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STRUCTURED SUPPLIER SELECTION FOR HIGH-VOLUME AUTOMOTIVE PROGRAMS USING THE AHP–MCDM APPROACH

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Abstract

Supplier selection is a make-or-break element for accomplishment in the automobile industry, where Original Equipment Manufacturers (OEMs) are high-volume assembly companies that depend on a massive network of suppliers. Car quality, cost competitiveness, and stability of manufacturing all directly depend on suppliers and therefore the pivotal role of sourcing in new program launches. The paper recommends a structured process for supplier selection of high-volume automotive programs such as internal requirements, sourcing tactics, and selection processes. The approach focuses on decision streams for design ownership, supplier types, and off-the-shelf options, and mapping the step-by-step procurement process through request for quotation (RFQ) processes, supplier capability assessment, and cost analysis. To solidify decision-making, the Analytic Hierarchy Process (AHP) is integrated at the evaluation stage to facilitate a systematic comparison of suppliers across different criteria such as cost, quality, capacity, and supply chain resilience. The findings indicate that Quality Performance (22%) and Cost & Commercials (18%) hold the highest relative weights, emphasizing their critical influence in supplier selection for automotive programs. By systematizing process of supplier selection and utilization of AHP, in this study, decision-making is improved, costs are minimized, and risks are avoided in high-volume automobile production.

Keywords Automotive supplier selection; High-volume manufacturing; Supplier evaluation; Request for Quotation (RFQ); Should-Cost analysis; Analytic Hierarchy Process (AHP); Multi-criteria decision-making (MCDM); Supply chain resilience

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1. Introduction

The automotive industry operates as one of the highly complex global supply chains, characterized by extensive outsourcing of components to a multi layered network of Tier 1, Tier 2, and Tier 3 suppliers. OEMs (Original Equipment Manufacturers) act as integrators of thousands of parts sourced across diverse geographies, where each supplier's contribution has a direct impact on the vehicle's performance, safety, and production schedule. Given the competitive landscape of high-volume vehicle programs, supplier selection is a procurement activity and a strategic decision that defines product cost, quality, delivery reliability, and long-term partnerships (Choi & Krause, 2006; Suraraksa & Shin, 2019).

As new automotive programs introduce innovations in electrification, lightweight materials, and digital technologies, sourcing decisions have become increasingly complex. Supplier partnerships often extend across multiple programs, with intellectual property rights, design ownership, and technical expertise shaping OEM strategies. Comparative studies of supplier selection practices in different regions, such as Suraraksa and Shin's (2019) analysis of the Thai automotive sector, highlight that while cost, quality, and delivery remain dominant, sustainability and monitoring practices are gaining importance in strategic sourcing decisions. Similarly, research on multicriteria decision-making (MCDM) in the automotive industry demonstrates the value of structured frameworks, such as the Analytic Hierarchy Process (AHP), in ranking suppliers against multiple, often conflicting, criteria (Jamil, Besar, & Sim, 2013). This study advances existing AHP–MCDM approaches by embedding them into a holistic sourcing workflow tailored to high-volume automotive programs, bridging theoretical evaluation models with practical industry applications.

Additionally, the rise of global supply chain disruptions—including trade wars, pandemics, and geopolitical uncertainties—emphasizes the need for resilient supplier networks that ensure business continuity and competitive advantage (Wagner & Bode, 2008). This paper addresses the structured process of supplier selection for high-volume automotive programs. It explores internal alignment on design ownership, classification of supplier engagement models, and the sequential steps of sourcing, including request for quotation (RFQ) issuance, cost benchmarking, supplier evaluation, and decision-making factors. By integrating conventional sourcing practices with AHP–MCDM methods, the goal is to provide a comprehensive framework that both practitioners and researchers can apply to enhance supplier selection strategies in the automotive sector.

The primary research objective of this study is to develop and validate an AHP-based multi-criteria framework that quantifies the relative importance of supplier selection criteria—such as cost, quality, delivery reliability, and supply chain resilience—to support data-driven decision-making in high-volume automotive programs.

2. Aligning Internal Requirements

The system level architecture draws component level needs. When we work on systems, designs for each component within system are finalized for maximizing the purpose of each

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component and ultimately help save cost, time and space in the car. Decision for design ownership of each component is complex and often involves various factors. One of the major factors in determining design ownership is the internal resources the engineering team has for that project. Another one is intellectual property and patents. The designs that are key IP for that OEM would often be manufactured internally at the OEM plant or built to print at a tier 1 (Handfield et al., 2020).

There are four kinds of suppliers - Full-Service Suppliers (FSS), Build to Print (BTP), Off the Shelf (OTS) and Co-developers as shown in *Figure 1*.

Full-Service Suppliers are responsible for most elements of the project. From design, testing to program management, suppliers take charge in each step of the product development. These suppliers usually own the IP, expertise, trade knowledge or technology for that commodity. OEMs find worth in awarding business to industry leaders of that domain instead of trying to invent the wheel (Takeishi, 2001).

Build to Print suppliers are those that manufacture parts exactly according to the engineering drawings created by the OEM design team. The tolerances, materials, and key details are specified by the OEM. These suppliers are typically chosen to reduce costs, protect design ownership and intellectual property, or when designs are reused from previous programs (Monczka et al., 2015).

