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SELECTION OF FORKLIFT UNIT FOR WAREHOUSE OPERATION BY APPLYING MULTI-CRITERIA ANALYSIS

ABSTRACT

This paper presents research related to the choice of the criteria that can be used to perform an optimal selection of the forklift unit for warehouse operation. The analysis has been done with the aim of exploring the requirements and defining relevant criteria that are important when investment decision is made for forklift procurement, and based on the conducted research by applying multi-criteria analysis, to determine the appropriate parameters and their relative weights that form the input data and database for selection of the optimal handling unit. This paper presents an example of choosing the optimal forklift based on the selected criteria for the purpose of making the relevant investment decision.

KEYWORDS

multi-criteria analysis, Delphy method, investment management, logistics, forklift

1. INTRODUCTION

Handling of palette loads in warehouses that includes receiving, transport, disposal, as well as loading and unloading of goods, cannot be envisioned without appropriate transport/handling equipment, primarily forklift vehicles [1, 2]. There are many kinds and types of forklifts that are used in warehouses while their technical and operational characteristics depend mainly on the following: type of load, type and size of the warehouse designed for handling these loads and finally on the possibility of the warehouse managers to obtain optimal handling equipment that will meet their needs. In practice, big dilemmas regarding investment decision-making into appropriate transport/handling vehicles occur frequently due to various reasons: there are many vendors offering these products in the market, the prices vary and technical characteristics differ mutually in addition to the fact that branded products always carry some advantage in the market.

From the methodological aspect, the investment decision-making process during selection of the optimal forklift in this paper is based on the following steps:

1. Choice and selection of the criteria;
2. Application of the DELPHY method in the course of criteria evaluation (determining specific weight);
3. Ranking selected criteria by significance;
4. Analysis of the ranking results;
5. Selection of the relevant criteria – defining prevailing criteria in order to choose among all considered and analyzed criteria an optimal number with the highest relative values that are mutually stable;
6. Normalization of the values and allocation of the relative values to the selected criteria;
7. Multi-criteria analysis by applying the VIKOR method (selected multi-criteria method);
8. Verification of the proposed methodology procedure in the concrete example.

This paper analyses ten (10) criteria that can be prevailing for a company when making the decision for investing into transportation/handling units for warehouse operation, forklifts in this particular case.

The definition of the above mentioned criteria is based on the following:

1. Experience-based knowledge of the authors;

2. Research conducted in various companies that deal with internal transport, loading and unloading of palette goods;
3. System analyses performed with authorized representatives and sellers of transportation means from the aspect of experience they had with the customers.

The research started from the initial assumption that every forklift can perform a set task consisting of lifting, lowering and transport of the palette goods to the defined location. Investment decision-making in selecting the forklift unit is conditioned by the previously defined optimal criteria stated below:

1. K1 – purchase price;
2. K2 – average maintenance costs;
3. K3 – maximum bearing capacity;
4. K4 – maximum weight of the load during handling (bearing capacity);
5. K5 – fuel consumption;
6. K6 – service network;
7. K7 – manufacturer's warranty;
8. K8 – movement speed (with/without load);
9. K9 – lifting/lowering speed, and
10. K10 – supply of spare parts.

The stated number and type of criteria are adjusted to conditions in which the actual decision on the purchase of the specific transportation/handling vehicle is being made and does not exclude the possibility that under different conditions a different structure and number of the selected criteria may apply.

2. SELECTION AND DESCRIPTION OF CRITERIA

An optimal investment decision on procurement of necessary transport/handling units depends on the selection of appropriate optimal criteria and their evaluation. Both mentioned parameters are the result of the performed studies. Weights of the selected criteria, used in the said example, are taken from warehousing companies as well as representatives/distributors on the territory of the Republic of Serbia. The listed criteria are expressed in both numerical and descriptive values, so it is necessary in the process of surveying to weight them all descriptively or according to recommended scale with weights varying from 1 to 10.

Criterion K1 – purchase price: In any case, this is an important criterion, even without studying its weight. The prices of forklift units differ in the market and depend on the manufacturer. During the decision-making process, the purchase price should not be the prevailing element for the buyer. Of course, from the aspect of multi-criteria analysis and MIN-MAX strategy, MIN values are more desirable.

