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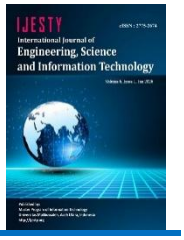

Supplier Selection for Small and Medium Enterprises: An Integrated DEMATEL- ANP Approach for Decision Making

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Abstract

ABC Bakery, a small and medium enterprise (SME), relies heavily on high-quality raw materials to meet the growing demand of its local market. Given the importance of raw material quality in product outcomes, selecting the right supplier becomes a critical task. This research applies the DEMATEL and ANP methods to identify the most suitable supplier for ABC Bakery. Through DEMATEL, the relationships between various supplier selection criteria, including Price, Quality, Delivery, Flexibility, and Responsiveness, are analyzed to understand how these factors interrelate. The ANP method is then used to perform pairwise comparisons of both the criteria and the suppliers. The results reveal that Price and Quality are the most influential factors in the supplier selection process, with Price having the greatest weight, followed by Quality. On the other hand, Delivery, Flexibility, and Responsiveness have relatively lower weights, indicating they play a less critical role than Price and Quality. Based on the ANP analysis, Supplier 1 emerges as the preferred supplier, with the highest weight of 0.44, followed by Supplier 2 (0.34) and Supplier 3 (0.22). This study demonstrates that using DEMATEL and ANP enables a more informed, structured supplier selection process, helping ABC Bakery make better procurement decisions aligned with its operational and quality goals.

Keywords: *Supplier_Selection, DEMATEL, ANP, Price, Quality.*

1. Introduction

ABC Bakery is a small and medium-sized enterprise based in Samarinda, dedicated to meeting local market demand. The company's production process relies heavily on high-quality raw materials, including flour, sugar, eggs, and other essential ingredients. The careful selection of these materials is critical, as it directly impacts the taste, appearance, and shelf life of the cakes produced, making it a vital aspect of maintaining product quality.

The need for raw materials, especially high-quality flour, is closely linked to the number of customer orders. As demand for cakes increases, ABC Bakery needs to increase its raw material purchases. Consequently, ensuring a consistent and sufficient supply of these materials is crucial to avoid production disruptions and meet the growing customer demand effectively.

Given this demand, ABC Bakery requires a reliable supplier capable of providing raw materials that meet quality standards, are competitively priced, and delivered on time, with the Flexibility to accommodate fluctuating demand. The business faces challenges in choosing the most suitable supplier, as several suppliers in Samarinda offer varying qualities, pricing, services, and delivery flexibility. Thus, a structured, well-informed decision-making process is essential for selecting the right supplier, thereby enhancing production efficiency, maintaining high-quality products, and ultimately improving customer satisfaction.

Suppliers play a pivotal role in the success of small industries, significantly influencing their quality, efficiency, and overall competitiveness. A well-chosen supplier ensures a steady supply of raw materials and components critical for production, essential for meeting market demands and maintaining operational continuity. According to Ferreira and Silva [1], effective supplier selection enables small enterprises to negotiate better pricing and delivery terms, thereby enhancing their capacity to deliver high-quality products to customers. Furthermore, strategic relationships with suppliers can lead to improved innovation and Responsiveness to market changes, as suppliers provide insights and capabilities that small firms may lack [1]. In today's competitive environment, where agility is crucial, small industries that establish strong partnerships with reliable suppliers are better positioned to respond to customer needs and adapt to market fluctuations, ultimately leading to sustained growth and success [2].

The application of Multicriteria Decision Making (MCDM) methods is essential in addressing supplier selection challenges, particularly for small and medium-sized enterprises (SMEs) that often operate with limited resources and expertise. MCDM provides a structured approach to evaluating multiple conflicting criteria inherent to supplier selection, such as Price, quality, delivery time, and sustainability practices. According to Wang et al [3], MCDM models enhance decision-making accuracy by facilitating a comprehensive analysis of suppliers based on various performance metrics, thereby supporting SMEs in making informed choices—furthermore, Momeni et al.

Momeni et al. [4] emphasized that the use of MCDM frameworks fosters collaboration and supplier involvement in innovative processes, which are critical in a rapidly changing business environment. Additionally, another research demonstrated that integrating MCDM techniques can significantly optimize the supplier selection process by addressing the specific needs and constraints of SMEs [5]. Liu and Park [6] discussed how MCDM helps in managing supply chain risks, highlighting its importance for SMEs that may lack the resilience of larger firms.

