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Identifying Determinants of Supplier Selection in the Heavy Automotive Industry: Strategic Insights and Future Directions

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ABSTRACT

Supplier selection criteria in the heavy automotive industry remain underexplored compared to the broader automotive sector, with most existing frameworks adapted from passenger-vehicle contexts. Such adaptations frequently overlook sector-specific priorities, including work safety, technological capability, and operational risk resilience. This gap in validated industry-specific models limit effective supplier evaluation in this complex sector. Hence, this study aims to develop and validate a supplier selection framework specifically tailored to the heavy automotive industry by integrating systematic literature review and expert judgement. Twelve key criteria were extracted from literature and refined through expert evaluation using the Analytic Hierarchy Process – Online System (AHP-OS), involving eight senior industry professionals. This study uniquely integrates AHP-OS modelling with expert judgement to deliver an industry-specific evaluation model for heavy automotive procurement. The final model demonstrated high consistency (CR = 2.2%) and revealed strong alignment between academic and industry perspectives, particularly in the prioritisation of Quality, Cost, and Delivery Performance. A Spearman correlation analysis ($\rho = 0.294$) comparing literature-based and expert-derived rankings further highlighted evolving priorities, including the growing importance of Technological Capability and Sustainability. The validated framework contributes a structured, context-specific tool for enhancing supplier evaluation in the heavy automotive sector, bridging theoretical insights and practical industry needs.

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1. Introduction

The heavy automotive industry forms a critical foundation for global transportation networks, underpinning infrastructure vital to economic development. Within this sector, supplier selection is a key element of supply chain management, directly impacting operational efficiency, product quality, cost control, and overall competitiveness. Poor supplier selection can lead to serious consequences, including production delays, warranty claims, product recalls, and reputational damage emphasising the need for a structured and rigorous selection process. To address increasing operational demands, companies generally adopt one of three sourcing strategies: (1) strengthening relationships with existing suppliers, (2) sourcing from new vendors, or (3) producing specialised components internally [1]. Although established partnerships may offer logistical and operational advantages, evolving requirements often call for alternative procurement approaches or supplier development initiatives to sustain performance expectations. This framework (Figure 1) provides a visual overview of the decision paths whether through internal production, existing suppliers, or new sourcing and highlights when supplier development becomes necessary.

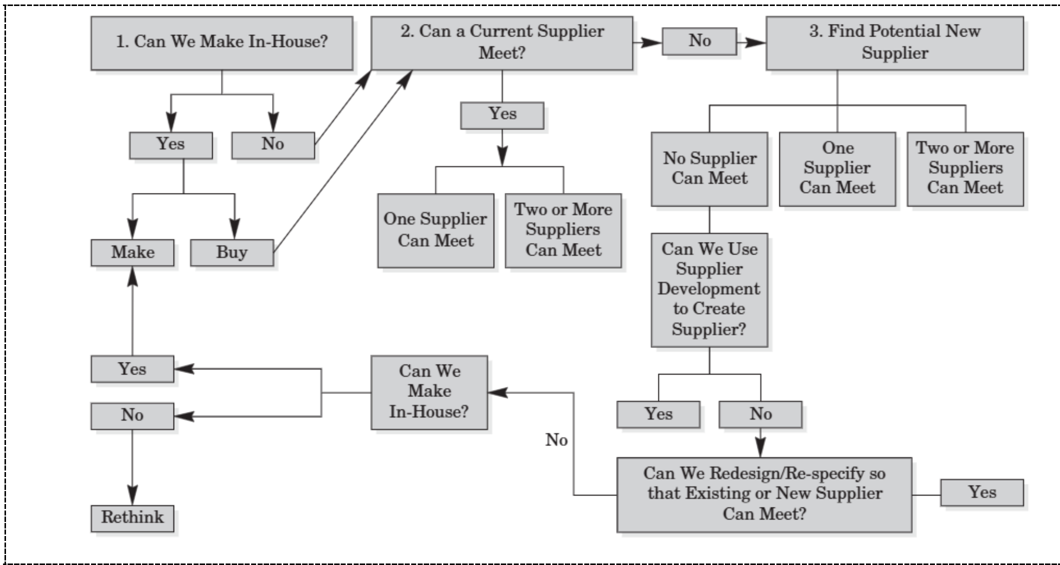

Fig. 1. Identification of potential sources a new need/requirements
Note: Johnson, Leenders and Flynn,2011, p317

The strategies include in-house production (make), engaging existing suppliers, or sourcing new vendors. Internal production suits highly specialised needs; established suppliers offer familiarity and reliability; while new sourcing introduces innovation or fills gaps. Where suitable suppliers are unavailable, companies may need to invest in supplier development or product redesign, requiring close collaboration with requisitioners.

Supplier selection plays a pivotal role in supply chain performance, influencing cost efficiency, quality assurance, and operational resilience [2,3]. In the heavy automotive industry, supplier decisions are closely tied to risk mitigation and long-term competitiveness [4]. While traditional models prioritised cost and quality, recent studies show a growing interest in intangible considerations such as brand reputation and market reach. Manello and Calabrese [5] found that firms increasingly favour suppliers associated with premium brands as proxies for reliability. However, Ahmad *et al.,* [6], using Fuzzy AHP and Z-TOPSIS in a Malaysian context, reaffirmed the dominance of cost, quality, and delivery—highlighting that traditional metrics still prevail in emerging markets [2].

