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Research Article (Industrial Engineering)

A Hybrid Cut-Off Point AHP-TOPSIS Framework for Raw Material Supplier Selection in the Digital Printing Industry

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INFORMASI ARTIKEL

Diterima Redaksi: 13 Februari 2026
Revisi Akhir: 09 Maret 2026
Diterbitkan *Online*: 12 April 2026

KATA KUNCI

Supplier Selection
Cut-Off Point
AHP
TOPSIS
Digital Printing Industry

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A B S T R A K

Raw material supplier selection is a strategic decision that influences production continuity, operational efficiency, and product quality, particularly in the digital printing industry, which is inherently time-sensitive. In practice, supplier selection processes are often based primarily on partial considerations of price and quality, which may lead to delivery delays, mismatches in supply quantity, and inconsistencies in material quality. This study aims to develop a hybrid decision-making framework integrating the Cut-Off Point method, Analytical Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to support systematic and data-driven raw material supplier selection. The initial stage employs the Cut-Off Point method combined with Focus Group Discussion (FGD) to identify relevant evaluation criteria, resulting in five main criteria and twenty subcriteria. The AHP method is applied to determine criteria weights with consistency testing, while TOPSIS is used to rank supplier alternatives based on their relative closeness to the ideal solution. A case study was conducted in a digital printing manufacturing company using real operational data from 2025. The results indicate that delivery is the most influential criterion with a weight of 0.42, where delivery punctuality emerges as the most dominant subcriterion with a weight of 0.50. TOPSIS analysis shows that supplier PT. C achieves the highest preference value of 0.5843 and is therefore prioritized as the best supplier. The proposed hybrid framework enhances the objectivity of supplier selection processes and provides managerial implications for improving raw material supply reliability in the digital printing industry.

INTRODUCTION

Supplier selection is a strategic decision that directly influences production continuity, operational efficiency, and customer satisfaction in manufacturing companies. Suboptimal supplier performance, particularly in terms of delivery punctuality, fulfillment of supply quantities, and consistency of raw material quality, may lead to production delays, increased operational costs, and the inability of companies to meet customer demand. In increasingly competitive industrial environments, companies are therefore required to adopt more systematic, objective, and data-driven approaches to supplier selection [1], [2].

The digital printing industry exhibits operational characteristics that differ from those of conventional manufacturing sectors. This industry is inherently time-sensitive, highly dependent on rapid order fulfillment, and frequently exposed to fluctuating demand. The availability of key raw materials, such as printing sticker materials, becomes a critical factor in maintaining production continuity. Short lead times and stringent customer delivery expectations mean that delays in raw material supply can significantly disrupt production processes. Nevertheless, in practice, supplier selection in the digital printing industry is often based on limited considerations, such as price and subjective judgments from procurement personnel, without being supported by a structured evaluation framework [3], [4].

https://doi.org/10.56211/blendsains.v4i4.1617

Based on empirical observations within the company serving as the research object, recurring issues related to supplier performance were identified, including delivery delays, discrepancies in the quantity of raw materials received, and material rejection rates exceeding the company's established targets. These issues directly impact production schedules and limit the company's ability to meet customer demand effectively. Despite these challenges, supplier selection decisions have largely been made intuitively and have not yet incorporated systematic and measurable decision making methods. This situation highlights the need for a supplier evaluation approach capable of representing the company's actual operational conditions while supporting more objective and structured decision-making processes [5].

Multi Criteria Decision Making (MCDM) methods are widely applied to address decision making problems involving multiple and often conflicting criteria. The Analytical Hierarchy Process (AHP) is recognized as an effective method for determining the relative importance of criteria through pairwise comparisons, while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) provides a systematic approach for ranking alternatives based on their relative closeness to an ideal solution [6], [7]. Previous studies have demonstrated the successful application of AHP and TOPSIS in supplier selection within manufacturing sectors, including the integration of fuzzy approaches to enhance decision accuracy under conditions of uncertainty [8], [9]. The novelty of this study lies in the development of an integrated decision making framework that combines an initial screening stage (Cut-Off Point), hierarchical criteria weighting (AHP), and alternative ranking (TOPSIS) within a unified and context specific decision process. Compared to consensus based approaches such as the Delphi method, the Cut-Off Point technique provides a simpler and faster mechanism for initial criteria screening. This approach enables decision makers to quickly filter relevant criteria based on predefined threshold values, making it particularly suitable for practical industrial decision making environments where time efficiency is essential. Unlike prior studies that typically apply MCDM methods directly to all supplier alternatives or rely on predefined criteria [1], this research positions the Cut-Off Point as an initial filtering mechanism to ensure that only alternatives and criteria meeting minimum operational standards are included in subsequent analysis. This approach not only improves analytical precision but also strengthens the relevance of decision outcomes to the real operational conditions of the digital printing industry, which is inherently time-sensitive and often constrained by limited analytical resources. Therefore, the contribution of this study is not only methodological but also practical, as it provides a supplier selection model that is more adaptive, efficient, and readily implementable within industrial management contexts.