The Analytic Network Process (ANP) is used in supplier selection because it can handle complex decision-making environments with interdependent criteria. A significant advantage of ANP is its ability to assess the mutual influence among criteria, thereby enhancing the robustness of supplier assessments [7]. Khulud et al. [8] suggested that MCDM approaches such as ANP can be important for sustainable supplier selection, as they enable a comprehensive evaluation of interconnected factors. Although Rodríguez-Carrillo et al provided insights into the application of MCDM methods for SMEs, their work primarily focuses on innovation assessment rather than supplier selection specifically [9]. The study by Tronnebati et al. [10] indicates that ANP effectively integrates with other methodologies for green supplier evaluation, demonstrating its adaptability in contemporary sustainable practices. Mokadem [11] explored supplier selection criteria for lean or agile strategies but did not directly address ANP's role in evaluating conflicting criteria within the supply chain. Finally, Kellner and Utz [12] discussed various approaches, including ANP, for processing supplier selection criteria, confirming their relevance for enhancing supplier management strategies aligned with organizational goals and sustainability initiatives. These studies collectively affirm that ANP is a valuable tool for supplier selection, enabling organizations to make informed, strategic choices as they navigate supplier relationships.

The combination of the Analytic Network Process (ANP) and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) is recognized as a beneficial approach for addressing supplier selection challenges, as it can model interdependencies among criteria. The ANP facilitates evaluations by capturing the interactions and relationships between criteria, while DEMATEL identifies and quantifies these interdependencies, clearly illustrating how different factors influence one another. Khan et al. [13] discussed integrating DEMATEL into the ANP, suggesting that it can help mitigate decision-making fatigue from extensive pairwise comparisons in traditional ANP applications. Additionally, Hatefi and Tamošaitienė [14] highlighted the utility of fuzzy DEMATEL models for elucidating risk relationships in construction projects, thereby reinforcing their importance in sectors characterized by uncertainty. Moreover, integrating DEMATEL with ANP enables systematic prioritization of criteria based on their interrelationships, as noted by Jiang et al. [15], thereby providing a structured framework for informed decision-making in supplier evaluations. In general, integrating ANP and DEMATEL improves decision-making effectiveness by accounting for the intricate relationships among criteria in the supplier selection process.

This study is unique in its focus on flour supplier selection for bakery MSMEs, utilizing the DEMATEL and ANP methods. Unlike previous studies, which often include sub-criteria, this approach considers only criteria and alternatives, simplifying the decision-making process. This streamlined method is particularly beneficial for MSMEs with limited resources and time, as it reduces complexity while still supporting effective decision-making.

2. Literature Review

2.1. Criteria of Supplier Selection

In supplier selection, Price is a critical factor that cannot be overlooked. Göncü and Çetin found that, in the analysis of supplier selection criteria in the healthcare sector, Price ranked second in importance after on-time Delivery, indicating that costs must be given significant consideration in the selection process [16]. Additionally, supplier performance evaluation includes not only Price but also quality and on-time Delivery [17]. Ferreira and Silva also noted in their review of the literature that Price, alongside product quality and adherence to delivery timelines, is among the six most widely recognized criteria in supplier selection [1]. Thus, considering Price is not only crucial for cost reduction but also for ensuring the continued quality and service of the selected supplier.

Quality is a crucial criterion in supplier selection because it directly impacts customer satisfaction and production outcomes. The quality of goods and services provided by suppliers significantly contributes to a company's success in achieving its strategic and operational goals [1]. The quality assessments should be conducted in conjunction with other factors such as Price and delivery time to ensure informed supplier selection decisions [18][19]. Furthermore, quality is one of several key criteria to consider, as poor quality can increase company costs through returns and product failures [20]. Therefore, quality not only increases a company's competitiveness but also builds long-term, mutually beneficial relationships with suppliers.

Delivery criteria in supplier selection are factors that influence supply chain performance and customer satisfaction. Several studies have used multiple criteria, including Delivery, quality, and Price, in supplier selection [21]. Furthermore, research has demonstrated the importance of on-time Delivery as part of supply chain performance evaluation, recommending delivery monitoring as a key step to improve performance [22]. Another study has noted that timely, on-specification Delivery significantly impacts procurement success in the service sector, although its primary focus is on developing a sustainable supplier evaluation system [23]. Finally, they found that Delivery, alongside quality and Price, is an important criterion for evaluating supplier performance. This underscores the importance of Delivery in ensuring operational continuity [24]. These studies clearly demonstrate the importance of delivery criteria in the supplier selection process to support supply chain efficiency and effectiveness.

