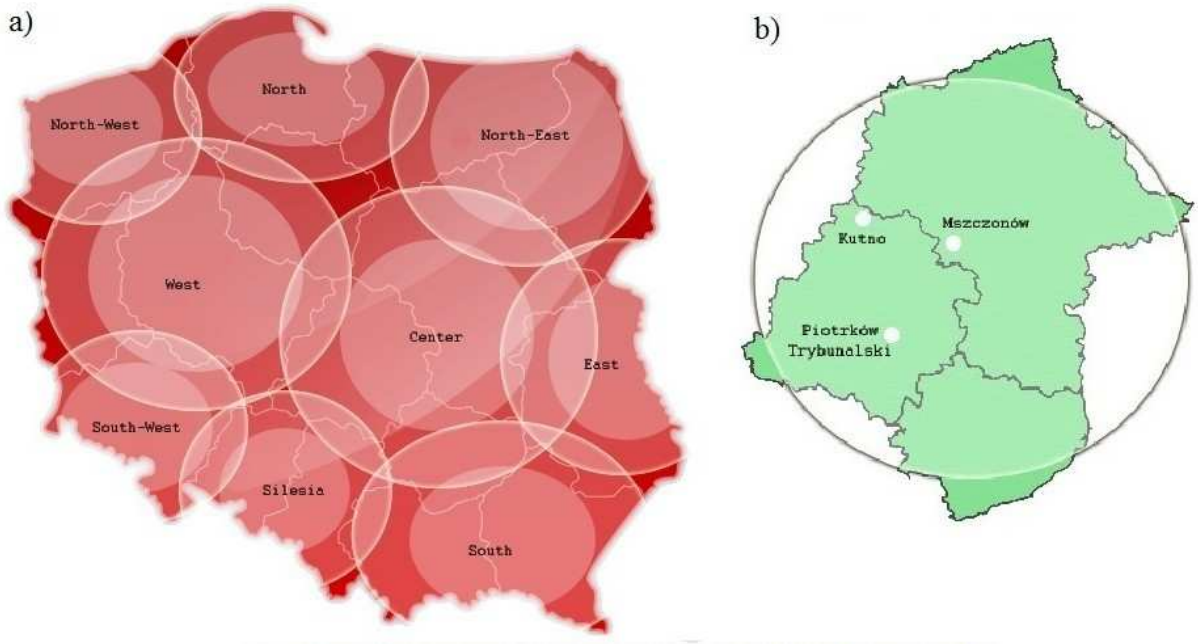

Fig. 2. Alternatives of the location problem, a) macroscopic analysis, b) microscopic analysis
Rys. 2. Warianty dla problemu lokalizacji a) analiza makroskopowa b) analiza mikroskopowa

In the first stage 9 alternatives - regions in Poland is defined. They are as follows: North-West (NW), North (N), North-East (NE), West (W), Center (C), East (E), South-West (SW), Silesia (SIL), South (S). The alternatives are illustrated in figure 2(a). The average radius measured from the central point of each region is between 100 and 250 km.

The alternatives are evaluated by the set of criteria and subcriteria, which are maximized. They represent different areas, such as:

- technical e.g. road infrastructure (Cr1) split into highways (Cr11), expressways (Cr12) and total road infrastructure (Cr13); and rail infrastructure (Cr2) with electrified (Cr21) and standard gauge (Cr22);
- economical e.g. Gross Domestic Product (GDP - Cr3) measured in Polish currency as a value of GDP (Cr31) or GDP per capita (Cr31); salaries in transportation/ logistic sector (Cr 8);
- social e.g. probability of getting higher education level within logistics (Cr4) including number of logistic post-graduate schools (Cr 41), number of different specializations in these schools (Cr 42) and number of different logistic specializations in higher education (Cr 43);
- organizational e.g. number of logistic companies in different sectors (Cr 5), such as private sector (Cr 51) and public sector (Cr 52); warehouse management (Cr 6) including technical subcriteria such as: different types of warehouse construction (Cr 61) i.e. building, containers, sites etc., and different space (Cr 62); number of deliveries carried out by road transportation (Cr 7) including number of goods delivered measured in [t] (Cr 71) and [tkm] (Cr 72), number of goods dispatched measured in [t] (Cr 73) and [tkm] (Cr 74).

