UNIVERSITY OF NIS FACULTY OF MECHANICAL ENGINEERING

THE FIFTH INTERNATIONAL CONFERENCE
TRANSPORT AND LOGISTICS

til 2014

CRITERIA SYSTEM DEFINING IN MULTICRITERIA DECISION MAKING PROBLEM AT TRANSPORT – STORAGE SYSTEM ELEMENTS CHOICE

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Abstract

Combining the methods for determining the relative importance of criteria and classical alternatives ranking methods, the optimal decision is made about certain multicriteria problem regardless the nature of parameters describing it. Solving the decision - making problem requires firstly defining the criteria system, and then determining their relative importance. Starting base at criteria defining is the fact that at solving each problem we can adopt various number and kind of criteria depending on corresponding decisions and information available. Also, an unique set of criteria of considered problem usually is not available to a decision maker. In this work the correlation test was used for getting the set of independent criteria and reducing their number to operating and acceptable level.

Key words*: criterion, correlation, decision- making*

1. INTRODUCTION

In the field of operational researches, theorists and practitioners have developed a great number of methods and approaches in multicriteria decision-making. Making a base for designing a new solution of logistics concept is basically coincided and connected to the proces of development of logistics centers (LC) , which unite different subsystems and provide complex logistics services [9].

Key part of every logistics strategy, or part of a big chain of supply that connects the manufacturers, deliverers and customers also represents the transport – storage system. Modern transport engineering is characterized by constant development of devices for transport and manipulation and is the base for planing and designing.

Generally, at considering any problem in domain of logistics and logistics systems (either choice of location or equipment in transportation and storage of materials) there is a great number of technically feasible alternatives, and the task of designer is to choose from the set of possible solutions the one that best meets the technical and economic conditions defined by the terms of reference.

Decision maker, in great number of such real problems/situations, must meet one or more goals as well as the numerous conflict criteria (multicriteria analysis). Final order of a problem's alternatives thus depends on applied technique of multicriteria decision-making, and especially on the procedure of defining the evaluation criteria, transformation (normalization) of criteria and determination of their relative significance. When relative significance of criteria is considered, to every criterion is added its weight value, on the base of expert evaluation and evaluation of other participants in decision-making, which is why it is desirable to involve a wider circle of experts and all other interested parties [19].

Solving the decision-making problem, in the domain of logistics and logistics systems, requires firstly defining the criteria system and later determination of their relative significance. At solving any problem we can adopt different number and kinds of criteria depending on corresponding decisions and information available. Also, an unique set of criteria of considered problem usually is not available to a decision maker. So, within the application of multicriteria decision-making model, mostly the carrying out of the following steps is required [1]:

- defining relevant criteria and alternatives,
- giving numerical values for relative importance (weight), as well as alternatives influence on these criteria,
- getting numerical values that determine final result of alternatives ranking.

In literature, researchers during the application of multicriteria decision-making model, mostly direct their attention to second and third step, while the first step, connected to criteria defining, is significantly neglected.

In application of multicriteria decision-making approach, the choice criteria are directly defined without certain tests of their independence or other characteristics [20].

Because of the independent nature of criteria it is very important to limit their number and in that way provide sufficient models sensitivity to changes in criteria weight, as well as the easier determination of their relative significance .

From survey of literature [3,10,13], notable is the fact that generally the choice of criteria requires application of formal procedures of set determination of approximately seven plus or minus two independent criteria.

On the other hand, it is necessary to point out the fact that in procedure of determining the relative criteria weights, subjective decisions have crucial role, and in literature there is a tendency that it is easier to expres a subjective attitude on criteria weights (significance) by comparing criteria importances by pairs instead of individually.

Therefore, classical technique makes the comparing process too complicated and bulky with the aim of collecting, in the right way, the decision maker's estimate, so in order to eliminate this deficiency while comparing at all hierarchical levels of problems, a fuzzy logic, that is fuzzy AHP (Analytic Hierarchy Process) technique is used. Respectively, for the purpose of easier carrying out the procedure of relative weights determination by AHP technique or fuzzy AHP, a set of approximately 7 independent criteria is required [10,13].