Flexibility is a criterion that should be considered in supplier selection because it directly affects the company's ability to adapt to changes in market demand and customer expectations. It is noted that Flexibility in supplier capacity allows firms to respond rapidly to demand fluctuations, thereby enhancing overall supply chain resilience and efficiency [25]. Similarly, it is emphasized that a supplier's ability to provide customized solutions and adjust production schedules can significantly enhance collaboration and strengthen strategic partnerships, making Flexibility an essential factor in supplier selection [26]. A systematic review highlights that flexible suppliers enable businesses to better manage uncertainties, particularly in volatile markets, resulting in reduced costs and improved service quality [27].

Responsiveness is an essential criterion in supplier selection, as it reflects a supplier's ability to respond quickly to shifts in demand and adapt to changing market conditions. It has been demonstrated that in high-velocity market environments, Flexibility combined with Responsiveness can substantially mitigate risks associated with supply chain disruptions [28]. Additionally, the systematic review of risk-based procurement practices highlights the growing need for suppliers to demonstrate not only cost-effectiveness but also Responsiveness to foster resilience in procurement strategies [28]. Lastly, it has been reported that incorporating Responsiveness alongside other criteria, such as quality and cost, is essential for optimizing supplier partnerships and ensuring a seamless supply chain [29]. Thus, including Responsiveness in supplier selection is critical to enhancing operational agility and achieving strategic business objectives.

2.2. DEMATEL ANP

DEMATEL has been employed in various studies, demonstrating its growing importance in supplier selection contexts. For instance, it has been noted that DEMATEL has become a prevalent technique in supply chain research, particularly in supplier selection studies [30]. The method's versatility in uncovering causal relationships among factors influencing supply chain decisions has been emphasized, thereby helping firms make informed supplier choices. This is especially pertinent in complex environments where conventional decision-making methods may fall short [30]. Additionally, others have further acknowledged the broad applicability of DEMATEL in modelling barriers to green computing adoption, which shares similarities with supplier selection in evaluating multiple interconnected criteria [31]. Their findings reveal that DEMATEL effectively categorizes factors into cause-and-effect groups, thereby improving decision clarity. This classification is integral to supplier selection as firms must understand how different criteria, such as quality, cost, and delivery reliability, interact to influence overall supplier performance [31].

DEMATEL can handle both qualitative and quantitative aspects in supplier evaluation. In addition, DEMATEL is a holistic approach that enables organizations to consider multiple factors effectively, thereby assisting in selecting suppliers aligned with strategic business objectives [32]. The application of DEMATEL in supplier selection has also been illustrated by Dong & Yuan [33] , who integrated it with data-driven methodologies to address carbon emissions in the selection process. This integration showcases DEMATEL's adaptability in contemporary contexts, highlighting how it enhances the decision-making framework needed to tackle emerging challenges such as sustainability in supply chains. The synergy between DEMATEL and robust optimization frameworks enhances the supplier selection strategy by providing a structured analysis that incorporates environmental considerations [33].

The use of DEMATEL in the pharmaceutical supply chain has been demonstrated by Zhan et al., who connect supplier selection to product lifecycle management. This illustrates how DEMATEL not only aids in evaluating supplier performance but also helps in understanding the long-term operational impact of supplier choices [34]. A multicriteria framework combining DEMATEL with other decision-making tools can be used for supplier sustainability evaluation, highlighting DEMATEL's role in developing strategies that consider economic, social, and environmental factors in supplier selection [35].

The application of the Analytic Network Process (ANP) in supplier selection is gaining traction as organizations increasingly recognize its value in addressing the complexities of supplier evaluation. Unlike traditional methods, ANP enhances decision-making by allowing consideration of interdependencies among criteria and factors, thereby providing a multifaceted perspective on supplier assessment. Recent literature reflects the growing significance of ANP in supplier selection frameworks. For instance, Ou et al. highlight a hybrid decision-making model that employs ANP to evaluate sustainable development performance in high-tech companies, demonstrating the method's adaptability for supplier selection through sustainability-related metrics [36]. The authors' integrated approach underscores ANP's role in facilitating informed decisions by assessing various interconnected sustainability criteria and their impacts on supplier performance.