For the DM one of the most important criteria is a transportation infrastructure, including road and rail one. Those criteria indicate how attractive and easy to reach the location of LC is. The economic value of the region represented by the GDP is also of the great importance for DM, because it shows the demand for services in the considered area. The DM highly appreciates the number of transportation and logistic companies placed in the selected region, which gives him more opportunities to expand LC. To be up to well developed LC skilled and well qualified employees are required. This is another criteria highly weighted by the DM. Less significant factor is the amount of storage space and the value of freight transportation carried out by vehicles as well as salaries' level encouraging potential employees to apply for the job, giving the possibility to create new places of employment and reducing rate of unemployment. To evaluate the importance of the criteria the DM would like to make comparisons between them. He expects that the final result would give him information which alternative is the most preferable one and which is the worst. He would also like to know how far the alternatives in the final hierarchy are. The analyst decided to chose AHP method to meet the DM's expectations. The computational experiments are carried with the application of AHP project tool available on web page http://www.ahpproject.com. In the first phase of the experiments the hierarchical structure of the decision problem is constructed. At the top of the structure the aim of the decision problem is presented i.e. to find "the best" region for the LC location (0 level). On the 1 level the criteria are listed and on the 2 level subcriteria are presented. On the last level of the hierarchy the alternatives are showed. In the next step the DM preferences regarding pairwise comparisons between criteria, subcriteria and alternatives are modelled and calculated. The results of the comparisons between criteria are presented in table 1. The strongest preference, which equals 8 points, has the criterion Cr 3 (GDP) over Cr 5 (number of different companies in sectors), while the criteria Cr 1 (road infrastructure) and Cr 2 (rail infrastructure) are equivalent - 1 point. The DM also makes pairwise comparisons between subcriteria and between alternatives. The information is implemented in the AHP tool and the computational experiments are carried out. The results are presented in figure 3 - ranking A.

The best location of LC is the Center Region. This alternative has the highest value of additive utility function i.e. 0,231. The most important advantage of this alternative is the developed road deliveries system with the weight 0,068 and warehouse management - 0,063. Some may consider that a significant amount of storage space, rather discourages the construction of logistic center, but in reality, the demand for storage space is still growing. This situation is also confirmed by the high amount of goods transported, which must be stored and serviced. A perfect place is the logistic center. The next region in the ranking is Silesia. The difference between this alternative and the leader is insignificant - equals 0,029. The most important advantage of Silesia is highly developed rail and road infrastructure and GDP, as well. It can be seen that the disproportion between the leaders and the last three ranking positions is high. The last position in the ranking is occupied by East Region, which is characterized by the lowest level of economical factors in the eastern part of Poland.

Table 1. Matrix of comparisons between criteria in the first stage of location problem
Tabela 1. Macierz porównań pomiędzy kryteriami dla pierwszego etapu problemu lokalizacji

		Criteria							
		Cr 1	Cr 2	Cr 3	Cr 4	Cr 5	Cr 6	Cr 7	Cr 8
Criteria	Cr 1	1	1	0,5	2	4	0,5	0,667	2
	Cr 2	1	1	0,5	2	4	0,5	0,667	2
	Cr 3	2	2	1	4	8	1,25	1,5	4
	Cr 4	0,5	0,5	0,25	1	2	0,666	0,333	1
	Cr 5	0,25	0,25	0,125	0,5	1	0,143	0,167	0,5
	Cr 6	2	2	0,8	3	7	1	1	3,5
	Cr 7	1,5	1,5	0,667	3	6	1	1	3
	Cr 8	0,5	0,5	0,25	1	2	0,286	0,333	1

The DM makes the final decision to locate the LC in Center Region. Next, the microscopic analysis is carried out - second stage of the analysis. Three alternative cities are considered i.e. Kutno, Mszczonów, Piotrkow Trybunalski. Their location is presented in figure 2 (b). The structure of this problem is similar to the structure presented in the first stage. The aim of the decision situation presented in the second stage is to select the place for LC, on the first level criteria Cl 1 - Cl 6 are presented, on the next level the subcriteria are described, and finally on the third level - 3 alternative places are described. The set of criteria includes the domestic transportation network (Cl 1) with a distance from motorways (Cl 11), from expressways (Cl 12), from rail stations (Cl 13) etc.; existing infrastructure (Cl 2) including necessary equipment i.e. gas (Cl 21), electricity (Cl 22), water (Cl 23), container terminal (Cl 24) etc., economical area (Cl 3), including economical zone (Cl 31) and tax credits (Cl 32); area (Cl 4) with its characteristic (Cl 41), availability for investments (Cl 42); social aspects (Cl 5) including unemployment level (Cl 51), number of employees (Cl 52); European transportation network (Cl 6) with an access to TENT (Trans-European Transportation Network) corridors (Cl 61), AGTC - European Agreement on Important International Combined Transport Lines and Related Installations (Cl 62), AGC (European Agreement on Main International Railway Lines) tracks (Cl 63). Based on given DM preferences the computational experiments are carried out. Their results are presented in figure 3 (ranking B).

