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# Evaluation and Selection of Best Priority Sequencing Rule in Job Shop Scheduling using Hybrid MCDM Technique

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**Abstract.** Priority Sequencing Rules provide the guidance for the order in which the jobs are to be processed at a workstation. The application of different priority rules in job shop scheduling gives different order of scheduling. More experimentation needs to be conducted before a final choice is made to know the best priority sequencing rule. Hence, a comprehensive method of selecting the right choice is essential in managerial decision making perspective. This paper considers seven different priority sequencing rules in job shop scheduling. For evaluation and selection of the best priority sequencing rule, a set of eight criteria are considered. The aim of this work is to demonstrate the methodology of evaluating and selecting the best priority sequencing rule by using hybrid multi criteria decision making technique (MCDM), i.e., analytical hierarchy process (AHP) with technique for order preference by similarity to ideal solution (TOPSIS). The criteria weights are calculated by using AHP whereas the relative closeness values of all priority sequencing rules are computed based on TOPSIS with the help of data acquired from the shop floor of a manufacturing firm. Finally, from the findings of this work, the priority sequencing rules are ranked from most important to least important. The comprehensive methodology presented in this paper is very much essential for the management of a workstation to choose the best priority sequencing rule among the available alternatives for processing the jobs with maximum benefit.

## 1. Introduction

Job sequencing is determining the order in which jobs are processed at one or more workstations. Generally, a variety of tasks are carried out at each workstation. When workstations are densely loaded, the order of processing is very crucial in terms of costs associated with jobs waiting for processing and the cost of idle time at the workstations. If schedules are not precisely planned to avoid job traffic jam, waiting lines will develop. Such situations become complicated and lay pressure on management to establish scheduling procedures to process the workload efficiently.

In this line of direction, there are a number of priority sequencing rules or heuristics that are used to select the order in which the jobs will be processed at a workstation. The decision about which job to be processed next is made with priority sequencing rules whenever the workstation becomes available for further processing. Employing priority sequencing rules is worthwhile as the last minute information on operating conditions is also integrated into schedule as it evolves. The effectiveness of any given sequence generated by a priority sequencing rule is judged in terms of performance measures. Some of the performance measures are mean job completion time, average number of jobs in the system, mean job tardiness, utilization etc. Selecting the best priority sequencing rule to



determine the sequence of processing the jobs at a workstation is a challenging problem. Out of the usable priority sequencing rules, no choice is clearly the best for a management of a workstation to decide. Hence, a thorough method of selecting the right choice is essential in managerial decision making perspective. The methodology which is adopted should be able to structure complex problems well by considering multiple criteria explicitly so that it leads to more informed and improved decisions. The methods which fulfil the above said quality are multi criteria decision making (MCDM) techniques.

MCDM techniques consider and solve decision and planning problems comprising multiple criteria. Their objective is to support decision-makers in taking the best decision. The analytic hierarchy process (AHP) is a well-structured MCDM technique in this line of direction. The AHP method is a decision-making approach developed by Saaty [1,2,3]. Since the AHP approach is based on judgements from a decision maker having real time knowledge and experience, it agrees well with the behaviour of the decision maker. Rangone developed an analytic hierarchy process framework for measuring and comparing the overall performance of various manufacturing divisions based on non-financial and financial performance criteria [4]. Kamal adopted the analytic hierarchy process (AHP) for superior decision making in project management i.e. for selection of best contractor to execute a project [5]. Author presented group decision making using the AHP and used Expert Choice professional software for implementing the AHP. Liang developed AHP-based model for evaluation of project continuation or termination which is based on benchmarking method [6]. Author illustrated the formulated approach using research and development (R&D) case study in Taiwan. Tahriri formulated AHP based supplier selection model and utilized it in a steel manufacturing company in Malaysia [7]. Amanda et al. opted the analytic hierarchy process (AHP) with ratings for prioritization of research and development projects in a Brazilian aerospace institution [8]. Dalalah et al. adopted the analytic hierarchy process (AHP) for selection of cranes [9]. Authors considered three crane types as alternatives and used Expert Choice software to perform experimental assessments. Subramanian and Ramanathan reviewed the literature to find the significant research gaps that exist in the application of the AHP method and prepared a comprehensive listing of AHP applications [10]. Sivakumar et al. adopted analytic hierarchy process (AHP) and Taguchi loss functions for evaluation and selection of relevant vendor for the production process in the green mining industries based on economic, environmental benefits and risk factors [11]. Luthra et al. investigated the barriers in the supply chain to implement sustainable consumption and production (SCP) and evaluated fifteen barriers using Analytic hierarchy process (AHP) to determine their relative importance [12].

