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A Market-Oriented Approach to Procurement Market and Supplier Selection in Agricultural Supply Chains

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ABSTRACT

Within agricultural supply chains, decisions concerning the choice of procurement markets and suppliers constitute an important strategic issue. The performance and competitiveness of an agricultural business are strongly influenced by its ability to identify suppliers capable of adapting efficiently to changing market requirements and demand conditions. Because supplier evaluation involves several, often competing considerations, the selection process can be formulated as a multi-criteria decision-making problem in which alternative suppliers must be assessed systematically against a defined set of criteria. In view of this complexity, the present study develops an integrated decision-support model for selecting procurement markets and suppliers in agricultural supply chains. The proposed framework combines the Best Worst Method (BWM), which is employed to establish the relative significance of the evaluation criteria, with the multi-objective optimisation based on simple ratio analysis (MOOSRA) method, which is used to determine the ranking of competing suppliers. The applicability of the framework is demonstrated through a case study involving supplier evaluation within an agricultural supply chain. Four alternative suppliers were assessed using six criteria, namely product price, delivery lead time, product quality, delivery reliability, sustainability compliance, and financial stability. Based on the resulting evaluation and ranking, Supplier 2 was identified as the most appropriate alternative for the agricultural company examined in the case study.

1. Introduction

Supply chain management (SCM) encompasses the coordinated management of activities, processes, and inter-organisational relationships involving the different actors that constitute a supply chain. Within the agricultural sector, achieving an efficient and effectively implemented supply chain remains challenging, and the identification of appropriate suppliers represents a particularly important concern. Procurement activities therefore require systematic planning to ensure that the necessary volumes of agricultural products and production inputs are obtained at the required quality level and delivered within the specified period. At the same time, procurement decisions must account for the dependability of potential suppliers. Consequently, agricultural firms

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need to make informed decisions regarding both the procurement market and the suppliers from which they source.

For organisations participating in agricultural supply chains, supplier selection constitutes a fundamental component of procurement management and can have substantial implications for overall organisational performance. It is also an important element of strategic planning because a firm's ability to achieve superior performance and sustain competitive advantage is closely associated with its capacity to establish effective relationships with dependable suppliers [1]. Supplier-related decisions have a direct bearing on four major competitive priorities, namely quality, delivery, flexibility, and cost [2]. Accordingly, supplier evaluation should extend beyond the identification of an economically attractive alternative and should seek to determine suppliers that provide an appropriate overall fit, reduce procurement-related exposure, and support durable buyer-supplier relationships. The strategic importance of selecting an appropriate procurement market and supplier base has become more pronounced as agricultural firms operate in increasingly volatile business environments. Globalisation, technological advancement, seasonal variations in agricultural production, and continuous changes in supply and demand conditions all contribute to the complexity of procurement decisions. Selecting an appropriate procurement market can consequently assist agricultural firms in controlling expenditure, improving the quality of acquired products, securing continuity of supply, and strengthening their competitive position.

Supplier assessment from a market-oriented perspective requires consideration of several dimensions, including purchasing price, dependability of deliveries, responsiveness to customer requirements, reputation within the market, and the capacity to maintain sustainable business relationships over the long term. Such internal evaluation factors must also be considered alongside external conditions that can affect procurement outcomes. Regulatory constraints, geopolitical uncertainty, climatic variability, and broader economic developments may substantially alter the attractiveness and reliability of alternative procurement markets and suppliers. Against this background, the present study examines the criteria and methodological approaches relevant to procurement market and supplier selection in agricultural supply chains, while incorporating market conditions that may influence strategic business decisions. To address this decision problem, an integrated model employing BWM and MOOSRA is proposed. BWM is used to establish the relative weights of the relevant selection criteria, whereas MOOSRA is subsequently applied to evaluate and rank the available suppliers.

The remainder of this paper is organised into five sections. Section 2 discusses the underlying problem and reviews the pertinent literature. The methodology underpinning the proposed model is presented in Section 3. Section 4 describes the case study and analyses the results generated through implementation of the proposed model. The principal conclusions and final observations are presented in Section 5.

2. Problem Analysis with a Review of Relevant Literature

SCM brings the various actors involved in a supply chain together within an interconnected and coordinated framework. The removal of organisational and transactional barriers among trading partners supports the rapid and uninterrupted exchange of information. Moreover, the application of digital monitoring technologies can strengthen operational visibility while improving the coordination of equipment and activities within complex logistics systems [3]. In the agricultural context, supply chains encompass considerably more than conventional logistics functions, such as operational management, transportation, warehousing, and information processing. They also incorporate a wider range of managerial and commercial activities, including customer relationship management, demand forecasting and planning, procurement, and related functions.