The best location for LC in Poland is Mszczonow, with value of utility function 0,390. This alternative has the most attractive location thanks to highly developed European and domestic transportation network. The next alternative in the ranking is Piotrkow Trybunalski with U_i, which equals 0,314 and the last one location is Kutno ($U_i = 0,296$).

Preference of the first alternatives to the other locations is significant. The difference between the second (Piotrkow Trybunalski) and third place (Kutno) in ranking is very small and it equals 0,018. Economical analysis of alternatives shows that Kutno is the best location due to its membership in the Lodz Special Economic Zone. Piotrkow Trybunalski turns out to be the best location in terms of social development.

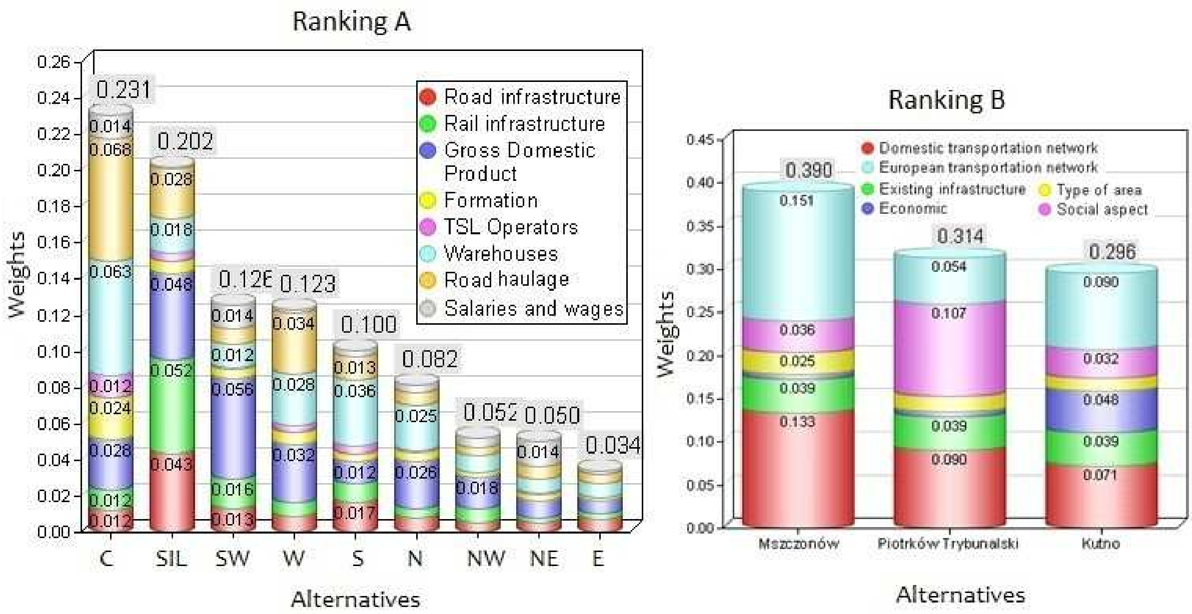

Fig. 3. The results of the computational experiments of location problem – AHP method.
Ranking A – first stage, ranking B – second stage.
Rys. 3. Rezultaty eksperymentów obliczeniowych dla problemu lokalizacji – metoda AHP.
Ranking A – pierwszy etap, ranking B- drugi etap.