Another noteworthy study by Assaf et al. uses an ANP-based multicriteria decision-making model to select the best project delivery systems for offsite construction projects. This study underscores the importance of interdependent criteria in procurement decisions, emphasizing the relevance of ANP for a holistic evaluation of potential suppliers and their delivery systems [37]. The methodology facilitates criterion weighting based on dependencies, thereby enhancing the robustness of the decision-making process.

In a practical application, Stokić et al. developed a comprehensive approach for vehicle procurement using a hybrid model that combines ANP with the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. Their study demonstrates that ANP can effectively identify interdependencies among procurement criteria, thereby improving strategic decisions in supplier selection [38]. This integration highlights how combining ANP with other methodologies can further enhance its effectiveness in tackling complex supplier evaluation scenarios. Furthermore, Shiue et al. elaborate on the use of ANP within a strategic multiple criteria group decision-making framework for continuous auditing systems, integrating it with DEMATEL and goal programming techniques [39]. The DEMATEL-ANP framework can be used to develop a multicriteria decision-making model for supplier selection, addressing the sector's complexity and supporting sustainability and operational objectives [16]. This application emphasizes ANP's versatility across contexts and its ability to accommodate multiple perspectives from different stakeholders, particularly in supplier selection, where varied criteria must be considered.

3. Methods

This study employs the DEMATEL and ANP methods to identify the best supplier for ABC Bakery. This study employed a quantitative approach using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method, which is designed to identify and analyze causal relationships among interrelated factors within complex systems [40]. ANP is applied to perform pairwise comparisons of both the criteria and potential suppliers. The research methodology consists of the following steps:

1. Identification of Supplier Selection Criteria:
   The first step in the supplier selection process is identifying the relevant criteria that will guide the decision-making. These criteria typically include Price, Quality, Delivery, Flexibility, and Responsiveness. The selection of these criteria is based on the company's specific needs and priorities. Price is important for cost control, while Quality ensures that the supplier meets the required product standards. Delivery is essential to maintaining operational efficiency; Flexibility ensures the supplier can adapt to changing demands, and Responsiveness reflects how quickly a supplier can address issues or concerns. Properly identifying and prioritizing these criteria is essential to making an informed, effective supplier selection decision.
2. Exploring Relationships Between Criteria Using DEMATEL
   After identifying the criteria, experts assess the degree of direct influence among them using a numerical scale (e.g., 0–4), where higher scores represent stronger effects. To ensure computational stability, the direct-relation matrix is normalised so that all values lie between 0 and 1. The normalisation value (N) is obtained by determining the maximum scaling factor (S) and direct relationship matrix (X) as follows:

$$S = \left[\sum_{j=1}^{n} x_{ij,} \ \sum_{i=1}^{n} x_{ij,}\right] \quad (1)$$

$$N = \frac{1}{S} X \quad (2)$$

The total relation matrix T, which captures both direct and indirect relationships among the criteria, is calculated using the normalised matrix (N) and the identity matrix (I) as follows:

$$T = N(I - N)^{-1} \quad (3)$$

Based on the total relationship matrix, two main indicators are calculated, namely D (dispatching power) and R (receiving power).

$$D_i = \sum_{j=1}^{n} \quad t_{ij} \quad (4)$$
$$R_i = \sum_{j=1}^{n} \quad t_{ji} \quad (5)$$

The next step is to conduct a Prominence and Relation Analysis and create a Cause-Effect Diagram.