The systemic nature of SCM emphasises the coordinated optimisation of activities and the development of productive relationships among participating stakeholders. An important objective is to establish mutual trust between supply chain actors while ensuring that information concerning market requirements is communicated effectively. Such coordination facilitates the timely provision of agricultural products and production inputs, while rationalising the supplier base and supporting the development of stable resources for enduring and mutually advantageous supplier relationships. Agricultural and food supply chains are characterised by continuous interactions involving farmers, businesses, consumers, and institutional actors, meaning that effective coordination and the efficient movement of resources are fundamental to maintaining supply chain sustainability [4]. Since supplier performance directly affects the quality of products and services available throughout the chain, organisations must devote considerable attention to the identification of appropriate suppliers and procurement markets. This makes supplier and sourcing-market selection a persistent and strategically significant challenge within agricultural supply chains.

2.1 Procurement Planning and Supplier Management

Procurement represents a coordinated process through which agricultural organisations obtain the products, raw materials, machinery, equipment, tools, and other resources required to maintain continuous supply chain operations. Its fundamental purpose is to secure the necessary inputs in a reliable manner while controlling associated expenditure. This requires ensuring that the appropriate materials are obtained in suitable quantities and conditions, at the required time and location, from dependable suppliers, with the necessary level of service [5]. Consequently, effective procurement requires a clearly defined planning framework that establishes appropriate objectives, procedures, and operational guidelines. The formulation of an effective procurement plan requires the integration of procurement requirements with several interconnected organisational functions. In agricultural production, this includes technical specifications, material categories, required quantities, auxiliary inputs, machinery, and tools. From a sales perspective, procurement planning incorporates activities directed towards obtaining favourable purchasing conditions, selecting suppliers, managing IT-related procurement requirements, and understanding relevant pricing conditions. Workforce considerations are also important, particularly employee training and ensuring that personnel possess an adequate understanding of procurement procedures.

The transition from procurement planning to effective implementation requires the planned requirements to be translated into a material balance or material plan. This balance is determined by relating the quantity of material required for a single unit of production to the anticipated overall production volume. Although such planning is commonly undertaken for an annual period, the resulting requirements can be disaggregated further to reflect the characteristics and seasonal patterns of particular agricultural production activities. A material balance generally specifies the relevant material classification codes and descriptions together with unit costs, measurement units, required quantities, aggregate material value, and the corresponding procurement schedule [5]. Nevertheless, procurement planning is not determined exclusively by material requirements and inventory considerations. Procurement policies, available stock, variations in market prices, seasonal availability, and the sales policies adopted by suppliers can also alter procurement requirements. Further refinement may therefore be undertaken according to the functional classification of materials, agricultural production requirements, supplier segmentation, and the optimisation of order quantities.

Determining appropriate inventory levels is another central component of procurement planning because inventory policies establish when replenishment should be initiated. Identifying this threshold is challenging because procurement decisions are shaped by the simultaneous interaction of several cost and operational variables. From an economic perspective, the procurement quantity should be determined at a level that minimises the aggregate expenditure associated with purchasing, storage, and investment in working capital. Within agricultural supply chains, however, procurement decisions must satisfy additional operational constraints. An appropriate procurement strategy needs to preserve continuity of market supply while controlling purchasing and storage expenditure and accounting for the seasonal nature and perishability of agricultural products. For products that are sensitive to temperature, maintaining appropriate environmental conditions throughout transportation and storage is particularly important because temperature monitoring contributes to the preservation of product quality and safety [6].

Procurement market analysis requires a comprehensive assessment of both the costs associated with sourcing and the risks that may affect supply. Market research consequently constitutes a fundamental yet complex component of procurement management. Its scope is shaped by the organisation's procurement policies and encompasses the identification of an appropriate sourcing market, examination of its structure, and evaluation of available alternatives according to factors such as offer conditions, product quality, availability, and price. Establishing a systematic procurement framework can substantially reduce exposure to sourcing-related risks. This is particularly important in agricultural supply chains, where interruptions in the supply market can immediately threaten procurement continuity. Such exposure may be reduced through systematic monitoring of market conditions or by maintaining inventory at an appropriate level to provide a buffer against supply disruptions.

