

SESSION A:

EARTH MOVING AND TRANSPORTATION MACHINERY

A hybrid SWARA–MULTIMOORA approach for production job prioritization

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ABSTRACT

Efficient prioritization of production jobs is a critical task in manufacturing systems, especially in environments with limited resources, multiple customer orders, and conflicting operational objectives. Production managers must determine which jobs should be processed first while considering several criteria such as due date urgency, profit margin, processing time, customer importance, and setup time. This decision-making problem can be effectively addressed using multi-criteria decision-making (MCDM) methods. In this paper, a hybrid SWARA–MULTIMOORA model is proposed for prioritizing production jobs. The SWARA (Step-wise Weight Assessment Ratio Analysis) method is applied to determine the relative importance of evaluation criteria based on expert judgment, while the MULTIMOORA (Multi-Objective Optimization by Ratio Analysis plus the Full Multiplicative Form) method is used to rank production jobs. The proposed approach is illustrated through a case study involving five production orders in a manufacturing environment. The results demonstrate that the model provides a systematic, transparent, and practical decision-support tool for production managers, enabling more effective scheduling decisions and improved utilization of manufacturing resources. The proposed methodology can be easily integrated into existing production planning and scheduling systems.

KEYWORDS

Job prioritization, Production planning, MCDM, Decision support systems.

1. INTRODUCTION

In today's highly competitive manufacturing environment, efficient production planning and scheduling have become essential for achieving operational excellence and maintaining customer satisfaction. Manufacturing companies are constantly challenged by increasing product variety, fluctuating customer demands, limited production capacities, and strict delivery deadlines. Under such conditions, production managers must continuously make complex decisions regarding the prioritization and sequencing of production jobs in order to optimize the utilization of available resources and minimize production delays. Production job prioritization represents one of the most important activities in manufacturing systems because it directly affects delivery performance, production efficiency, operational costs, and customer relationships [1]. In practice, production managers are often required to determine which production order should be processed first while simultaneously considering several conflicting criteria. These criteria may include due date urgency, profit margin, customer importance, processing time, setup time, machine availability, and production costs. Since these criteria are usually conflicting in nature, the decision-making process becomes significantly more complicated. Traditional production scheduling approaches frequently rely on simple dispatching rules such as First Come First Served (FCFS), Shortest Processing Time (SPT), or Earliest Due Date (EDD). Although such methods are easy to implement, they often fail to provide satisfactory solutions in complex manufacturing environments where multiple decision criteria must be considered simultaneously [2]. Consequently, manufacturing organizations increasingly apply multi-criteria decision-making (MCDM) methods to improve the quality and consistency of scheduling decisions.

Multi-criteria decision-making methods provide systematic and structured approaches for evaluating alternatives according to multiple criteria. These methods help decision-makers analyze complex problems, reduce subjectivity, and improve

the transparency of decision-making processes. Various MCDM techniques have been widely applied in manufacturing systems, including AHP, TOPSIS, VIKOR, ELECTRE, MOORA, and MULTIMOORA methods [3],[4], [5]. Among these methods, MULTIMOORA has attracted considerable attention due to its robustness, simplicity, and ability to provide reliable ranking results through the integration of multiple evaluation mechanisms. In addition to alternative ranking methods, determining the relative importance of evaluation criteria is also a crucial step in MCDM problems. The SWARA (Step-wise Weight Assessment Ratio Analysis) method has become increasingly popular for criteria weighting because it enables experts to express their judgments in a simple and flexible manner. Unlike some traditional weighting methods, SWARA requires fewer pairwise comparisons and allows decision-makers to determine criteria importance through a step-wise evaluation process. This paper proposes a hybrid SWARA–MULTIMOORA model for prioritizing production jobs in manufacturing systems. The SWARA method is employed to determine the weights of evaluation criteria based on expert opinions, while the MULTIMOORA method is used to rank production jobs according to their overall performance. The proposed model aims to support production managers in making more rational, transparent, and efficient scheduling decisions. To demonstrate the applicability of the proposed methodology, a case study involving five production jobs is presented. The jobs are evaluated according to several important production criteria, including due date urgency, profit margin, customer importance, processing time, and setup time. The obtained results illustrate the effectiveness of the hybrid model in identifying production priorities and improving decision-making quality in manufacturing environments.