Based on the identified research gap, this study proposes a hybrid Cut-Off Point, AHP, TOPSIS framework for raw material supplier selection in the digital printing industry. The Cut-Off Point method is employed as an initial stage to identify the most relevant evaluation criteria based on expert judgment, supported through Focus Group Discussion (FGD). Subsequently, the AHP method is applied to determine the weights of the selected criteria and subcriteria while considering consistency in expert assessments, whereas TOPSIS is utilized to rank supplier alternatives objectively. The integration of these three stages represents the novelty of this study, as it combines initial criteria screening, hierarchical weighting, and alternative ranking into a comprehensive and structured decision making process.

The objectives of this study are threefold: (1) to identify and prioritize supplier selection criteria and subcriteria that align with the operational characteristics of the digital printing industry; (2) to develop a decision-making framework based on the integration of the Cut-Off Point, AHP, and TOPSIS methods; and (3) to determine the best raw material supplier based on the company's real operational data. The contribution of this study lies in providing an applicative, structured, and context-specific supplier selection model that can serve as a managerial decision-support tool for manufacturing industries characterized by high sensitivity to supply timeliness.

LITERATURE REVIEW

Supplier Selection in Supply Chain Management

Supplier selection represents a strategic decision within supply chain management, as it directly influences product quality, cost efficiency, and the continuity of production processes. The complexity of supplier selection decisions increases with the growing number of criteria that must be considered, including material quality, price, delivery reliability, supply flexibility, and operational sustainability aspects [10]. Inappropriate supplier selection can lead to production disruptions, increased operational costs, and reduced customer satisfaction.

In the context of the digital printing industry, the time sensitive nature of production makes raw material supply reliability a critical factor. Short lead times and high demand fluctuations require companies to implement systematic and data driven supplier evaluation systems. However, in many medium scale manufacturing companies, supplier selection processes are still frequently conducted intuitively without the support of structured analytical approaches.

Multi-Criteria Decision Making in Supplier Selection

Multi-Criteria Decision Making (MCDM) approaches have been widely applied in supplier selection because they enable the consideration of multiple, often conflicting criteria simultaneously. The Analytical Hierarchy Process (AHP) is commonly used to determine the relative importance of criteria through systematic pairwise comparisons, while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is employed to identify the best alternative based on its relative closeness to both positive and negative ideal solutions [11].

Recent studies have also indicated a growing trend toward the use of hybrid models in supplier selection to enhance decision accuracy. The integration of data collection approaches, such as Delphi methods or expert judgment, with AHP and TOPSIS has been shown to produce more comprehensive decision outcomes, particularly in industries where quantitative data availability is limited [10].

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a multi criteria decision making method developed by Saaty to determine the priority of alternatives through a hierarchical structure and pairwise comparisons among criteria. This method enables decision-makers to systematically integrate both quantitative and qualitative aspects while assessing the consistency of judgments through the consistency ratio. AHP has been widely applied in supplier selection due to its ability to determine criteria weights objectively and systematically, particularly in decision contexts involving subjective expert considerations [8], [12].

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a Multi Criteria Decision Making (MCDM) method that identifies the best alternative based on its relative closeness to the positive ideal solution and its farthest distance from the negative ideal solution. This approach enables quantitative ranking of alternatives by simultaneously considering all evaluation criteria. TOPSIS has been widely applied in supplier selection studies due to its ability to produce stable and easily interpretable rankings, making it particularly suitable for multi-criteria decision-making in situations with limited data availability [9], [13].

Cut-Off Point Concept in Multi-Criteria Decision Making

In the context of multi criteria decision making, an initial screening stage of alternatives or criteria is often conducted using the concept of threshold or screening criteria, which involves establishing minimum standards that must be satisfied before alternatives are further analyzed. This approach aims to reduce analytical complexity while ensuring that the evaluated alternatives meet minimum operational requirements [14].

This initial screening stage becomes particularly important in supplier selection problems, where the number of criteria and alternatives is often substantial. Without a proper filtering process, multi criteria analysis may become less focused and more difficult to interpret from a managerial perspective. Consequently, several hybrid MCDM studies have begun to incorporate an initial criteria identification stage based on expert judgment before proceeding to weighting and ranking processes [10].

In this study, the Cut-Off Point concept is applied as an initial screening mechanism to identify supplier criteria and alternatives that meet minimum operational standards before further analysis using AHP and TOPSIS is conducted. This approach is expected to enhance analytical precision while ensuring that decision outcomes remain relevant to the operational conditions of the digital printing industry.

 https://doi.org/10.56211/blendsains.v4i4.1617

METHODOLOGY

Research Design

This study is classified as applied research aimed at developing a decision-making framework for raw material supplier selection in the digital printing industry using a Multi Criteria Decision Making (MCDM) approach. The hybrid framework integrates the Cut-Off Point method, Analytical Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which have been widely applied in supplier selection studies to enhance the objectivity and accuracy of decision making [1], [2].

Research Object and Data Sources

The research object is a digital printing manufacturing company characterized by time sensitive production processes and a high dependence on reliable raw material supply. Research data were obtained from supplier operational records, management interviews, and Focus Group Discussions (FGDs) involving internal company experts. Expert based data collection approaches are commonly employed in supplier selection studies to capture qualitative aspects of decision-making [5].