Global trends reflect a strategic shift in supplier collaboration, especially in outsourcing technical expertise [7]. Sustainability is also reshaping evaluation standards. Saidani *et al.* reported that over 93% of a typical heavy vehicle's materials can be reused, highlighting the need for suppliers with eco-efficient, remanufacturing, and lifecycle management capabilities [8]. However, practical integration remains limited due to data gaps, high implementation costs, and managerial inertia [9]. As a result, many firms, especially in resource-constrained contexts, still prioritise cost, quality, and delivery above sustainability.

Real-world examples further illustrate this shift. PROTON's past challenges with product quality were partly due to weak supplier evaluation systems. Subsequent reforms including structured supplier development and a strategic alliance with Geely enabled technology sharing, improved cost efficiency, and faster innovation cycles [10,11]. While PROTON's transformation is notable, such progressive practices are not yet standardised across the Malaysian automotive sector. Many SMEs continue to rely on conventional, cost-focused models, reinforcing the need for adaptable and multi-criteria evaluation frameworks.

Traditional supplier selection frameworks in emerging markets have largely prioritised cost, delivery performance, and product quality as core evaluation criteria [12]. However, the growing complexity of global supply chains driven by technological advancement, regulatory requirements, and sustainability pressures has broadened these considerations. Newer dimensions such as innovation capacity, environmental responsibility, and risk management are now critical to supplier evaluation [8,13]. In response, Multi-Criteria Decision-Making (MCDM) approaches have gained traction, providing structured methodologies for assessing both quantitative and qualitative criteria [13]. Despite their potential, many MCDM applications in the heavy automotive industry remain fragmented, lacking integrated frameworks that coherently address operational, strategic, and sustainability factors [9,14].

Multi-Criteria Decision-Making (MCDM) tools such as AHP [14], Fuzzy AHP [15], and TOPSIS [16] are widely adopted in supplier selection due to their capacity to evaluate both tangible and intangible factors. However, each method presents distinct strengths and drawbacks. For instance, while AHP offers structural clarity, it suffers from judgment consistency issues [14], especially in large-scale hierarchies. Fuzzy AHP addresses subjectivity through linguistic variables [15], yet may complicate interpretation in time-sensitive environments. In contrast, hybrid methods like AHP–TOPSIS [17] aim to balance analytical rigour with decision speed, though their implementation remains data-intensive. To address risk and uncertainty, Junaid *et al.,* [18] proposed a neutrosophic AHP-TOPSIS model tailored for supply chain risk, pushing beyond conventional fuzziness by incorporating indeterminacy. Suraraksa and Shin [19] reinforce this by comparing supplier selection factors in Thai automotive firms, stressing the need for adaptable models sensitive to national contexts.

A key advancement is the operationalisation of these methods. Kant and Dalvi [20] designed a diagnostic questionnaire to evaluate criteria and perceived benefits, offering a replicable tool for real-world assessment. Conversely, Brandes *et al*. [21] shift focus from tool to strategy, arguing that supplier selection must align with long-term relationship management a dimension often undervalued in AHP-based models. Tirkolaee *et al.,* [22] advance the field by integrating fuzzy logic with multi-objective programming, explicitly modelling sustainability and reliability—two criteria frequently overlooked in classical MCDM. Goepel [23] tackled the usability barrier by introducing AHP-OS, an online platform that streamlines group decision-making, addressing the often-cited issue of accessibility in traditional AHP applications. Kumar *et al.,* [24], in an applied heavy locomotive context, demonstrated the efficacy of integrating Taguchi loss functions with AHP–TOPSIS, highlighting how tailored hybridisation can enhance precision in technical sectors. Yet, as Masoumi *et al.,* [25] argue, methodological innovation alone is insufficient without process alignment, emphasising that sustainable supply chain decisions must also be embedded into organisational practices an area where current AHP-based models still fall short.

To address these shortcomings, the Analytic Hierarchy Process – Online System (AHP-OS) has emerged as a promising alternative. As a cloud-based tool, AHP-OS supports real-time collaboration, automated consistency checks, and dynamic scenario testing the key advantages over conventional models [19,23]. In the heavy automotive context, AHP-OS improves strategic alignment by offering a scalable and transparent platform that incorporates emerging priorities such as sustainability [8], innovation [14], and risk management [25], thereby fostering responsive and stakeholder-inclusive decision-making.

Although supplier selection has been widely studied in the broader automotive industry, research specifically focused on the heavy automotive sector remains scarce [14]. Existing frameworks are often adapted from passenger vehicle contexts, emphasising traditional metrics like cost, quality, and delivery [25], while neglecting industry-specific concerns such as technological capability, risk resilience, and supplier reputation [8,14]. Moreover, these models rarely consider strategic dimensions like make-or-buy decisions or multi-sourcing strategies and often lack real-time adaptability [14,25]. Few existing frameworks have been empirically validated for the heavy automotive industry, revealing a persistent gap in both research and practice [8].

This study addresses that gap by systematically identifying, validating, and prioritising supplier selection criteria through a combination of literature review and expert evaluation using AHP-OS. The proposed framework integrates theoretical insights with practical industry needs, providing a transparent, scalable, and strategically aligned tool. Additionally, the study employs Spearman rank correlation to compare literature-based and expert-derived priorities, offering deeper insight into the alignment and divergence of supplier evaluation practices in the heavy automotive industry.

2. Methodology

2.1 Research Design

This study employs a mixed-methods approach, integrating a systematic literature review with primary data collection through expert judgment. The literature review was conducted to identify supplier selection criteria established in prior research, while the expert survey provided industry-based insights using the Analytic Hierarchy Process–Online System (AHP-OS). This combined design ensures that the prioritisation of criteria reflects both established academic findings and practical perspectives from the heavy automotive industry.