REDESIGN OF THE LOGISTIC SYSTEM

The second decision problem presented in this paper is formulated as a multiobjective ranking problem of the redesign scenarios of the part of logistic system of Kimball Electronics Poland (KEP) Company. Its activity is focused on production and assembly of electronic components for automotive industry and medical devices. This is a worldwide system, which has been operated at Polish market since the year 2001. The company trades with over 200 different suppliers from Asia, USA and Europe (see figure 4). The redesign process refers to the part of the logistic system and the deliveries from 19 suppliers are analyzed. The DM is the operator of the system. He takes into account the interest of stakeholders, such as suppliers, forwarders, different logistic centers and customers. The analysis of the existing logistic system indicates that some changes should be made. Thus, four alternative scenarios are proposed. They are constructed intuitively, on the basis of the DM and analysts' experience. The alternatives are differentiated by the transportation modes, number of haulers, number and type of warehouses and number of suppliers. Alternative W1 represents the existing logistic system. The main modifications in alternative W2 are focused on the change of hauler and transportation modes used in China, Great Britain and Ireland. For example, in China air transportation mode is replaced with sea transportation mode. To reduce logistics' costs an offer made by a new hauler should be accepted. Changes concerning a new hauler exchange are also assumed in analyzed Great Britain and Ireland. In alternative W3 new cross-docking warehouses in China and Korea are added and an additional warehouse in Texas, as well. Those changes provide the reduction of deliveries' costs, reduction of transportation delays etc. The changes of suppliers from Asia and USA location are considered in alternative W4. The most important manufacturer is located in Czech Republic. This alternative assumes changes of transportation modes e.g. from sea to road. The advantage is the reduction of distances between KEP and suppliers. The main disadvantage is the increase of transportation costs. In the alternative W5 new warehouses and cross-docking warehouses are added.

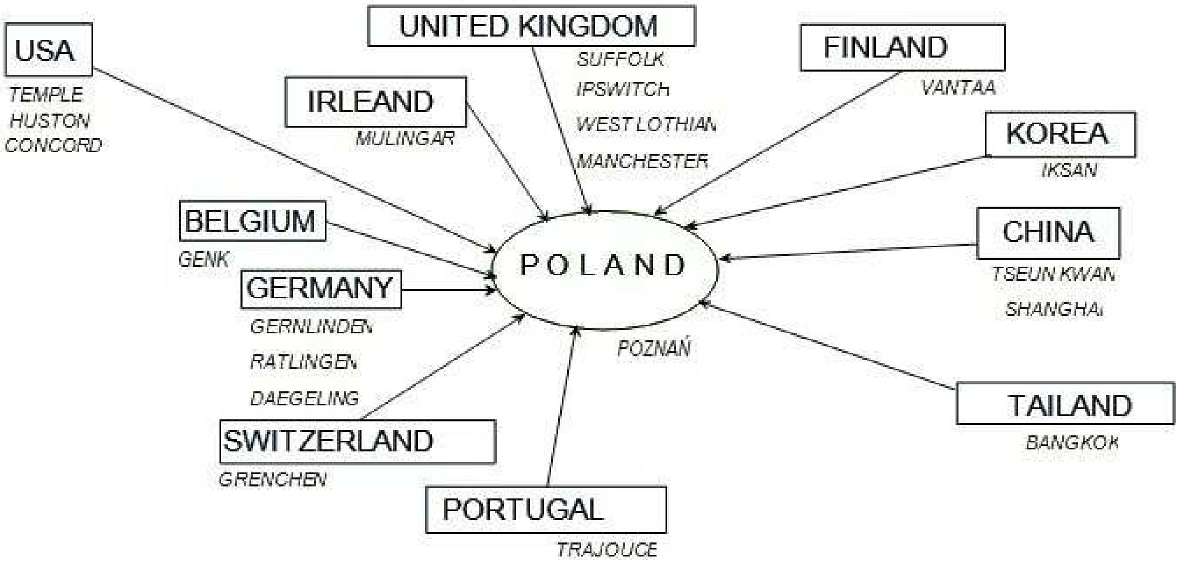

Fig. 4. Map of the KEP logistic system
Rys. 4. Mapa systemu logistycznego KEP

The redesign scenarios of the logistic system are evaluated by the set of the following criteria: delivery time (Cri 1); costs of delivery (Cri 2); costs of system`s redesign (Cri 3); efficiency of warehouse equipment utilization (Cri 4); flexibility of the system (Cri 5) including frequency of deliveries, payment conditions; quality of delivery (Cri 6), including number of damages, number of incorrect goods delivered; punctuality of the system (Cri 7).