The main contribution of this study is the development of an integrated decision-support framework that combines the advantages of SWARA and MULTIMOORA methods for production job prioritization. The proposed approach provides practical benefits for manufacturing organizations by enabling better resource allocation, improved production scheduling, and enhanced operational performance. The remainder of this paper is organized as follows. Section 2 explains the proposed SWARA–MULTIMOORA methodology. Section 3 presents the case study and computational procedure. Section 4 discusses the obtained results, while Section 5 provides concluding remarks and recommendations for future research.

2. METHODOLOGY

This section presents the proposed hybrid SWARA–MULTIMOORA methodology for prioritizing production jobs in manufacturing systems. The methodology consists of two main phases. In the first phase, the SWARA method is used to determine the relative importance of evaluation criteria based on expert judgments. In the second phase, the MULTIMOORA method is applied to rank production jobs according to the obtained criteria weights [6].

The proposed methodology enables decision-makers to evaluate production jobs systematically while considering multiple conflicting criteria simultaneously. The overall framework of the proposed model is illustrated through the following steps:

- Definition of evaluation criteria and production jobs,
- Determination of criteria weights using SWARA,
- Construction of the decision matrix,
- Application of the MULTIMOORA method,
- Ranking of production jobs according to final results.

2.1. Applications of SWARA and MULTIMOORA Methods

Numerous studies have applied SWARA and MULTIMOORA methods to solve complex industrial and manufacturing problems. Researchers have demonstrated that these methods provide reliable and practical solutions in environments characterized by uncertainty, conflicting objectives, and multiple evaluation criteria. The SWARA method has been applied in supplier selection, risk assessment, logistics management, personnel evaluation, and manufacturing strategy development [7]. Due to its flexibility and simplicity, SWARA is particularly useful in situations where expert judgment is required to determine the relative importance of criteria. Several studies have shown that SWARA provides consistent and realistic criteria weights while reducing the computational burden associated with traditional weighting approaches. Similarly, MULTIMOORA has been successfully utilized in various engineering and manufacturing applications, including machine selection, facility location, project evaluation, material selection, and production optimization [8]. Researchers have emphasized that the integration of multiple ranking mechanisms within MULTIMOORA improves ranking stability and increases the reliability of final decisions. In manufacturing environments, hybrid MCDM models combining weighting and ranking methods have become increasingly common [9], [10], [11].

The integration of SWARA with ranking methods such as TOPSIS, VIKOR, and MOORA has demonstrated promising results in solving complex production and operational problems. Hybrid approaches allow decision-makers to benefit from the strengths of multiple methods simultaneously. Despite the growing number of studies involving MCDM methods in manufacturing systems, limited research has focused specifically on the application of hybrid SWARA–MULTIMOORA models for production job prioritization. Most existing studies primarily concentrate on supplier selection, machine evaluation, or strategic decision-making problems, while operational scheduling decisions remain relatively under-explored. Therefore, this study aims to fill this research gap by proposing a hybrid SWARA–MULTIMOORA model for prioritizing production jobs in manufacturing systems [12]. The proposed approach contributes to the existing literature

by providing a practical and systematic framework for improving production scheduling decisions under multiple conflicting criteria.

The proposed hybrid model combines the strengths of both SWARA and MULTIMOORA methods. SWARA enables accurate determination of criteria importance based on expert knowledge, while MULTIMOORA provides a robust ranking mechanism through multiple evaluation perspectives. The integrated methodology offers several advantages:

- systematic evaluation of production jobs,
- consideration of multiple conflicting criteria,
- reduction of subjective bias,
- improved transparency of decision-making,
- practical applicability in manufacturing environments.

The proposed model can be effectively integrated into existing production planning and scheduling systems to support production managers in prioritizing jobs and improving manufacturing performance.

2.1.1 SWARA Method

The SWARA (Step-wise Weight Assessment Ratio Analysis) method is an MCDM weighting technique developed for determining the relative importance of criteria through expert evaluation. The method is based on the opinions and experience of decision-makers and enables a simple and flexible weighting process. One of the main advantages of SWARA is that it requires fewer comparisons than traditional methods such as AHP. Furthermore, the method allows experts to express their judgments gradually according to the significance of criteria [13].

The SWARA procedure consists of the following steps.

