A forklift is a very important and common equipment for transporting materials in many different locations such as workshops, warehouses, supermarkets, etc. This equipment has the effects of reducing labor consumption of workers, ensuring the safety of goods and improving labor efficiency. That is why forklift selection is very important. In order to choose a forklift, it is necessary to consider many parameters such as lifting capacity, lifting height, travel speed, safety level, price, maintenance cost, level of impact on the environment, ease of use, etc. However, today there are many types of forklifts on the market, these forklifts have different specifications and prices, making it difficult for shoppers to choose a product in many available types. This study has applied multi-criteria decision-making (MCDM) methods for forklift selection. Two MCDM methods having been used are the COCOSO (Combined Compromise Solution) method and PIV (Proximity Indexed Value) method. Two different methods having also been used to calculate the weights for the criteria are the ENTROPY method and MEREC (Method based on the Removal Effects of Criteria) method. The selection of the best type of forklift applies to the six available types. Six criteria having been used to describe each alternative are lifting height, maximum lifting height, minimum lifting height, fork length, fork width, and price. Each MCDM method will be used in combination with two weight methods. Thus, the ranking results of forklifts are shown in four different series of numbers. An amazing result has occurred that the best and worst forklifts have been consistently determined to be the same in all cases examined. This is the outstanding advantage of the COCOSO and PIV methods compared to other MCDM methods

Keywords: forklift selection, MCDM method, COCOCO method, PIV method, weight method

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FORKLIFT SELECTION BY MULTI-CRITERIA DECISION-MAKING METHODS

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1. Introduction

A forklift is a very useful equipment for transporting heavy materials in workshops, warehouses, or supermarkets [1]. Using a forklift not only helps reduce energy consumption for workers but also improves labor productivity. Using a forklift also works to ensure the safety of heavy goods [2]. Therefore, forklift selection plays a very important role in the health of workers as well as the normal operation status of factories. However, the large number of forklifts available on the market with many different characteristics makes forklift selection a challenge for shoppers [3]. Many parameters should be considered when choosing a forklift such as price, maximum load to be lifted, maximum height to be lifted, travel speed, etc. That is, the selection of forklifts needs to consider many criteria. Therefore, the application of multi-criteria decision-making methods for forklift selection is necessary.

2. Literature review and problem statement

For forklift selection, many studies have been carried out using different MCDM methods. The weights of forklift criteria have also been calculated using different methods. In [4], the WASPAS method has been used to select the best alternative among ten types of old forklifts. Seven different parameters have been used to describe each alternative including price, year of manufacture, spent real time, lifting capacity, maximum lifting height, factors affecting the environment, and repairability upon problem occurrence. In this study, the weights of the criteria have been determined by the FUCOM method. When using the FUCOM method to calculate weights for criteria, asking customers' opinions about the importance of the criteria is necessary. This means that the weighting value of the criteria will depend on their opinions. In [5], the TOPSIS method has been used to select the best forklift from four different alternatives. Five parameters have been selected to describe each alternative including lifting weight, battery life, lifting height, maximum travel speed and selling price. In this study, the weights of the criteria have been designated according to the subjective opinions of the authors. So clearly the type of forklift chosen will depend on the subjective opinion of the buyer. In [6], the MOORA method has been used to rank ten different types of forklifts. The criteria having been used in this study include price, year of manufacture, spent real time, maximum lifting capacity, maximum lifting height, factors affecting the environment, and repairability upon problem occurrence. The FUCOM method has been also used to calculate the weights for seven criteria. In this case, the choice of forklift type still depends on the subjective opinion of the customer. In [7], the VIKOR method has been used to choose the best forklift from five different types. Ten different parameters including price, maintenance cost, lifting capacity, maximum lifting height, fuel consumption, product distribution network, manufacturer reputation, maximum travel speed, lifting speed and spare parts availability have been chosen as ten criteria for evaluating each alternative. The weights of the criteria have been calculated using the DELPHI method. This is a method of determining weights for criteria based on synthesizing the opinions of a number of respondents.