From a theoretical standpoint, the preferred procurement outcome would be the acquisition of agricultural products and materials that simultaneously provide high quality, favourable cost, and reliable availability. Achieving all three conditions concurrently is considerably more difficult in practical settings. Seasonal production patterns, fluctuations in prices, the perishable nature of agricultural products, and the financial and operational burden associated with excessive inventory can create significant trade-offs among procurement objectives. Procurement operations must therefore be designed for efficiency, with purchasing cycles appropriately synchronised with both agricultural production schedules and the corresponding cycles of market supply.

2.2 Supplier Selection Policy

Identifying an appropriate supplier can be regarded as one of the most consequential stages of procurement. The intrinsic quality of an agricultural product does not by itself guarantee procurement value when the supplying organisation is unable to preserve that quality or fulfil delivery commitments. Supplier suitability therefore depends on several interconnected capabilities, including the capacity to satisfy order requirements, maintain specified product standards throughout fulfilment, meet agreed delivery schedules, and provide economically competitive terms. For example, a supplier may commit to supplying a particular quantity on a specified date, yet delayed delivery or non-compliance with the agreed quality requirements can significantly diminish the practical value of the transaction for the buyer. Supplier selection must consequently commence with the identification of qualified sources that can consistently provide the required agricultural products and production inputs in accordance with procurement requirements.

A comprehensive supplier assessment normally considers both the current capabilities and longer-term viability of potential suppliers. Financial soundness and the ability to remain operational over an extended period are important because unstable suppliers may create additional sourcing risks. Adequate production or supply capacity is likewise necessary to ensure that the quantities requested by the buyer can be fulfilled accurately and consistently. In addition, suppliers should demonstrate conformity with required quality specifications, dependable delivery performance, short lead times, competitive pricing, and sufficiently flexible payment or financing arrangements. Their responsiveness to changes in customer requirements and market conditions is also relevant. Other dimensions that may distinguish alternative suppliers include experience in agricultural production or supply activities, market standing, previous business relationships, and the capacity to develop stable, long-term partnerships.

Supplier selection has strategic implications because it can influence operational effectiveness, expenditure control, product quality, and the broader performance of agricultural supply chains. Since the same agricultural product or production input can generally be obtained from several potential sources, organisations must determine not only which suppliers to engage but also how many suppliers should form part of the procurement portfolio. This decision is particularly important when both competitive procurement and security of supply are considered. Dependence on a single source can increase vulnerability to production failures, adverse climatic conditions, sudden price movements, and logistical interruptions. Such vulnerabilities can become especially pronounced in food supply chains where local logistics systems possess limited flexibility [7]. Maintaining alternative sources can therefore provide an important safeguard against procurement disruption. Furthermore, suppliers offering the same price cannot necessarily be considered equivalent because variations in product quality, delivery performance, available capacity, and long-term dependability may produce substantially different procurement outcomes.

A commonly adopted approach to managing the supplier portfolio is based on the Pareto Optimum, commonly expressed as the 80:20 rule. Under this arrangement, approximately 80% of a particular procurement requirement is assigned to a principal supplier, whereas the remaining 20% is distributed among alternative suppliers. Although dividing procurement volumes among several sources may generate higher transaction and purchasing costs than concentrating the entire requirement with one supplier, diversification provides important strategic benefits. First, it strengthens supply continuity by creating alternative sourcing options. If the principal supplier encounters a crop failure, operational closure, financial difficulties, or transportation-related disruption, procurement volumes can be redirected towards other suppliers, thereby reducing the likelihood of a severe interruption. Secondly, maintaining relationships with alternative suppliers strengthens the buyer's negotiating position. The principal supplier has a greater incentive to sustain acceptable product quality, dependable delivery performance, and competitive pricing when the buyer retains the ability to reallocate orders to alternative sources if existing procurement conditions become unsatisfactory.

The determination of an appropriate supplier portfolio therefore requires a trade-off between economic efficiency and security of supply. Excessive supplier diversification may increase procurement complexity and costs, whereas excessive dependence on a limited number of sources can heighten disruption exposure. The quantity assigned to each supplier should consequently be sufficient to provide an incentive for the supplier to give adequate priority to the buyer's requirements and commit the necessary resources to fulfilling them [5]. Within agricultural supply chains, purchasing decisions are consequently influenced by four broad groups of determinants: environmental factors, organisational factors, interpersonal factors, and individual factors.