The research in this work is directed to the possibility of correlation test application for comparing the independent criteria and reduction of their number to operational and acceptable level. The correlational analysis aim is to determine if there is a quantitative concurrence (correlational link) between the observed phenomena variations (in this case criteria), and if there is, at what degree. In other words, correlational analysis shows the degree of dependence between variables, that is, it measures the intensity of already determined connection between two variables. Application of correlational analysis is illustrated in multicriteria problem of decision-making in the procedure of material handling equipment selection (forklift).

2. CORRELATION ANALYSIS

Statistical methods are used for determining the representative characteristics of significantly different elements' sets. Statistics is subjective: statisticians are trying to explain or predict the material world in arbitrary, but sensible way, by using the theory of probability, mathematics and common sense. Unlike statistics, the theory of probability gives a unique and repeatable solution for the defined problem.

Namely, the change of one feature of statistical set often influences the change of other features due to interconnection. Connection between features can be differentiated both by direction and intensity of connection.

The strongest or the narrowest connectioin between features is functional connection, that is, such connection that each value of one feature responds exactly to certain value of the other.

Looser link between features which are subject to smaller or larger deviations, is called correlative (or stochastic) link. Set of statistical methods used for studying interconnections of statistical features and phenomena (direction, intensity, shape) is called the theory of correlation, and main indicators of correlational links are the regression equation and correlation coefficient.

Hence, dependence research in statistical analysis has two main directions:

1. form of dependence, researcehed by regression analysis and
2. intensity of dependence, determined by correlational analysis.

Connection intensity degree between the variables which are in linear relation is measured by:

- covariance as absolute measure of correlation intensity and
- coefficient of simple linear correlation, as a relative measure of correlational link intensity.

If we observe two phenomena, it is a simple correlation, and if there are more phenomena, then it is a multiple correlation. It is also possible to examine if it is a linear or curvilinear link. Unlike regression analysis, in correlation analysis both observed phenomena are treated as random variables. Here there is no difference between dependent and independent variables. It does not matter which phenomenon we shall mark with X and which one with Y, because we shall get the same results.

Therefore, in further analysis we introduce the term of correlation coefficient, which represents the degree indicator of quantitative concurrence between variables.

On the ground of correlation test results it is possible to conclude that if there is a relation between two criteria, one of them will be sufficient to predict their behaviour, while the other one will be eliminated.

3. HYPOTHESES ON CORRELATION COEFFICIENT – MATHEMATICAL BACKGROUND

Popular method of theorem proving in mathematics is *deductio ad absurdum*, bringing to contradictions if opposite assertion is assumed [11]. In most of the fields where statistics is applied it is not possible to derive a rigorous proof, but the method of bringing to contradictions is essentially the base of statistical proof.

In statistics, unlike mathematics, absolute contradiction rarely occurs. The task of hypotheses testing statistics theory is to quantify the degree of doubt in some hypothesis. Choice between two hypothesis, let us call them H_0 – zero hypothesis and H_1 – alternative hypothesis, occurs in different fields of application. Actually, whenever it is necessery to prove some assertion or verify a new theory.

So, if we want to prove some assertion, then we take the opposite assertion (or neutral or existing state) as zero hypothesis, and assertion itself for hypothesis H_1.

Aim of examination procedure is to examine, on the base of results, if there are proofs against hypothesis H_0 and in favour of hypothesis H_1. Test is done if the statistics is defined S (test statistics) and the set of values for S for which we reject the hypothesis H_0 (rejection area or critical area) [11]. The conclusion of the test can be one of the following two:

- We reject H_0, because we obtained S in the rejection area and as an explanation we offer hypothesis H_1;
- We do not reject H_0, because we obtained S outside the rejection area and we do not have proof against H_0.

At hypotheses testing, two kinds of mistakes are possible:

- first kind error appears if H_0 is rejected when H_0 is correct,
- second kind error appears if H_0 is rejected when H_1 is correct.