3. Performing Pairwise Comparisons with ANP for Criteria and Alternatives
   The Analytic Network Process (ANP) is then applied to perform pairwise comparisons for both the selection criteria and the alternatives. In this step, decision-makers compare each criterion and each alternative relative to one another, assessing their importance and preferences. The pairwise comparison matrices help assign weights to each criterion, reflecting its relative importance in the decision-making process. Similarly, alternatives are compared based on how well they satisfy each criterion. This step is essential for structuring the decision-making process and developing a comprehensive evaluation model that accounts for both the criteria and the alternatives, along with their interrelationships.
4. Conducting Consistency Test
   Once the pairwise comparisons are completed, it is essential to check the consistency of the judgments made using the Consistency Ratio (CR) in the ANP method. The consistency test ensures that the comparisons made between the criteria and alternatives are logically coherent. If the CR value exceeds the acceptable threshold (typically 0.10), it indicates inconsistent judgments and may require adjustments. This step is important because it ensures the reliability of the pairwise comparisons and the robustness of the decision-making process. A low consistency ratio confirms that the judgments made are sound and dependable, leading to valid conclusions.
5. ANP Calculation to Obtain Weights for Criteria and Alternatives
   The final step in the ANP process is to calculate the weights for each criterion and alternative. This is done by using an eigenvector method or other mathematical techniques to aggregate the results from the pairwise comparisons. The weights represent the relative importance of each criterion in the supplier selection process and indicate how well each alternative performs relative to these criteria. By performing this calculation, decision-makers obtain a clear ranking of both the criteria and the alternatives, which helps to identify the most suitable supplier. The ANP method thus provides a structured and quantitative approach to decision-making, ensuring that all relevant factors are systematically considered in the evaluation process.

4. Result and Discussion

This study uses the DEMATEL method to analyze the relationships and interdependencies among criteria in the supplier selection process. By assessing the direct and indirect influences among criteria such as Price**,** Quality**,** Delivery**,** Flexibility, and Responsiveness, DEMATEL provides a comprehensive understanding of how these factors interact. This relationship matrix is crucial for constructing an Analytic Network Process (ANP) model, as it serves as the foundation for evaluating the relative importance and dependencies of the criteria. The insights from DEMATEL enable a more accurate, structured decision-making process in ANP, enabling the effective prioritization of supplier selection factors based on their mutual influence.

Table 1. Results of the Relationship Assessment Between Criteria

Criteria	Supplier Selection	Price	Quality	Delivery	Flexibility	Responsiveness
Supplier Selection	0	4	4	4	4	4
Price	4	0	4	1	1	1
Quality	4	4	0	1	1	1
Delivery	4	4	1	0	4	4
Flexibility	4	3	1	4	0	4
Responsiveness	4	3	1	4	3	0

Table 1 shows the results of the relationship assessment between criteria using the DEMATEL method. The matrix illustrates the influence of each criterion on the others, with values ranging from 0 to 4. A value of 0 indicates no influence, while a 4 represents a very strong influence. For example, Supplier Selection has a very strong influence on all other criteria, as indicated by the consistent 4 in the respective columns. Similarly, Price has a strong influence on Supplier Selection, Quality, and Delivery, while its influence on Flexibility and Responsiveness is relatively weaker, with a score of 1.

In this matrix, Quality exhibits a strong influence on both Supplier Selection and Price, but its effect on Delivery, Flexibility, and Responsiveness is moderate. On the other hand, Delivery has a significant influence on Supplier Selection, Price, and Responsiveness, and shows a balanced relationship with Flexibility. Flexibility and Responsiveness are relatively influenced by Supplier Selection, Delivery, and Price, but their influence on other criteria is less pronounced, demonstrating their reactive roles in the supplier selection process. This matrix highlights the importance of understanding the interdependencies between criteria when making informed decisions in supplier selection.

Table 2 presents the Normalisation Matrix (D), a step in the DEMATEL process. This matrix shows the normalized values of the relationships between criteria, calculated by dividing each element of the relationship matrix by the maximum value in its respective column. The primary function of normalization in DEMATEL is to scale the relationship values between criteria so they are comparable across criteria, ensuring that the magnitude of the values does not skew the analysis.

Table 2. Normalisation Matrix (D)

Criteria	Supplier Selection	Price	Quality	Delivery	Flexibility	Responsiveness
Supplier Selection	0	0.2	0.2	0.2	0.2	0.2
Price	0.2	0	0.2	0.05	0.05	0.05
Quality	0.2	0.2	0	0.05	0.05	0.05
Delivery	0.2	0.2	0.05	0	0.2	0.2
Flexibility	0.2	0.15	0.05	0.2	0	0.2
Responsiveness	0.2	0.15	0.05	0.2	0.15	0

The next step of DEMATEL is to subtract the identity matrix from the normalization matrix (D). The results of subtracting the identity matrix from the normalization matrix (D) are shown in Table 3. The matrix results are then subjected to inverse operations, as shown in Table 4. In the next stage, the total relation matrix is obtained by multiplying the normalization matrix and the inverse matrix. The resulting total relation matrix is shown in Table 5.