Environmental factors encompass the microeconomic and macroeconomic circumstances under which procurement decisions are made. These circumstances include the magnitude of primary demand, prevailing economic expectations, the cost and accessibility of capital, technological progress, applicable legal and political requirements, competitive conditions within the market, climatic variability, and seasonal patterns affecting agricultural production. Collectively, these conditions can alter the availability, market price, and quality of agricultural products and production inputs accessible through different procurement markets. Organisational factors are associated with the institutional framework through which procurement activities are planned, governed, and executed. They include organisational objectives, procurement policies, established procedures, and the operational systems supporting purchasing activities. The increasing strategic relevance of procurement functions is largely associated with the need to control supply-related uncertainties and secure dependable access to agricultural products and production materials. In this context, organisations are increasingly using long-term supplier agreements to strengthen supply continuity and reduce their vulnerability to seasonal variations in market conditions.

Interpersonal factors originate from the interactions among individuals participating in procurement decisions. Different stakeholders contribute to the purchasing process according to their respective responsibilities and can influence one another during the decision-making process. Users are responsible for applying the acquired products or materials in operational activities, whereas influencers affect purchasing choices through recommendations, specialist knowledge, or technical assessments. Buyers are responsible for negotiating procurement terms and formalising purchasing agreements. Decision-makers possess the authority to approve or reject purchasing decisions, while gatekeepers regulate access to and distribution of information relevant to procurement activities. Individual factors reflect differences in the personal characteristics and behavioural tendencies of those participating in procurement decisions. The manner in which a procurement participant evaluates alternatives may be influenced by characteristics such as age, income, educational attainment, organisational position, professional background, assertiveness, and willingness to accept risk. Considering these individual differences alongside environmental, organisational, and interpersonal conditions provides a more comprehensive basis for understanding procurement behaviour. An integrated assessment of all four categories can assist agricultural organisations in making more appropriate supplier choices, strengthening procurement effectiveness, and reducing vulnerabilities throughout agricultural supply chains.

2.3 Criteria and Models for Supplier Selection

A comprehensive examination of the existing literature indicates that supplier evaluation has frequently been reduced to price, with purchasing decisions sometimes being based almost exclusively on this criterion. Such an approach is insufficient for agricultural supply chains, where supplier suitability is determined by a broader combination of quantitative and qualitative considerations. The multidimensional nature of supplier selection requires organisations to assess alternatives across several criteria rather than relying on a single measurable attribute. These criteria may be organised using a hierarchical decision structure or considered within a single evaluation level. Among the hierarchical configurations reported in supplier selection studies, a three-level structure is particularly common. At the first level, the principal evaluation criteria are specified; the second level contains the corresponding sub criteria; and the third level comprises the supplier alternatives being evaluated. Based on the preceding analysis, frequently considered dimensions of supplier assessment include delivery time, total cost, payment conditions, product quality, the quality assurance period, and supplier creditworthiness. These dimensions capture both the commercial and operational characteristics that determine whether a supplier can satisfy the requirements of an agricultural organisation.

Delivery time (C1) can be further differentiated into pre-payment delivery (C11) and post-payment delivery (C12). This criterion is particularly important because procurement schedules must be synchronised with agricultural production requirements and prevailing market demand. Failure to align delivery schedules with operational requirements may create shortages of essential inputs, interrupt production activities, accelerate the deterioration of perishable goods, or result in inventory levels that exceed practical requirements. Total cost (C2) represents another central consideration in procurement and contractual decisions. Supplier assessment should not be based on a single price observation because the cost of agricultural products and production materials can vary considerably over time. Changes in market supply and demand, seasonal availability, climatic conditions, and transportation expenditure can all contribute to price fluctuations. Continuous monitoring and evaluation of these cost conditions are therefore necessary when comparing alternative suppliers.

Payment terms (C3) describe the financial arrangements under which procurement transactions are settled. Possible arrangements include bank transfer payment (C31), payment supported by a bank guarantee or acceptance order (C32), and advance payment (C33). The selected arrangement can influence an organisation's financial planning, liquidity, and cash-flow requirements. In agricultural procurement, advance payment may be requested by some suppliers to support production activities or facilitate order preparation, whereas other suppliers may permit settlement after the products have been delivered. Product quality (C4) has direct implications for the practical value and subsequent use of procured agricultural products and materials. Quality deficiencies can adversely affect storage characteristics, processing activities, usability, and acceptance in the target market. Inadequate-quality deliveries may consequently generate spoilage, production losses, rejected consignments, or materials that are unsuitable for their intended application. Assessment under C4 may therefore incorporate characteristics such as conformity with technical specifications, compliance with safety requirements, freshness, and functional performance.