When using this method, the type of forklift selected also depends on the subjective opinions of the respondents. In [8], the VIKOR method has been used to rank seven different types of forklifts. The criteria are divided into three groups, including economic criteria, technical criteria, and safety criteria. In this study, the AHP method has been used to calculate the weights for the criteria. When using the AHP method to calculate weights for criteria, it is also necessary to ask customers' opinions about the priority order of the criteria. Each customer has different views on the importance of the criteria. Thus, choosing the type of forklift will not ensure objectivity. In [9], the MCRAT method has been used to rank six different types of forklifts. The criteria having been used include price, lifting height, lowering speed, lifting speed, lifting capacity, range requirements, manufacturer reputation and spare parts availability. The weights of these criteria have been calculated using the BWM method. When using the BWM method to calculate the weights for the criteria, we must also rely on the opinions of the respondents. That means the customer's subjective thoughts will govern the type of forklift selected. In [10], the MARCOS method has been used to rank four types of forklifts. Nine parameters have been selected as criteria for each type of forklift, including price, lifting capacity, lifting height, lifting speed, lowering speed, circling speed, battery life, noise, and spare parts availability. In this study, the CRITIC method has been used to calculate the weights for the criteria. This is a method that considers the correlation between criteria. This means that the weights of the criteria depend on each other. This can lead to conflicts in criteria within an option. In [11], the MABAC method has been used to rank seven types of forklifts. The DEMATEL method has been used to calculate the weights for the criteria. Ten criteria having been used include price, warranty period, product distribution network, spare parts availability, maintenance cost, fuel consumption, maximum lifting capacity, maximum lifting height, maximum travel speed at no load, and lifting and lowering speed. To use the DEMATEL method, a graph of the relationship between the criteria needs to be created. This is a very complicated job. On the other hand, the graph of the relationship between the criteria also depends on each person's point of view. Therefore, the type of forklift selected will also be influenced by each customer's personal perspective.

Some of the above studies have shown that different MCDM methods and weight methods have been widely used in the ranking of forklifts. However, when using MCDM methods to rank alternatives, a complication often occurs that is the phenomenon of rank inversion [12]. PIV is known to be a new method that has the advantage of minimizing rank inversion [13]. COCOSO is also known to be a new method that can minimize rank inversion [14]. However, so far, neither of these methods has been used to rank forklifts.

When using MCDM methods to rank forklifts, it is necessary to calculate the weights for the criteria [15]. Entropy is the weight method with high accuracy and has been recommended for use [16]. The MEREC method has also been recommended for use [17]. When using these two methods, the weighting of the criteria is based only on the obvious numbers without regard to the buyer's point of view. This will provide us with the most objective information, independent of any person's subjective opinion. However, no documents have been found that have applied these two methods (Entropy and MEREC) to calculate the weights for the criteria of forklifts. This gap will also be filled by this study. The simultaneous use of two MCDM (PIV and COCOSO) methods and two weight methods is to find the best forklift.

3. The aim and objectives of the study

The aim of this study is to determine the best forklift among the available alternatives.

To achieve the aim, the following objectives should be accomplished:

– to calculate the weights for the criteria using the Entropy method;

– to calculate the weights for the criteria using the MEREC method;

– to rank the forklifts using the COCOSO method;

– to rank the forklifts using the PIV method.

4. Materials and methods

4. 1. The Entropy method

Determination of the weights of the criteria using the Entropy method is performed in the following sequence [18].

Step 1. Calculate the normalized value for the criteria:

$$n_{ij} = \frac{y_{ij}}{m + \sum_{i=1}^{m} y_{ij}^2}. \quad (1)$$

In which, y_{ij} is the value of criterion j corresponding to alternative I; m is the number of alternatives.