Criterion K2 – average maintenance costs: This criterion is one of the indicators showing the quality of the forklift unit. The maintenance costs are characterized by both direct and permanent costs. The research shows that the average maintenance costs vary from one model to another and from one manufacturer to another. In their technical instructions all manufacturers require periodic maintenance (change of oil, replacement of assemblies, chains, hydraulics, etc.) fully in accordance with the technical requirements and sustainable warranty. Here as well, from the aspect of multi-criteria analysis (MIN-MAX strategy), MIN values are more desirable.

Criteria K3 and K4 – maximum bearing capacity/ maximum weight of the load: These criteria are related to specific client's requirements and capability of the particular vehicle to respond to those requirements when handling the loads under certain conditions. Higher bearing capacity is in direct correlation with the purchase price of the unit. From the aspect of multi-criteria analysis (MIN-MAX strategy) MAX values are more desirable.

Criterion K5 – fuel consumption: Permanent direct operational cost of the unit powered by the internal combustion engine significantly affects the profit and total operational costs. From the aspect of multi-criteria analysis and MIN-MAX strategy, MIN values are more desirable.

Criterion K6 – service network: This criterion significantly affects the selection of the forklift unit. Lack of competent service network does not give the possibility to the client to expect that, in case of failure, the forklift will be repaired within a short period of time. The supply level of the service network with spare parts is also an indicator showing the service network quality. The development of the service network is based on the data showing the number of locations for maintenance/repair purposes in areas provided with authorized maintenance/repair shops and supply level of these shops with necessary spare parts. From the aspect of multi-criteria analysis (descriptive with YES – NO), more preferable is the YES value.

Criterion K7 – manufacturer's warranty: Manufacturer's warranty expressed in years is related to the warranty issued by the manufacturer confirming that all vital assemblies of the forklift unit are of good quality and reliable in operation for a certain - warranted number of years. During the warranty period all costs of repairs caused by the poor quality are borne by the manufacturer. The longer the warranty period, the more economical the product for the buyer. From the aspect of multi-criteria analysis (values 0-10), the higher value is preferred.

Criterion K8 – movement speed (with/without load): This criterion can also have an impact on the client's selection of the forklift. The movement speed, as an important transportation/handling characteristic of one forklift unit, directly affects the time required for the realization of a task as well as the number of units in operation. From the aspect of multi-criteria analysis (numerical values), the HIGHER value is preferred.

Criterion K9 – lifting/lowering speed: This criterion that denotes the time required for lifting/lowering operations in the course of transportation/handling work also affects the number of units required in operation. From the aspect of multi-criteria analysis (numerical values), the HIGHER value is preferred.

Criterion K10 – supply of spare parts: This criterion is similar to criterion K6. However, according to the experience-based knowledge, certain representatives that work in the Serbian market do not have in supply all of the required spare parts that are subject to frequent replacement, so that their delivery can take several weeks which prolongs the repair of the forklift unit. From the aspect of multi-criteria analysis (descriptive YES – NO), the YES value is preferred.

3. DELPHY METOD

The evaluation of the previously selected criteria was done by applying the DELPHY method based on the expert knowledge and appraisals obtained through the survey and statistic data processing. For the purpose of the paper herein, a suitable survey form was created, filled out by 20 competent experts engaged in: planning, transport realization and commercial (sales) activities.

The DELPHY METHOD was used in the evaluation of the defined optimal criteria because it showed excellent results during the past work [3, 4, 5, 6], especially when defining the relative weights of criteria in traffic-related projects (selection of the optimal traffic system, selection of the optimal transportation means, etc.) and civil engineering practice (selection of variant solutions during the preparation of general and preliminary designs in civil engineering and building construction, variant solutions for railway lines, roads, etc.) [7, 8, 9, 10]. This method is based on the knowledge accumulated by numerous experts in order to obtain the average values as well as relative weights $\acute{\omega}$ through comparison methods for the evaluation of certain conditions, criteria, and the like. In cases where the experts' opinions were significantly opposed, final appraisals and opinions regarding the particular issue were obtained through repeated iterations.

4. REQUIREMENTS AND SURVEY RESULTS

For the purpose of defining the relative weights of the stated criteria, the relevant survey was performed on a sample of 20 experts (N = 20) employed in different companies based on logistics as their core activity. Considering the survey form, every surveyed expert was also obliged to evaluate K1-K10 criteria based on their opinion on the scale from 1 to 10, where higher grade indicates higher significance of the analyzed criterion. The sum of all grades per one survey form carries 100 points.

All surveyed persons filled out the form correctly. For the purpose of processing the survey results, *Microsoft Office* package was used as well as SPSS program for statistic data processing. *Table 1* shows survey results according to the adopted criteria for every and each expert separately.