Step 1: Ranking of Criteria: First, experts rank the evaluation criteria according to their importance in descending order. The most significant criterion is placed in the first position. Assume that the criteria are represented as $C_1, C_2, C_3, \dots, C_n$. Where: C_j represents the j -th criterion, n is the total number of criteria.

Step 2: Determination of Comparative Importance: Starting from the second criterion, experts determine the comparative importance of criterion j relative to the previous criterion ($j-1$). The comparative importance coefficient is denoted as s_j . If the criterion has equal importance compared to the previous one, then:

$$s_j = 0 \quad (1)$$

Higher values of s_j indicate lower importance of the current criterion relative to the previous criterion.

Step 3: Calculation of the Coefficient k_j : The coefficient k_j is calculated using the following equation:

$$k_j = s_j + 1 \quad (2)$$

For the first criterion:

$$k_1 = 1 \quad (3)$$

Step 4: Calculation of Recalculated Weights: The recalculated weight q_j is obtained recursively. For the first criterion:

$$q_1 = 1 \quad (4)$$

For the remaining criteria:

$$q_j = \frac{q_{j-1}}{k_j} \quad (5)$$

Step 5: Determination of Final Criteria Weights The final normalized weights are calculated using:

$$w_j = \frac{q_j}{\sum_{j=1}^n q_j} \quad (6)$$

where: w_j represents the final weight of criterion j , $\sum_{j=1}^n q_j$ is the total sum of recalculated weights. The obtained weights are later used in the MULTIMOORA ranking procedure.

2.1.2 MULTIMOORA Method

MULTIMOORA (Multi-Objective Optimization by Ratio Analysis plus Full Multiplicative Form) is an advanced MCDM method developed as an extension of the MOORA technique [14], [15], [16]. The method integrates three different evaluation approaches:

- Ratio System
- Reference Point Approach
- Full Multiplicative Form

The integration of these components improves the robustness and reliability of ranking results. Assume that there are m production jobs and n evaluation criteria. The decision matrix is represented as:

$$X = [x_{ij}] \quad (7)$$

where: x_{ij} represents the performance value of alternative i under criterion j , $i = 1, 2, \dots, m$, $j = 1, 2, \dots, n$.

Step 1: Construction of the Decision Matrix: The decision matrix includes all production jobs and their corresponding values according to each evaluation criterion. The matrix can be represented as:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (8)$$

Step 2: Normalization of the Decision Matrix: The decision matrix is normalized to eliminate differences in measurement units. The normalized value is calculated as follows:

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (9)$$

where: x_{ij}^* is the normalized value, x_{ij} is the original value.

Step 3: Ratio System Approach In the Ratio System, beneficial criteria are maximized while non-beneficial criteria are minimized. The overall assessment value for each alternative is calculated as:

$$Y_i = \sum_{j=1}^g w_j x_{ij}^* - \sum_{j=g+1}^n w_j x_{ij}^* \quad (10)$$

where: g is the number of beneficial criteria, w_j is the weight of criterion j , Y_i is the performance score of alternatives i .

Higher values of Y_i indicate better alternatives.

Step 4: Reference Point Approach: In the Reference Point Approach, the best performance values for each criterion are identified as reference points. The deviation from the reference point is calculated using:

$$D_i = \max_j |r_j - w_j x_{ij}^*| \quad (11)$$

where: r_j represents the reference value, D_i is the maximum deviation for alternative i . Smaller deviation values indicate better alternatives.

Step 5: Full Multiplicative Form: The Full Multiplicative Form evaluates alternatives by multiplying beneficial criteria and dividing them by non-beneficial criteria. The overall utility value is calculated as:

$$U_i = \frac{\prod_{j=1}^g x_{ij}^{w_j}}{\prod_{j=g+1}^n x_{ij}^{w_j}} \quad (12)$$

Higher values of U_i represent better alternatives.

Step 6: Final Ranking of Alternatives: The final ranking of production jobs is obtained by combining the rankings derived from the three MULTIMOORA components:

- Ratio System,
- Reference Point Approach,
- Full Multiplicative Form.

The production job with the best overall ranking is considered the highest priority for processing.