Step 2. Calculate the value of Entropy measure for each criterion:

$$e_j = \sum_{i=1}^{m}\left[n_{ij}\cdot\ln\left(n_{ij}\right)\right] - \left(1-\sum_{i=1}^{m} n_{ij}\right)\cdot\ln\left(1-\sum_{i=1}^{m} n_{ij}\right). \quad (2)$$

Step 3. Calculate the weight for each criterion, where n is the number of criteria:

$$w_j = \frac{1-e_j}{\sum_{j=1}^{n}\left(1-e_j\right)}. \quad (3)$$

The application of the Entropy method to weighting the forklift criteria will be carried out in the next chapter of this paper.

4. 2. The Method based on the Removal Effects of Criteria method

The sequence to determine the weights of the criteria by the MEREC (Method based on the Removal Effects of Criteria) method is as follows [19].

Step 1. Calculate the normalized values in accordance with the two formulas (4) and (5). The formula (4) applies to the as-large-as-possible criteria, and the formula (5) applies to the as-small-as-possible criteria:

$$n_{ij} = \frac{\min y_{ij}}{y_{ij}}, \quad (4)$$

$$n_{ij} = \frac{y_{ij}}{\max y_{ij}}. \quad (5)$$

Step 2. Calculate the S_i and S'_{ij} values for each alternative in accordance with the two formulas (6) and (7), respectively:

$$S_i = Ln\left[1+\left(\frac{1}{n}\sum_{j}^{n}\left|Ln\left(n_{ij}\right)\right|\right)\right]. \quad (6)$$

$$S'_{ij} = Ln\left[1+\left(\frac{1}{n}\sum_{k,k\neq j}^{n}\left|Ln\left(n_{ij}\right)\right|\right)\right]. \quad (7)$$

Step 3. Calculate the E_j values and the weight w_j of the criteria in accordance with the two formulas (8) and (9), respectively:

$$E_j = \sum_{i=1}^{m}\left|S'_{ij} - S_i\right|. \quad (8)$$

$$W_j = \frac{E_j}{\sum_{j}^{n} E_j}. \quad (9)$$

The application of the MEREC method to weighting the forklift criteria will be carried out in the next chapter of this paper.

4. 3. The COmbined COmpromise SOlution method

The steps to rank the alternatives by the COCOSO (Combined Compromise Solution) method are as follows [20].

Step 1. Normalize data in accordance with the two formulas (10), (11):

$$n_{ij} = \frac{y_{ij} - \min y_{ij}}{\max y_{ij} - \min y_{ij}}. \quad (10)$$

$$ni_j = \frac{y_{ij} - \max y_{ij}}{\min y_{ij} - \max y_{ij}}. \quad (11)$$

The formula (10) applies to the as-large-as-possible criteria, and the formula (11) applies to the as-small-as-possible criteria.

Step 2. Calculate the S_i and P_i values in accordance with the two formulas (12) and (13), respectively:

$$S_i = \sum_{j=1}^{n}\left(w_j \cdot n_{ij}\right), \quad (12)$$

$$P_i = \sum_{j=1}^{n}\left(n_{ij}\right)^{w_j}. \quad (13)$$

In which, w_j is the weight of the j^{th} criterion.

Step 3. Calculate the k_{ia}, k_{ib}, and k_{ic} values in accordance with the formulas (14), (15) and (16), respectively:

$$k_{ia} = \frac{P_i + S_i}{\sum_{j=1}^{n}\left(P_i + S_i\right)}. \quad (14)$$

$$k_{ib} = \frac{S_i}{\min S_i} + \frac{P_i}{\min P_i}. \quad (15)$$

$$k_{ic} = \frac{\lambda \cdot S_i + (1-\lambda)P_i}{\lambda \cdot \max S_i + (1-\lambda)\max P_i}. \quad (16)$$

In [20], λ is a coefficient, usually chosen as 0.5.