Co-Development means OEM and suppliers are both co-owners of the design, both companies' engineering teams closely work to find the correct solution for the application. These type serves for deeper collaboration within both companies and are generally used for newer technology that hasn't been adopted widely yet, or both have expertise in the product application. Such arrangements foster deeper technical integration and knowledge sharing (Cabigiosu & Camuffo, 2012).

Off the shelf (OTS) solutions - The existing automotive components that are readily available in the market today, are used to be part of the system. These are the most cost effective and supply chain efficient path for the OEM. Commodities like adhesive, fasteners, foams or consumables can fall under this category if it's communized with OTS solution (Schiele et al., 2011).

Once internal alignment has been reached for sourcing requirements for that component, the supply chain team takes it to the next steps which we will discuss further in detail.

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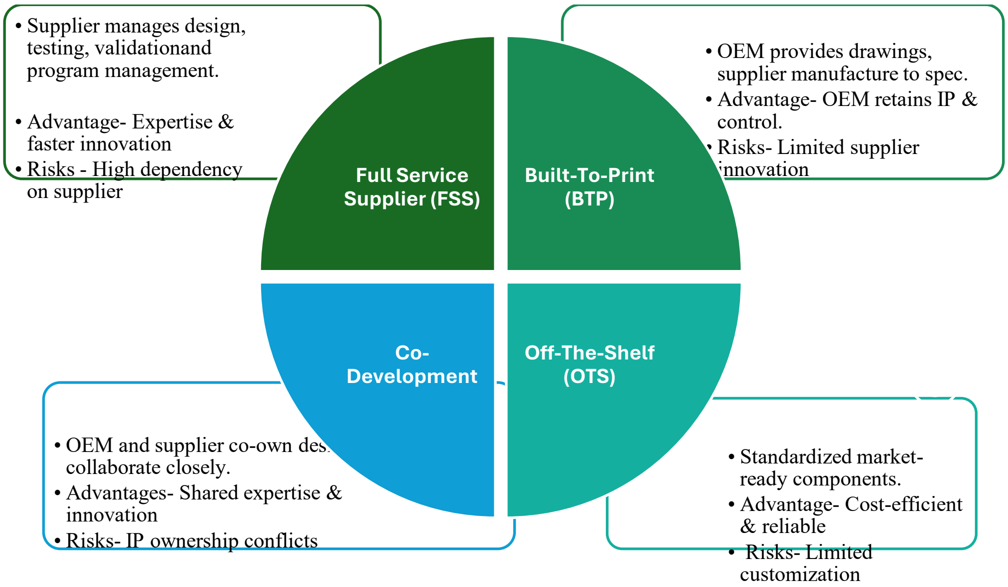

Figure 1 Comparison of Automotive Supplier Engagement Models. The figure illustrates four key supplier strategies—Full-Service Supplier (FSS), Build-to-Print (BTP), Co-Development, and Off-the-Shelf (OTS)—highlighting their core features, advantages, and risks in automotive sourcing decisions.

3. Steps for Supplier Selection

3.1 RFX (RFI/ RFP/ RFQ) – Procurement Requests

The first step for the supply chain team is the RFX Phase. During this phase, the supply chain procurement team sends an official "Request for X" package to multiple shortlisted suppliers identified through initial market research. RFX encompasses various types of procurement requests, including "Request for Information (RFI)," "Request for Proposal (RFP)," and "Request for Quotation (RFQ). (Tiwari et al., 2019)."

The final RFQ package contains essential documents such as the Engineering Statement of Work (ESOW), Supplier Quality Manual (SQM), packaging forms, and technical requirements. This comprehensive package provides suppliers with sufficient information to prepare their quotations. (Choi & Hartley, 1996).

While the suppliers work on their quotations, the OEM's cost engineering team concurrently calculates a "Should Cost." This cost serves as a benchmark for the sourcing team, enabling them to conduct data-driven negotiations with the suppliers. It also helps instill financial discipline within the team, ensuring adherence to cost targets (Ellram, Tate, & Feitzinger, 2013).

Typically, between 5 and 10 Tier-1 suppliers receive RFQ packages to encourage price and service competition, which allows the OEM to leverage the competitive landscape. The number of suppliers may be lower depending on the availability of players in the market for the relevant

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technology or similar products (Ho et al., 2010). As the Tier 1 suppliers submit their detailed quotes, the procurement team compiles the sourcing progress and keeps all cross-functional team members informed. It is recommended that OEMs utilize online procurement platforms to track all important RFX communications with key project participants and streamline the evaluation process (Hartley & Choi, 1996; Schoenherr & Speier-Pero, 2015).

Figure 2 Process Flow of RFX in Supplier Selection. The flow illustrates how procurement progresses from preliminary market research to structured requests (RFI, RFP, RFQ), finalizing with supplier evaluation and shortlisting.

3.2 Supplier Evaluation

The next important step is to assess the supplier's competencies and capabilities for the project. The OEM supplier engineering team evaluates the supplier to understand their facility, engineering team, product line, and industry experience. A structured framework is established company-wide to quantify supplier performance across all partners. Some commonly adopted methods for evaluating suppliers include facility audits, historical quality scorecards for existing suppliers, and cross-functional reviews (Choi & Hartley, 1996). This study focuses on sourcing a "Full-Service Supplier" because they typically have the highest requirements. Original Equipment Manufacturers (OEMs) should have an audit format to standardize this process (Humphreys et al., 2003).