Table 3. Result of Identity Matrix (I)-Normalisation Matrix (D)

Criteria	Supplier Selection	Price	Quality	Delivery	Flexibility	Responsiveness
Supplier Selection	1	-0.2	-0.2	-0.2	-0.2	-0.2
Price	-0.2	1	-0.2	-0.05	-0.05	-0.05
Quality	-0.2	-0.2	1	-0.05	-0.05	-0.05
Delivery	-0.2	-0.2	-0.05	1	-0.2	-0.2
Flexibility	-0.2	-0.15	-0.05	-0.2	1	-0.2
Responsiveness	-0.2	-0.15	-0.05	-0.2	-0.15	1

Table 4. Result of Inverse Matrix

Criteria	Supplier Selection	Price	Quality	Delivery	Flexibility	Responsiveness
Supplier Selection	1.66	0.77	0.58	0.66	0.63	0.66
Price	0.55	1.36	0.43	0.33	0.32	0.33
Quality	0.55	0.53	1.26	0.33	0.32	0.33
Delivery	0.76	0.71	0.43	1.45	0.59	0.62
Flexibility	0.74	0.65	0.41	0.6	1.41	0.6
Responsiveness	0.70	0.62	0.39	0.58	0.52	1.41

Table 5. Total Relation Matrix

Criteria	Supplier Selection	Price	Quality	Delivery	Flexibility	Responsiveness
Supplier Selection	0.66	0.77	0.58	0.66	0.63	0.66
Price	0.55	0.36	0.43	0.33	0.32	0.33
Quality	0.55	0.53	0.26	0.33	0.32	0.33
Delivery	0.76	0.71	0.43	0.45	0.59	0.62
Flexibility	0.74	0.65	0.41	0.60	0.41	0.60
Responsiveness	0.70	0.62	0.39	0.58	0.52	0.41

The DEMATEL method provides valuable insights into the relationships among criteria by analyzing two key components: Ri (Row Influence) and Ci (Column Influence). The values in the Ri column represent the total influence each criterion receives from other criteria, while the Ci column indicates the total influence each criterion exerts on others. For example, Supplier Selection has equal values for Ri and Ci, both at 3.96, signifying that it has a balanced influence on and is equally influenced by other criteria. In contrast, Price shows a negative net influence (Ri - Ci = -0.55), suggesting that it primarily influences other criteria more than it is influenced itself.

The sum of Ri + Ci reveals the total interaction for each criterion. Supplier Selection has the highest total influence (7.93), indicating its central role in the decision-making process. In contrast, Price has a lower total influence (5.18), reflecting its more limited impact on the overall system. Delivery and Flexibility both have strong positive net influences (1.26), meaning other criteria more influence them than they influence others. Responsiveness, with a net influence of 0.94, also plays an essential role, though it is somewhat less influential than Delivery and Flexibility. These results help identify the most influential criteria in the decision-making process, guiding the prioritization of factors in supplier selection.

Table 6. Table of Influence between criteria

Criteria	Ri	Ci	Ri+Ci	Ri-Ci
Supplier Selection	3.96	3.96	7.93	0
Price	2.32	2.87	5.18	-0.55
Quality	2.32	1.92	4.24	0.39
Delivery	3.55	2.29	5.84	1.26
Flexibility	3.41	2.15	5.56	1.26
Responsiveness	3.23	2.29	5.51	0.94