Step 4. Calculate the k_i values in accordance with the formula (17):

$$k_i = \left(k_{ia} \cdot k_{ib} \cdot k_{ic}\right)^{1/3} + \frac{1}{3}\left(k_{ia} + k_{ib} + k_{ic}\right). \quad (17)$$

Step 5. Rank the alternatives, the best alternative is the one with the largest k_i.

4. 4. The Proximity Indexed Value method

The ranking of alternatives by the *PIV* (Proximity Indexed Value) method is performed in the following sequence [21].

Step 1. Calculate the normalized values in accordance with the formula (18):

$$n_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{m} y_{ij}^2}}. \quad (18)$$

Step 2. Calculate the normalized values taking into account the weights of the criteria in accordance with the formula (19):

$$v_{ij} = w_j \cdot n_{ij}. \quad (19)$$

Step 3. Calculate the u_i values in accordance with the two formulas (20) and (21). For the as-large-as-possible criteria, the formula (20) will be used. The formula (21) will be used for the as-small-as-possible criteria:

$$u_i = v_{\max} - v_i. \quad (20)$$

$$u_i = v_i - v_{\min}. \quad (21)$$

Step 5. The formula (22) is used to calculate the scores of the alternatives:

$$d_i = \sum_{i=1}^{m} u_i. \quad (22)$$

Step 6. Rank the alternatives in accordance with the principle that the alternative with the smallest d_i is the best one.

5. Ranking results of forklifts

5. 1. Calculation of the weights for the criteria using the Entropy method

Six types of small forklifts have been used for the ranking in this study. In accordance with the information from the supplier, six parameters have been used to describe each product, including:

*C*1: Maximum lifting capacity (kg);
*C*2: Maximum lifting height (mm);
*C*3: Minimum lifting height (mm);
*C*4: Fork length (mm);
*C*5: Fork width (mm);
*C*6: Price (million Vietnamese dong).

The two criteria *C*3 and *C*6 are as small as possible, the remaining four criteria are as large as possible. Data on six types of forklifts are summarized in Table 1.

The normalized values have been calculated in accordance with the formula (1), as shown in Table 2.

Table 1

Types of forklifts

Criteria / Type	C1	C2	C3	C4	C5	C6
Forklift-1	2,000	200	80	1,150	550	4.75
Forklift-2	2,000	200	80	1,220	685	4.95
Forklift-3	2,500	200	80	1,150	550	4.95
Forklift-4	2,500	200	80	1,220	685	5.15
Forklift-5	3,000	200	80	1,150	550	5.35
Forklift-6	3,000	220	60	1,220	685	5.5

Table 2

Normalized values in the Entropy method

Criteria / Type	C1	C2	C3	C4	C5	C6
Forklift-1	5.195×10^{-5}	0.00081	0.00225	0.00014	0.00024	0.02915
Forklift-2	5.194×10^{-5}	0.00081	0.00225	0.00014	0.00030	0.03038
Forklift-3	6.493×10^{-5}	0.00081	0.00225	0.00014	0.00024	0.03038
Forklift-4	6.493×10^{-5}	0.00081	0.00225	0.00014	0.00030	0.03160
Forklift-5	7.792×10^{-5}	0.00081	0.00225	0.00014	0.00024	0.03283
Forklift-6	7.792×10^{-5}	0.00089	0.00169	0.00014	0.00030	0.03375

The e_j and w_j values are calculated in accordance with the two formulas (2) and (3), respectively. The results are summarized in Table 3.

Table 3

e_j and w_j values in the Entropy method

Criteria / Par.	C1	C2	C3	C4	C5	C6
e_j	−0.0034	−0.0300	−0.0664	−0.0066	−0.0116	−0.4819
w_j	0.1520	0.1561	0.1616	0.1525	0.1533	0.2245

The weights of the criteria that have been calculated by the Entropy method will be used to rank the forklifts in the next section of this paper.

5. 2. Calculation of the weights for the criteria using the Method based on the Removal Effects of Criteria method

The two formulas (4) and (5) have been used to calculate the normalized values, the results are shown in Table 4.