While audits and certifications provide valuable insights, supplier evaluation in high-volume automotive programs increasingly requires structured and quantitative methods. High-volume automotive programs demand decisions that balance multiple, and sometimes conflicting, criteria such as cost, quality, delivery reliability, technological capability, scalability, and sustainability. Relying solely on traditional methods risks bias and fails to capture trade-offs across dimensions.

To address this complexity, this study applies a Multi-Criteria Decision-Making (MCDM) framework, integrating the Analytic Hierarchy Process (AHP) to systematically prioritize evaluation criteria and objectively rank suppliers. AHP enables decision-makers to structure the evaluation problem hierarchically, perform pairwise comparisons among criteria, and derive consistent weights that reflect organizational priorities (Saaty, 2008; Ho, Xu, & Dey, 2010). When integrated into an MCDM framework, AHP allows OEMs to combine qualitative assessments and quantitative metrics, ensuring a transparent, data-driven, and replicable supplier evaluation process.

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The following subsections present the performance criteria—engineering capabilities, manufacturing facilities, and sustainability—before the AHP–MCDM approach for supplier ranking is presented.

3.2.1 Cost and Commercials

Cost remains among the most decisive in supplier selection, particularly in high-volume automotive programs where even minor fluctuations in unit price can translate into large financial impacts over the life of a vehicle. When suppliers quote on a commodity, the cost package typically contains various components:

Piece Price / Unit Price: The per-part cost is the most obvious aspect, impacting directly on the bill of materials (BOM). OEMs try to achieve economies of scale and push suppliers toward process optimization in manufacturing as part of competitive bidding in order to achieve cost competitiveness.

Engineering, Design, and Testing (ED&T) Costs: ED&T costs cover supplier activity in prototype development, verification testing, and redesign. ED&T costs are necessary at early stages of the program as they validate design practicability and performance compliance. OEMs generally allocate ED&T costs to production quantities, but ED&T costs play a major role in negotiations with suppliers (Monczka et al., 2015).

Tooling Costs: Tooling is a heavy up-front cost, particularly for items that require custom jigs, dies, or molds. Suppliers quote tooling separately or as part of piece costs. OEMs must look beyond the absolute tooling cost to payment terms (e.g., buy-off timing, amortization) and ownership rights in tooling (Handfield et al., 2020).

These direct costs are augmented by OEMs with increasing focus on total cost of ownership (TCO), which adds the costs of logistics, packaging, carrying inventory, quality losses, warranty costs, and potential risks by the suppliers (Ellram, Tate, & Feitzinger, 2013). A supplier with slightly lower unit price but without delivery reliability, for example, can increase indirect costs through line stoppages or express shipping. Similarly, poor quality performing suppliers can generate higher downstream warranty and recall costs.

Analytically, cost is best evaluated not in isolation but together with other attributes such as quality, delivery, and sustainability. In the AHP–MCDM approach, cost is given a relative value and calculated against these factors so that purchasing decisions are not price-driven but value-driven as a whole.

3.2.2 Quality Performance

The emphasis on excellent quality determines the long-term success of the company. It is more of a value than a checklist. Every stream of operation, from their tiers to the final delivery and customer satisfaction, should strive for the best quality of work, product, and service. Studying the defect/scrap rates for their manufacturing facility can help understand their quality controls and manufacturing competency. Warranty and customer quality scorecards can indicate

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upstream performance. Advance Product Quality Planning (APQP) training and knowledge in the team can be beneficial for the new program and product development phase, and ensure a smooth transition from R&D to production. Most OEMs regulate their tiers to hold Quality certifications like ISO, IATF, etc., to follow industry standards. To achieve global standardization, organizations such as ISO and IATF provide certifications for manufacturing facilities. Verification of these certifications, such as ISO 9001 and IATF 16949, can be one of the quickest ways to gauge a facility's capabilities (Sroufe & Curkovic, 2008).

3.2.3 Delivery and Supply Chain Reliability

Delivery performance is a key criterion to establish supplier reliability, with direct consequences for the OEM's production continuity and launch timetables. All those crucial indicators of on-time delivery (OTD), lead time flexibility, and logistics capability are measured to make certain the supplier will not interrupt high-volume timetables. OEMs also assess packaging conformance and supply base risk drivers like geographic concentration and Tier-2 dependencies that can expose programs to shipping delays or raw material shortages. To increase resilience, suppliers with robust demand forecasting capabilities, diversified logistics infrastructure, and risk mitigating proactivity are preferred. As Ho, Xu, and Dey (2010) would have it, consistent delivery performance not only supports cost and quality objectives, it enhances the general responsiveness and flexibility of the automotive supply chain.

3.2.4 Manufacturing Capacity

One of the most critical aspects of the automotive industry is manufacturing capabilities. Audits assess the current utilization of the facility for ongoing projects and determine whether machine utilization can accommodate the forecasted annual volumes efficiently. If the present facility is fully occupied, it’s essential to inquire about any expansion plans for the factory layout or whether management is open to future growth.