Table 2 shows standard deviations per criterion, and relative weights of every criterion separately, while *Table 3* shows criteria listed per sequence of relative weight values obtained through the processing of survey forms.

Total sum of relative weights is 1. According to *Table 3*, the biggest weight among the criteria K1-K10 is carried by the criterion K1 (purchase price) with relative weight of 0.1445, followed by criterion K7 (manufacturer's warranty) with relative weight of 0.143 and criterion K-6 (service network) with relative weight of 0.1235. The smallest relative weight is carried by criterion K9 (lifting/lowering speed) with the relative weight of 0.0485 and criterion K8 (movement speed with/without load) with the relative weight of 0.051. The range of relative weights shows that the selected criteria are characterized by certain instability. This instability refers particularly to the fact that, according to the conducted survey, criterion K1 has 2.979 times higher relative weight as compared to criterion K8, 2.8333 times higher relative weight as compared to criterion K9 and 2.3306 times higher relative weight as compared to criterion K4.

To avoid the domination of certain criteria, the number of criteria is to be optimized. Optimization of the number of criteria based on their relative weights reduces the original number of 10 criteria to 7 relevant ones. The reduction of the initial number of criteria K1-K10 provides relevant criteria to be used in the process of multi-criteria analysis for the defined alternatives. Once the relevant criteria that have sufficient advantage and stability have been defined, the final relative weights of criteria K1-K7 are obtained and shown in *Table 4*.

5. MULTI-CRITERIA ANALYSIS

The multi-criteria analysis is one of the methods in use for the selection of the optimal transport/handling unit. The paper herein uses "VIKOR" multi-criteria analysis, developed at the Faculty of Civil Engineering, the University of Belgrade [11, 12, 13]. Since the application of this method has achieved satisfactory results [8, 9, 10, 14, 15, 16] it was the best recommendation to use it through our work.

The "VIKOR" method has been developed based on the elements from compromise ranking.

Table 1 - Expert survey results

N survey/criterion	Purchase price	Average maintenance cost	Max. bearing capacity	Max. load weight	Fuel consumption	Service network	Manufacturer's warranty	Movement speed (with/without load)	Speed of lifting/lowering load	Spare parts supply	Total value
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	Σ
1	10	8	12	8	7	7	13	12	13	10	100
2	16	5	10	8	12	12	14	7	10	6	100
3	15	14	10	6	12	12	12	4	4	11	100
4	16	12	13	5	9	9	12	6	6	12	100
5	10	14	9	4	13	14	15	3	5	13	100
6	20	10	5	5	10	14	15	3	3	15	100
7	15	14	10	6	12	12	12	4	4	11	100
8	9	13	7	7	7	18	20	1	0	18	100
9	12	12	8	8	8	18	18	1	1	14	100
10	18	15	10	10	15	13	12	1	1	5	100
11	14	14	5	5	8	15	15	5	5	14	100
12	15	15	4	5	8	15	15	3	3	17	100
13	18	14	3	3	5	10	18	4	5	20	100
14	19	15	9	4	4	11	16	3	0	19	100
15	16	5	10	8	12	12	14	7	10	6	100
16	10	8	12	8	7	7	13	12	13	10	100
17	15	12	9	9	11	13	13	8	4	6	100
18	15	10	10	6	12	12	12	4	4	15	100
19	16	12	13	5	9	9	12	6	6	12	100
20	10	14	9	4	13	14	15	3	5	13	100
Total Σ	289	236	178	124	194	247	286	97	102	247	2,000

Table 2 - Standard deviations per criterion and relative weights of every criterion separately

N survey/criterion	Purchase price	Average maintenance cost	Max. bearing capacity	Max. load weight	Fuel consumption	Service network	Manufacturer's warranty	Movement speed (with/without load)	Speed of lifting / lowering load	Spare parts supply
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
Total Σ	289	236	178	124	194	247	286	97	102	247
Relative weight ώ	0.1445	0.1180	0.0890	0.0620	0.0970	0.1235	0.1430	0.0485	0.0510	0.1235
Standard deviation	3.268268494	3.155613211	2.845125101	1.935812083	2.939745782	3.030980387	2.319255779	3.150187964	3.796119903	4.392277913

Starting from the constraint forms of the *Lp* metrics used in compromise programming, for the *aj* alternative the following expressions are obtained:

$$S_j = \sum_{i=1}^{n} \omega_i \frac{f_i^* - f_{ij}}{f_i^* - f_j^-} \quad (\text{for } p = 1) \tag{1}$$

$$R_j = \max_i \omega_i \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \; (\text{for } p = \infty) \tag{2}$$

where:

n – criterion number;

ω_i – weight of criterion i

$$f_i^* = \max_j f_{ij}; \quad f_i^- = \min_j f_{ij}; \; i = 1, n$$

S_j – distance measure of $R(F,1)$ from the ideal point for alternative j;

R_j – distance measure of $R(F,\infty)$ from the ideal point for alternative j.