2.2 Data Sources and Search Strategy

Relevant academic publications were retrieved from Scopus, ScienceDirect, and Google Scholar using keywords such as “supplier selection,” “supply chain management,” “heavy automotive industry,” “AHP,” “TOPSIS,” and “MCDM models.” A systematic screening procedure was applied to ensure the quality and relevance of the literature.

First, titles and abstracts of all retrieved records were examined to exclude studies outside the research scope. Duplicates were identified and removed. Subsequently, a full-text review was conducted using predetermined inclusion and exclusion criteria. Only studies that (i) focused on supplier evaluation or assessment models, (ii) applied Multi-Criteria Decision-Making (MCDM) techniques, and (iii) were relevant to the automotive or heavy automotive sector were retained.

The review process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [26], ensuring transparency and methodological rigour. The steps included:

i. Title and abstract screening.
ii. Duplicate removal.
iii. Full-text review based on inclusion and exclusion criteria.

In total, 1,200 records were retrieved from databases, with an additional 20 identified through other sources. After removing duplicates, 950 articles remained. Following title and abstract screening, 800 were excluded, leaving 150 for full-text assessment. Of these, 60 were included in the qualitative synthesis and 10 in the quantitative synthesis. The identification, screening, eligibility, and inclusion process is summarised in Figure 2. Although the initial search yielded more than 1,200 publications, rigorous screening reduced the dataset to 10 quantitative studies. While most of these studies originated from the broader automotive industry, their methodological robustness and relevance to supplier evaluation justified their inclusion. Given the scarcity of research focusing specifically on the heavy automotive sector, insights from general automotive studies were adapted to reflect heavy-vehicle supplier selection considerations. The smaller dataset is acknowledged as a limitation; however, it allowed for a more focused and in-depth synthesis aligned with the strategic objectives of this study.

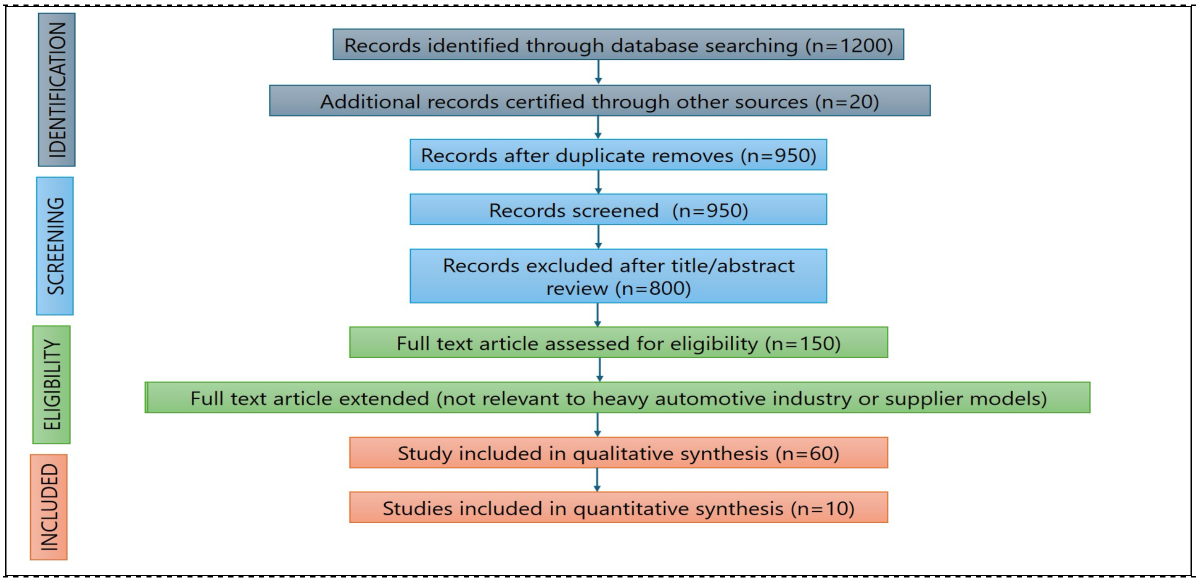

Fig. 2. Flowchart of article identification, screening, eligibility, and inclusion process

2.3 Extraction of Supplier Selection Criteria

Supplier selection criteria were identified through a combination of qualitative and quantitative extraction from a broad range of literature sources. Primary extraction was based on the 20 selected articles [5, 16-18, 20, 23-24, 25-37], where key criteria were identified qualitatively, and quantitative data such as weightings or rankings were extracted from 10 articles where available, particularly from studies employing multi-criteria decision-making (MCDM) techniques such as AHP, TOPSIS, FAHP, RAHP and Hybrid models [16, 17, 19, 27-33]. To ensure a comprehensive set of evaluation criteria, additional supporting sources including academic studies, industry reports, and domain-specific literature were reviewed. This broader approach allowed for the consolidation of relevant factors that may not have been emphasized fully within the core articles. Ultimately, twelve supplier selection criteria were identified: Cost, Quality, Delivery Performance, Technological Capability, Sustainability, Financial Capability, Capacity and Capability, Reputation, Service, Flexibility, Relationship, and Risk [5,16,17,19,20,21,27–30,32–36]. While 20 core articles were systematically reviewed, only a subset directly supported the final twelve selection criteria, as indicated by the respective citations. This consolidated list formed the basis for the expert evaluation phase.

Quantitative data were extracted from ten selected studies that employed multi-criteria decision-making (MCDM) methods [16,17,19,27-33]. Where studies provided multiple types of evaluation (e.g., supplier selection and supplier monitoring), only supplier selection-related data were considered to maintain consistency with the research objectives. Table 1 presents the summary of extraction and adaptation processes undertaken for each selected study during the quantitative data aggregation phase. This ensures consistency in the handling of supplier selection criteria and alignment with the objectives of this research.