Table 4

Normalized values in the MEREC method

Criteria / Type	C1	C2	C3	C4	C5	C6
Forklift-1	1.0000	1.0000	1.0000	1.0000	1.0000	0.8636
Forklift-2	1.0000	1.0000	1.0000	0.9426	0.8029	0.9000
Forklift-3	0.8000	1.0000	1.0000	1.0000	1.0000	0.9000
Forklift-4	0.8000	1.0000	1.0000	0.9426	0.8029	0.9364
Forklift-5	0.6667	1.0000	1.0000	1.0000	1.0000	0.9727
Forklift-6	0.6667	0.9091	0.7500	0.9426	0.8029	1.0000

The S_i values have been calculated in accordance with the formula (6), the results are as shown in Table 5.

The S'_{ij} values have been calculated in accordance with the formula (7), the results are as shown in Table 6.

Table 5

S_i values

Criteria / Type	C1	C2	C3	C4	C5	C6
Forklift-1	0.0241	0.0241	0.0241	0.0241	0.0241	0.0241
Forklift-2	0.0620	0.0620	0.0620	0.0620	0.0620	0.0620
Forklift-3	0.0533	0.0533	0.0533	0.0533	0.0533	0.0533
Forklift-4	0.0904	0.0904	0.0904	0.0904	0.0904	0.0904
Forklift-5	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697
Forklift-6	0.1637	0.1637	0.1637	0.1637	0.1637	0.1637

Table 6

S'_j values

Criteria / Type	C1	C2	C3	C4	C5	C6
Forklift-1	0.0241	0.0241	0.0241	0.0241	0.0241	0.0000
Forklift-2	0.0620	0.0620	0.0620	0.0527	0.0270	0.0454
Forklift-3	0.0174	0.0533	0.0533	0.0533	0.0533	0.0365
Forklift-4	0.0558	0.0904	0.0904	0.0813	0.0564	0.0803
Forklift-5	0.0046	0.0697	0.0697	0.0697	0.0697	0.0654
Forklift-6	0.1046	0.1501	0.1221	0.1553	0.1321	0.1637

The two formulas (8) and (9) have been used respectively to calculate the E_j and w_j values, the results are as shown in Table 7.

Table 7

E_j and w_j values in the MEREC methods

Criteria / Par.	C1	C2	C3	C4	C5	C6
E_j	0.1947	0.0136	0.0416	0.0267	0.1005	0.0719
w_j	0.4335	0.0302	0.0926	0.0595	0.2239	0.1602

Thus, the calculation of the weights of the criteria by the two Entropy and MEREC methods has ended. These sets of weights will be used in conjunction with MCDM methods in the ranking of forklifts in the next part of this paper.

5. 3. Ranking of forklifts using the Combined Compromise Solution method

The normalized values have been calculated in accordance with the two formulas (10) and (11), the results are summarized in Table 8.

Table 8

Normalized values in the COCOSO method

Criteria / Type	C1	C2	C3	C4	C5	C6
Forklift-1	0.00	0.00	0.00	0.00	0.00	1.00
Forklift-2	0.00	0.00	0.00	1.00	1.00	0.73
Forklift-3	0.50	0.00	0.00	0.00	0.00	0.73
Forklift-4	0.50	0.00	0.00	1.00	1.00	0.47
Forklift-5	1.00	0.00	0.00	0.00	0.00	0.20
Forklift-6	1.00	1.00	1.00	1.00	1.00	0.00

The S_i, P_i, k_{ia}, k_{ib}, k_{ic} and k_i values have been calculated in accordance with the formulas (12)–(16), respectively.

In Tables 9, 10, they are respectively the values of these parameters and the ranks of the forklifts when using the two different weight methods.