The quality assurance period (C5) is especially significant where agricultural products or production materials are susceptible to quality deterioration during transportation or storage. Depending on the nature of the procured item, this period may be specified in days, months, or years. The duration of quality assurance can influence decisions concerning storage, product handling, replacement, and the longer-term dependability of procurement arrangements. Supplier creditworthiness (C6) provides an indication of the reliability and standing of a supplier and can be evaluated using prior collaboration (K61) and market reputation (K62). Historical performance is particularly informative when alternative suppliers obtain comparable evaluations across the remaining selection criteria. Previous business experience can provide evidence concerning a supplier's consistency, reliability, and ability to maintain satisfactory commercial relationships.

Following the comprehensive assessment of supplier proposals, the available alternatives must be systematically ordered to determine which supplier offers the most appropriate overall option before contractual negotiations are initiated. A broad range of decision-support approaches has been developed for this purpose. These include DEA and MCDM techniques, among which AHP, ANP, TOPSIS, VIKOR, CoCoSo, and MARCOS is frequently applied. Other approaches include mathematical programming, artificial intelligence-based models, and fuzzy logic techniques [8-11]. The suitability of each approach depends on the characteristics of the decision problem, the nature of the available information, and the requirements of the application context. Collectively, these methods provide structured mechanisms for comparing competing suppliers and supporting procurement decisions based on multiple evaluation dimensions rather than relying solely on price.

2.4 Literature Review

The literature contains a broad range of approaches for addressing supplier selection, reflecting the multidimensional nature of this procurement problem. MCDM techniques are particularly prevalent, and many investigations combine complementary methods to account for different aspects of supplier evaluation. One approach integrates BWM, fuzzy Shannon entropy, and fuzzy MULTIMOORA to evaluate supplier alternatives [11]. Another study introduces a data-driven, multi-stage framework that combines stochastic fuzzy BWM with multi-objective optimisation to address sustainable and resilient supplier selection together with order allocation [12]. AHP has also been implemented within an interval type-2 fuzzy environment to support the identification of green suppliers [8]. Other research has applied multiple MCDA techniques under fuzzy conditions to evaluate sustainable suppliers and subsequently examined the robustness of the resulting rankings when the weights assigned to the criteria were varied [13]. Pythagorean fuzzy AHP and fuzzy TOPSIS have likewise been integrated for green supplier selection [14]. An alternative framework combines DEA, FUCOM, and CoCoSo for supplier evaluation and additionally incorporates an approach for allocating orders among the selected alternatives [15]. MCDA has also been used to compare biomass-based production chains and determine the preferred alternative according to technical and economic criteria defined by the decision-maker [16].

Beyond MCDM-based approaches, supplier selection has been investigated through linear programming, heuristic and metaheuristic procedures, and other optimisation techniques. A multi-stage hybrid framework has been developed to jointly optimise supplier selection and order allocation while accounting for disruption risks and the influence of disruptive technologies [9]. A separate review has examined studies addressing the combined supplier selection and order allocation problem [17]. A two-stage hybrid framework has also been proposed to coordinate supplier selection, order allocation, and pricing decisions across supply chain participants [18]. In its first stage, an integrated Multi-Objective Mixed-Integer Nonlinear Programming (MOMINLP) model is formulated to minimise costs while simultaneously evaluating supplier performance.

Interval type-2 fuzzy DEMATEL and MABAC have been integrated in another study to determine the relative significance of risk factors and rank failure modes in an automotive supply chain [19]. The Language Entropy Weight Method (LEWM) has also been combined with Multi-Objective Programming (MOP) to address sustainable supplier selection and order allocation, with its practical applicability demonstrated through a case study in automobile manufacturing [20]. Another framework employs BWM to establish the weights of sustainability criteria and Evidential Reasoning (ER) to evaluate suppliers under uncertain conditions. This assessment is subsequently incorporated into a bi-objective mathematical model that seeks to balance sustainability considerations against economic costs while accounting for demand, capacity, inventory, and permissible shortage constraints [21].