Table 1
Summary of extraction and adaptation processes for quantitative data from selected studies

No.	Source	Extraction Process
1	Jamil, Besar & Sim [16]	Criteria weights were extracted directly from their AHP-based supplier selection model without further adaptation.
2	Al-Hazza *et al.* [27]	Only supplier selection-related priorities were extracted; auxiliary ranking elements not relevant to initial selection were excluded.
3	Suraraksa & Shin [19]	Only supplier selection criteria were extracted. Post-engagement monitoring criteria were excluded to ensure consistency in focusing solely on initial supplier evaluation.
4	Vasiljevic *et al*. [28]	Criteria derived through Rough AHP and Fuzzy AHP were adapted into a flattened structure suitable for this study's framework.
5	Amin & Rajhans [17]	Criteria weights focused on quality, cost, and delivery dimensions were extracted without the need for modification.
6	Tyagi *et al.* [29]	Relevant supplier-side evaluation criteria were selected from customer-focused AHP-TOPSIS outputs.
7	Dweiri *et al.* [30]	Supplier selection-specific factors were extracted, excluding post-contract monitoring components.
8	Yadav *et al.* [31]	Criteria related to resilience were selectively adapted to align with standard supplier evaluation categories.
9	Ashtana & M. Gupta [32]	Initial AHP criteria weights developed for ANN-GA modeling were adapted and slightly modified to match the context of supplier selection in the heavy automotive industry.
10	Torgul *et al.* [33]	Uniform AHP output weights were normalized where necessary to integrate into the consolidated dataset.

The extracted weights from these studies were then averaged and normalized to ensure comparability across different methodologies and sources.

2.4 Expert Judgement Data Collection

Primary data were collected from eight (8) experts with significant experience in supplier evaluation, procurement, and supply chain management within the heavy automotive sector. Experts were invited to perform pairwise comparisons of the twelve identified criteria using the Analytic Hierarchy Process - Online System (AHP-OS). The AHP-OS platform provided a cloud-based environment for real-time data input, automatic consistency checking, and systematic aggregation of judgments. The aim was to validate and prioritize the supplier selection criteria identified from literature review: Cost, Quality, Delivery Performance, Technological Capability, Sustainability, Financial Capability, Capacity and Capability, Reputation, Service, Flexibility, Relationship, Risk [5,16, 17,19,20,21,27-30,32-36]. The demographic and professional profiles of the participating experts are summarized in Table 2.

Table 2
Demographic and professional profiles of expert respondents

ID	Gender	Age Range	Experience	Industry/ Field	Role/ Position
R1	Male	40-45	12	Automotive	Procurement Manager
R2	Male	40-45	14	Management and Engineering	Managing Director
R3	Male	30-35	9	Engineering	Production Manager
R4	Male	30-35	5	Business Administration	Special Officer
R5	Female	35-40	15	Management (Procurement)	Logistics & Procurement
R6	Male	35-40	17	Automotive	Senior Engineer
R7	Male	40-45	12	Management Procurement (Supplier)	Director
R8	Male	35-40	8	Automotive Technology	Engineer

2.5 AHP-OS Analysis and Consistency Validation

This study employed the Analytic Hierarchy Process - Online System (AHP-OS) due to its effectiveness in handling complex decision-making problems involving multiple criteria. AHP-OS provided a cloud-based platform offering real-time collaboration, automatic consistency checking, and efficient prioritization of alternatives [23]. The hierarchy structure developed for this study was based on the synthesized literature findings and expert evaluations:

I. Level 1 (Goal): To identify and prioritize key supplier selection criteria relevant to the heavy automotive industry.
II. Level 2 (Criteria): Main criteria were defined, including Cost, Quality, Delivery Performance, Technological Capability, Sustainability, Financial Capability, Capacity and Capability, Reputation, Service, Flexibility, Relationship, and Risk.
III. Level 3 (Sub-criteria): Sub-criteria were excluded where insufficient detailed data was available.
IV. Level 4 (Alternatives): Alternatives were not real suppliers but were represented through literature-based weight evaluations reflecting the relative importance of each criterion.

Expert judgments were synthesized through AHP-OS, and the prioritized ordering of the criteria was established based on the normalized weights derived from the aggregated expert input. The individual pairwise comparison matrices from the experts were aggregated into a group consensus matrix through AHP-OS. The consistency of the aggregated judgments was assessed, yielding a group Consistency Ratio (CR) of 0.021923, which is well below the acceptable threshold of 0.1, confirming the reliability of the expert evaluations. Priority weights for each criterion were derived from the aggregated matrix and normalized to ensure that the total sum equaled one [1,23].

2.6 Saaty's Pairwise Comparison Scale

Pairwise comparisons among the twelve supplier selection criteria were conducted using the basic scale proposed by Saaty [38]. This scale assigns numerical values ranging from 1 to 9 to express the relative importance between two elements, where 1 indicates equal importance and 9 indicates extreme importance of one element over another. The Saaty's pairwise comparison scale utilized is summarized in Table 3.

Table 3
Saaty's pairwise comparison scale

Scale	Meaning
1	"*i*" is equally important to "*j*"
3	"*i*" is slightly more important than "*j*"
5	"*i*" is more important than "*j*"
7	"*i*" is very strong important to "*j*"
9	"*i*" is extremely more important to "*j*"
2,4,6,8	Intermediate values

Using this scale, experts conducted pairwise comparisons, and the resulting matrices were processed through AHP-OS to calculate the global weights of each criterion and assess judgment consistency. Experts conducted pairwise comparisons among the twelve supplier selection criteria using Saaty's fundamental 1–9 scale. The scale provides standardized interpretations of relative importance between elements, as summarized in Table 3.