Criteria Selection Using the Cut-Off Point Method

The initial criteria selection was conducted using the Cut-Off Point approach to determine the minimum relevance threshold of criteria based on expert assessments. Such screening approaches are commonly applied in multi criteria decision making to reduce analytical complexity while enhancing the focus of criteria evaluation [4].

$$C = \frac{s_{Max} + s_{Min}}{2} \tag{1}$$

Criteria with values greater than or equal to the cut off threshold (≥ C) were considered for subsequent stages of analysis.

Criteria Weighting Using the Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) method was employed to determine the relative importance weights of criteria and subcriteria through pairwise comparisons. Developed by Saaty, this method has been widely applied in multi criteria decision-making due to its ability to simultaneously accommodate both quantitative and qualitative data [8], [12].

Matrix normalization was performed using:

$$r_{ij} = \frac{a_{ij}}{\sum_{i-1}^{n} a_{ij}} \tag{2}$$

The priority weights were calculated using:

$$w = \frac{\sum_{j-1}^{n} r_{ij}}{n} \tag{3}$$

The consistency of the judgments was evaluated using:

$$CR = \frac{CI}{RI} \tag{4}$$

Where:

$$CI = \frac{\lambda_{Max} - n}{n-1} \tag{5}$$

A consistency ratio (CR) value of ≤ 0.1 indicates an acceptable level of judgment consistency.

Supplier Ranking using TOPSIS

The TOPSIS method was employed to determine the best supplier alternative based on its relative closeness to the positive ideal solution and its distance from the negative ideal solution. This method has been widely applied in supplier selection studies due to its ability to generate stable alternative rankings that are easily interpretable from a managerial perspective [9], [13].

The decision matrix normalization was performed using:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i-1}^{m} x_{ij}^2}} \tag{6}$$

The weighted normalized matrix was calculated using:

$$y_{ij} = w_j r_{ij} \tag{7}$$

The distances to the ideal solutions were determined using:

$$D_i^+ = \sqrt{\sum_{j-1}^{n} (y_{ij} - y_j^+)^2} \tag{8}$$

$$D_i^- = \sqrt{\sum_{j-1}^{n} (y_{ij} - y_j^-)^2} \tag{9}$$

The preference values were calculated using:

$$V_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{10}$$

Alternatives with the highest preference values were prioritized as the best suppliers.

RESULTS AND DISCUSSION

Results of Criteria Selection using the Cut-Off Point Method

The initial stage of this study involved selecting supplier evaluation criteria using the Cut-Off Point method to identify the criteria most relevant to the operational needs of the digital printing company. The criteria assessment process was conducted through Focus Group Discussions (FGDs) involving management representatives, procurement personnel, and technical staff with direct experience in managing raw material suppliers. The management participants involved in the data collection included the head of graphic design, the production manager, the finishing goods manager, and the finance manager, all of whom have more than seven years of experience in the digital printing industry.

Data collection was subsequently conducted using questionnaires distributed to managerial decision makers to identify the main evaluation criteria. The assessment was categorized into three levels: moderately important (CP), assigned a score of 1; important (P), assigned a score of 2; and very important (SP), assigned a score of 3. The results of the criteria data collection are presented in Table 1.

Table 1. Cut-Off Point

Criteria	Rating			Score Cut-Off Point
	CP	P	SP	
Quality			12	12
Delivery			12	12
Performance History			12	12
Warranty and Claim Policies	3	3		6
Price			12	12
Technical Capability	1	5		6
Financial Position	3	3		6
Procedural Compliance	3	2		5
Communication System			12	12
Reputation and Position in Industry	4			4
Desire for Business	2	4		6
Management and Organization	3	2		5

 https://doi.org/10.56211/blendsains.v4i4.1617

Operation Control	4	2		6
Repair Service	3	2		5
Attitudes	3	2		5
Impression	3	2		5
Packaging ability	4			4
Labor relations record	1	4	2	7
Geographical location	4			4
Amount of past business	3	2		5
Training aids	4			4
Reciprocal arrangements	6			6

The calculation of the Cut-Off Point values based on Equation (1) is presented as follows:

$$C = \frac{12 + 4}{2} = 8$$

The calculated natural Cut-Off Point value for the criteria was 8. Based on this threshold, only criteria with ≥ 8 were selected for further analysis. The comparison results using the Cut-Off Point method indicate that five main criteria were selected from the initial 22 criteria, along with 20 sub criteria that reflect the actual operational conditions of the digital printing industry. These criteria were identified through Focus Group Discussions and supported by relevant theoretical and empirical literature. The complete results are presented in Table 2.

Table 2. Criteria and Sub Criteria for Supplier Selection

No.	Criteria	Sub Criteria
1	Delivery (A)	Delivery punctuality (A1) Accuracy of delivered quantity (A2) Delivery frequency (A3) Type of delivery vehicle (A4)
2	Quality (B)	Compliance of materials with specified requirements (B1) Material defect rate (B2) Product quality information availability (B3) Consistency of product quality (B4)
3	Price (C)	Consistency of payment terms (C1) Price conformity with specified requirements (C2) Price comparison frequency (C3) Price stability (C4)
4	Company Performance (D)	Responsiveness in problem handling (D1) Company performance history (D2) Operational efficiency (D3) Company profitability ratio (D4)
5	Communication System (E)	Effective communication with vendors (E1) Message delivery and communication integrity (E2) Personal communication service (E3) Ease of warranty claim process (E4)

Results of Calculations using the AHP Method

The pairwise comparison matrices presented in Tables 3–8 were constructed based on expert judgments obtained from four managerial experts involved in the Focus Group Discussion (FGD). The final comparison values were calculated using the geometric mean of the pairwise comparison scores provided by the experts, following the standard aggregation approach commonly applied in AHP studies.