Considering the hypotheses interpretation, it is usually more important not to make the first kind error, because in that way we would prove assertion that is not correct (hypothesis H_1). First kind error value maximum is the level of test significance and is marked with α. For the significance level value usually are taken the standard values 0.1,0.05,0.01. Standard choice is a convention which we do not need to stick to, but it provides comparison of different results, and it also facilitates calculations because standard tables can be used. By reducing the level of significance, the probability of second kind error increases. Let (X,Y) be a random vector. From two-dimensional distribution of vectors (X,Y) we take a circumference sample n: (X_1,Y_1), (X_2,Y_2),…, (X_n,Y_n). Here the pairs (X_i,Yi) are independent, while the random values from the same pair have specified common distribution and can be dependent, with correlation coefficient ρ. By method of moments we get evaluation for ρ:

$$r = \frac{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)\cdot\left(Y_i - \bar{Y}\right)}{\sqrt{\left(\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2\right)\cdot\left(\sum_{i=1}^{n}\left(Y_i - \bar{Y}\right)^2\right)}} \quad (1)$$

Statistics r is called the sample coefficient of correlation or the estimated value of the parameter ρ. For hypotheses testing, as for finding the confidence interval, of use is the following theoreme:

Theoreme 1: If random vector (X,Y) has two-dimensional normal distribution with ρ=0, then the statistics

$$t = r\sqrt{\frac{n-2}{1-r^2}} \quad (2)$$

has t(n-2) distribution.

Testing of hypothesis about simple linear equation coefficient on the basic set ρ, on the ground of its estimate from random sample r is based on the assumption about normality of common distribution for variables X and Y. During the testing we use t distribution of probabilities. Shown theoreme is used for testing the hypothesis Ho: ρ=0 in case when vector has normal distribution, or when the sample's circumference is big, so normal approximation can be accepted. Therefore, two hypothesis, in the order: Zero hypothesis H_0: ρ = 0 (in basic set there is no linear correlation between two variables) and Alternative hypothesis H_1: ρ ≠ 0 (in basic set there is linear correlation between two variables) are tested by correlation test.Simple linear correrlation coefficient in basic set ρ, ie. in sample r, can take values only in the interval -1 and 1, ie. $-1 \le \rho \le 1$ and $-1 \le r \le 1$. If the empirical points are scattered all over the diagram, then between the two variables there is no linear correlation and $r \approx 0$. If variables are not connected, r is equal to zero. When greater values of independantly variable X respond also to greater values of dependently variable Y and vice versa: by decrease in value of independent X, decline the values of dependent Y – then it is a positive correlation (r>0). Conversely, when greater values of independently variable X respond to smaller values of dependently variable Y, i.e. by decrease in value of independent X, increase the values of dependent Y – then it is a negative correlation (r<0). The general rule is: the closer the coefficient value of simple linear correlation to one, the interdependence between the observed phenomena is stronger. The correlation coefficient never has the values 1 or -1, because it would mean that between the phenomena there is a mathematical, not statistical connection.

Most commonly used parametric test of significance for testing the zero hypothesis is the Student's t-test. It is used for testing the significance of differences between two arithmetic means. Conditions for t-test application:

- both variables that are tested must be numerical,
- in case that the sample value is less than 30 units, the disposition should be normal or at least symmetrical.

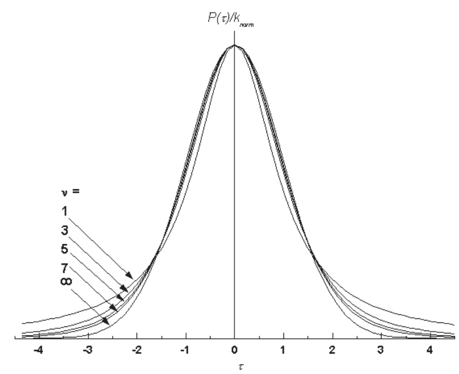


Fig.1 Student's t – distribution with ν degrees of freedom

Interpretation of obtained value of t-test is based on Student's t – disposition with ν degrees of freedom (Fig. 1) and Student's tables of t – disposition critical values. Function of t – distribution is symmetrically decreasing, and with increase in leeway degrees the surface enveloped by tails decreases, and the distribution increasingly approaches the standard normal distribution.