2.7 Weight Normalization and Aggregation

The weights assigned to each supplier selection criterion by the experts were retrieved from the AHP-OS output and normalized to ensure consistency and comparability across all criteria. Normalization adjusted the derived weights so that their total sum equaled one, preserving the proportionality of relative importance among criteria. After normalization, the priority weights were consolidated to establish the final ranking of supplier selection criteria for the heavy automotive industry.

Additionally, the results from the expert evaluations were compared against the findings extracted from the systematic literature review. This comparative analysis served to validate the consistency between theoretical insights and industry perspectives, thereby reinforcing the robustness of the study's conclusions. To statistically validate the alignment between literature-based rankings and expert based rankings, a Spearman rank correlation analysis was subsequently conducted [39]. To examine the degree of alignment between supplier selection priorities derived from the literature and expert evaluations, the Spearman rank correlation coefficient *(ρ)* was employed. The formula is expressed as follows [40]:

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (1)$$

Where,

r_s is the Spearman rank correlation coefficient
d_i is the difference between paired ranks
n is the number of criteria (n=12 in this study)

This non-parametric test is suitable for comparing ordinal data and measure strength and direction of association between two ranked variables. It is particularly useful in validating the consistency of qualitative judgements (expert-based) against structured literature findings. The use of AHP-OS [23] facilitated systematic pairwise comparisons, automatic consistency checking, and real-time aggregation of expert inputs, ensuring a transparent and reliable prioritization process suitable for complex supplier evaluation scenarios.

3. Result and Discussion

3.1 Extraction of Supplier Selection Criteria from Literature

A combination of qualitative and quantitative extraction was performed from selected journal articles. Table 4 presents the extracted data from each study, including the decision-making method used, the criteria considered, and the main findings regarding supplier selection priorities.

Table 4
Extraction of key data from articles

Articles	Method Used	Criteria Considered	Findings
Brandes, Brege and Brehmer [23]	Analytical Model	Cost; Supplier Relationships	Emphasizes collaborative supplier relationships.
Jamil, Besar and Sim [16]	AHP, FAHP, TOPSIS ,FTOPSIS, FAHPiFTOPSIS	Delivery Time; Support Service; Quality; Technology; Price; Capacity; Background; Flexibility; Systems; SPC	Prioritizes Price, Quality and Delivery. Other factors given equal importance .
Al Hazza *et al.,* [27]	Hybrid MCDM (Delphi & AHP)	Price; Delivery Time; Rejection Rate; Flexibility; Online Ranking	Prioritize Price, Rejection rate and Online ranking.
Suraraksa and Shin [19]	AHP-OS	Cost; Quality; Capacity; Service; Finance; ICT; Sustainability	Quality is the top priority.
Vasiljevic *et al.,* [28]	Rough MCDM (AHP, Fuzzy AHP, Rough AHP)	Finance; Logistics; Quality; Communication; Certification	Product Certification most important; Quality prioritized in Fuzzy AHP; Equal rank for discounts.
Kadir, Tam and Ali [34]	Multiple-Case Study	Quality; Cost; Delivery; Reputation; Long-term Relationship; Financial Capability	Non-performance criteria preferred during downturns.
Butdee *et al.,* [35]	AHP, FAHP	Plan Risk; Source Risk; Delivery Risk; Make Risk; Return Risk	Plan Risk is most significant.
Mzougui *et al.,* [36]	AHP, DEMATEL	Product Features; Suppliers; Transport; Finance; Facilities; Strategy; Environment	Top risks: Natural disasters, facilities, HR, policy breakdown, transport inefficiency.
Junaid *et al.,* [18]	AHP merged with TOPSIS, Neutrosophic AHP	Supply Chain Resilience; Agility; Robustness	Agility is the most critical factor.
Amin and Rajhans [17]	AHP, TOPSIS	Quality; Cost; Distance; Lead Time; Credit Period; Discount	Quality and delivery more important than cost.

Tyagi [29]	AHP-TOPSIS	Customer Response Time; On-Time Delivery; Information Sharing; Production Efficiency; Innovation	Focus on improving efficiency and delivery.
Manello and Calabrese [5]	Empirical Strategy (Ex-post analysis)	Customer Diversification; Volume; Brands; Tech; M&A; Proximity	Reputation more influential than classical criteria.
Masoumi *et al*., [25]	Systematic Review & Content Analysis	Stakeholder Input; Legislation; Standards; Resources; Outputs	Sustainability emphasized across SSCM.
Salomon, Tramarico and Silva Marins [37]	AHP	Capability; Certification; Quality; Reliability; Service; Flexibility; Sub-suppliers; Payment Terms; Price; History	Prioritizes load, payment, and reliability.
Tirkolaee *et al.,* [22]	Hybrid (Fuzzy Decision-Making & Multi-Objective Programming)	Automation; Cost; Return Cost; Shelf Life; Flexibility; Partnership; Integration; Sustainability; Human Rights	Integration, partnership, and process performance are top priorities.
Dweiri *et al.,* [30]	AHP	Quality; Cost; Delivery; Service; Financial Capability	Quality is ranked highest, followed by cost and delivery.
Yadav *et al.,* [31]	Fuzzy AHP	Quality; Cost; Resilience; Agility; Risk	Resilience and quality are the dominant factors.
Ashtana and M. Gupta [32]	AHP to support ANN-GA	Quality; Delivery; Cost; Technology; Service	Delivery and cost are prioritized for hybrid modeling input preparation.
Torgul *et al.,* [33]	AHP	Quality; Cost; Service	Equal weight given initially; normalization was required to adjust inconsistencies.
Kant and Dalvi [20]	Questionnaire Development and Empirical Analysis	Cost; Quality; Delivery; Relationship Management; Technology; Flexibility; Service	A validated questionnaire developed identifying key supplier evaluation criteria; highlighted that cost, quality, and delivery are the most critical factors influencing supplier selection benefits.