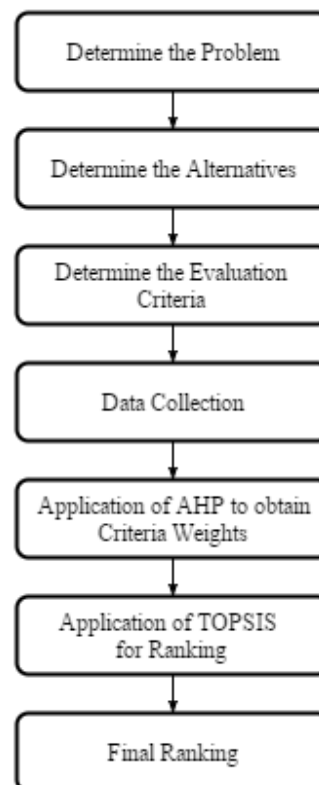
In recent times, the concept of competitive benchmarking is adopted in establishing performance measures and setting goals to measure the present product performance against that of best companies [13,14]. The competitive benchmarking led to the evolution of the technique for order preference by similarity to ideal solution (TOPSIS) to solve MCDM complications. The uncommon feature of TOPSIS technique is that the chosen alternative has the closest geometric distance from the positive ideal solution (PIS) and the farthest geometric distance from the negative ideal solution (NIS). Aizhen adopted TOPSIS method for thorough and extensive assessment of environmental quality [15]. Li-juan highlighted the significance of supplier selection in supply chain management (SCM) and formulated a model for supplier selection using TOPSIS technique [16]. Wang and Hsu employed TOPSIS technique to evaluate the business operation performance of ten listing companies in the Taiwan stock market to guide investors in selection of target stock shares and investment financial programs [17]. Tong adopted TOPSIS method to derive the overall performance index (OPI) for multiple responses and to determine the optimal factor/level combination with the maximum OPI value [18]. Huang et al. proposed a combined entropy weight and TOPSIS method for selection of suitable information system [19]. Vijay and Sankar presented a logical procedure using TOPSIS method for evaluation of CNC machines in terms of specifications and cost [20]. Li et al. adopted entropy weight and TOPSIS method for evaluation of safety conditions of four coal mines in order to improve the safety levels and ensure safe production of coal mines [21]. Monjezi et al. adopted TOPSIS as a MCDM technique to investigate the blasting operation in a lime stone mine and to select the most relevant blasting

pattern[22]. Lin et al. presented an integrated approach adopting analytic hierarchy process (AHP) and the technique for order preference by similarity to ideal solution (TOPSIS) to facilitate designers in identifying customer requirements and design characteristics [23]. Bhutia and Phiponadopted combined AHP and TOPSIS hybrid methodology for supplier selection in a supply chain cycle [24]. They have calculated the priority weights for each criterion based on Analytic Hierarchy Process (AHP) and then applied these weights to the TOPSIS method to rank suppliers. In this paper, an integrated methodology is demonstrated for evaluating and selecting the best priority sequencing rule by using hybrid multi criteria decision making technique (MCDM), i.e., analytical hierarchy process (AHP) coupled with technique for order preference by similarity to ideal solution (TOPSIS).

The remainder of this paper is classified as follows. The proposed model, AHP methodology and TOPSIS methodology are discussed in section 2. Then in section 3, the study area job shop sequencing, priority sequencing rules (alternatives) and performance measures (evaluation criteria) are explained. In section 4, numerical illustration of the proposed methods and results are presented. And lastly section 5 concludes the paper.