The next step is to calculate the threshold from the average value in the Total Relation Matrix (Table 5), yielding a threshold of 0.52. Compare the threshold value with the contents of all cells in the total relation matrix (Table 5). If it exceeds the threshold value, there is a relationship. Supplier Selection has a significant influence on all other criteria, with values ranging from 0.55 to 0.77, all of which exceed the threshold of 0.52. This indicates that Supplier Selection plays a central role in the decision-making process, with a relatively strong effect on other factors such as Price, Quality, Delivery, Flexibility, and Responsiveness. Its impact is consistently strong across all relationships. The relationship between Price and other criteria shows that its influence on Supplier Selection (0.55) and Quality (0.53) is strong enough to be significant, as both values exceed the threshold. However, its influence on Delivery, Flexibility, and Responsiveness is weak (all values below 0.52), meaning that Price does not significantly affect these criteria in the supplier selection process. Quality has a moderate influence on Supplier Selection (0.55) and Price (0.53), both of which exceed the threshold, indicating a noticeable impact on these criteria. However, its influence on Delivery, Flexibility, and Responsiveness is weak, as all these values are below 0.52. This suggests that Quality plays a lesser role in influencing these criteria. Delivery has strong influences on Supplier Selection (0.76) and Price (0.71), with values for both exceeding the threshold. Quality (0.43) shows a moderate influence. Its relationship with Flexibility, Responsiveness, and Quality shows a weaker influence. However, Delivery remains a significant factor in the decision-making process for selecting a supplier. Flexibility has a strong influence on Supplier Selection (0.74) and Delivery (0.60), both of which exceed the threshold, indicating it plays an important role in the decision-making process. However, its influence on Price and Responsiveness is relatively weak, with values below 0.52, suggesting that Flexibility does not significantly affect these criteria. Responsiveness influences Supplier Selection (0.70) and Delivery (0.58), both of which exceed the threshold, making them significant relationships. However, its influence on Price, Quality, and Flexibility is weak, as the values for these relationships fall below the threshold of 0.52.

The relationship between the criteria is illustrated in Figure 1, based on the DEMATEL results. Figure 1 illustrates the cause-and-effect relationships between various criteria using arrows to indicate the direction of influence. For instance, the relationship between quality and Price is represented by a line with an arrow pointing from quality to Price, indicating that the quality of the product or service influences Price. This implies that higher quality often leads to a higher price, but Price does not affect quality, as indicated by the absence of an arrow pointing in the opposite direction. The same approach is used to depict the relationships between other criteria in the system. Each arrow represents a one-way influence, and the direction of the arrows clarifies which criteria are the cause and which are the effect.

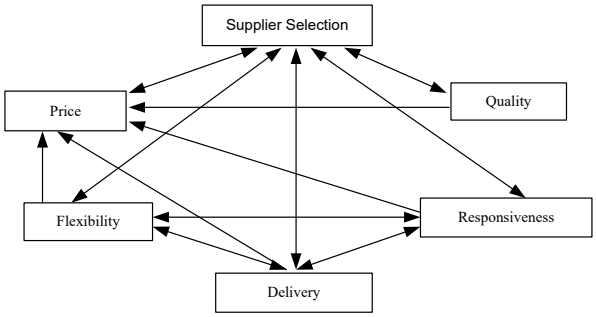

Fig 1. Result Relationship with DEMATEL

After determining the relationship direction with DEMATEL, the next step is to conduct pairwise comparisons with the ANP to identify the best supplier. Pairwise comparisons require a consistency test to determine whether the comparisons are consistent. Table 7 presents the results of the Consistency Ratio (CR) test from the pairwise comparison matrix of criteria in the Analytic Network Process (ANP) method. The Consistency Ratio is used to assess the extent to which decision-makers' subjective assessments during pairwise comparisons of criteria are consistent. This step is crucial because it ensures that judgments are logical and coherent, minimizing potential errors in the decision-making process. In this case, the CR values in the table are all below the standard tolerance threshold of 0.10 (10%), indicating that the consistency of the evaluations is acceptable and that no significant inconsistencies are present in the judgments.

Table 7. Table of Consistency Ratio

Comparison	Consistency Ratio
Criteria for Supplier Selection	0.035
Criteria for Delivery	0.009
Criteria for Flexibility	0.009
Criteria for Responsiveness	0.023
Alternative for Price Criteria	0.000
Alternative for Quality Criteria	0.018
Alternative for Delivery Criteria	0.000
Alternative for Flexibility Criteria	0.000
Alternative for the Responsiveness Criteria	0.000

The results of the Analytic Network Process (ANP) are summarised in Table 8, which presents the weighted importance of each criterion in the supplier selection process. Price is the most significant criterion, with a weight of 0.40. This indicates that cost plays a dominant role in decision-making, reflecting its importance in determining the overall competitiveness and affordability of the supplier's offerings. In many industries, controlling costs and ensuring competitive pricing are essential for businesses to maintain profitability, as reflected in this high weight for Price.

Quality follows closely behind Price, with a weight of 0.34. This demonstrates that the quality of the product or service provided by the supplier is also a critical factor, though slightly less important than Price. The emphasis on Quality indicates that while cost is important, the supplier must also meet the required standards to ensure customer satisfaction, durability, and performance. This weight suggests that customers prioritise getting good value for their money, which means suppliers must deliver quality products at competitive prices.