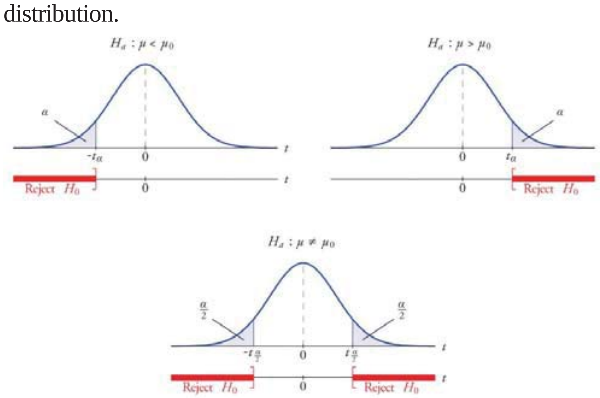


Fig. 2 Rules of accepting the H_0 hypothesis as correct, nd rejecting the alternative H_1

If the realized t-value is less than border table value for appropriate number ν and threshold (level) of significance, zero hypothesis is accepted as correct, and the alternative hypothesis is rejected:

- t-realized < t (ν and 0,05) ⇒ Ho is not rejected because the risk is bigger than 5% (p>0).

Reversely, if the realized t-value is equal or greater than the border table value, for corresponding number ν and threshold of significance, zero hypothesis is rejected as incorrect, and the alternative hypothesis is accepted:

- t-realized ≥ t (ν and 0,05) ⇒ zero hypothesis is rejected for risk level p=0,05, respectively for safety level P=0,95(95%);
- t-realized ≥ t (ν and 0,01) ⇒ H_0 is rejected for risk level p=0,01, respectively for safety level P=0,99 (99%).

4. CORRELATIONAL TEST CARRYING OUT ILLUSTRATION AT DETERMINING THE CRITERIA IN FORKLIFT CHOICE PROCEDURE

Generally, for the needs of multicriteria problems in choice of material handling equipment, different approaches have been developed [2,6,7,17,18]. Namely, at solving the multicriteria decision-making problem, and especially when it comes to the choice of material handling equipment, there is a variant when the criteria for choice of the most acceptable alternative are taken directly from manufacturers'catalogues. In that case, by applying the correlational test we expect to get the reduced and independent set of criteria. The reason for test application lies in the already mentioned fact that in literature there is no clearly defined procedure of criteria choice.

Therefore there is no unique set of criteria for choice, i.e. it varies and, besides that the criteria of choice must be independent, in literature prevails a tendency that their number has to be approximately seven. It is expected, at the same time, that models with fewer criteria become more sensitive to changes of criteria weights and lead to more expressed mutual distance of ranking results [21]. The aim is to establish the final number of independent criteria in situations when it is necessary, and then to apply some of the approaches for determination of relative weights or their significance (for example fuzzy AHP technique). On the base of correlational test it is possible to determine the intensity of already established connection between two variables, ie. for this purpose it is necessary to determine the degree of correlarion between two random variables.

For numerical illustration of correlational test in further works there will be considered an example of three wheel electro forklift choice within one logistical centre, in particular for the needs of handling the material within its transport – storage system. It is a multicriteria problem of equipment choice where, let us suppose, for ranking more alternatives of forklifts that satisfy in advance required parameters, for choice criteria the initial set of 20 characteristics was observed (Table 1). At this moment, the considered alternatives could be left aside because the goal is to show the procedure of defining the set of independent criteria for evaluation of alternative solutions. Starting sample that is considered consists of 25 forklifts of different manufacturers. Basic (starting) criteria are, one after the other (characteristics from manufacturers catalogs): A-Capacity (kg), B-Maximum lift height (mm), C- Travel speed with the load (km/h), D-Travel speed without the load (km/h), E-Lift speed with the load (m/s), F-Lift speed without the load (m/s), G-Turning radius (mm), H-Length to fork face (mm), I-Engine power (kW), J-Wheelbase (mm), K-Total width (mm), L-Noise level (dB), M-Battery voltage (V), N-Battery capacity (Ah), O-Tilt angle (°), P-Forklift mass (kg), Q-Forks length (mm), R-Oil pressure in the installation (bar), S-Battery weight (kg) and T-Total height to top of overhead guard (OG) (mm). Their initial values are collected from appropriate catalogs. The task is to, from sample of 25 different values that takes 20 variables, using the correlational test, determine the intensity of connection between two variables and in this way reduce the initial number of independent criteria for evaluation of alternative solutions.