Ranking according to measures S_j and R_j provides two ranking lists of alternatives that significantly differ one from another. Measure S gives a ranking list where the best alternative is the one that obtains minimal S_j, i.e. where the biggest group benefit may be

Table 3 - Criteria listed dependent on relative weight values

No.	Criterion	Relative weights ῶ
1	K1	0.1445
2	K7	0.1430
3	K6	0.1235
4	K10	0.1235
5	K2	0.1180
6	K5	0.0970
7	K3	0.0890
8	K4	0.0620
9	K9	0.0510
10	K8	0.0485
TOTAL		1.0000

identified (advantage is given to satisfying the majority of the criteria). Measure R gives the ranking list where the best alternative is the one characterized by minimum deviation from the ideal solution (so-called minimax decision-making strategy), which implies that the better variant solution should not be also a very bad one according to certain criteria *fj*.

The alternative a_j is better than a_k if according to measure S the relation $S_j < S_k$ is satisfied, or if according to measure R the relation $R_j < R_k$ is obtained. Based on measures S_j and R_j the ranking of alternatives is performed and the position of alternative a_j is determined in $s(a_j)$ and $r(a_j)$ ranking lists.

In order to obtain the incorporated ranking list, a compromise programming with S_j and R_j as criteria functions is applied. In this double-criteria problem, the ideal alternative has the following benefit values:

$$S^* = \min_j S_j \tag{3}$$

$$R^* = \min_j R_j \tag{4}$$

The new ranking measure may be:

$$Q_j = vQS_j + (1-v)QR_j \tag{5}$$

where:

$$QS_j = \frac{S_j - S^*}{S^- - S^*}$$

$$QR_j = \frac{R_j - R^*}{R^- - R^*}$$

$$S^- = \max_j S_j$$

$$R^- = \max_j R_j$$

v – difficulty of the decision-making strategy by majority of criteria.

From the multi-criteria aspect, the alternative a_j is better than a_k, when ranked by Q, if $Q_j < Q_k$ is satisfied and has a higher position in the rank list.

Then, VIKOR introduces a modified measure R_j so that the value obtained from the expression

$$R_j = \max_i \omega \frac{f_i^* - f_{ij}}{f_i^* - f_j^-} \tag{6}$$

is added to r_j value that is determined based on the following relation:

$$r_j = \begin{cases} 0, & \text{if } R_j = R \\ \dfrac{S_j - R^-}{100}, & \text{if } R_j = R^- \text{ for two or more indices} \end{cases} \tag{7}$$

If all R_j values $j = 1,J$, are mutually different, the mentioned modification is not applied. This has been introduced in order to enable ranking according to R_j for cases when $R_j = 1$ for every j (this may happen when criteria weights ω_i are equal and when $n < J$).

From the multi-criteria aspect, the VIKOR method proposes as the best alternative the one that ranks first in the compromise ranking list for $v = 0.5$ only if it demonstrates:

- "sufficient advantage" over the successive alternative (condition *U1*), and
- "sufficiently stable" first position with the change of weight v (condition *U2*).

For the purpose of "advantage" evaluation, the difference between measures Q_j for $v = 0.5$ is applied. The alternative a' has sufficient advantage over the successive alternative a'' from the ranking list if:

$$Q(a'') - Q(a') \geq DQ \tag{8}$$

where DQ is the "advantage limit" that is defined based on theoretical values of Q and the number of variant solutions J as:

$$DQ = \min\left(0.25; \frac{1}{j-1}\right).$$

The number 0.25 is a limit value for cases characterized by a small number of alternatives.