Flexibility, with a weight of 0.09, has a relatively smaller influence in the supplier selection process. This suggests that while Flexibility, such as the ability to adapt to changes in demand, customize products, or adjust delivery schedules, is valuable, it is less important than Price and Quality. Flexibility may still play a role in supporting the relationship between the business and the supplier, especially in industries that experience frequent demand fluctuations or require custom solutions.

Delivery has the lowest weight of 0.06, indicating it is the least important criterion in this analysis. This could mean that, while timely and efficient Delivery is essential, it is not a major deciding factor compared to other criteria like Price and Quality. In some cases, businesses may be willing to tolerate slightly longer delivery times if the supplier offers better prices or higher-quality products.

Responsiveness has a weight of 0.11, making it more important than Delivery but still relatively less significant than Price and Quality. This suggests that suppliers' ability to respond quickly to inquiries, resolve issues, and provide customer support is valued. Still, it is not as critical as the core factors of Price and Quality. Responsiveness may be important for maintaining a good supplier relationship, especially in industries where quick adaptation to market changes is necessary.

The results from the ANP (Analytic Network Process) for the supplier selection process indicate the relative importance and suitability of each supplier based on the weighted criteria. Supplier 1 has the highest weight of 0.44, indicating it is the most favourable option among the three. This indicates that Supplier 1 best aligns with the decision-making criteria, providing a balanced combination of factors such as Price, quality, Flexibility, Delivery, and Responsiveness that make it the preferred choice.

Supplier 2 comes second with a weight of 0.34, making it a solid alternative, though not as strong as Supplier 1. While it may offer competitive pricing or adequate quality, it falls short in certain areas compared to Supplier 1, resulting in a lower score. Supplier 3, with the lowest weight of 0.22, ranks third in the selection process, indicating it is less optimal than the other two suppliers. Although Supplier 3 meets the basic requirements, it does not perform well across the weighted criteria, making it the least favourable choice. The results show a clear preference for Supplier 1, with Supplier 2 as a secondary option and Supplier 3 trailing.

Table 8. Result of ANP

Name	Weighting
Supplier Selection	1
Price	0.40
Quality	0.34
Flexibility	0.09
Delivery	0.06
Responsiveness	0.11
Supplier 1	0.44
Supplier 2	0.34
Supplier 3	0.22

5. Conclusion

Based on the results of this research, the DEMATEL method was successfully used to determine the relationships among the criteria for selecting flour suppliers in small industries, namely ABC bakery. Price has a notable impact on Supplier Selection and Quality, but its influence on other criteria, such as Delivery, Flexibility, and Responsiveness, is relatively weaker. Quality has a moderate effect on Supplier Selection and Price, but it plays a lesser role in influencing Delivery, Flexibility, and Responsiveness. Delivery has a significant influence on Supplier Selection, Price, and Quality, but its impact on Flexibility and Responsiveness is weaker. Flexibility and Responsiveness also strongly affect Supplier Selection and Delivery. Still, their influence on other factors, such as Price and Quality, is less pronounced. Price emerges as the most dominant factor in the decision-making process, with other criteria providing supporting roles.

In conclusion, the ANP analysis indicates that Price and Quality are the most influential criteria in the decision-making process, with Price having the highest weight of 0.40, followed by Quality at 0.34. This suggests that cost and product quality are the primary factors driving supplier selection. On the other hand, Flexibility, Delivery, and Responsiveness have significantly lower weights, indicating that while these criteria still play a role, they are less important than Price and Quality. Flexibility and Responsiveness are relatively less influential, with weights of 0.09 and 0.11, respectively, and Delivery is the least influential criterion, with a weight of 0.06

In conclusion, the ANP analysis for ABC Bakery's supplier selection process reveals a clear ranking of the suppliers based on the established criteria. Supplier 1, with the highest weight of 0.44, emerges as the most suitable and preferred supplier for the bakery, as it best meets the business's criteria and requirements. Supplier 2, with a weight of 0.34, follows closely, indicating that while it is a strong option, it is slightly less optimal compared to Supplier 1. Supplier 3, with the lowest weight of 0.22, ranks third, suggesting that it is the least favourable choice among the three suppliers

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