So, from two-dimensional distribution of random vector (X,Y) there was taken a sample of circumference n=25: (X_1,Y_1), (X_2,Y_2),…, (X_{25},Y_{25}). Here the pairs of variables (Xi,Yi) are independent, while random values from the same pair have specified mutual distribution and can be dependent, with correlation coefficient r.

In the use of equation (1), n corresponds to the sample value of 25 forklifts, Xi, Yi represent the criteria pairs for which we calculate the correlation coefficient, and $\bar{X}$ and $\bar{Y}$ their average values.

$$r = \frac{\sum_{i=1}^{25}\left(X_i - \bar{X}\right)\cdot\left(Y_i - \bar{Y}\right)}{\sqrt{\left(\sum_{i=1}^{25}\left(X_i - \bar{X}\right)^2\right)\cdot\left(\sum_{i=1}^{n}\left(Y_i - \bar{Y}\right)^2\right)}} \qquad (3)$$

Table 1 Forklifts characteristical values for 20 criteria

Manufacturer	Model	Capacity (kg)	Max. lift height (mm)	Travel speed with the load (km/h)	Travel speed without the load (km/h)	Lift speed with the load (m/s)	Lift speed without the load (m/s)	Turning radius (mm)	Length to fork face (mm)	Engine power (kW)	Wheelbase (mm)
TOYOTA	7FBEST10	1000	3310	12	12.5	0.32	0.52	1230	1565	7.5	985
TOYOTA	7FBEST13	1250	3310	12	12.5	0.31	0.52	1400	1725	7.5	1145
TOYOTA	7FBEST15	1500	3310	12	12.5	0.3	0.52	1450	1780	7.5	1200
CAT	2ET2500	1300	3000	16	16	0.48	0.6	1440	1774	11.5	1249
CAT	2ETC3000	1600	3000	16	16	0.49	0.6	1548	1887	11.5	1357
CAT	2ETC3500	1800	3000	16	16	0.44	0.55	1548	1887	11.5	1357
CAT	2ETC4000	2000	3000	16	16	0.4	0.55	1655	1995	11.5	1465
HYSTER	J30XNT	1361	3032	15.7	15.7	0.39	0.65	1481	1808	4.8	1290
HYSTER	J35XNT	1588	3032	15.7	15.7	0.36	0.65	1577	1903	4.8	1386
HYSTER	J40XNT	1814	3032	15.7	15.7	0.34	0.65	1577	1903	4.8	1386
NISSAN	TX30N	1350	3300	14.5	14.5	0.34	0.515	1525	1895	10.7	1300
NISSAN	TX35N	1600	3300	14.5	14.5	0.31	0.515	1525	1895	10.7	1300
NISSAN	TX40N	1800	3300	16	16	0.32	0.6	1635	2005	14.6	1410
YALE	ERP13VC	1250	3320	12	12.5	0.3	0.51	1398	1724	6	1168
YALE	ERP15VC	1500	3320	12	12.5	0.3	0.51	1452	1778	6	1222
YALE	ERP15VT	1500	3320	16	16	0.43	0.59	1476	1805	12	1290
YALE	ERP16VT	1600	3320	16	16	0.43	0.59	1476	1805	12	1290
YALE	ERP18VT	1800	3390	16	16	0.41	0.58	1676	1896	12	1494
YALE	ERP20VT	2000	3390	16	16	0.4	0.58	1676	1999	12	1494
JUNGHEINRECH	EFG110	1000	3000	12	12.5	0.29	0.5	1293	1623	6	1038
JUNGHEINRECH	EFG113	1250	300	12	12.5	0.25	0.5	1401	1731	6	1146
JUNGHEINRECH	EFG115	1500	3000	12	12.5	0.24	0.5	1455	1785	6	1200
JUNGHEINRECH	EFG213	1300	3000	10	16	0.48	0.6	1440	1774	11.5	1249
JUNGHEINRECH	EFG218	1800	3000	10	16	0.44	0.55	1655	1995	11.5	1465
JUNGHEINRECH	EFG220	2000	3000	10	16	0.4	0.55	1655	1995	11.5	1465