## 2. The Proposed Model

The overall procedure of the present study is shown in Figure 1. After determining the study area i.e. job shop sequencing, different priority sequencing rules are identified. Then for evaluation and selection of the best priority sequencing rule, the criteria are determined. According to these criteria, the required data for the entire procedure is collected from the related workstation. After building the evaluation criteria hierarchy, the criteria weights are determined by applying the AHP method. The performances of the alternatives corresponding to the evaluation criteria are performed and tabulated. Finally, MCDM technique TOPSIS is employed to obtain the final ranking results. The major steps of the entire procedure are described in detail in the following subsections.



**Figure 1.** The Overall Procedure.

### 2.1. Analytic Hierarchy Process (AHP) Methodology

The Analytic Hierarchy Process (AHP) is a multi-criteria decision making technique that allows qualitative and quantitative, financial and non-financial measures to be considered and trade-offs among them to be addressed. The AHP technique integrates different measures into a single global score for ranking the alternatives. It is mainly based on pair-wise comparison judgements [5]. The AHP methodology is described in seven steps.

**Step 1:** Formulation of relative comparison decision matrix (A)

$$A_{M \times M} = [b_{ij}] = \begin{bmatrix} 1 & b_{12} & b_{13} & \dots & \dots & b_{1M} \\ \frac{1}{b_{12}} & 1 & b_{23} & \dots & \dots & b_{2M} \\ \frac{1}{b_{13}} & \frac{1}{b_{23}} & 1 & \dots & \dots & b_{3M} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \frac{1}{b_{1M}} & \frac{1}{b_{2M}} & \dots & \dots & \dots & 1 \end{bmatrix}$$

where  $i, j = 1, 2, \dots, M$ .

Let  $C_1, C_2, \dots, C_M$  denote the set of criteria, while  $b_{ij}$  represents a quantified judgement on a pair of criteria,  $C_i$  and  $C_j$ . Saaty [1,2,3] constituted a measurement scale for pair-wise comparison.

**Step 2:** Computation of normalized decision matrix. Each set of column values is added and then each value is divided by its respective column sum value.

**Step 3:** Calculation of priority weights. The mean of rows of normalized decision matrix is determined and the priority weights of the decision-maker's criteria are obtained. A set of  $M$  numerical weights  $w_1, w_2, \dots, w_M$  are determined.

**Step 4:** Determination of the vector  $Aw^T$ , where  $A$  is the pairwise comparison matrix and  $w^T$  is the  $M$ -dimensional column weight vector.

**Step 5:** Computation of  $\frac{1}{M} \sum_{i=1}^{i=M} \frac{i^{\text{th}} \text{ entry in } AW^T}{i^{\text{th}} \text{ entry in } W^T}$

**Step 6:** Calculation of the Consistency Index (CI)

$$CI = \frac{(\text{Step 5 Result}) - M}{M - 1}$$

**Step 7:** Comparison of Consistency Index (CI) to the Random Index (RI) for the proper value of  $M$ . The value of the Random Index is found from Table 1.

**Table 1.** The Random Index Table.

Matrix Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.124	1.32	1.41	1.46

CR (consistency ratio) is the final ratio to be determined. If consistency ratio is lesser than 0.1, the pairwise comparison matrix is consistent and the attained weights can be used. The CR is computed

as follows:  $CR = \frac{CI}{RI}$ .

## 2.2. TOPSIS Methodology

**Step 1:** Determine a decision matrix for the ranking. The matrix structure is expressed as follows:

$$M = \begin{matrix} & F_1 & F_2 & \cdots & F_j & \cdots & F_n \\ \begin{matrix} a_1 \\ a_2 \\ \vdots \\ a_i \\ \vdots \\ a_j \end{matrix} & \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1j} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2j} & \cdots & f_{2n} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ f_{i1} & f_{i2} & \cdots & f_{ij} & \cdots & f_{in} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ f_{j1} & f_{j2} & \cdots & f_{jj} & \cdots & f_{jn} \end{bmatrix} \end{matrix}$$

Where  $a_j$  represents the alternatives,  $j = 1, 2, 3, \dots, J$ ;  $F_i$  denotes  $i_{th}$  attribute or criterion,  $i = 1, 2, 3, \dots, n$  and  $f_{ij}$  is a crisp value specifying the performance rating of each alternative  $a_j$  against each criterion  $F_i$ .