A further stream of research integrates several methodological approaches to construct more comprehensive supplier selection frameworks. One such model allows decision-makers to define and prioritise economic, social, and circular criteria using fuzzy BWM, followed by supplier assessment through a fuzzy inference system (FIS). The framework is further enhanced through machine learning, which updates and refines supplier criterion scores using information from previous selection decisions, thereby supporting an adaptive and data-driven evaluation process [22]. Another two-stage framework applies fuzzy BWM in the first stage to evaluate suppliers according to economic, environmental, social, and circular dimensions. The second stage employs a multi-objective mixed-integer linear programming (MOMILP) model to optimise a multi-product, multi-period Closed-Loop Supply Chain (CLSC) network. In addition to supplier-related decisions, this stage incorporates inventory management, location-routing decisions, vehicle scheduling, and quantity discount considerations to enhance the efficiency of the overall supply chain configuration [10].

3. Methodology of the Paper

The methodology was initially established by formulating the procurement market and supplier selection problems within the context of agricultural supply chains. This problem formulation provided the basis for a systematic examination of the relevant literature, from which the principal evaluation criteria and potential supplier alternatives applicable to the agricultural procurement

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market were identified. Following the identification of these decision elements, suitable analytical techniques were selected to address the resulting multi-criteria problem. The resulting framework combines two complementary methods: BWM is employed to determine the relative weights of the evaluation criteria, whereas MOOSRA is subsequently used to assess and rank the alternative agricultural suppliers. The overall structure of the proposed model is illustrated in Figure 1.

Fig.1: Methodology for Procurement Market and Supplier Selection in Agricultural Supply Chains

3.1 BWM Method

The first stage of the proposed framework involves applying BWM to establish the relative weights assigned to the criteria used for agricultural supplier evaluation. The procedure is implemented according to the sequence of steps presented below [23].

Defining Decision Criteria: A set of decision criteria {c1, c2, …, cn} for evaluating agricultural suppliers is first established.

Identifying Key Criteria: The criteria representing the highest and lowest levels of importance should first be identified according to their respective significance within the agricultural procurement decision-making process.

Best-to-Others Comparison: The best criterion is compared against all other criteria using a scale from 1 to 9. This forms the Best-to-Others vector A_B, where each value represents how much the best criterion is preferred over the others. The value for the best criterion itself is always 1, Eq. (1).

$$A_B = (a_{B1}, a_{B2} \dots, a_{Bn}) \tag{1}$$

Others-to-Worst Comparison: Each criterion is then compared to the worst criterion using the same 1–9 scale. This generates the Others-to-Worst vector A_W , where each value indicates the relative preference of a criterion over the worst one. As in the previous step, the worst criterion is assigned a value of 1, Eq. (2):

$$A_W = (a_{1W}, a_{2W} \dots, a_{nW})^T \tag{2}$$

Deriving Optimal Weights: The final step involves calculating the optimal weight values $(w_1^*, w_2^*, \dots, w_n^*)$ by solving a mathematical optimization model, Eq. (3).

$$\begin{aligned}
&\text{Min } \xi \\
&s.t. \\
&\left|\frac{w_B}{w_j} - a_{Bj}\right| \le \xi, for\ all\ j \\
&\left|\frac{w_j}{w_W} - a_{jW}\right| \le \xi, for\ all\ j \\
&\sum_j w_j = 1 \\
&w_j \ge 0, \text{ for all j}
\end{aligned} \tag{3}$$

3.2 MOOSRA Method

The subsequent stage applies MOOSRA to evaluate and establish the ranking of the agricultural supplier alternatives. The procedure is carried out according to the sequence of steps specified below [6; 24].

Constructing Decision-Making Matrix:

$$X_{ij} = \begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{bmatrix} \tag{4}$$

Normalizing the Decision Matrix, using Eq. (5).

$$X_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^{2}}} \tag{5}$$

where, X_{ij}^{*} denotes the normalized value, where *i = 1, 2, …, n* and *j = 1, 2, …, m*.

Calculating Alternative Performance Scores (Y_i), using Eq. (6).

$$Y_i = \frac{\sum_{j=1}^{g} w_j X_{ij}^{*}}{\sum_{j=g+1}^{n} w_j X_{ij}^{*}} \tag{6}$$

g represents the number of criteria that need to be maximized, (*n* - *g*) represents the number of criteria that need to be minimized, w_j is the weight assigned to criterion j^{th}.