1. Pairwise Comparison of Criteria and Sub Criteria.

Table 3 presents the results of the pairwise comparison matrix among the evaluation criteria.

Table 3. Pairwise Comparison Matrix of Criteria

Criteria	**Delivery**	**Quality**	**Price**	**Company Performance**	**Communication System**
Delivery	1	2.71	3.41	2.78	5.60
Quality	0.37	1	2.91	2.51	3.81
Price	0.29	0.34	1	2.06	2.34
Company Performance	0.36	0.40	0.49	1	2.71
Communication System	0.18	0.26	0.43	0.37	1
Total	2.20	4.71	8.23	8.73	15.45

Table 4 presents the results of the pairwise comparison matrix for the delivery sub criteria

Table 4. Pairwise Comparison Matrix of Delivery Sub Criteria

Sub Criteria	**A1**	**A2**	**A3**	**A4**
A1	1	3.08	3.08	3.94
A2	0.32	1	2.06	2.99
A3	0.32	0.49	1	3.08
A4	0.25	0.33	0.32	1
Total	1.90	4.90	6.46	11.01

Table 5 presents the results of the pairwise comparison matrix for the quality sub criteria

Table 5. Pairwise Comparison Matrix of Quality Sub Criteria

Sub Criteria	**B1**	**B2**	**B3**	**B4**
B1	1	2.38	2.63	3.94
B2	0.42	1	2.45	2.78
B3	0.38	0.41	1	3.22
B4	0.25	0.36	0.31	1
Total	2.05	4.15	6.39	10.94

Table 6 presents the results of the pairwise comparison matrix for the price sub criteria

Table 6. Pairwise Comparison Matrix of Price Sub Criteria

Sub Criteria	**C1**	**C2**	**C3**	**C4**
C1	1	2.45	3.08	3.08
C2	0.41	1	2.63	2.91
C3	0.32	0.38	1	2.63
C4	0.32	0.34	0.38	1
Total	2.06	4.17	7.09	9.63

Table 7 presents the results of the pairwise comparison matrix for the Company Performance sub criteria

Table 7. Pairwise Comparison Matrix of Company Performance Sub Criteria

Sub Criteria	D1	D2	D3	D4
D1	1	2.91	3.08	3.94
D2	0.34	1	2.06	2.78
D3	0.32	0.49	1	3.08
D4	0.25	0.36	0.32	1
Total	1.92	4.76	6.46	10.80

Table 8 presents the results of the pairwise comparison matrix for the Communication System sub criteria

Table 8. Pairwise Comparison Matrix of Communication System Sub Criteria

Sub Criteria	E1	E2	E3	E4
E1	1	2.21	2.06	3.46
E2	0.45	1	2.45	2.45
E3	0.49	0.41	1	3.31
E4	0.29	0.41	0.30	1
Total	2.23	4.03	5.81	10.22

2. Priority Weighting, Normalization, and Consistency Testing

After the pairwise comparison matrix was established, priority weighting, normalization, and consistency testing were performed using Equations (2), (3), (4), and (5). The assessment was considered consistent when the consistency ratio (CR) value was ≤ 0.1.

Table 9 presents the results of the overall criteria calculations.

Table 9. Normalization Matrix Among Criteria

Criteria	Normalization					Weight	Eigen Vector	CF	CI	Consistency Ratio (CR)
	Delivery	Quality	Price	Company Performance	Communication System					
Delivery	0.45	0.58	0.41	0.32	0.36	0.42	2.26	5.33	0.05	**0.05**
Quality	0.17	0.21	0.35	0.29	0.25	0.25	1.35	5.33		
Price	0.13	0.07	0.12	0.24	0.15	0.14	0.74	5.17		
Company Performance	0.16	0.08	0.06	0.11	0.18	0.12	0.60	5.05		
Communication System	0.08	0.06	0.05	0.04	0.06	0.06	0.31	5.19		
TOTAL	1.00	1.00	1.00	1.00	1.00	1.00	Eigen Max	5.21		

Table 10 presents the calculation results of the delivery sub criteria.

Table 10. Normalization Matrix of Delivery Sub Criteria

Sub Criteria	Delivery Normalization				Weight	Partial Weight	Eigen Vector	CF	CI	Consistency Ratio (CR)
	A1	A2	A3	A4						
A1	0.53	0.63	0.48	0.36	0.50	0.50	2.12	4.26	0.06	**0.061**
A2	0.17	0.20	0.32	0.27	0.24	0.24	1.02	4.23		
A3	0.17	0.10	0.15	0.28	0.18	0.18	0.72	4.08		
A4	0.13	0.07	0.05	0.09	0.09	0.09	0.35	4.08		
Total	1.00	1.00	1.00	1.00	1.00		Eigen Max	4.17		

Table 11 presents the calculation results of the quality sub criteria.