Table 4 - Final relative weights of criteria K1-K7

No. of criterion	Initial mark of criterion	Description of the relevant criterion	Relative weights ῶ	Reduced relative weights ῶ for K1-K7
1	K1	Purchase price	0.1445	0.18
2	K7	Manufacturer's warranty	0.143	0.17
3	K6	Service network	0.1235	0.15
4	K10	Spare parts supply	0.1235	0.14
5	K2	Average maintenance cost	0.118	0.13
6	K5	Fuel consumption	0.097	0.12
7	K3	Max. bearing capacity	0.089	0.11

The first alternative in the compromise ranking list has "sufficiently" stable position if it fulfils at least one of the following conditions:

a) It has the first position in the ranking list according to *QS*;
b) It has the first position in the ranking list according to *QR*;
c) It has the first position in the ranking list according to *Q* for $v = 0.25$ and $v = 0.75$.

In case the first alternative from the compromise ranking list does not fulfil both *U1* and *U2* conditions, it is considered that the alternative is not "sufficiently" better than the alternative on the second position. In such cases the VIKOR method forms a group of compromise solutions that includes both first and second alternatives. If the first alternative does not fulfil only condition *U2* then the group of compromise solutions shall include only the second alternative from the compromise ranking list.

Results of the VIKOR method are as follows:

- Ranking lists according to measures *QR*, *Q* (for $v = 0.5$) and *QS*, and
- Compromise alternative or group of compromise solutions.

The obtained results are the basis for the decision-making process and the selection of the final (multi-criteria optimal) solution. The assessment of the alternatives is a process of documented evaluation and comparison of possible alternatives fully in accordance with their characteristics, with the aim of defining the optimal one. In order to enable this process to be adequately realized, the reliable basic documents shall be available and the criteria and indicators for the comparison purposes clearly defined and socially verified.

6. AN EXAMPLE OF SELECTING THE OPTIMAL TRANSPORT/HANDLING UNIT

The performed studies have their application in practice when an optimal forklift unit is to be selected for the purpose of warehouse operation. The selection of the optimal transport/handling unit (forklift) is a segment of the investment decision management process. For the purpose of testing the research herein, five (5) possible forklifts (alternatives) are analyzed, out of which the optimal alternative is to be selected for the Investor fully in accordance with the previously analyzed criteria (*Table 5*). Five (5) forklift models (alternatives) of different manufacturers were selected and analyzed. According to their basic characteristics, all selected forklift models meet the requirements for warehouse operation.

All considered criteria values (input values for multi-criteria analysis) such as purchase price, warranty period, service network, spare parts supply, average maintenance costs, fuel consumption and maximum bearing capacity have been taken from the forklift manufacturers. The manufacturers and models taken for the research purpose were not named due to legal reasons.

Based on the analyzed criteria and their weights, the alternative (optimization of investment activity) for selecting the most optimal forklift unit was chosen by applying the VIKOR multi-criteria method.

Based on the obtained results, the following may be concluded:

1. According to min-max strategy, the best – optimal solution is alternative V5;
2. According to compromise strategy, the best – optimal solution is alternative V2;
3. According to major benefit, the best – optimal solution is alternative V2.

Considering the input values for both chosen and selected criteria and input values, the group of alternatives – compromise solutions shows that the best – optimal choice is alternative V2, followed by alternatives V1 and V5 (characteristics of every and each alternative are shown in *Table 5*). The obtained result demonstrates that the multi-criteria analysis may be applied in investment decision management when selecting the optimal transport/handling unit - forklift. Alternative V2 showed sufficient advantage and stability (0.7%, 17.8% and 21.7%) as compared to alternatives V1 and V5.

Table 5 - Input values for multi-criteria analysis

ALTERNATIVES manufacturer, model and type Vi	CRITERIA						
	Purchase price (EUR)	Manufacturer's warranty (working hours)	Service network	Spare parts supply	Average maintenance cost (EUR/ working hour)	Fuel consumption (EUR/ working hour)	Max bearing capacity (t)
	0.18	0.17	0.15	0.14	0.13	0.12	0.11
V1	25,600	3,600	yes	yes	1.06	3	3.5
V2	18,900	4,200	no	yes	0.84	3.5	3.4
V3	27,800	4,000	yes	yes	1.14	3.2	4
V4	15,600	2,000	no	no	1.5	4	3.5
V5	22,500	3,800	yes	no	1.3	3.2	3.7

RESULTS

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    Alternative list
A 1. Forklift V 1
A 2. Forklift V 2
A 3. Forklift V 3
A 4. Forklift V 4
A 5. Forklift V 5

    Criteria list
f 1. Purchase price (EUR)
f 2. Manufacturers warranty (points)
f 3. Service network(grade)
f 4. Supply of spare parts (grade)
f 5. Average maintenance cost (EUR)
f 6. Fuel consumption (EUR)
f 7. Maximum bearing capacity(points)

  Extremization index
  0.  1.  1.  1.  0.  0.  1.