The DM expresses his preferences by ranking the set of criteria from the best to the worst. He sees that the distances between two following criteria are not always the same. The most important criteria are: delivery time and costs of system`s redesign. Very high positions in the ranking have costs of delivery and punctuality of the system. The quality of delivery is also highly appreciated. The remaining criteria are of the less importance for the DM.

The DM is also very sensitive to changes between values of criteria e.g. he expresses the preference between two compared alternatives if the difference of delivery time is higher than half of a day, if the time of delivery is higher than 3 days the alternatives are hardly comparable.

He expects that the final result would give him information which alternative is the most preferable one and which is the worst. The considered redesign scenarios are characterized by a high complexity that is why the DM assumes that some of the alternatives might be incomparable.

Table 2. Matrix of performances for the problem of the logistic system redesign
Tabela 2. Macierz wartości kryteriów dla problemu reorganizacji systemu logistycznego

	Time of delivery [days]	Cost of delivery [PLN]	[Cost of system's redevelopment [PLN]	Efficency of warehouse reserves utilization [mln PLN/m2]	System's agility [note]	Quality of delivery [%]	Punctuality of the system [%]
Direction of preference	min	min	min	max	max	max	max
Alternative W1	9,21	55 111	0	3,67	4,4	87,4	93,1
Alternative W2	10,80	47 237	2 000	3,64	4,4	87,3	93,1
Alternative W3	9,64	41 118	39 000	1,44	5,4	89,7	95,6
Alternative W4	7,00	52 507	24 000	3,78	4,6	89,3	95,3
Alternative W5	11,38	53 995	28 000	3,10	4,4	85,6	92,6

To meet the DM's expectations the Electre III method is selected. The computational experiments are carried out with an application of the original software ELECTRE III/IV DATA SALVAGE

VERSION 3.0. In the first step of the computational experiments, a matrix of performances is constructed (see table 2). The criteria Cri 1, Cri 2 and Cri 3 are minimized, while the criteria from Cri 4 to Cri 7 are maximized. The DM preferences are defined and presented in table 3. The DM defines indifference *q*, preference *p* and veto *v* thresholds and weights w for each criterion. Comparing alternative W2 and alternative W4 with respect to highly weighted criterion Cri 1, it could be noticed that these alternatives are incomparable because the difference between them is higher than 3 days of delivery time. Considering other example with Cri 2 i.e. cost of delivery, alternative W2 is strongly preferred to alternative W4 because the difference between their values exceed preference threshold p=3500 PLN. Weights are differentiated in the scale from 1 to 10, where 10 is assigned to the most preferable criterion by the DM. In the problem considered in this paper the highest value of weights have Cri 1 and Cri 3 - 10 points, while the lowest weight has Cri 5 - 5 points. In the next step of Electre III method, the outranking relation is constructed and then exploited. The concordance matrix and credibility matrix are computed (figure 5). In every matrix, pairwise comparisons between alternatives are presented. That is why on the diagonal there is always value 1. The value 0,8 in concordance matrix between W4 (row) and W1 (column) indicates that there is a clear evidence that alternative W4 outranks alternative W1, while the value 0,19 between W5 and W3 proves that there is a poor evidence that W5 outranks W3. Computational experiments of the values presented in concordance matrix do not include veto threshold. The results of outranking relations, which include *v* are presented in credibility matrix. Its interpretation is very similar to the interpretation of concordance matrix, but the values are changes. Finally, based on descending and ascending distillations the ranking of alternatives is computed (see figure 6).

Concordance matrix

	W1	W2	W3	W4	W5
W1	1	0.85	0.37	0.32	0.76
W2	0.81	1	0.19	0.43	0.91
W3	0.76	0.81	1	0.63	0.81
W4	0.8	0.64	0.65	1	0.76
W5	0.46	0.43	0.19	0.38	1

Credibility matrix

	W1	W2	W3	W4	W5
W1	1	0.85	0	0	0.76
W2	0.81	1	0	0	0.91
W3	0	0	1	0.24	0.81
W4	0.8	0.64	0.068	1	0.76
W5	0	0	0	0	1

Fig. 5. Results of computational experiments with application of Electre III method
Rys. 5. Rezultaty eksperymentów obliczeniowych z wykorzystaniem metody Electre III