**Step 2:** Determine the normalized decision matrix  $R(=[r_{ij}])$ . The normalized value  $r_{ij}$  is computed as:

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^J f_{ij}^2}} \quad j = 1, 2, 3, \dots, J; \quad i = 1, 2, 3, \dots, n.$$

This step converts various dimensional attributes into non-dimensional attributes that allows comparisons across criteria.

**Step 3:** Determine the weighted normalized decision matrix. It is obtained by multiplying the normalized decision matrix by its associated weights. The weighted normalized value  $v_{ij}$  is determined as:

$$v_{ij} = w_i \times r_{ij} \quad j = 1, 2, 3, \dots, J; \quad i = 1, 2, 3, \dots, n.$$

Where  $w_i$  denotes the weight of the  $i_{th}$  criterion or attribute and  $\sum_{i=1}^n w_i = 1$ .

**Step 4:** Determine the positive-ideal solution (PIS) and negative-ideal solution (NIS).

$$A^* = \left\{ \tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_i^* \right\} = \left\{ \left( \max_j v_{ij} \mid i \in I' \right), \left( \min_j v_{ij} \mid i \in I'' \right) \right\}$$

$$i = 1, 2, 3, \dots, n; \quad j = 1, 2, 3, \dots, J.$$

$$A^- = \left\{ \tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_i^- \right\} = \left\{ \left( \min_j v_{ij} \mid i \in I' \right), \left( \max_j v_{ij} \mid i \in I'' \right) \right\}$$

$$i = 1, 2, 3, \dots, n; \quad j = 1, 2, 3, \dots, J.$$

Where  $I'$  is associated with the benefit criteria and  $I''$  is associated with the cost criteria.

**Step 5:** Determine the separation measures, adopting the n-dimensional Euclidean distance. The separation of each alternative from the PIS ( $D_j^*$ ) is calculated as follows:

$$D_j^* = \sqrt{\sum_{i=1}^n (v_{ij} - v_i^*)^2} \quad j = 1, 2, 3, \dots, J.$$

Likewise, the separation of each alternative from the NIS ( $D_j^-$ ) is calculated as follows:

$$D_j^- = \sqrt{\sum_{i=1}^n (v_{ij} - v_i^-)^2} \quad j = 1, 2, 3, \dots, J.$$

**Step 6:** Determine the relative closeness to the ideal solution. The relative closeness of the alternative  $a_j$  is obtained as:

$$CC_j^* = \frac{D_j^-}{D_j^* + D_j^-} \quad j=1,2,3,\dots,J.$$

Where the  $CC_j^*$  index value varies between 0 and 1. The higher the index value implies the better the performance of the alternatives.

**Step 7:** Rank the preference order.

### 3. Job Shop Sequencing

Several jobs need to be carried out at one or more workstations. Generally, different types of tasks are performed at each workstation. If schedules are not cautiously planned to avoid blockage, waiting lines will develop. Such complex situations put pressure on administration to work out scheduling procedures to manage the workload effectively. One way to develop schedules in job shops is by adopting priority sequencing rules, which allows the schedule for a workstation to evolve over a period of time. The selection of job to be processed is made with priority sequencing rules whenever the workstation is ready for further processing.

Priority sequencing rules are simple heuristics adopted to select the sequence in which the jobs are to be processed. The most common are mentioned below.

- First come, first served (FCFS): Jobs are processed in the order in which they arrive at the workstation.
- Last come, first served (LCFS): Jobs are processed in the order of last to first in which they arrive at the workstation.
- Shortest processing time (SPT): Jobs are processed in order of the processing time required at the workstation, with the job requiring the least processing time at the workstation scheduled first.
- Longest processing time (LPT): Jobs are processed in order of the processing time required at the workstation, with the job requiring the longest processing time at the workstation scheduled first.
- Earliest due date (EDD): Jobs are processed in the order in which they are due for delivery to the customer.
- Critical ratio (CR): Jobs are processed in order of increasing critical ratio (the ratio of time required by work left to be done to time left to do the work)
- SLACK - Jobs are processed in order of increasing slack time (time until due date minus remaining time to process)

The above mentioned priority sequencing rules are generally based on the following assumptions.