When identical importance is assigned to all criteria, the preceding expression can be reduced to the following form, as given in Eq. (7):

$$Y_i = \frac{\sum_{j=1}^{g} X_{ij}^{*}}{\sum_{j=g+1}^{n} X_{ij}^{*}} \tag{7}$$

Ranking Alternatives: The agricultural supplier alternatives are ranked based on their Y_i values, the higher the score, the better the alternative.

4. Case Study: Selection of a Seed Supplier for Agricultural Production

The organisation examined in the case study is engaged in crop cultivation and the distribution of agricultural products and is currently evaluating alternative sources for certified seeds. Since seeds constitute essential production inputs, supplier selection can have direct consequences for procurement expenditure, crop quality, production planning, and the dependability of the overall supply. Several procurement-related difficulties have prompted the company to reconsider its existing supplier arrangements. Delays in deliveries from the incumbent supplier have interfered with planned planting activities, while increasing prices of agricultural inputs have intensified the requirement to identify a supplier offering greater cost efficiency. Environmental performance is another consideration for the company, which seeks to establish cooperation with suppliers whose production activities incorporate responsible environmental practices. Six criteria were therefore selected to evaluate and rank the alternative suppliers operating in the agricultural input market.

Product price (C1) is expressed in dollars per unit and denotes the purchasing cost associated with one unit of seed. A lower value generally improves procurement cost efficiency; however, price alone cannot determine supplier suitability because a lower-priced product may potentially be accompanied by inferior quality. Delivery lead time (C2) is specified in days and measures the average period extending from the placement of an order to the arrival of the corresponding seed consignment at the company's warehouse. Extended lead times can interfere with planting plans and consequently affect production activities. Conversely, shorter delivery periods provide the company with greater flexibility when scheduling procurement and agricultural operations. Product quality (C3) is evaluated using the number of defective units identified per 1,000 units supplied. This measure captures the extent to which delivered seeds fail to satisfy the specified quality requirements. A smaller defect rate indicates a more dependable product and therefore represents a more favourable supplier performance. Delivery reliability (C4) is expressed as a percentage and reflects the share of orders that arrive both on schedule and in the required quantity, represented by On-Time In-Full (OTIF). A higher OTIF percentage indicates greater consistency in fulfilling contractual delivery commitments and therefore signifies stronger supplier reliability.

Sustainability compliance (C5) is assessed on the basis of ISO 14001 certification and reflects the extent to which a supplier applies environmental management practices throughout seed production and processing. These practices encompass responsible utilisation of resources, waste control, and efficient energy use. Energy performance and the incorporation of sustainability principles into agricultural production-system design have become increasingly relevant to achieving an appropriate balance between productivity and long-term environmental performance [25]. Accordingly, suppliers possessing ISO 14001 certification are treated as satisfying the required environmental responsibility condition. Financial stability (C6) represents the supplier's financial strength and longer-term business viability and is assessed using its credit rating. Within the present study, the ratings are converted into numerical scores, with AAA assigned a score of 5, AA assigned a score of 3, and A assigned a score of 1. Among these categories, AAA denotes the strongest level of financial stability.

Following the establishment of the evaluation framework, company management identified four candidate seed suppliers operating within the agricultural input market. Their respective performances against the six criteria are presented in Table 1. The alternatives exhibit different strengths and weaknesses across the evaluation dimensions. Supplier A has the lowest unit price, but this cost advantage is accompanied by a comparatively long delivery lead time and a greater incidence of product defects. Supplier B demonstrates a more balanced performance by combining relatively favourable price conditions with efficient delivery and satisfactory product quality. Supplier C achieves the shortest delivery lead time and the highest delivery reliability; however, its price is comparatively high, and it lacks the required sustainability certification. Supplier D has the highest purchasing cost among the alternatives but compensates for this disadvantage through superior product quality and compliance with the specified environmental requirements.

Table 1
Seed Supplier Evaluation Data

Supplier	C1	C2	C3	C4	C5	C6
Alternative 1	2.5	30	15	85	1	1
Alternative 2	3.2	14	8	95	5	3
Alternative 3	3.8	5	10	98	1	1
Alternative 4	4.5	20	5	99	5	5

As specified in the methodology, the weighting stage commenced with the implementation of BWM to establish the relative importance of the criteria used for agricultural supplier selection. This procedure first required the identification of the criteria representing the highest and lowest levels of importance. Product price (C1) was selected as the best criterion because it was considered the most important, whereas financial stability (C6) was assigned as the worst criterion due to its comparatively lower importance. The subsequent assessment involved a systematic comparison of the selected criteria, beginning with the best-to-others matrix reported in Table 2, followed by the others-to-worst matrix provided in Table 3.