Table 11. Normalization Matrix of Quality Sub Criteria

Sub Criteria	Quality Normalization				Weight	Partial Weight	Eigen Vector	CF	CI	Consistency Ratio (CR)
	B1	B2	B3	B4						
B1	0.49	0.57	0.41	0.36	0.46	0.46	1.93	4.21	0.055	**0.061**
B2	0.20	0.24	0.38	0.25	0.27	0.27	1.16	4.27		
B3	0.18	0.10	0.16	0.29	0.18	0.18	0.75	4.09		
B4	0.12	0.09	0.05	0.09	0.09	0.09	0.36	4.09		
Total	1.00	1.00	1.00	1.00	1.00		Eigen Max	4.17		

Table 12 presents the calculation results of the price sub criteria.

Table 12. Normalization Matrix of Price Sub Criteria

Sub Criteria	Price Normalization				Weight	Partial Weight	Eigen Vector	CF	CI	Consistency Ratio (CR)
	C1	C2	C3	C4						
C1	0.49	0.59	0.43	0.32	0.46	0.46	1.95	4.28	0.063	**0.070**
C2	0.20	0.24	0.37	0.30	0.28	0.28	1.19	4.28		
C3	0.16	0.09	0.14	0.27	0.17	0.17	0.68	4.11		
C4	0.16	0.08	0.05	0.10	0.10	0.10	0.41	4.09		
Total	1.00	1.00	1.00	1.00	1.00		Eigen Max	4.19		

Table 13 presents the calculation results of the Company Performance sub criteria.

Table 13. Normalization Matrix of Company Performance Sub Criteria

Sub Criteria	Company Performance Normalization				Weight	Partial Weight	Eigen Vector	CF	CI	Consistency Ratio (CR)
	D1	D2	D3	D4						
D1	0.52	0.61	0.48	0.36	0.49	0.49	2.09	4.23	0.052	**0.057**
D2	0.18	0.21	0.32	0.26	0.24	0.24	1.02	4.23		
D3	0.17	0.10	0.15	0.29	0.18	0.18	0.72	4.08		
D4	0.13	0.08	0.05	0.09	0.09	0.09	0.36	4.08		
Total	1.00	1.00	1.00	1.00	1.00		Eigen Max	4.16		

Table 14 presents the calculation results of the Communication System sub criteria.

 https://doi.org/10.56211/blendsains.v4i4.1617

Table 14. Normalization Matrix of Communication System Sub Criteria

Sub Criteria	Communication System Normalization				Weight	Partial Weight	Eigen Vector	CF	CI	Consistency Ratio (CR)
	E1	E2	E3	E4						
E1	0.45	0.55	0.35	0.34	0.42	0.42	1.79	4.23	0.065	**0.072**
E2	0.20	0.25	0.42	0.24	0.28	0.28	1.20	4.32		
E3	0.22	0.10	0.17	0.32	0.20	0.20	0.84	4.11		
E4	0.13	0.10	0.05	0.10	0.10	0.10	0.39	4.12		
Total	1.00	1.00	1.00	1.00	1.00		Eigen Max	4.20		

Table 15 presents the complete priority weights of all criteria and sub criteria.

Table 15. Priority Weights of Criteria and Subcriteria

Criteria	Partial Weight	Sub Criteria	Partial Weight	Global Weight
Delivery	0.42	Delivery punctuality	0.50	0.211
		Accuracy of delivered quantity	0.24	0.103
		Delivery frequency	0.18	0.075
		Type of delivery vehicle	0.09	0.036
Quality	0.25	Compliance of materials with specified requirements	0.46	0.116
		Material defect rate	0.27	0.069
		Product quality information availability	0.18	0.047
		Consistency of product quality	0.09	0.022
Price	0.14	Consistency of payment terms	0.46	0.065
		Price conformity with specified requirements	0.28	0.040
		Price comparison frequency	0.17	0.024
		Price stability	0.10	0.014
Company Performance	0.12	Responsiveness in problem handling	0.49	0.059
		Company performance history	0.24	0.029
		Operational efficiency	0.18	0.021
		Company profitability ratio	0.09	0.010
Communication System	0.06	Effective communication with vendors	0.42	0.025
		Message delivery and communication integrity	0.28	0.016
		Personal communication service	0.20	0.012
		Ease of warranty claim process	0.10	0.006

Results of Calculations using the TOPSIS Method

In the initial stage, a weighted decision matrix of supplier alternatives against the subcriteria was constructed. The assessment results obtained from management decision-makers through questionnaires were processed using the geometric mean formula. The calculation results are presented in Table 16.