3. CASE STUDY

This section presents the application of the proposed hybrid SWARA–MULTIMOORA model in a manufacturing environment. The objective of the case study is to prioritize production jobs by considering multiple operational and managerial criteria simultaneously. The case study involves five production jobs processed in a manufacturing company operating under limited production capacity and strict delivery requirements. Production managers must determine the order in which jobs should be processed in order to improve resource utilization, minimize delays, and satisfy customer demands. A manufacturing company receives multiple customer orders that must be processed on shared production resources. Due

to limited machine availability and time constraints, production managers need to establish priorities among production jobs. In this study, five production jobs are considered:

$$J_1, J_2, J_3, J_4, J_5 \quad (13)$$

The prioritization process is based on five evaluation criteria frequently used in manufacturing decision-making:

Table 1: The prioritization process is based on five evaluations

Criteria	Description	Type
C_1	Due date urgency	Benefit
C_2	Profit margin	Benefit
C_3	Customer importance	Benefit
C_4	Processing time	Cost
C_5	Setup time	Cost

The first three criteria are beneficial criteria, meaning that higher values are preferred. The last two criteria are non-beneficial (cost) criteria, where lower values are desirable. A team of production experts participated in the evaluation process and provided judgments regarding the relative importance of criteria.

Step 2: Determination of Criteria Weights Using SWARA: The SWARA method was applied to determine the weights of evaluation criteria according to expert opinions. The experts ranked the criteria in the following order of importance:

$$C_1 > C_2 > C_3 > C_4 > C_5 \quad (14)$$

where: C_1 : Due date urgency, C_2 : Profit margin, C_3 : Customer importance, C_4 : Processing time, C_5 : Setup time.

The comparative importance coefficients (s_j), recalculated coefficients (k_j), and normalized weights (w_j) were calculated according to the SWARA procedure. The results are presented in Table 2.

Table 2: Criteria Weights Obtained Using SWARA

Criteria	s_j	k_j	q_j	w_j
C_1	–	1.00	1.000	0.300
C_2	0.20	1.20	0.833	0.250
C_3	0.25	1.25	0.666	0.200
C_4	0.33	1.33	0.500	0.150
C_5	0.50	1.50	0.333	0.100

The obtained results indicate that due date urgency (C_1) is the most significant criterion with a weight of 0.300, followed by profit margin (C_2) and customer importance (C_3). Processing time and setup time received relatively lower importance weights. These findings are consistent with real manufacturing environments where meeting delivery deadlines and maintaining customer satisfaction are considered primary operational objectives.

Step 3: Construction of the Decision Matrix: After determining the criteria weights, the decision matrix was constructed based on the evaluations of production jobs. The decision matrix is presented in Table 3.

Table 3: Initial Decision Matrix

Jobs	C_1	C_2	C_3	C_4	C_5
J_1	9	8	7	5	4
J_2	7	9	8	6	5
J_3	10	6	9	4	3
J_4	6	7	5	8	6
J_5	8	8	6	5	4

The values in the matrix represent the performance of each production job according to the corresponding criterion.

4.1 Application of the MULTIMOORA Method

The MULTIMOORA method was applied to rank the production jobs according to the weighted criteria. The decision matrix was normalized using vector normalization in order to eliminate differences in measurement scales. The normalized matrix is shown in Table 4.

Table 4: Normalized Decision Matrix

Jobs	C_1	C_2	C_3	C_4	C_5
J1	0.495	0.467	0.438	0.388	0.396
J2	0.385	0.525	0.501	0.466	0.495

Jobs	C_1	C_2	C_3	C_4	C_5
J3	0.550	0.350	0.564	0.310	0.297
J4	0.330	0.408	0.313	0.621	0.594
J5	0.440	0.467	0.376	0.388	0.396

The Ratio System approach was applied by maximizing beneficial criteria and minimizing cost criteria. The obtained performance scores are presented in Table 5.

Table 5: Ratio System Results

Jobs	Y_i	Rank
J_1	0.255	2
J_2	0.228	3
J_3	0.289	1
J_4	0.111	5
J_5	0.226	4

According to the Ratio System results, production job J_3 achieved the highest score and was ranked as the best alternative. The Reference Point Approach was applied by determining the maximum deviation of each alternative from the ideal reference point. The results are shown in Table 6.