      Criteria function values
A 1    25600.000  3600.000     1.000     1.000     1.000     6.000     3.000
A 2    18900.000  4200.000     0.000     1.000     0.000    84.000     3.000
A 3    27800.000  4000.000     1.000     1.000     1.000    14.000     3.000
A 4    15600.000  2000.000     0.000     0.000     1.000     5.000     4.000
A 5    22500.000  3800.000     1.000     0.000     1.000     3.000     3.000
F*     15600.000  4200.000     1.000     1.000     0.000     3.000     4.000
F-     27800.000  2000.000     0.000     0.000     1.000    84.000     3.000

Al.no. \ Ranking list by individual criteria
A 1         4   4   1   1   2   3   2
A 2         2   1   4   2   1   5   3
A 3         5   2   2   3   3   4   4
A 4         1   5   5   4   4   2   1
A 5         3   3   3   5   5   1   5

Weighting values w(i)
   0.18   0.17   0.15   0.14   0.13   0.12   0.11
Weight v =   0.571


Ranking lists by measures : QR , Q and QS
QR – Minimax strategy,  Q – Compromise,  QS – Major benefit
  R.L.QR           R.L.Q and Q(J)         R.L.QS
  A 5  0.140         A 2   0.107         A 2  0.429
  A 1  0.148         A 1   0.114         A 1  0.438
  A 2  0.150         A 5   0.292         A 3  0.452
  A 4  0.170         A 3   0.509         A 5  0.513
  A 3  0.180         A 4   0.893         A 4  0.593

   RANKING LIST
   1. 0.107  forklift V 2
   2. 0.114  forklift V 1
   3. 0.292  forklift V 5
   4. 0.509  forklift V 3
   5. 0.893  forklift V 4

Compromise solution for final decision
 Group of alternatives                                Advantage
A 2.Forklift V 2                                        0.7 %
A 1.Forklift V 1                                       17.8 %
A 5.Forklift V 5                                       21.7 %

Preferential stability analysis
Weight intervals for individual criteria
F(i) S.  FAC.  WD(i)   WD1   W0(i)   WG1   WG(i)   FAC.  S.
F 1  3  0.997  0.179  0.179  0.180  0.194  0.471    4.1  2
F 2  3  0.946  0.162  0.162  0.170  1.000  1.000  888.8  3
F 3  1  0.000  0.000  0.147  0.150  0.150  0.150    1.0  3
F 4  3  0.646  0.095  0.095  0.140  0.144  0.146    1.1  2
F 5  3  0.983  0.128  0.128  0.130  0.142  1.000  888.8  1
F 6  2  0.000  0.000  0.077  0.120  0.122  0.122    1.0  3
F 7  3  0.589  0.068  0.068  0.110  0.135  0.192    1.9  4
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7. CONCLUSION

The paper shows the methodological approach to be applied for the selection of relevant criteria based on which the optimal forklift unit for warehouse operation will be chosen by using the multi-criteria analysis. Relative weights of criteria to be used as input parameters for the multi-criteria analysis were obtained through the conducted studies so that the optimal handling unit can be chosen. The methodology applied in this paper together with the obtained results can be very helpful in the investment decision-making process referring to the procurement of a new handling unit. The example used in this paper will show that the lowest market price of a forklift unit is not the key factor to be considered in making the decisions about procurement.

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ABSTRAKT

IZBOR VILJUŠKARA ZA RAD U SKLADIŠTU PRIMENOM VIŠEKRITERIJUSKE ANALIZE

U radu su prikazani rezultati istraživanja vezani za izbor kriterijuma pomoću kojih se može izvršiti optimalni izbor viljuškara za rad u skladištu. Analiza je sprovedena sa ciljem da se istraže zahtevi i definišu relevantni kriterijumi koji su bitni kada je u pitanju donošenje investicione odluke za nabavku viljuškara, te da se na osnovu sprovedenog istraživanja primenom višekrtirijumske analize, odrede odgovarajući parametri i njihove relativne težine koji čine ulazne podatke i bazu za izbor optimalnog sredstva. U radu je prikazan primer izbora optimalnog viljuškara na osnovu odabranih kriterijuma u funkciji donošenja odgovarajuće investicione odluke.

KLJUČNE REČI

višekriterijumska analiza, delphy metod, upravljanje investicijom, logistika, viljuškari

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