The specific processing techniques planned for the quoted commodities should be examined to ascertain whether the supplier has relevant experience and if the team is willing to apply lessons learned from previous projects. Examples of such techniques include a particular type of coating, 2K injection molding, and sandwich molding.

Key performance indicators (KPIs) such as Site Safety Score, Environmental Health and Safety (EHS) initiatives, carbon footprint, World Health Organization (WHO) goals, employee satisfaction surveys, and scrap rates should be carefully analyzed to gain a comprehensive understanding of the supplier's performance. These metrics help OEMs assess not only operational performance but also sustainability and workforce resilience (Gualandris & Kalchschmidt, 2016).

3.2.5 Engineering and Innovation Capabilities

The supplier engineering team plays a crucial role in the program’s success. It consists of experts in tooling, design, quality, materials, testing, technical program management, and customer support. Each member of this cross-functional team plays a crucial role in the

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project's overall success. The depth and integration of these cross-functional roles determine the supplier's ability to collaborate with OEMs effectively, manage technical risks, and deliver on performance targets (Ho et al., 2010).

Understanding the design and tooling capabilities, the design and process validation testing and their knowledge in existing projects for the quoted commodity is all factors within this criterion for AHP. This criteria is mainly important in next generation Electric Vehicles as technological advancements directly influence performance of component and hence the overall vehicle (Agrawal, S. J. 2025)

3.2.6 Sustainability and Compliance

Compliance and sustainability are also more relevant during supplier selection since automotive OEMs are faced with greater regulatory requirements and customer needs for eco-friendly products. Suppliers are screened for compliance with environmental management systems such as ISO 14001 and their ability to measure and reduce their carbon footprint across operations. Higher-value suppliers conduct life cycle analysis (LCA) to quantify environmental effects from raw material extraction through end-of-life disposal, thereby assisting OEMs in meeting regulatory guidelines while reducing total system emissions (Chowdhury, 2025; Gualandris & Kalchschmidt, 2016).

Yet another aspect is circularity and recyclability programs by suppliers, particularly in plastics, polymers, and electronics applied to high-volume automotive programs. OEMs increasingly value partners that make use of recycled material, are designed for disassembly, and minimize waste through closed-loop systems. Beyond environmental metrics, social responsibility metrics—such as ethical labor practices, employee safety, and diversity and inclusion practices—are of significant importance to ensure compatibility with global ethical standards for sourcing. Sellers who link their reporting procedures to frameworks such as the UN Sustainable Development Goals (SDGs) or broader ESG disclosures not only enhance compliance but also more effectively lock in OEMs' sustainability narratives to stakeholders.

3.2.7 Risk and Strategic Fit

Risk and strategic fit elements ensure that supplier relationships are strong throughout the program life cycle. Financial well-being is another primary motivator, as suppliers in bad credit or liquidity issues risk poor delivery performance, quality degradation, or even insolvency at timely program phases (Handfield et al., 2020). OEMs typically have checks on financial well-being using third-party credit reports or internal audits to guard against such vulnerabilities. Similarly, geopolitical risk exposure, trade barriers, and supplier regulatory problems will need to be investigated, especially in international supply chains that are subject to tariffs, sanctions, or domestic instabilities.

Strategic alignment is more than risk management to overall alignment with the OEM's long-term strategy. Choose suppliers usually have strong relationship capital by means of past successful collaborations, being open to co-investment in novel technology, and being sensitive

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to engineering changes. Additionally, forward-thinking EV readiness, digitalization, and Industry 4.0 solution providers will be more inclined to join the OEM's future innovation agendas and competitive visions. These characteristics guarantee partnerships extend beyond transactional exchanges and serve the overall purposes of the OEM in terms of clean mobility, digitalization, and sustainable growth (Schiele, Calvi, & Gibbert, 2011; Cabigiosu & Camuffo, 2012).

Table 1. *Hierarchy of Criteria and Sub-Criteria Used for Supplier Evaluation in Automotive Programs*

Cost & Commercials	Unit cost / quoted price
	Total cost of ownership (TCO)
	Cost reduction potential / should-cost alignment
Quality Performance	Historical defect rates (PPM, DPPM)
	Warranty/recall performance
	Quality management systems (ISO 9001, IATF 16949)
	First Time Quality (FTQ) metrics
Delivery & Supply Chain Reliability	On-time delivery performance (OTD)
	Lead time and flexibility
	Logistics capability & packaging compliance
	Supply chain risk (geographic concentration, tier-2 dependency)
Manufacturing & Capacity	Production technology expertise (e.g., molding, coatings, machining)
	Capacity availability vs. OEM forecast volumes
	Scalability & expansion capability
	Process certifications (ISO/TS, Lean practices, Six Sigma)
Engineering & Innovation Capability	Design and tooling expertise
	R&D investments and patents
	Co-development readiness (DFMEA, PFMEA participation)
	Simulation & validation test facilities
Sustainability & Compliance	Environmental management (ISO 14001, carbon footprint, LCA)