Manufacturer	Model	Total width (mm)	Level of noise (dB)	Voltage (V)	Battery capacity (Ah)	Tilt (°)	Forklift mass (kg)	Forks length (mm)	Installation pressure (bar)	Battery weight (kg)	Total height to top of OG (mm)
TOYOTA	7FBEST10	990	62.4	24	400	5	2550	800	140	372	2055
TOYOTA	7FBEST13	990	62.4	24	700	5	2820	800	140	600	2055
TOYOTA	7FBEST15	990	62.4	24	800	5	2930	800	140	676	2055
CAT	2ET2500	1060	66	24	400	7	2698	1150	200	679	2040
CAT	2ETC3000	1060	66	24	500	7	2957	1150	200	812	2040
CAT	2ETC3500	1120	66	24	500	7	3213	1150	200	812	2040
CAT	2ETC4000	1120	66	24	600	7	3331	1150	200	974	2040
HYSTER	J30XNT	1050	69	36	750	5	2313	1067	155	670	2070
HYSTER	J35XNT	1050	69	36	800	5	2372	1067	155	670	2070
HYSTER	J40XNT	1116	69	36	1000	5	2390	1067	155	700	2070
NISSAN	TX30N	1105	61	36	680	4	2955	1070	140	700	2110
NISSAN	TX35N	1105	61	36	680	4	3155	1070	140	700	2110
NISSAN	TX40N	1105	61	48	750	4	3365	1070	140	1050	2110
YALE	ERP13VC	996	59	24	735	5	2700	1000	155	570	1980
YALE	ERP15VC	996	59	24	840	5	2905	1000	155	642	1980
YALE	ERP15VT	1050	65	48	500	5	2990	1000	180	673	2070
YALE	ERP16VT	1050	65	48	500	5	2990	1000	180	673	2070
YALE	ERP18VT	1116	65	48	750	5	3280	1000	180	962	2070
YALE	ERP20VT	1116	65	48	750	5	3290	1000	180	962	2070
JUNGHEINRECH	EFG110	990	63	24	625	5	2570	1150	160	481	2090
JUNGHEINRECH	EFG113	990	63	24	875	5	2760	1150	185	648	2090
JUNGHEINRECH	EFG115	990	63	24	1000	5	2870	1150	210	730	2090
JUNGHEINRECH	EFG213	1060	66	24	400	7	2698	1100	200	679	2040
JUNGHEINRECH	EFG218	1120	66	24	600	7	3156	1100	200	974	2040
JUNGHEINRECH	EFG220	1120	66	24	600	7	3331	1100	200	974	2040

After the calculated value of correlation coefficient for every pair of criteria, further testing of linear correlation coefficient is based on already mentioned Student's disposition with n-2 degrees of freedom, while the obtained t – value is interpreted in the same way as in the classic Student's t-test.

Statistical test p-value (significance level) is compared to predefined significance level α which is a proof of positive relation between two criteria. In this research α=0.01 was chosen as critical value.

In case that p-value is less than 0.01, we conclude that there is a proof of positive relation between two criteria and one of them can be eliminated.

It should be mentioned one more time that the test is mathematically defined by formula (2).

For the needs of this work, because of easier carrying out the extensive calculations when getting the values of correlation coefficient and statistical p-value, the shown procedure is automatized by development of program tools in the environment of Microsoft Excel. Given program tools have restrictions regarding the number of criteria, maximum 25.

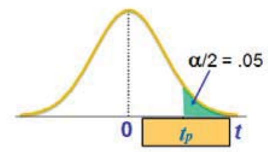
For arbitrary criteria pair (eg. Criterion A: Capacity and G: Turning radius) the program addition calculates t-value, twosided t-distributions with 23 (n-2) degree of freedom, by using the expression (2). For this arbitrary criteria par, t=12,263 and r=0.935. The program then determines, one after the other, onesided and twosided p – value in t – distribution (Table 2).