Table 16. Weighted Decision Matrix of Supplier Alternatives with Respect to Sub Criteria

Supplier	Delivery				Quality				Price			
	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
PT. A	3.663	5.118	7.326	5.207	6.654	4.757	5.566	6.062	4.606	4.141	6.402	4.949
PT. B	4.281	2.711	5.010	7.085	4.949	5.450	5.664	7.238	7.707	6.402	5.958	6.031
PT. C	4.527	2.991	6.964	5.635	5.335	6.880	4.949	6.293	5.826	6.160	5.384	6.901
PT. D	3.224	5.244	5.264	6.701	6.701	3.948	4.865	4.681	5.207	3.984	5.803	5.544
PT. E	3.130	3.936	5.439	5.091	3.936	5.635	4.821	6.300	4.427	4.949	4.899	6.853

Table 16. Weighted Decision Matrix of Supplier Alternatives with Respect to Sub Criteria (Continued)

Supplier	Company Performance				Communication System			
	D1	D2	D3	D4	E1	E2	E3	E4
PT. A	6.853	4.899	4.304	4.924	7.085	2.893	2.378	4.427
PT. B	6.964	7.416	5.635	5.856	6.055	4.695	6.839	5.635
PT. C	6.300	7.238	6.901	6.481	6.192	3.873	4.787	4.865
PT. D	7.969	6.481	4.450	5.422	6.640	6.853	5.856	6.735
PT. E	6.236	5.981	6.701	7.172	6.031	3.464	5.450	3.080

Next, the normalized decision matrix values for each criterion and selected supplier alternatives were calculated. The normalization values were computed using Equation (6). The calculation results are presented in Table 17.

Table 17. Normalized Matrix of Supplier Alternatives Based on Sub Criteria

Supplier	Delivery				Quality				Price			
	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
PT. A	0.430	0.554	0.539	0.388	0.530	0.392	0.480	0.439	0.363	0.354	0.501	0.363
PT. B	0.503	0.293	0.369	0.528	0.394	0.449	0.488	0.525	0.607	0.548	0.466	0.442
PT. C	0.532	0.323	0.513	0.420	0.425	0.567	0.427	0.456	0.459	0.527	0.421	0.506
PT. D	0.379	0.567	0.388	0.500	0.534	0.326	0.420	0.339	0.410	0.341	0.454	0.406
PT. E	0.368	0.426	0.400	0.380	0.314	0.465	0.416	0.457	0.349	0.424	0.384	0.502

Table 17. Normalized Matrix of Supplier Alternatives Based on Sub Criteria (Continued)

Supplier	Company Performance				Communication System			
	D1	D2	D3	D4	E1	E2	E3	E4
PT. A	0.445	0.339	0.338	0.366	0.494	0.283	0.201	0.388
PT. B	0.452	0.513	0.442	0.435	0.422	0.460	0.579	0.494
PT. C	0.409	0.500	0.541	0.481	0.432	0.379	0.406	0.427
PT. D	0.517	0.448	0.349	0.403	0.463	0.671	0.496	0.591
PT. E	0.405	0.414	0.526	0.533	0.421	0.339	0.462	0.270

Next, the weighted normalized matrix was calculated by applying Equation (7) to the normalized decision matrix values. The calculation results are presented in Table 18.

Table 18. Weighted Normalized Matrix of Supplier Alternatives Based on Sub Criteria

Supplier	Delivery				Quality				Price			
	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
PT. A	0.0909	0.0567	0.0403	0.0141	0.0616	0.0270	0.0224	0.0098	0.0237	0.0141	0.0119	0.0052
PT. B	0.1062	0.0301	0.0276	0.0192	0.0458	0.0309	0.0227	0.0117	0.0397	0.0218	0.0111	0.0063
PT. C	0.1123	0.0332	0.0383	0.0153	0.0494	0.0390	0.0199	0.0101	0.0300	0.0210	0.0100	0.0072
PT. D	0.0800	0.0581	0.0290	0.0182	0.0620	0.0224	0.0195	0.0075	0.0268	0.0136	0.0108	0.0058
PT. E	0.0777	0.0436	0.0299	0.0138	0.0364	0.0319	0.0194	0.0101	0.0228	0.0168	0.0091	0.0071

Table 18. Weighted Normalized Matrix of Supplier Alternatives Based on Sub Criteria (Continued)

Supplier	Company Performance				Communication System			
	D1	D2	D3	D4	E1	E2	E3	E4
PT. A	0.0262	0.0098	0.0072	0.0038	0.0124	0.0047	0.0024	0.0022
PT. B	0.0266	0.0148	0.0094	0.0045	0.0106	0.0076	0.0070	0.0028
PT. C	0.0241	0.0144	0.0115	0.0050	0.0108	0.0062	0.0049	0.0024
PT. D	0.0304	0.0129	0.0074	0.0042	0.0116	0.0110	0.0060	0.0033
PT. E	0.0238	0.0119	0.0111	0.0056	0.0105	0.0056	0.0056	0.0015

Subsequently, the positive ideal solution values, negative ideal solution values, and the distances to both positive and negative ideal solutions were calculated using Equations (8) and (9). The results of these calculations are presented in Tables 19 and 20.