- The set of jobs is known; no new jobs arrive after processing begins; and no jobs are cancelled.
- Setup time is deterministic.
- Setup time is independent of processing sequence.
- Processing time is deterministic.
- There will be no interruptions while processing such as machine breakdowns, accidents etc.

Priority sequencing rules try to minimize completion time, number of jobs in the system, and job lateness, while maximizing facility utilization. The effectiveness of any given sequence is judged through performance measures. The criteria (performance measures) for evaluating job sequencing rules are listed below.

$C_1$ -Average number of jobs in the system

$C_2$ -Utilization

$C_3$ -Average job tardiness

$C_4$ -Total flow time

$C_5$ -Maximum job tardiness

$C_6$ -Total tardiness

$C_7$ -Average job completion time

#### C<sub>8</sub>-Makespan/Total processing time

Here only second criterion is a benefit criterion and the others are cost criteria. From the available priority sequencing rules, no choice is clearly the best. Hence, a comprehensive method of selecting the right choice is required. For evaluating and selecting the best priority sequencing rule, a hybrid multi criteria decision making technique (MCDM), i.e., analytical hierarchy process (AHP) with technique for order preference by similarity to ideal solution (TOPSIS) is adopted and demonstrated in the following sections.

### 4. Numerical Illustration

Our application is related to selecting the right choice from the available priority sequencing rules for a workstation located in Vellore. The management desires to find the best rule from the seven alternatives. A committee of decision makers is formed and the required data for the entire procedure is collected from the workstation.

#### 4.1. Analytic Hierarchy Process (AHP) Methodology

In this section, AHP technique is applied to calculate the weights of the criteria. To determine the relative weights, decision makers are asked to make pairwise comparisons using a suitable scale shown in Table 2. Then, a comprehensive pair-wise comparison matrix is built by unifying their grades. The final pair-wise comparison matrix is built as in Table 3. As per the procedure stated in section 2.1 the priority weights are calculated and tabulated in Table 3. From Table 3 as the CR (Consistency Ratio) value is less than 0.1, the judgements are acceptable.

**Table 2.** The Fundamental Scale for Pairwise Comparisons.

Intensity of Importance	Definition
1	Equal importance
3	Moderate Importance
5	Strong importance
7	Very strong importance
9	Extreme importance

<sup>a</sup>Intensities of 2,4,6 and 8 are used to express intermediate values. Intensities of 1.1,1.2,1.3, etc. are used for elements that are very close in importance.

**Table 3.** Pairwise Comparison Matrix and Priority Weights.

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	Priority Weights	Consistency Index	Random Index
C <sub>1</sub>	1.000	2.000	0.500	2.500	4.000	3.000	0.400	1.500	0.1396		
C <sub>2</sub>	0.500	1.000	0.333	2.000	3.500	3.000	0.286	0.667	0.0954		
C <sub>3</sub>	2.000	3.000	1.000	3.500	4.500	4.000	0.500	2.500	0.2114		
C <sub>4</sub>	0.400	0.500	0.286	1.000	2.000	1.500	0.250	0.400	0.0594	0.0276	1.41
C <sub>5</sub>	0.250	0.286	0.222	0.500	1.000	0.667	0.167	0.222	0.0344		
C <sub>6</sub>	0.333	0.333	0.250	0.667	1.500	1.000	0.200	0.286	0.0446		
C <sub>7</sub>	2.500	3.500	2.000	4.000	6.000	5.000	1.000	3.000	0.2927		
C <sub>8</sub>	0.667	1.500	0.400	2.500	4.500	3.500	0.333	1.000	0.1225		
Consistency Ratio										0.0196	

#### 4.2. Application of TOPSIS Method

The weights of the criteria are calculated by AHP till now, and then these values will be used in TOPSIS. Processing time (including setup times) and due dates for six jobs waiting to get processed at the workstation are collected and tabulated in Table 4.