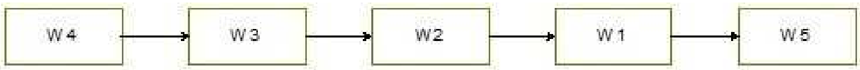

Fig. 6. Final ranking of alternatives of logistic system
Rys. 6. Ranking finalny wariantów systemu logistycznego

Table 3. DM's preferences for the problem of the logistic system redesign
Tabela 3. Preferencje decydenta dla problemu reorganizacji systemu logistycznego

Thresholds & weights	Criteria						
	Cri 1	Cri 2	Cri 3	Cri 4	Cri 5	Cri 6	Cri 7
q	0,4	500	200	0,03	0	0,5	0,3
p	0,5	3500	10000	0,5	0,2	1	1
v	3	16000	37000	2,5	1	1,2	1
w	10	8	10	5	6	7	8

The experiment proved that W1 is not the best solution for the KEP`s logistic system. The compromise solution is alternative W4. Its advantage is the reduced distance between suppliers and receiver, the shortest time of delivery and also very good efficiency of warehouse equipment utilization. The second position in the ranking has W3. This scenario is characterized by the low cost of delivery and high flexibility of the system. The worst position in the ranking has W5. This scenario assumes consolidation of suppliers and renting additional warehouse space in Great Britain and Germany. Costs connected with the organization of these changes i.e. new schedules for suppliers, forwarders and optional business units (warehouses) are high. Changes of transportation modes from air to road freight in Great Britain lengthens delivery time significantly (average value is 12 days). It increases costs of frozen capital and total delivery costs, too.

CONCLUSIONS

This paper presents the application of selected MCDA methods for development of two logistic systems. In both cases, the results of the computational experiments are presented as the ranking of alternatives and on the top of it a compromise solution is placed. In the first case the LC should be located in Mszczonow (Central Region of Poland). In the second decision problem the alternative W4 "change of the supplier`s location" should be applied to redesign the part of the logistic system. However, the final decision of the selection of the most satisfactory alternative makes the decision maker.

The analysis carried out by the authors of this paper show that the following aspects should be taken into account when selecting the most suitable MCDA method for the considered decision problems:

- characteristic of the decision problem; the problem should be well defined, analyzed and structured (e.g. application of some MCDA methods is not possible while considering the set of subcriteria);
- decision makers' preferences; how they perceive the decision situation, what their modeling preferences are, what their expectations of the form of final results are (e.g. results of computational experiments of some MCDA methods do not show the distance between alternatives, while other methods do not assume the incomparability between alternatives);
- characteristic of MCDA methods and their suitability to the problems considered.

Further steps of the research should be based on the analysis of the other logistic or distribution or transportation systems, their decision problems and solution based on the MCDA methodology. This analysis should result in the construction of the set of the key aspects of the most suitable MCDA method selection and their applicability in particular decision problems.

REFERENCES

Brans J.P., Vincke P., Mareschal B., 1986, How to Select and How to Rank Projects: The PROMETHEE Method. European Journal of Operational Research, 24 (2), 228-238.

Caliskan N., 2006, A Decision Support Approach for the Evaluation of Transport Investment Alternatives. European Journal of Operational Research, 175 (3), 1696-1704.

Council of Logistics Management, Oak Brook, IL, 1985.

Coyle J., Bardi E., Langley C., 1996, The Management of Business Logistics, West Publishing Company, New York.

Guitouni A., Martel J-M., 1998, Tentative Guidelines to Help Choosing an Appropriate MCDA Method. European Journal of Operational Research, 109 (2), 501-521.

Hillier F., Lieberman G., 1990, Introduction to Operations Research. McGraw-Hill, New York.

Jacquet-Lagreze E., Siskos J., 1982, Assessing a Set of Additive Utility Functions for Multicriteria Decision-Making, the UTA Method. European Journal of Operational Research, 10 (2), 151-164.

Korpela J., Lehmusvaara A., 1999, A Customer Oriented Approach to Warehouse Network Evaluation and Design. International Journal of Production Economics, 59 (13),135-146.

Roy B.,1985, Methodologie Multicitere d' Aide a la Decision. Economica, Paris.

Saaty T.L., 1980, The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. Mc-Graw Hill, New York.

Tarkowski J., Irestahl B., Lumsden K., 1995, Transportation-Logistics. Biblioteka Logistyka, Poznań (in Polish: Transport-Logistyka).