Table 2. Correlation coefficient and p-values for criteria pairs: A – to G; B – to G, C – to G D – to G; E – to G, F – to G

r	0.179	0.345	0.657	0.344	0.339	0.935
t_p	0.871	1.763	4.176	1.759	1.729	12.683
p	0.804	0.954	1.000	0.954	0.951	1.000
p-1	0.196	0.046	0.000	0.046	0.049	0.000
p-2	0.393	0.091	0.000	0.092	0.097	0.000
r		0.196	0.203	0.242	0.172	0.157
t_p		0.956	0.995	1.194	0.838	0.763
p		0.826	0.835	0.878	0.795	0.773
p-1		0.174	0.165	0.122	0.205	0.227
p-2		0.349	0.330	0.245	0.411	0.453
r			0.546	0.330	0.569	0.371
t_p			3.124	1.674	3.318	1.914
p			0.998	0.946	0.999	0.966
p-1			0.002	0.054	0.001	0.034
p-2			0.005	0.108	0.003	0.068
r				0.826	0.764	0.727
t_p				7.019	5.680	5.073
p				1.000	1.000	1.000
p-1				0.000	0.000	0.000
p-2				0.000	0.000	0.000
r					0.592	0.397
t_p					3.521	2.077
p					0.999	0.975
p-1					0.001	0.025
p-2					0.002	0.049
r						0.419
t_p						2.215
p						0.982
p-1						0.018
p-2						0.037

Values, in Table 2 are one after the other: r – correlation coefficient, t_p-obtained value for Student's distribution for significance level p, and p-1 and p-2 corresponding onesided and twosided p-value in t-distribution.

When p-value for every criteria pair is calculated, twosided p-value is entered into the matrix under the main diagonal (Table 3), whereby the pairs, whose p-values are less than previously defined value 0.01, are marked above the main diagonal by the sign "X".



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	Values of t for various probability levels, p							
	.75	.90	.95	.954	.975	.99	.995	.9995
21	.686	1.233	1.721	-	2.080	2.518	2.831	3.819
22	.686	1.321	1.717	-	2.074	2.508	2.819	3.792
23	.685	1.319	**1.714**	**1.759**	**2.069**	2.500	2.807	3.767
24	.685	1.318	1.711	.	2.064	2.492	2.797	3.745
25	.684	1.316	1.708	.	2.060	2.485	2.787	3.725
26	.684	1.315	1.706	.	2.056	2.479	2.779	3.707
27	.684	1.314	1.703	.	2.052	2.473	2.771	3.690
28	.683	1.313	1.701	.	2.048	2.467	2.763	3.674
29	.683	1.311	1.699		2.045	2.462	2.756	3.659
30	.683	1.310	1.697		2.042	2.457	2.750	3.646
⋮	⋮	⋮	⋮		⋮	⋮	⋮	⋮

Interpolation:

$$\left[\left(0,95-t_p\right)/\left(0.95-0.975\right)\right]/\left[\left(1.714-2.013\right)/\left(1.714-2.069\right)\right]=0.954$$

$$one-tailed\ p\text{-}value\ \left[\left(1-0,954\right)=0.046\right]$$

$$two-tailed\ p\text{-}value\ \left[2*0.028\right]=0,092$$

Fig.3. Values of t_p for Student's distribution with ν degrees of freedom

Elimination procedure itself, or reduction of criteria number (variables) that are in mutual correlation, from the shown table, could be presented through the following steps:

1. check if there are criteria which are not correlated to any other criteria (both by kind and column of given table), and if this is the case, they should be chosen for independent criteria;
2. check the correlation of every criteria (by kind) with other members, and if there is such criterion, choose it as independent one, other criteria in corelation discard;
3. If there are undeleted criteria left, go back to step 1, otherwise the process of correlation analysis is finished.

By using the listed rules of elimination procedure, the number of rules in this particular case is reduced from the original 20 to the following six criteria: A-Capacity (kg), B-Maximum lift height (mm), C- Travel speed with the load (km/h), E-Lift speed with the load (m/s), Q-Forks length (mm) and T-Total height to top of overhead guard (mm).

Thus obtained, the set of independent criteria satisfies the suggested number (seven plus or minus two) and it is possible to use it further on in the following stage of solving the multicriteria decision-making problems, i.e. in the procedure of determining their relative weights, and later also in the final ranking of suggested alternatives of the considered multicriteria problem.