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	Circularity & recyclability initiatives
	Social responsibility (labor standards, diversity & inclusion)
	Alignment with OEM sustainability goals (e.g., UN SDGs, ESG reporting)
Risk & Strategic Fit	Financial stability (credit ratings, bankruptcy risk)
	Geopolitical and regulatory exposure
	Relationship strength / preferred supplier status
	Alignment with OEM long-term strategy (EV readiness, digitalization, Industry 4.0)

4. Methodology for pairwise comparison

The Analytic Hierarchy Process (AHP) was applied in this study to quantify the relative importance of the supplier evaluation criteria identified in Section 3.2. Pairwise comparisons were conducted among the seven main criteria—Quality Performance, Cost & Commercials, Delivery & Supply Chain Reliability, Manufacturing & Capacity, Engineering & Innovation Capability, Sustainability & Compliance, and Risk & Strategic Fit. This approach enabled a structured comparison of each criterion's contribution to the overall supplier selection decision, transforming qualitative judgments into quantitative weights using Saaty's (2008) 1–9 fundamental scale.

Let the set of criteria be $\{C1, \dots, Cn\}$ with normalized weights $w = [w1, \dots, wn]^{\top}$

Defining the pairwise comparison matrix A = $[a_{ij}]$ by

$$a_{ij} = \frac{w_j}{w_i}$$

$$a_{ij} = \frac{1}{a_{ji}}$$

$$a_{ii} = 1$$

This matrix is positive, reciprocal, and consistent:

$$Aw = nw,$$

$$\lambda_{max} = n$$

$$CI = \frac{\lambda_{max} - n}{n - 1} = 0$$

$$CR = \frac{CI}{RI} = 0$$

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(For n=7, Saaty's RI=1.32)

Table 2. *Structure of the Pairwise Comparison Matrix for Criterion Weight Calculation in AHP*

	C1	**C2**	**C3**	**C4**
C1	1	w_1/w_2	w_1/w_3	w_1/w_4
C2	w_2/w_1	1	w_2/w_3	w_2/w_4
C3	w_3/w_1	w_3/w_2	1	w_3/w_4
C4	w_4/w_1	w_4/w_2	w_4/w_3	1

Calculating Pairwise comparison using weights

A. Pairwise-Comparison Matrix (Saaty scale entries)

Based on the Priorities: launch protection via Quality & Delivery, strong Manufacturing capability, balanced **Cost**, explicit but lower weights for Risk/Sustainability**,** we can formulate the following

-Quality ≈ Cost ≈ Delivery (equal importance → 1).

-Quality is moderately more important than Manufacturing & Engineering (2), and strongly more important than Risk & Sustainability (3).

-Cost equals Delivery (1), but is moderately above Engineering (2), moderately above Risk (2), and firmly above Sustainability (3).

-Delivery mirrors Cost's pattern.

-Manufacturing is slightly below the "Q/C/Del" tier (0.5 vs. Quality; 1 vs. Cost/Delivery), moderately above Risk/Sust (2).

-Engineering is a step below Manufacturing (0.5 vs. Cost/Delivery), moderately above Risk/Sust (2).

-Risk and Sustainability are equal (1), and below the operational/technical criteria.

Table 3: *Saaty's Fundamental Scale for the Analytic Hierarchy Process (AHP)*

Intensity of Importance	Definition	Explanation / Practical Meaning
1	Equal importance	Two criteria (or alternatives) contribute equally.
3	Moderate importance	Slightly favors one criterion or alternative over the other.

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5	Strong importance	Clearly favors one criterion or alternative.
7	Very strong importance	One criterion is strongly dominant over the other.
9	Extreme importance	Overwhelming evidence that one criterion is superior.
2, 4, 6, 8	Intermediate values	Represent compromise judgments between two adjacent levels.
Reciprocals (e.g., 1/3)	Inverse comparison	If A is favored over B by 3, then B is favored over A by 1/3.

Note. Saaty's scale provides the foundation for pairwise comparisons in the Analytic Hierarchy Process (AHP), allowing decision-makers to translate qualitative judgments into quantitative weights (Saaty, 2008).

For our case, Table 4 is created after Pairwise comparison

Table 4: *Expert Judgment Pairwise Comparison Matrix for Main Criteria in the Analytic Hierarchy Process (AHP)*

	Quality	Cost	Delivery	Manufacturing	Engineering	Risk	Sustainability
Quality	1	1	1	2	2	3	3
Cost	1	1	1	1	2	2	3
Delivery	1	1	1	1	2	2	3
Manufacturing	1/2	1	1	1	1	2	2
Engineering	1/2	1/2	1/2	1	1	2	2
Risk	1/3	1/2	1/2	1/2	1/2	1	1
Sustainability	1/3	1/3	1/3	1/2	1/2	1	1

B. Resulting Weights (principal eigenvector)

From the matrix above, Table 5 shows the derived priorities (normalized)

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Table 5 : *Derived Weights of Main Criteria from the Analytic Hierarchy Process (AHP)*

Criterion	Derived Weight
Quality	0.2185
Cost	0.1873
Delivery	0.1873
Manufacturing	0.1457
Engineering	0.1193
Risk	0.0754
Sustainability	0.0666

C. Consistency Check

1. λ_{max} = **7.0896**
2. CI = (λ_{max} − n) / (n − 1) = **0.0149**
3. RI (n=7) = **1.32**
4. **CR = CI / RI = 0.0113 → Acceptable** (≪ 0.10)

Pairwise comparison for Sub-Criteria weights calculations

Following the Criteria and sub-criteria based on our program priorities from Table 1.