Wegryn G., Siprelle A., 2001, Combined Use of Optimization and Simulation Technologies to Design an Optimal Logistics Network. Proceedings of the Annual Conference: Council of Logistics Management, Kansas City, 21 September - 3 October (CD Proceedings).

Włodarczak H., Szymański K., Żak J., 2003, Redesign of the Disribution System Based on Simulation Technique and MCDA* Methodology. Proceedings of the Second International Workshop on Freight Transportation and Logistics ODYSSEUS 2003, Mondello (Palermo), 27-30 May, 2003 (CD Proceedings).

Vincke P., 1992, Multicriteria Decision-Aid. John Wiley & Sons, Chichester.

Żak J., 2005, Multicriteria Decision Aid in Road Transportation. Politechnika Poznańska, Poznań (in Polish: Wielokryterialne wspomaganie decyzji w transporcie drogowym).

ZASTOSOWANIE METOD WIELOKRYTERIALNEGO WSPOMAGANIA DECYZJI W SYSTEMACH LOGISTYCZNYCH

STRESZCZENIE. W artykule przedstawiono zastosowanie dwóch różnych metod wielokryterialnego wspomagania decyzji (WWD) w dwóch systemach logistycznych. Jeden z nich to system zlokalizowany w Polsce, drugi to system o zasięgu międzynarodowym również działający na terenie Polski. W oparciu o dokładną analizę określono ich mocne i słabe strony. To umożliwiło skonstruowanie różnych wariantów - scenariuszy rozwoju dwóch rozpatrywanych systemów logistycznych. Rozwiązania te zostały stworzone heurystycznie i ocenione przez dwa zestawy kryteriów. W obydwu rozważnych przypadkach celem analizy było wyłonienie najkorzystniejszego wariantu. Problem decyzyjny został sformułowany jako wielokryterialny problem rankingowy, co oznacza że w obydwu przypadkach warianty zostały uszeregowane od najlepszego do najgorszego. W tym celu zastosowano metodykę WWD Autorzy przedstawili wybrane metody WWD, w tym Electre III oraz AHP. Metody te najlepiej odpowiadają specyfice dwóch rozważanych problemów decyzyjnych występujących w systemach logistycznych Następnie przeprowadzono eksperymenty obliczeniowe i zaprezentowano ich rezultaty. Autorzy poddali dyskusji otrzymane wyniki oraz przedstawili wnioski dotyczące przydatności zastosowanych metod WWD do analizowanych problemów.

Słowa kluczowe: reorganizacja systemów logistycznych, problem lokalizacji, metodyka WWD, metody Electre III i AHP.

ANWENDUNG VON MEHRFACHKRITERIEN-ENTSCHEIDUNGSHILFEMETHODEN IN LOGISTIKSYSTEMEN

ZUSAMMENFASSUNG. Der Artikel präsentiert die Anwendung von unterschiedlichen Mehrfachkriterien-Entscheidungshilfemethoden (MCDA) in zwei logistische Systeme. Eines von ihnen ist das polnische System, während das zweite ist ein weltweites System, auch in Polen tätig. Ihre Stärken und Schwächen werden auf Grund der genauen Analyse identifiziert. Sie führen zur Konstruktion der verschiedenen Alternativen - Entwicklungsszenarien der beiden logistischen Systeme. Die Alternativen sind heuristisch gestaltet und durch zwei verschiedene Gruppen von Kriterien ausgewertet. In beiden Fällen wird die Auswahl der begehrtesten Lösung erforderlich sein. Das Entscheidungsproblem wurde als Mehrfachkriterien-Problem formuliert, damit alle Entwicklungsszenarien sind in einen Rang von dem besten Platz bis zum schlimmsten Platz einreihen. Die Methodik der MCDA wird angewendet. Die Autoren präsentieren ausgewählten MCDA

Ranking-Methoden, einschließlich Electre III und AHP. Diese Methoden passen am besten zu den beiden Entscheidungsproblemen von logistischen Systemen. Die rechnerischen Experimente wurden durchgeführt und ihre Ergebnisse wurden vorgestellt. Die Autoren diskutieren die Ergebnisse von zwei MCDA Methoden und ziehen Schlussfolgerungen hinsichtlich ihrer Eignung für die analysierten Entscheidungsprobleme.

Codewörter: Umgestaltung von logistischen Systemen, Standort Problem, MCDA Methodik, Electre III und AHP Methoden.

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