3.2 Justification of Final Supplier Selection Criteria

Based on the review of existing literature, a set of supplier selection criteria was identified and justified according to their relevance and frequency of emphasis across multiple studies. Table 5 summarizes the key supplier selection criteria, the rationale for their inclusion, and the supporting studies from which each criterion was derived.

Table 5
Justification of key supplier selection criteria based on literature review

Category	Relevance of selection	Study
Cost	Most cited in literature and validate by experts	Brandes, Brege and Brehmer (2013); Jamil, Besar and Sim (2013); Al-Hazza *et al.,* (2022); Suraraksa and Shin (2019); Tirkolaee *et al.,* (2019); Kant and Dalvi (2017); Dweiri *et al.,* (2016); Ashtana and M. Gupta (2015); Torgul *et al.,* (2022)
Quality	Research highlights that quality-related failures in the supply chain led to significant financial and reputational damage.	Suraraksa and Shin (2019); Jamil, Besar and Sim (2013); Vasiljevic *et al.,* (2018); Kadir, Tam and Ali (2011); Kant and Dalvi (2017); Dweiri *et al.,* (2016); Ashtana and M. Gupta (2015); Torgul *et al.,* (2022)
Delivery Performance	Studies show that delivery reliability is crucial in just-in-time (JIT) supply chain strategies.	Jamil, Besar and Sim (2013); Al-Hazza *et al.,* (2022); Vasiljevic *et al.,* (2018); Kant and Dalvi (2017); Dweiri *et al.,* (2016); Ashtana and M. Gupta (2015)
Technological Capability	Studies show that technological capability directly impacts product quality and production efficiency.	Suraraksa and Shin (2019); Jamil, Besar and Sim (2013); Ashtana and M. Gupta (2015); Kant and Dalvi (2017)
Sustainability	Research indicates that sustainable sourcing enhances long-term profitability and market reputation.	Suraraksa and Shin (2019); Tirkolaee *et al.,* (2019), Shekarian *et al.,* (2023)
Financial Capability	Research confirms that financially stable suppliers are less likely to default on orders and can handle market fluctuations better.	Kadir, Tam and Ali (2011); Suraraksa and Shin (2019); Vasiljevic *et al.,* (2018); Dweiri *et al.*, (2016)
Capacity and Capability	Studies highlight that capacity constraints often lead to order backlogs, inefficiencies, and increased costs.	Suraraksa and Shin (2019); Jamil, Besar and Sim (2013)
Reputation	Research suggests that supplier reputation significantly influences buyer trust and long-term contracts.	Jamil, Besar and Sim (2013); Al-Hazza *et al.,* (2022); Kadir, Tam and Ali (2011); Manello and Calabrese (2019)
Service	Studies confirm that strong supplier service relationships enhance operational efficiency and reduce risks.	Suraraksa and Shin (2019); Vasiljevic *et al.,* (2018); Ashtana and M. Gupta (2015); Torgul *et al.,* (2022); Kant and Dalvi (2017)
Flexibility	Studies emphasize that supplier flexibility improves resilience and responsiveness in dynamic industries.	Jamil, Besar and Sim (2013); Al-Hazza *et al.* (2022); Kant and Dalvi (2017)
Relationship	Research shows that strong supplier relationships contribute to lower operational risks and higher efficiency.	Brandes, Brege and Brehmer (2013); Kadir, Tam and Ali (2011); Kant and Dalvi (2017)
Risk	Studies confirm that risk assessment in supplier selection prevents costly disruptions and protects business continuity.	Butdee *et al.,* (2015); Mzougui *et al.,* (2020); Junaid *et al.,* (2020); Yadav *et al.,* (2020)

3.3 Quantitative Aggregation of Supplier Selection Criteria from 10 Articles

Quantitative priority weights were extracted from the ten selected journal articles where numerical evaluations of supplier selection criteria were available. The studies utilized various multicriteria decision-making (MCDM) methods, including AHP, FAHP, and hybrid approaches, to prioritize factors important in supplier evaluation. To standardize the analysis, each supplier selection criterion identified across the studies was assigned a specific code, as shown in Table 6. This coding system (C1–C12) ensured consistency when aggregating and comparing weights across different sources.

Table 6
Supplier selection code assignment

No.	Criteria	Code
1	Cost	C1
2	Quality	C2
3	Delivery Performance	C3
4	Technological Capability	C4
5	Sustainability	C5
6	Financial Capability	C6
7	Capacity and capability	C7
8	Reputation	C8
9	Service	C9
10	Flexibility	C10
11	Relationship	C11
12	Risk	C12

Following the coding assignment, the extracted quantitative weights for each criterion were compiled..