Table 19. Ideal Solution Matrix

Ideal Solution	Delivery				Quality				Price			
	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
Positive (Max)	0.1123	0.0581	0.0403	0.0192	0.0620	0.0390	0.0227	0.0117	0.0397	0.0218	0.0119	0.0072
Negative (Min)	0.0777	0.0301	0.0276	0.0138	0.0364	0.0224	0.0194	0.0075	0.0228	0.0136	0.0091	0.0052

Table 19. Ideal Solution Matrix (Continued)

Ideal Solution	Company Performance				Communication System			
	D1	D2	D3	D4	E1	E2	E3	E4
Positive (Max)	0.0304	0.0148	0.0115	0.0056	0.0124	0.0110	0.0070	0.0033
Negative (Min)	0.0238	0.0098	0.0072	0.0038	0.0105	0.0047	0.0024	0.0015

Table 20. Distances to Positive and Negative Ideal Solutions

Supplier	D+	D-
PT. A	0.0329	0.0417
PT. B	0.0368	0.0382
PT. C	0.0314	0.0441
PT. D	0.0417	0.0400
PT. E	0.0517	0.0184

The final step involved calculating the preference values for each alternative (supplier) using Equation (10), as presented in Table 21.

Table 21. Ranking of Preference Values for Each Alternative (Supplier)

Supplier	Nilai	Rank
PT. A	0.5588	2
PT. B	0.5095	3
PT. C	0.5843	1
PT. D	0.4896	4
PT. E	0.2620	5

Based on the overall preference value calculations presented in Table 21, Supplier PT. C was identified as the alternative with the highest preference weight relative to the ideal solution, with a value of 0.5843. Based on the findings of this case study, the hierarchical structure of the criteria, subcriteria, and alternative elements can be illustrated as shown in Figure 1.

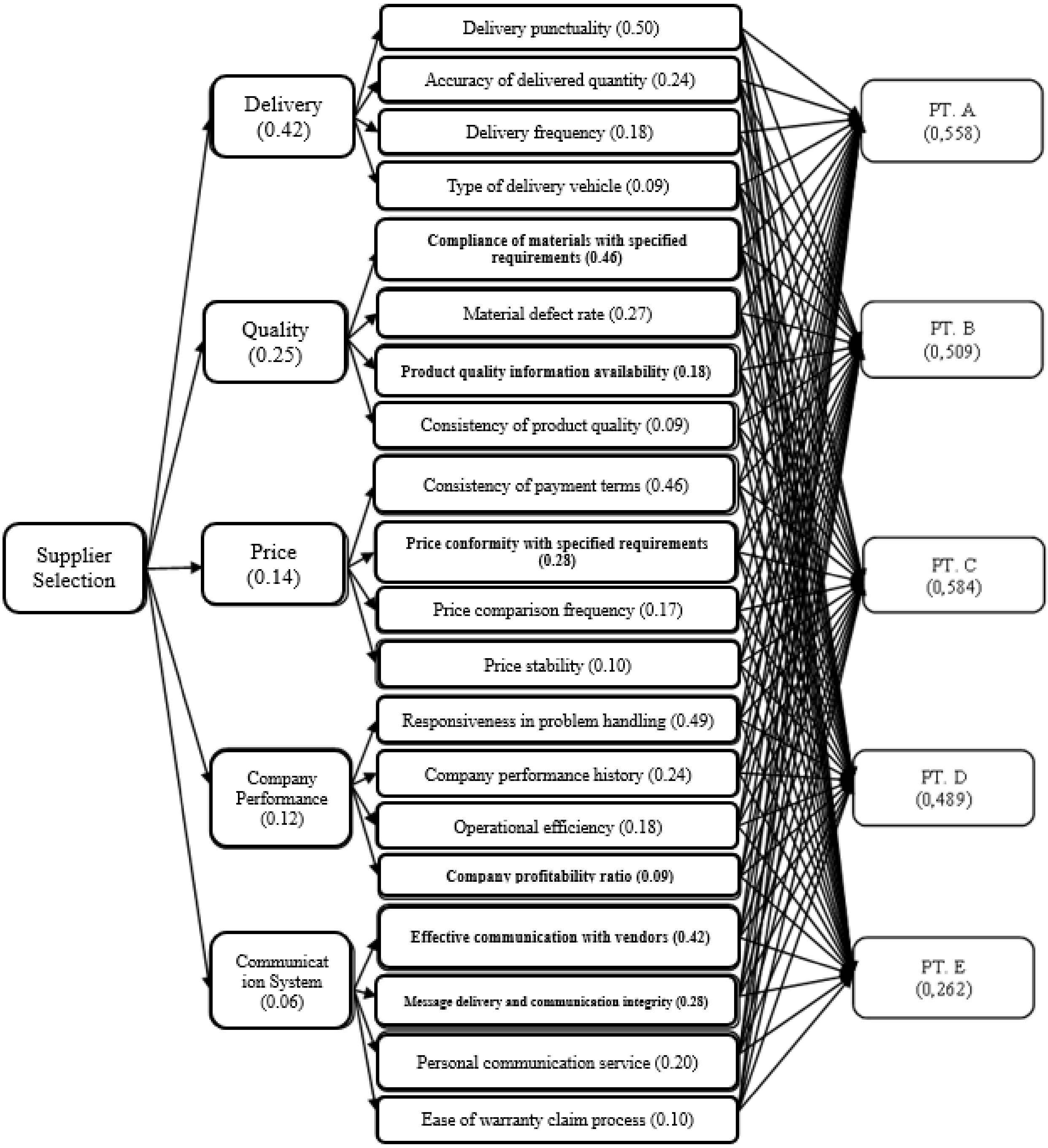

Figure 1. Hierarchical Structure of Raw Material Supplier Selection

Discussion

The findings indicate that delivery criteria emerged as the most dominant factor in raw material supplier selection within the digital printing industry. This result highlights that supply reliability, particularly delivery punctuality, significantly influences production continuity and customer satisfaction. These findings are consistent with previous supplier selection studies that identify quality, delivery performance, and price as primary evaluation factors in manufacturing sector supplier assessments [1], [2].