1. **Cost and Commercials**

	Unit price	**Total cost of ownership (TCO)**	**Should-cost / cost-reduction**
Unit price	1	1.833	3.667
Total cost of ownership (TCO)	0.545	1	2
Should-cost / cost-reduction	0.273	0.5	1

2. **Quality Performance**

	Defect rates (PPM/DPPM)	**Warranty/recall performance**	**Quality management**	**First Time Quality (FTQ)**

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			systems (ISO/IATF)	
Defect rates (PPM/DPPM)	1	2	2	2
Warranty/recall performance	0.5	1	1	1
Quality management systems (ISO/IATF)	0.5	1	1	1
First Time Quality (FTQ)	0.5	1	1	1

3. **Delivery and Supply Chain Reliability**

	On-time delivery (OTD)	**Lead time & flexibility**	**Logistics & packaging compliance**	**Supply chain risk (tier-2, geo)**
On-time delivery (OTD)	1	1.8	3	3
Lead time & flexibility	0.556	1	1.667	1.667
Logistics & packaging compliance	0.333	0.6	1	1
Supply chain risk (tier-2, geo)	0.333	0.6	1	1

4. **Manufacturing and Capacity**

	Process expertise	**Capacity vs. forecast**	**Scalability & expansion**	**Certifications/Lean/Six Sigma**
Process expertise	1	1	1.75	3.5
Capacity vs. forecast	1	1	1.75	3.5
Scalability & expansion	0.571	0.571	1	2
Certifications/Lean/Six Sigma	0.286	0.286	0.5	1

5. **Engineering and Innovation Capability**

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	Design & tooling expertise	Co-dev readiness (DFMEA/PFMEA)	Simulation & validation facilities	R&D investments & patents
Design & tooling expertise	1	1.4	1.4	2.333
Co-dev readiness (DFMEA/PFMEA)	0.714	1	1	1.667
Simulation & validation facilities	0.714	1	1	1.667
R&D investments & patents	0.429	0.6	0.6	1

6. **Sustainability and Compliance**

	ISO 14001 / LCA / carbon	Circularity & recyclability	Social responsibility	ESG / SDG alignment
ISO 14001 / LCA / carbon	1	1.8	3	3
Circularity & recyclability	0.556	1	1.667	1.667
Social responsibility	0.333	0.6	1	1
ESG / SDG alignment	0.333	0.6	1	1

7. **Risk & Strategic Fit**

	Financial stability	Geopolitical/regulatory exposure	Relationship / preferred status	Strategic fit (EV/Industry 4.0)
Financial stability	1	1.4	1.75	1.75
Geopolitical/regulatory exposure	0.714	1	1.25	1.25

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Relationship / preferred status	0.571	0.8	1	1
Strategic fit (EV/Industry 4.0)	0.571	0.8	1	1

Based on the above matrices, Table 6 shows the complete list of weights for Criteria and sub-criteria

Table 6: *Hierarchy of Criteria, Sub-Criteria, and Derived Weights in the Analytic Hierarchy Process (AHP) for Supplier Evaluation*

AHP Criterion	**Weight Input**	**Sub Weights inputs**	**Total sub weights**
1. Cost & Commercials	0.18		
Unit cost / quoted price		0.55	0.099
Total cost of ownership (TCO)		0.3	0.054
Cost reduction potential / should-cost alignment		0.15	0.027
2. Quality Performance	0.22		
Historical defect rates (PPM, DPPM)		0.4	0.088
Warranty / recall performance		0.2	0.044
Quality management systems (ISO 9001, IATF 16949)		0.2	0.044
First Time Quality (FTQ) metrics		0.2	0.044
3. Delivery & Supply Chain Reliability	0.18		
On-time delivery performance (OTD)		0.45	0.081
Lead time and flexibility		0.25	0.045
Logistics capability & packaging compliance		0.15	0.027
Supply chain risk (geographic concentration, tier-2 dependency)		0.15	0.027
4. Manufacturing & Capacity	0.15		
Production technology expertise (e.g., molding, coatings, machining)		0.35	0.0525

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Capacity availability vs. OEM forecast volumes		0.35	0.0525
Scalability & expansion capability		0.2	0.03
Process certifications (ISO/TS, Lean practices, Six Sigma)		0.1	0.015
5. Engineering & Innovation Capability	0.12		
Design and tooling expertise		0.35	0.042
R&D investments and patents		0.15	0.018
Co-development readiness (DFMEA, PFMEA participation)		0.25	0.03
Simulation & validation test facilities		0.25	0.03
6. Sustainability & Compliance *(gaining weight in automotive sourcing)*	0.07		
Environmental management (ISO 14001, carbon footprint, LCA)		0.45	0.0315
Circularity & recyclability initiatives		0.25	0.0175
Social responsibility (labor standards, diversity & inclusion)		0.15	0.0105
Alignment with OEM sustainability goals (e.g., UN SDGs, ESG reporting)		0.15	0.0105
7. Risk & Strategic Fit	0.08		
Financial stability (credit ratings, bankruptcy risk)		0.35	0.028
Geopolitical and regulatory exposure		0.25	0.02
Relationship strength / preferred supplier status		0.2	0.016
Alignment with OEM long-term strategy (EV readiness, digitalization, Industry 4.0)		0.2	0.016

Note. This table summarizes the hierarchical structure of main criteria and sub-criteria used in the Analytic Hierarchy Process (AHP) model for supplier evaluation. “Weight Input” represents the normalized importance of each main criterion, while “Sub-Weights Inputs” reflect local priorities under each category. “Total Sub-Weights” denote the global weight contribution of each sub-criterion to the overall decision hierarchy.