Table 7
Aggregated supplier selection criteria weights extracted from selected literature

Source	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Jamil, Besar and Sim (2013)	13.65	15.22	15.16	13.71	-	-	14.27	14.13	15.76	13.29	-	-
Al-Hazza *et al*., (2022)	43.84	21.81	9.44	-	19.27	-	-	-	-	5.64	-	-
Suraraksa and Shin (2019)	22.59	29.98	-	5.90	5.09	6.29	16.13	-	14.01	-	-	-
Vasiljevic *et al*., (2018)	25.22	37.77	9.83	2.29	-	7.86	-	5.90	3.17	3.71	1.31	2.95
Amin and Rajhans (2016)	6.10	63.15	16.87	-	-	-	-	-	13.88	-	-	-
Tyagi, M *et al*., (2014)	-	34.28	34.70	-	-	-	-	-	-	-	-	31.01
Dweiri *et al*., (2016)	46.53	27.72	15.84						9.90			
Yadav *et al*., (2020)	24.28	41.96	9.29	-	-	-	-	-	12.59	6.79	5.09	-
Ashtana & M. Gupta (2015)	13.43	50.29	26.03	-	-	6.77	3.48	-	-	-	-	-
Torgul *et al*., (2022)	0.65	0.65	0.65	0.04	0.3	-	0.01	-	0.65	-	-	-
Average Weight	**21.81**	**32.28**	**15.31**	**5.49**	**8.22**	**6.97**	**8.47**	**10.01**	**9.99**	**7.36**	**3.20**	**16.98**
Normalize Weight	14.93	22.10	10.48	3.75	5.63	4.77	5.80	6.85	6.84	5.04	2.19	11.62

Table 7 presents the detailed extraction of supplier selection criteria weights (C1–C12) across different studies, including the calculation of average weights and normalized weights to facilitate direct comparison

The normalization process ensured that the sum of all criteria weights equals 100%, allowing for a consistent basis for comparison with expert judgment results in subsequent analysis.

3.4 Expert Judgment Results (AHP-OS)

To validate the supplier selection criteria identified through the literature review, expert judgment data were collected using the Analytic Hierarchy Process - Online System (AHP-OS). Eight (8) experienced professionals from the heavy automotive and supply chain industries participated in the evaluation process by conducting pairwise comparisons among the twelve (12) supplier selection criteria. The resulting Consistency Ratio (CR) for the aggregated group judgment was 2.2%, well below the acceptable threshold of 10%, indicating a high level of logical consistency and reliability in the experts' responses. The consolidated priority weights and rankings derived from the expert judgments are summarized in Table 8.

Table 8
Consolidated priority weights and rankings from expert judgment

Criteria	Code	Priority Weight (%)	Rank
Quality	C2	15.8	1
Cost	C1	14.5	2
Technological Capability	C4	12.6	3
Delivery Performance	C3	11.4	4
Sustainability	C5	9.1	5
Service	C9	6.4	6
Financial Capability	C6	6.4	7
Capacity and Capability	C7	6.2	8
Relationship	C11	5.0	9
Reputation	C8	4.9	10
Flexibility	C10	4.2	11
Risk	C12	3.3	12

This section presented the extraction, justification, aggregation, and expert evaluation of supplier selection criteria. The results confirmed that Quality, Cost, and Technological Capability are the most important criteria for supplier selection in the heavy automotive industry. The integration of literature findings with expert judgment provided a comprehensive understanding of supplier evaluation priorities.

The individual consistency ratios (CR) for the eight (8) experts ranged between 1.90% and 35.30%. While a few individual CR values exceeded the recommended maximum of 10%, the overall group consistency remained at 2.2%, demonstrating reliable and logically consistent aggregated judgments. Note: Individual CR values were as follows: R1: 1.90%, R2: 1.30%, R3: 35.30%, R4: 34.90%, R5: 9.20%, R6: 9.50%, R7: 34.00%, R8: 2.10%. Despite minor deviations at the individual level, the group consistency result justifies proceeding with the consolidated priorities.

The Consolidated Decision Matrix, generated from the aggregation of individual judgments, served as the foundation for deriving the final priority weights. This matrix includes the pairwise comparisons among all twelve (12) criteria. The expert evaluation confirmed that: Quality (C2) is the most critical supplier selection criterion, followed closely by Cost (C1) and Technological Capability (C4), Criteria such as Risk (C12), Flexibility (C10), and Relationship (C11) were considered relatively less important.This prioritization reflects an industry emphasis on supplier reliability, technical competence, and operational excellence as key drivers in the heavy automotive sector.

3.5 Comparison between Literature Review and Expert Judgment Results

In order to further strengthen the validity of the findings, the supplier selection priorities derived from the literature review were compared against those obtained from the expert judgment analysis using AHP-OS. This comparative analysis highlights the similarities and differences between theoretical research insights and practical industry perspectives. Table 9 presents a comparison of the normalized priority weights, along with their respective ranks based on literature and expert evaluation.

Table 9
Comparison of supplier selection criteria priorities: Literature review vs expert judgment

Criteria	Code	Literature Weight (%)	Expert Weight (%)	Literature Rank	Expert Rank
Quality	C2	22.10	15.8	1	1
Cost	C1	14.93	14.5	2	2
Delivery Performance	C3	10.48	11.4	4	4
Technological Capability	C4	3.75	12.6	11	3
Sustainability	C5	5.63	9.1	8	5
Financial Capability	C6	4.77	6.4	10	7
Capacity and Capability	C7	5.8	6.2	7	8
Reputation	C8	6.85	4.9	5	10
Service	C9	6.84	6.4	6	6
Flexibility	C10	5.04	4.2	9	11
Relationship	C11	2.19	5.0	12	9
Risk	C12	11.62	3.3	3	12

The comparative analysis as shown in Table 9, reveals several key insights. Both literature and expert evaluations consistently ranked quality and cost as the most two critical criteria, indicating strong consensus between academic research and industry practice. However, Technological capability ranked 3rd by experts, was only placed 11th in the literature suggesting growing practical importance not yet reflected in published models. In contrast, risk was ranked 3rd in the literature, dropped to 12th in expert judgments, possibly reflecting improved supplier risk management or differing perceptions of risk within the heavy automotive sector. Other criteria such as delivery performance, sustainability, and service showed moderate consistentcy across both perspectives.