The dominance of delivery punctuality as a subcriterion further indicates that logistical aspects play a strategic role in maintaining supply chain stability. Previous studies have demonstrated that the application of MCDM methods such as AHP and TOPSIS enhances the objectivity of supplier selection decisions compared to conventional approaches based primarily on intuition or experience [3], [9]. The findings of this study reinforce these observations by showing that the integration of hybrid methods leads to a more systematic and transparent supplier evaluation process.

 https://doi.org/10.56211/blendsains.v4i4.1617

Furthermore, the incorporation of an initial screening stage using the Cut-Off Point method provides an additional methodological contribution compared to previous studies that typically apply weighting and ranking methods directly without prior criteria screening. This approach has proven effective in simplifying analytical complexity while improving the relevance of evaluation criteria to the company's actual operational conditions, as also suggested in several hybrid MCDM based supplier selection studies [4], [8].

The TOPSIS ranking results indicate that Supplier PT. C achieved the highest preference value compared to the other alternatives. This finding suggests that the supplier demonstrates the best overall performance in terms of material quality, price stability, and delivery reliability. These results are consistent with previous studies indicating that the integration of AHP and TOPSIS methods can produce more stable, objective, and managerially interpretable supplier selection decisions [15], [16].

From a practical perspective, the hybrid Cut-Off Point, AHP, TOPSIS framework developed in this study can serve as an applicable decision-support tool for the digital printing industry, particularly in enhancing transparency in supplier evaluation and reducing decision subjectivity. The proposed model also has the potential to improve the efficiency of supplier selection processes, especially for companies with limited analytical resources.

Nevertheless, this study has certain limitations, particularly because the case study was conducted within a single company, which requires cautious generalization of the findings. Additionally, the evaluation of criteria still involves elements of expert subjectivity, although consistency has been assessed using the AHP method. Future research may consider integrating historical supplier performance data, fuzzy approaches, or supply chain risk analysis to further enhance the accuracy and robustness of supplier evaluation.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study aimed to develop a decision making framework for raw material supplier selection in the digital printing industry through the integration of the Cut-Off Point method, Analytical Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The results indicate that the initial screening stage using the natural Cut-Off Point method successfully identified five relevant main criteria quality, delivery, price, company performance, and communication system along with a total of twenty subcriteria that reflect the company's operational requirements.

The weighting results obtained using the AHP method indicate that the delivery criterion has the highest priority weight, suggesting that supply reliability and delivery punctuality are the most critical factors in the inherently time sensitive digital printing industry. Furthermore, the ranking results derived from the TOPSIS method reveal that Supplier PT. C achieved the highest preference value and is therefore recommended as the best supplier based on its overall performance in terms of material quality, price stability, and delivery reliability.

Overall, the integration of the Cut-Off Point, AHP, and TOPSIS methods has proven effective in producing a more systematic, objective, and data driven supplier evaluation process compared to conventional approaches. The proposed hybrid framework not only enhances transparency in supplier decision making but also provides practical implications for digital printing companies in maintaining supply stability and improving operational efficiency.

Although this study provides practical contributions through the development of a supplier evaluation model based on the integration of the Cut-Off Point, AHP, and TOPSIS methods, it is limited to a single company case study; therefore, the generalization of its findings should be approached with caution. Future research is encouraged to test the proposed model across broader industrial contexts and to consider integrating historical supplier performance data, fuzzy approaches, or supply chain risk analysis to further enhance the robustness and validity of the decision-making model.

Recommendations

Based on the findings of this study, digital printing companies are encouraged to adopt more systematic and data driven supplier evaluation approaches, particularly through the integration of multi criteria methods such as the Cut-Off Point, AHP, and TOPSIS. This approach can enhance transparency in supplier selection processes, minimize decision-making subjectivity, and help maintain the stability of raw material supply under dynamic demand conditions.

In addition, the implementation of supplier evaluation models should be conducted periodically while considering changes in market conditions, supplier performance, and company production requirements. Future research may further develop the proposed model by incorporating sustainability variables, supply chain digitalization aspects, or historical supplier performance data, thereby enhancing the adaptability and comprehensiveness of decision-making models in response to the dynamic nature of manufacturing industries.

ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to PT Creative Digital Printing for providing data support and the opportunity to conduct this research. Appreciation is also extended to the respondents and experts involved in the Focus Group Discussion (FGD) process for their valuable insights and practical experience, which greatly contributed to the data collection and analysis stages. The author also thanks all parties who provided academic and technical support that enabled this research to be completed successfully.

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