Table 9

Some parameters in the COCOSO method and ranks of alternatives when the weights of the criteria are calculated by the Entropy method

Par. / Type	S_i	P_i	k_{ia}	k_{ib}	k_{ic}	k_i	Rank
Forklift-1	0.2245	1.0000	0.0658	2.1401	0.2120	1.1163	6
Forklift-2	0.4704	2.9327	0.1830	5.3216	0.5892	2.8622	3
Forklift-3	0.2407	1.8327	0.1115	3.0548	0.3590	1.6714	4
Forklift-4	0.4866	3.7427	0.2274	6.2135	0.7323	3.4025	2
Forklift-5	0.1969	1.6967	0.1018	2.6967	0.3279	1.4903	5
Forklift-6	0.7755	5.0000	0.3105	8.9377	1.0000	4.8214	1

Table 10

Some parameters in the COCOSO method and ranks of alternatives when the weights of the criteria are calculated by the MEREC method

Par. / Type	S_i	P_i	k_{ia}	k_{ib}	k_{ic}	k_i	Rank
Forklift-1	0.1602	1.0000	0.0617	2.0000	0.1987	1.0439	6
Forklift-2	0.4009	2.9515	0.1782	5.4539	0.5741	2.8919	3
Forklift-3	0.3343	1.6920	0.1077	3.7782	0.3470	1.9316	5
Forklift-4	0.5750	3.6255	0.2232	7.2141	0.7193	3.7691	2
Forklift-5	0.4656	1.7727	0.1189	4.6784	0.3833	2.3244	4
Forklift-6	0.8398	5.0000	0.3103	10.2412	1.0000	5.3208	1

Thus, the combination of the COCOSO method and MEREC weight method gives us the priority order of forklift trucks in the following order: Forklift-6 > Forklift-4 > Forklift-2 > Forklift-5 > Forklift-3 > Forklift-1.

5. 4. Ranking of forklifts using the Proximity Indexed Value method

The normalized values have been calculated in accordance with the formula (18), the results are as shown in Table 11.

The formulas from (19) to (22) have been applied to calculate the u_i and d_i values. In the two Tables 12, 13, a number of parameters in the PIV method and ranks of forklifts have been summarized when the weights of the criteria are calculated by the two different methods.

Table 11

Normalized values in the PIV method

Criteria / Type	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$
Forklift-1	0.3223	0.4013	0.4240	0.3960	0.3615	0.3791
Forklift-2	0.3223	0.4013	0.4240	0.4201	0.4502	0.3951
Forklift-3	0.4029	0.4013	0.4240	0.3960	0.3615	0.3951
Forklift-4	0.4029	0.4013	0.4240	0.4201	0.4502	0.4111
Forklift-5	0.4835	0.4013	0.4240	0.3960	0.3615	0.4270
Forklift-6	0.4835	0.4414	0.3180	0.4201	0.4502	0.4390

Table 12

Some parameters in the PIV method and ranks of alternatives when the weights of the criteria are calculated by the Entropy method

Par. / Type	u_i						d_i	Rank
	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$		
Forklift-1	0.0245	0.0063	0.0171	0.0037	0.0136	0.0000	0.0652	6
Forklift-2	0.0245	0.0063	0.0171	0.0000	0.0000	0.0036	0.0515	4
Forklift-3	0.0123	0.0063	0.0171	0.0037	0.0136	0.0036	0.0565	5
Forklift-4	0.0123	0.0063	0.0171	0.0000	0.0000	0.0072	0.0428	2
Forklift-5	0.0000	0.0063	0.0171	0.0037	0.0136	0.0108	0.0514	3
Forklift-6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0134	0.0134	1

Table 13

Some parameters in the PIV method and ranks of alternatives when the weights of the criteria are calculated by the MEREC method

Par. / Type	u_i						d_i	Rank
	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$		
Forklift-1	0.0699	0.0012	0.0098	0.0014	0.0199	0.0000	0.1022	6
Forklift-2	0.0699	0.0012	0.0098	0.0000	0.0000	0.0026	0.0835	5
Forklift-3	0.0349	0.0012	0.0098	0.0014	0.0199	0.0026	0.0698	4
Forklift-4	0.0349	0.0012	0.0098	0.0000	0.0000	0.0051	0.0511	3
Forklift-5	0.0000	0.0012	0.0098	0.0014	0.0199	0.0077	0.0400	2
Forklift-6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0096	0.0096	1

Thus, the ranking of forklifts by the two COCOSO and PIV methods with the two weight methods (Entropy and MEREC) has been completed. In Fig. 1, it is a chart comparing the ranking results of forklifts by different methods.