In summary, this study systematically identified and validated key supplier selection criteria for the heavy automotive industry through an integrated approach combining literature review analysis and expert judgment via AHP-OS. The results confirm the importance of Quality, Cost, Technological Capability, and Delivery Performance as dominant criteria influencing supplier selection decisions. While strong alignment was observed between theoretical and practical perspectives, notable differences, particularly in the perceived significance of Technological Capability and Risk, underscore the need to update and contextualize supplier evaluation frameworks. These findings provide a comprehensive and robust foundation for the developing more practical, aligned models in future research and practice.

3.6 Statistical Validation using Spearman Correlation Analysis

The alignment between the literature-based and expert-based rankings of supplier selection criteria was statistically examined using the Spearman rank correlation coefficient. The detailed calculations are presented in Table 10 using Eq. (1).

Table 10
Spearman rank correlation between literature and expert rankings

Literature Rank	Expert Rank	*d*	*d²*
1	1	0	0
2	2	0	0
4	4	0	0
11	3	8	64
8	5	3	9
10	7	3	9
7	8	-1	1
5	10	-5	25
6	6	0	0
9	11	-2	4
12	9	3	9
3	12	-9	81
	Sum of *d²*		**202**

Using the Spearman rank correlation formula:

$$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)} = 1 - \frac{6(202)}{12(144-1)} = 1 - \frac{1212}{1716} \approx 0.2943$$

The resulting Spearman correlation coefficient of approximately 0.29 indicates a low to moderate positive correlation between literature-based and expert-based rankings. This suggests some level of alignment particularly for criteria such as quality and cost but also highlights notable differences. For instance, technological capability was ranked significantly higher by experts compare to literature. While risk showed the reverse trend, ranked 3rd in literature but 12th by experts. These statistical findings support the qualitative comparison discussed in Section 3.5, reinforcing the view that industry practitioners and academic literature do not always align in prioritizing supplier evaluation criteria. Figure 3 illustrates the comparative ranks for further clarity.

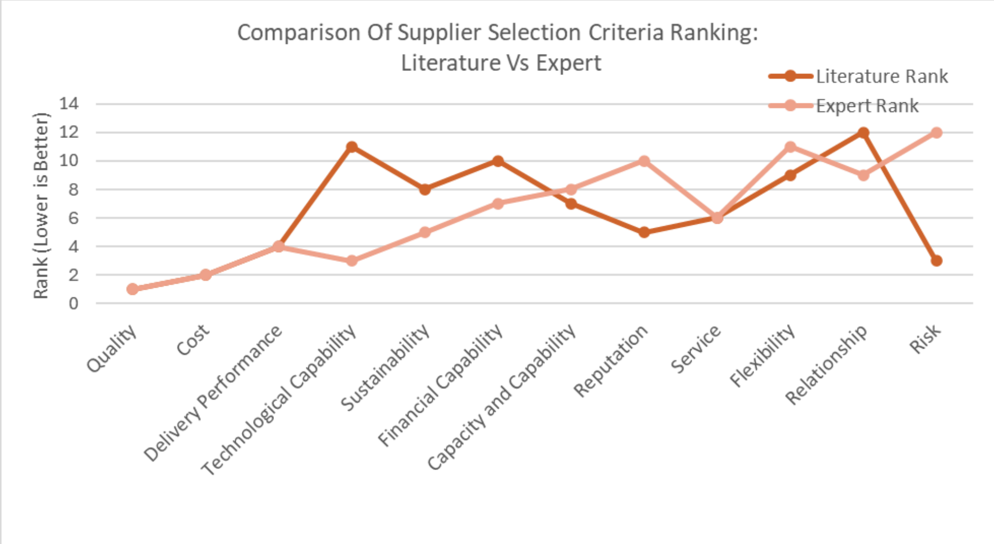

Fig. 3. Comparison of supplier selection criteria ranking: Literature Vs expert judgement

4. Conclusion and Future Recommendation

This study aimed to identify and prioritize key supplier selection criteria specifically relevant to the heavy automotive industry by integrating insights from literature review and expert judgment using the Analytic Hierarchy Process - Online System (AHP-OS). A systematic literature review yielded twelve (12) key criteria, which were extracted, justified, and coded. Quantitative aggregation of priority weights from ten (10) selected studies provided an initial theoretical prioritization of the criteria. Quality, Cost, and Delivery Performance emerged as dominant criteria across both sources. Notably, Technological Capability was ranked significantly higher by industry experts, while Risk was more emphasized in literature. The AHP-OS expert evaluations achieved a group consistency ratio of 2.2%, demonstrating logical reliability. The moderate Spearman correlation ($\rho \approx 0.29$) between literature and expert rankings confirmed partial alignment, highlighting the practical relevance of technological innovation and evolving risk perspectives in the sector.

This research contributes to a validated and structured framework for supplier evaluation in the heavy automotive context and underscores the value of combining academic models with real-world insights. Future research should expand the expert respondent base, include sector-specific subcategories such as buses, trucks, and explore advanced decision-making tools such as Fuzzy AHP or hybrid MCDM models. Longitudinal studies may also help capture evolving supplier priorities under shifting industry dynamics.

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Conflict of Interest Statement
The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions Statement
Dayang wrote the initial draft, conducted the experiments and data analysis. Siti Aimi conceptualized and designed the study, supervised the project, and reviewed the manuscript. Mohd Nasir and S.Sarifah contributed to data interpretation and reviewed the manuscript. All authors contributed to manuscript revision, read, and approved the final version.

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All data generated or analyzed during this study are included in this published article.

Ethics Statement
This study was conducted in accordance with the ethical standards of the institution.

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