5. Example: AHP–MCDM Supplier Selection (Automotive Vent System)

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Step 1 — Define the goal, alternatives, and criteria

Goal: Select the best Tier-1 supplier for the vent system.
Alternatives: Supplier A, Supplier B, Supplier C.
Main criteria & weights (from pairwise comparisons; CR ≤ 0.10)

Launch protection (Quality/Delivery), process capability (Manufacturing) and surface finish; cost matters but not at the expense of Q/D; engineering moderate; explicit Risk/ESG.

Let's say following are some of the characteristics of these suppliers that would help us rate them:

- A: IATF 16949; recent PPM ~20; 2K molding good; logistics OK; cost mid; ESG basic.
- B: Lowest piece price; longer lead time (SEA); solid QMS; logistics risk higher.
- C: Strong 2K & laser-etch; fastest lead time; mid cost; best ESG reporting.

Step 2 — Scores on AHP Scale

Following is the Scores for Suppliers on the AHP 1–9 scale

Supplier	Quality	Cost	Delivery	Manufacturing	Engineering	Risk	Sustainability
A	8	6	7	7	6	7	5
B	7	8	6	6	7	6	6
C	7	7	8	8	7	5	7

Step 3 — Normalize within each criterion & apply weight

(For each column: score ÷ column sum → local priority; then × criterion weight.)

Global priorities (sum of weighted local priorities):

Supplier	Global Priority
C	0.347
A	0.328
B	0.325

Ranking: C > A > B.

Step 4 — Sensitivity analysis (robustness)

- +20% weight to Cost (renormalized): C still #1; B rises to #2 (as expected) as shown in *Figure 3*.
- +20% weight to Delivery: C remains #1 as shown in *Figure 4*.
- +20% weight to Quality: C remains #1 as shown in *Figure 5*.

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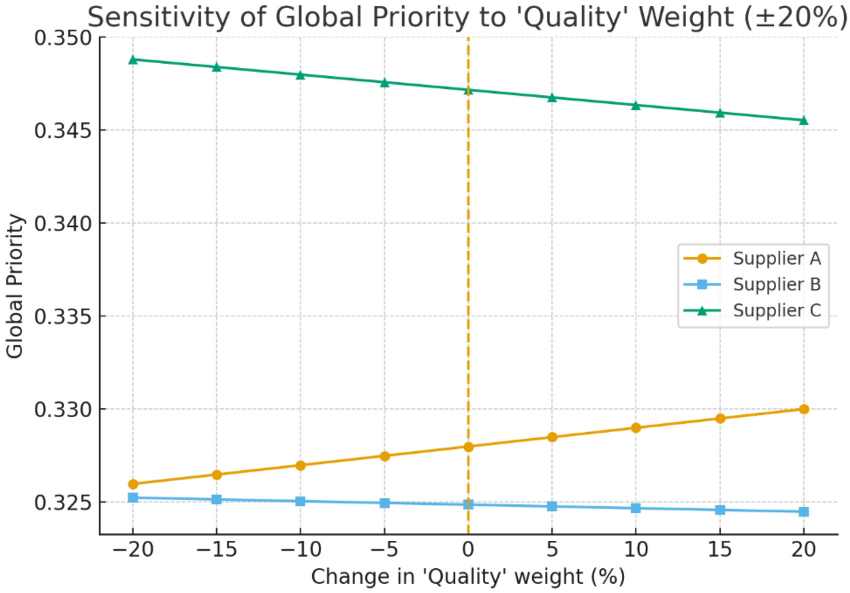

Figure 3

Sensitivity Analysis of Global Supplier Priority with Respect to 'Quality' Weight (±20% Variation)

Note. The figure illustrates how the global priority scores of Supplier A, Supplier B, and Supplier C vary when the weight assigned to the "Quality" criterion is adjusted by ±20%.