**Table 4.** Data collected from Workstation.

Job	Processing Time (days)	Due Date (days)
A	2	7
B	8	16
C	4	4
D	10	17
E	5	15
F	12	18

The performance measures (Criteria) with respect to each of the priority sequencing rules (alternatives) are calculated and tabulated in Table 5. Thus Table 5 is considered as the pairwise comparison decision matrix of alternatives with respect to each criterion. The normalized decision matrix is formed as in Table 6. After the weighted normalized decision matrix is formed, positive ideal solution (PIS) and negative ideal solution (NIS) are determined as in the following:

$$A^* = [0.0412, 0.0432, 0.0439, 0.0176, 0.011, 0.0093, 0.0865, 0.0463]$$

$$A^- = [0.0685, 0.0261, 0.1248, 0.0291, 0.0167, 0.0263, 0.1434, 0.0463]$$

Then the separation of each alternative from PIS and NIS are calculated, i.e. the  $D_j^*$  and the  $D_j^-$  of the seven alternatives are calculated by using formulae given in section 2.2 and tabulated in Table 7.

**Table 5.** Performance Measures calculation with respect to Priority Sequencing Rules.

	Average no. of jobs in the system	Utilization (in %)	Average job tardiness (days)	Total flow time (days)	Maximum job tardiness (days)	Total tardiness (days)	Average job Completion Time (days)	Total Processing time /Makespan (days)
FCFS	2.93	34.17	9	120	23	54	20	41
LCFS	4.07	24.55	16	167	34	96	27.83	41
SPT	2.63	37.96	6.67	108	23	40	18	41
LPT	4.37	22.91	18	179	35	108	29.83	41
EDD	2.68	37.27	6.33	110	23	38	18.33	41
CR	3.24	30.83	9.67	133	24	58	22.17	41
SLACK	3.24	30.83	9.5	133	26	57	22.17	41

**Table 6.** Normalized Decision Matrix.

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>
FCFS	0.3289	0.4076	0.2952	0.3285	0.3183	0.2952	0.3285	0.3780
LCFS	0.4569	0.2929	0.5249	0.4571	0.4706	0.5249	0.4571	0.3780
SPT	0.2953	0.4529	0.2188	0.2956	0.3183	0.2187	0.2956	0.3780
LPT	0.4906	0.2733	0.5905	0.4900	0.4844	0.5905	0.4899	0.3780
EDD	0.3009	0.4446	0.2076	0.3011	0.3183	0.2078	0.3010	0.3780
CR	0.3637	0.3678	0.3172	0.3640	0.3322	0.3171	0.3641	0.3780
SLACK	0.3637	0.3678	0.3116	0.3640	0.3599	0.3116	0.3641	0.3780

### 4.3. Results and Discussion

Finally, the closeness coefficients of seven alternatives are calculated by this formula:

$$CC_j^* = \frac{D_j^-}{D_j^* + D_j^-} \quad j=1,2,3,\dots,J .$$

These values are tabulated in Table 7. According to the closeness

coefficients of seven alternatives, the ranking order of the seven alternatives is determined as EDD> SPT> FCFS> SLACK> CR> LCFS> LPT. In the chosen case study EDD is determined as the most appropriate priority sequencing rule for processing the jobs in the workstation. In other words, EDD rule is closer to the PIS and farther from the NIS.