Table 6: Reference Point Results

Jobs	D_i	Rank
J_1	0.025	1
J_2	0.050	4
J_3	0.044	3
J_4	0.066	5
J_5	0.038	2

Smaller deviation values indicate better alternatives. According to the Reference Point Approach, job J_1 achieved the best performance. The Full Multiplicative Form was then applied to evaluate the utility of each production job. The obtained results are presented in Table 7.

Table 7: Full Multiplicative Form Results

Jobs	U_i	Rank
J_1	3.281	2
J_2	3.063	4
J_3	3.527	1
J_4	2.351	5
J_5	3.071	3

The results again confirm that production job J_3 represents the best alternative among the evaluated jobs. The final ranking was determined by combining the rankings obtained from the three MULTIMOORA components. The obtained ranking indicates that job J_3 should receive the highest production priority due to its urgent delivery requirement, high customer importance, and relatively low processing and setup times. The proposed SWARA–MULTIMOORA model successfully integrates multiple criteria into a unified decision-making framework and provides production managers with a practical tool for improving scheduling decisions in manufacturing systems. The final results are presented in Figure 1.

Final Ranking of Production Jobs

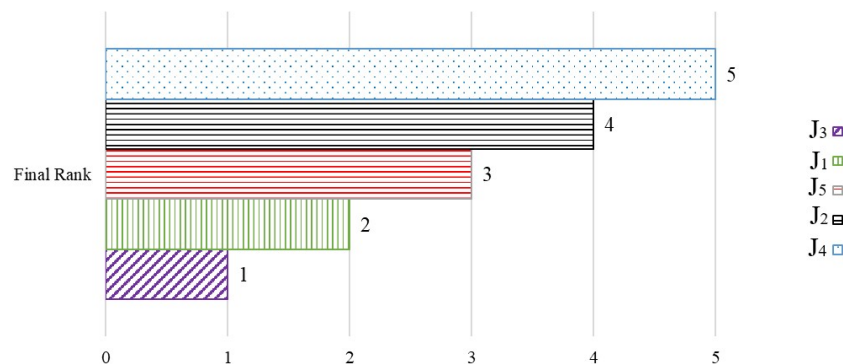


Figure 1: Final Ranking of Production Jobs

4. RESULTS AND DISCUSSION

The results obtained from the proposed SWARA–MULTIMOORA model demonstrate its effectiveness in prioritizing production jobs in a manufacturing environment. The final ranking showed that job J_3 achieved the highest priority among all evaluated alternatives. This result was consistent across all three MULTIMOORA components, confirming the reliability and stability of the proposed methodology. Job J_3 obtained the best performance mainly due to its high due date urgency and customer importance, which were identified as the most significant criteria through the SWARA weighting process. In addition, the job had relatively low processing and setup times, positively influencing its final ranking. In contrast, job J_4 received the lowest priority because of its longer processing and setup times. This finding highlights the importance of evaluating multiple criteria simultaneously rather than relying on a single operational factor. The SWARA results indicated that due date urgency was the most important criterion, followed by profit margin and customer importance. This reflects the practical requirements of modern manufacturing systems, where on-time delivery and customer satisfaction are critical for maintaining competitiveness. The MULTIMOORA method provided a comprehensive and systematic evaluation framework by integrating different ranking approaches. The proposed model reduces subjectivity in production scheduling decisions and supports more objective and efficient resource allocation. Furthermore, the methodology is flexible and can be adapted to different manufacturing environments by including additional criteria according to operational requirements. The model may also be integrated into modern production planning and Industry 4.0 systems to support real-time scheduling decisions. Overall, the obtained results confirm that the hybrid SWARA–MULTIMOORA model represents an effective decision-support tool for production job prioritization and can significantly improve manufacturing scheduling performance.

5. CONCLUSION

This paper proposed a hybrid SWARA–MULTIMOORA model for production job prioritization in manufacturing systems. The SWARA method was used to determine criteria weights, while the MULTIMOORA method was applied to rank production jobs according to multiple criteria. The results showed that the proposed methodology provides a systematic and reliable framework for production scheduling decisions. The model successfully identified the most suitable production priority by considering both operational and managerial factors. The proposed approach can help manufacturing companies improve resource utilization, scheduling efficiency, and customer satisfaction. In addition, the methodology is flexible and can be integrated into existing production planning systems. Future research may focus on extending the model using fuzzy logic, artificial intelligence techniques, and real-time scheduling applications in Industry 4.0 environments.

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