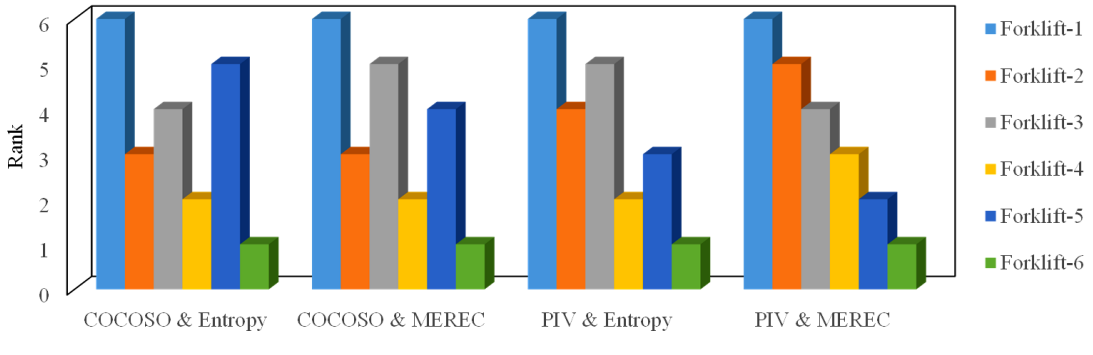

Fig. 1. Ranking of forklifts

In the next part of this paper, the ranking results of forklifts by different methods will be discussed.

6. Discussion of the ranking results of forklifts

The chart analysis in Fig. 1 shows that:

– the ranking results of forklifts are not exactly the same when using different MCMD methods. This is also consistent with claims in some published documents [13, 14];

– the ranking results of forklifts are not exactly the same when using different weight methods. This issue has also been mentioned in many previous documents [4, 22, 23];

– forklift No. 1 has been always determined to be the worst, forklift No. 6 has been always determined to be the best of the six alternatives reviewed.

The limitation of this study is that it only ranked forklifts based on six criteria. Forklift selection will become more comprehensive if other criteria such as warranty period, maintenance cost, factors affecting the environment, ease of use, etc. are considered. This is the work to be done in the near future.

The disadvantage of this study is that the weighting of the criteria does not take into account the opinion of the decision-maker. When considering the opinion of the decision-maker, the PIPRECIA method can be used [24]. Then you need to conduct a survey to ask the experts about the importance of the criteria.

7. Conclusions

1. When using the Entropy method, the weights of maximum lifting capacity, maximum lifting height, minimum lifting height, fork length, fork width and price have been determined as 0.1520, 0.1561, 0.1616, 0.1525, 0.1533 and 0.2245, respectively.

2. When using the MEREC method, the weights of maximum lifting capacity, maximum lifting height, minimum lifting height, fork length, fork width and price have been determined as 0.4335, 0.0302, 0.0926, 0.0595, 0.2239 and 0.1602, respectively.

3. The ranking results of forklifts by the COCOSO method show that forklift No. 1 is the worst type, on the contrary, forklift No. 6 is the best type.

4. The ranking results of forklifts by the PIV method show that forklift No. 1 is the worst type, on the contrary, forklift No. 6 is the best type. The best forklift is the one with a lifting capacity of 3,000 kg, a maximum lifting height of 200 mm, a minimum lifting height of 60 mm, a fork length of 1,220 mm, a fork width of 685 mm, and a price of 5.5 million VND.

Conflicts of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

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