Table 2
Best-to-Others Matrix

Best-to-Others	Product Price	Delivery Lead Time	Product Quality	Delivery Reliability	Sustainability Compliance	Financial Stability
Product Price	1	2	4	5	7	9

Table 3
Others-to-Worst Matrix

Others to the Worst	Financial Stability
Product Price	9
Delivery Lead Time	7
Product Quality	6
Delivery Reliability	5
Sustainability Compliance	3
Financial Stability	1

Using the comparison matrices established in the preceding stage, the BWM model was solved by applying Eq. (3), with the resulting values reported in Table 4. The Input-Based CR obtained from the analysis was 0.222, indicating that the level of consistency achieved in the pairwise comparisons were within an acceptable range.

Table 4
BWM Results

Weights	C1	C2	C3	C4	C5	C6
	0.414	0.252	0.126	0.101	0.072	0.036

The BWM results demonstrate that C1 carries the greatest weight among the evaluated criteria, confirming product price as the dominant consideration in the selection of a seed supplier. Conversely, C6 receives the smallest weight and therefore represents the least influential criterion. The criterion weights derived from BWM were subsequently transferred to the next stage of the analysis, where MOOSRA was employed to determine the ranking of the agricultural supplier alternatives. This stage commenced with the normalisation of the decision matrix given in Table 5, which was performed using Eq. (5).

Table 5
Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6
A1	0.349	0.769	0.737	0.450	0.139	0.167
A2	0.447	0.359	0.393	0.503	0.693	0.500
A3	0.531	0.128	0.491	0.519	0.139	0.167
A4	0.629	0.513	0.246	0.524	0.693	0.833

The criterion weights obtained from the preceding BWM analysis were subsequently applied to the normalised decision matrix, producing the weighted decision matrix presented in Table 6.

Table 6
Weighted Decision Matrix

	C1	C2	C3	C4	C5	C6
A1	0.145	0.194	0.093	0.045	0.010	0.006
A2	0.185	0.090	0.050	0.051	0.050	0.018
A3	0.220	0.032	0.062	0.052	0.010	0.006
A4	0.260	0.129	0.031	0.053	0.050	0.030

The final stage of the MOOSRA procedure involved calculating the overall performance score associated with each agricultural supplier alternative. These scores provided the basis for establishing the final supplier ranking. Using Eq. (6), the performance value of each alternative was calculated, and the resulting scores are reported in Table 7. The results reported in Table 7 indicate that A2 achieves the highest overall ranking among the seed supplier alternatives, with A3 and A1 occupying the second and third positions, respectively. A4 records the lowest performance score and consequently ranks fourth. Accordingly, the analysis recommends Supplier A2 as the preferred choice for an agricultural company.

Table 7
Performance Scores and Ranking

	$\sum_{j=1}^{g} w_j X_{ij}^*$	$\sum_{j=g+1}^{n} w_j X_{ij}^*$	$Y_i = \frac{\sum_{j=1}^{g} w_j X_{ij}^*}{\sum_{j=g+1}^{n} w_j X_{ij}^*}$	Ranking
A1	0.154	0.338	0.456	3
A2	0.168	0.275	0.610	1
A3	0.130	0.252	0.516	2
A4	0.164	0.389	0.420	4

5. Conclusion

Enhancing supply chain performance in agricultural companies requires effective procurement and systematic supplier evaluation. MCDM methods, supported by operational research techniques and computational tools, can improve procurement decisions by enabling suppliers to be assessed against quality, delivery, cost, and other relevant criteria. Accordingly, this study proposed a procurement market and supplier selection model based on BWM and MOOSRA. BWM was used to determine the criterion weights, while MOOSRA applied to rank the agricultural suppliers. The proposed model was evaluated through a seed supplier selection case involving four suppliers and six criteria: product price, delivery lead time, product quality, delivery reliability, sustainability compliance, and financial stability. The BWM results identified product price (C1) as the most important criterion and financial stability (C6) as the least important. Based on these weights, MOOSRA ranked the suppliers and identified Supplier 2 as the preferred alternative. A key limitation is the relatively small supplier pool, which was constrained by the specific requirement for certified seeds. Future studies should examine larger agricultural procurement cases and different markets to further validate and compare the model's performance. Developing hybrid models that incorporate heuristic or metaheuristic approaches also represents a potential direction for addressing more complex supplier selection problems.

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