All attention in the work is directed only to the representation of necessary criteria choice procedure for the procedure of solving the multicriteria decision-making problem in the procedure of equipment choice within one logistical system such as logistics centre.

Other steps of solving such a problem (multicriteria analysis), given in the introductory lines of the work, in this case were not considered.

Table 3 Criteria pairs correlation(pairs in correlation marked with "X")

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
A				X			X	X		X	X					X			X	
B	0.393																			
C	0.091	0.349		X		X							X							
D	0.000	0.330	0.005		X	X	X	X	X	X	X	X							X	
E	0.092	0.245	0.108	0.000		X			X	X	X	X		X	X			X		
F	0.097	0.411	0.003	0.000	0.002					X		X								
G	0.000	0.453	0.068	0.000	0.049	0.037		X	X	X	X					X			X	
H	0.000	0.479	0.088	0.000	0.068	0.057	0.000		X	X	X					X			X	
I	0.013	0.219	0.184	0.001	0.001	0.543	0.009	0.005		X	X			X		X			X	
J	0.000	0.377	0.038	0.000	0.009	0.009	0.000	0.000	0.006		X					X			X	
K	0.000	0.299	0.035	0.000	0.004	0.028	0.000	0.000	0.001	0.000						X			X	
L	0.081	0.716	0.094	0.000	0.002	0.000	0.060	0.105	0.970	0.018	0.033									
M	0.079	0.162	0.001	0.014	0.465	0.016	0.034	0.064	0.066	0.025	0.042	0.533			X					
N	0.408	0.317	0.910	0.079	0.000	0.682	0.383	0.482	0.003	0.685	0.496	0.555	0.601		X					
O	0.200	0.640	0.437	0.035	0.000	0.417	0.301	0.320	0.137	0.173	0.185	0.015	0.008	0.006				X		X
P	0.000	0.443	0.643	0.113	0.314	0.230	0.001	0.001	0.000	0.003	0.005	0.241	0.256	0.499	0.414				X	
Q	0.217	0.064	0.405	0.039	0.205	0.400	0.109	0.067	0.434	0.089	0.051	0.113	0.629	0.969	0.049	0.625		X		
R	0.079	0.203	0.862	0.031	0.004	0.602	0.128	0.188	0.083	0.075	0.190	0.029	0.286	0.172	0.000	0.139	0.001			
S	0.000	0.713	0.229	0.000	0.065	0.197	0.000	0.000	0.000	0.000	0.000	0.234	0.119	0.667	0.142	0.000	0.075	0.034		
T	0.993	0.442	0.158	0.625	0.248	0.736	0.669	0.520	0.518	0.836	0.354	0.682	0.015	0.347	0.009	0.808	0.536	0.276	0.676	

5. CONCLUSION

In the work itself, the fact was pointed out that solving the problem of decision-making requires firstly defining the criteria system, and then determining their relative significance before final ranking of the considered multicriteria problem alternatives. Also, the fact was pointed out that a unique set of criteria of considered problem most often is not available to decision-maker. Correlation test was used for getting a set of independent criteria, more precisely reduction of their number to operative and acceptable level for determining the relative weights and later on the procedure of ranking the alternatives.

In the end, it is also necessary to mention a few important limitations that follow the carrying out of correlation test. Firstly, correlation test determines only the level of correlation for every criteria pair, and as it is determined there is not a unique way of obtaining the set of independent criteria (seven plus or minus two). Set of independent criteria can be different for the same value of correlation coefficient, but also by changing the values of significance level, the number of pairs in correlation changes. In this way the pairs in correlation become the pairs without correlation and vice resa. It becomes clear that defining the set of independent criteria requires, in that case, repetition and check of procedure for choosing the set of seven plus or minus two independent criteria. However, the result of such approach can lead to a situation where the available criteria, i.e. the most commonly used ones in previous researches, can become preferential to the less significant criteria, and as such be used for solving the equipment choice problem. It is obvious that the model becomes more sensitive to changes of criteria weights, so for that purpose it is necessary to analyse also the statistically significant differences between the original and the reduced set of criteria to final ranking. In this way, by application of correlation test, we could come to a cognition whether and to which extent the final ranking of alternatives differs for the reduced number of criteria in relation to the original set.

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