**Table 7.** Computations of  $D_j^*$ ,  $D_j^-$  and  $CC_j^*$ .

	$D_j^*$	$D_j^-$	$CC_j^*$	Ranking order
FCFS	0.02225	0.08424	0.7910	3
LCFS	0.08827	0.01795	0.1690	6
SPT	0.00240	0.10431	0.9775	2
LPT	0.10620	0.00006	0.0006	7
EDD	0.00199	0.10497	0.9814	1
CR	0.03371	0.07291	0.6838	5
SLACK	0.03291	0.07383	0.6917	4

### 5. Conclusion

The objective of this study is to demonstrate the methodology of evaluating and selecting the best priority sequencing rule for processing jobs at a workstation by using hybrid multi criteria decision making technique (MCDM). This paper used analytical hierarchy process (AHP) to derive criteria weights based on pairwise comparison and adopted technique for order preference by similarity to ideal solution (TOPSIS) for evaluating and selecting the best priority sequencing rule. Then the numerical illustration (case study) of eight main criteria and seven alternatives is taken into consideration and the methodology is applied to it. The results guide the management of the workstation to choose the best priority sequencing rule among the available alternatives for processing the jobs with maximum benefit. For further research, the usage of fuzzy sets to describe uncertainties in different factors can be incorporated and hybrid MCDM techniques can be adopted under fuzzy environment.

### References

- [1] Saaty TL 1990 *European journal of operational research*. **489**-26.
- [2] Saaty TL 1990 *Decision making for leaders: the analytic hierarchy process for decisions in a complex world*.RWS publications.
- [3] Saaty TL and Kearns KP 2014 *Analytical planning: The organization of system*. Elsevier.
- [4] Rangone A 1996 *International Journal of Operations & Production Management*.**16**104-19.
- [5] Al-Harbi KM2001 *International journal of project management*. **19**19-27.
- [6] Liang WY 2003 *Benchmarking: An International Journal*.**10**445-56.
- [7] Tahriri F, Osman MR, Ali A, Yusuff RM and Esfandiary A 2008 *Journal of Industrial Engineering and Management*. **15**4-76.
- [8] da Silva AC, Belderrain MC and Pantoja FC 2011 *Journal of Aerospace Technology and Management*. **23**39-48.
- [9] Dalalah D, Al-Oqla F and Hayajneh M 2010 *Jordan Journal of Mechanical and Industrial Engineering*. **45**67-78.
- [10] Subramanian N and Ramanathan R 2012 *International Journal of Production Economics*.**138**215-41.
- [11] Sivakumar R, Kannan D and Murugesan P 2015 *Resources Policy*. **46**64-75.
- [12] Luthra S, Mangla SK, Xu L and Diabat A 2016 *International Journal of Production Economics*.

- [13] Camp RC Benchmarking: the search for industry best practices that lead to superior performance 1989 *Milwaukee, Wis.: Quality Press; Quality Resources.*
- [14] Zairi M and Leonard P 1994 *Practical Benchmarking: The Complete Guide.* Springer Science & Business Media.
- [15] Aizhen LC 1999 [*J.*]. *JOURNAL OF GEOLOGICAL HAZARDS AND ENVIRONMENT PRESERVATION.* **2**.
- [16] Li-juan MA 2002 [*J.*]. *Industrial Engineering and Management.* **6008**.
- [17] Wang TC and Hsu JC Evaluation of the business operation performance of the listing companies by applying TOPSIS method 2004 *InSystems, Man and Cybernetics, 2004 IEEE International Conference.* **2** 1286-1291. IEEE.
- [18] Tong LI, Wang CH, Chen CC and Chen CT 2004 *European Journal of Operational Research.* **156**433-44.
- [19] Huang J Combining entropy weight and TOPSIS method for information system selection 2008 *In2008 IEEE Conference on Cybernetics and Intelligent Systems.* 1281-1284. IEEE.
- [20] Athawale VM and Chakraborty S A TOPSIS method-based approach to machine tool selection 2010 *InInternational conference on Industrial engineering and operations management.*
- [21] Li X, Wang K, Liu L, Xin J, Yang H and Gao C Application of the entropy weight and TOPSIS method in safety evaluation of coal mines 2011 *Procedia Engineering.* **262**085-91.
- [22] Monjezi M, Dehghani H, Singh TN, Sayadi AR and Gholinejad A 2012 *Arabian journal of geosciences.* **5**95-101.
- [23] Lin MC, Wang CC, Chen MS and Chang CA 2008 *Computers in industry.* **59**17-31.
- [24] Bhutia PW and Phipon R 2012 *IOSR Journal of Engineering.* **2**43-50.