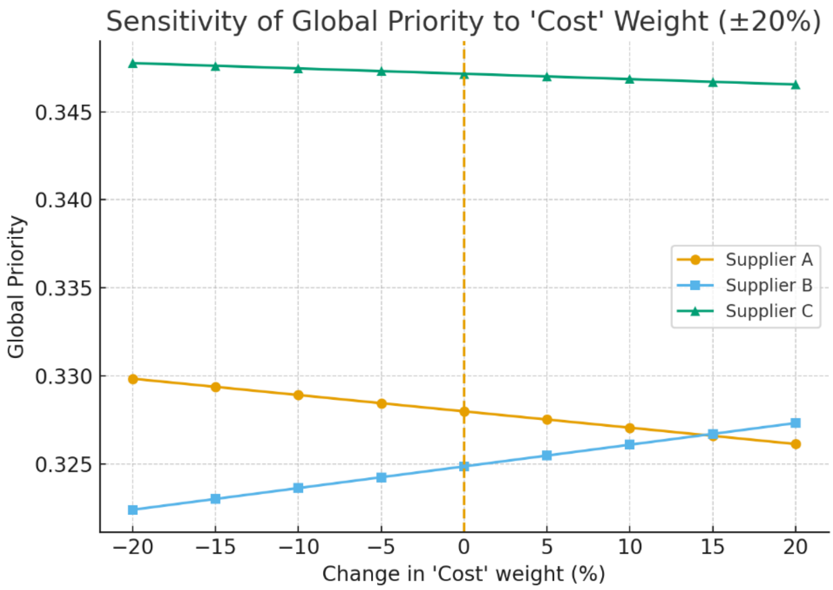

Figure 4

Sensitivity Analysis of Global Supplier Priority with Respect to 'Cost' Weight (±20% Variation)

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Note. The figure shows how the global priority values of Supplier A, Supplier B, and Supplier C change when the "Cost" criterion weight is varied by ±20% from its baseline value. The vertical dashed line at 0% indicates the original weight allocation. Sensitivity analysis helps determine how stable supplier rankings remain when the relative importance of "Cost" changes in the Analytic Hierarchy Process (AHP) model.

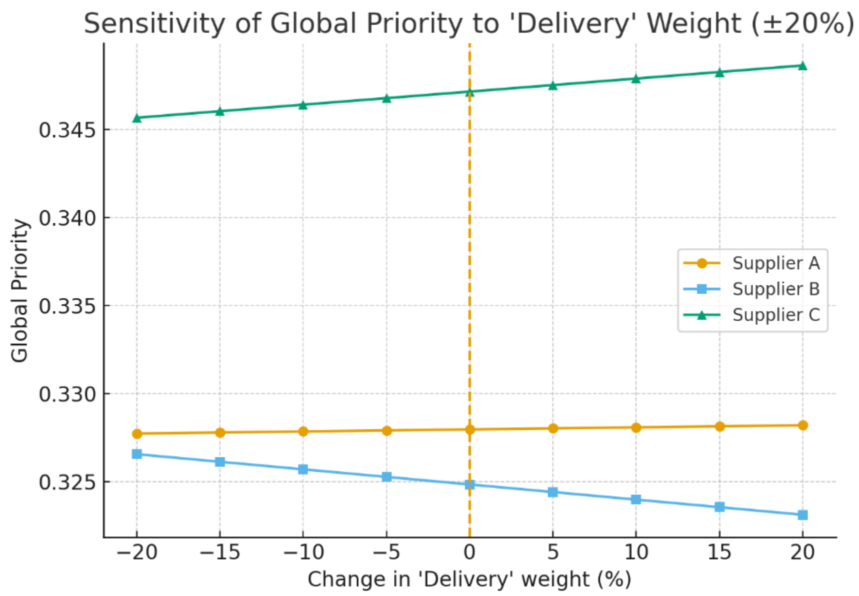

Figure 5

Sensitivity Analysis of Global Supplier Priority with Respect to 'Delivery' Weight (±20% Variation)

Note. The figure illustrates how changes in the "Delivery" criterion weight, within a ±20% range, affect the global priority scores of Supplier A, Supplier B, and Supplier C. The dashed vertical line marks the baseline (0%) weight value. This analysis assesses the robustness of supplier rankings in the Analytic Hierarchy Process (AHP) model when the relative importance of the "Delivery" factor varies.

Results and Recommendations

Based on the AHP–MCDM analysis, Supplier C achieves the highest global priority (0.347) driven by superior Delivery and Manufacturing performance while maintaining competitive Cost and the strongest ESG reporting. Sensitivity tests confirm rank stability under ±20% shifts in Quality, Delivery, and Cost weights. We recommend awarding to Supplier C; consider dual-source C (80%) / A (20%) as a risk-mitigation option during ramp.

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6. Conclusion

This study presented a structured framework for supplier selection in high-volume automotive programs by integrating traditional sourcing practices with quantitative decision-making tools, specifically the Analytic Hierarchy Process (AHP) and Multi-Criteria Decision Making (MCDM). The framework aligns internal engineering and procurement objectives, defines supplier engagement models, and applies a standardized approach to evaluate potential suppliers based on both technical and strategic factors.

The AHP–MCDM analysis established weighted criteria that reflect the priorities of high-volume automotive programs. Among the seven main criteria, Quality Performance (0.22), Cost & Commercials (0.18), and Delivery & Supply Chain Reliability (0.18) emerged as the most influential factors, followed by Manufacturing & Capacity (0.15), Engineering & Innovation Capability (0.12), Risk & Strategic Fit (0.08), and Sustainability & Compliance (0.07). These weights underscore the continuing dominance of quality, cost, and delivery in supplier evaluation, while highlighting the growing importance of sustainability and risk management in modern automotive sourcing.

Applying this framework in an automotive sourcing context demonstrated that AHP–MCDM enables OEMs to quantify subjective judgments, ensure consistency in decision-making, and rank suppliers objectively according to program priorities. The weighted structure and sensitivity analysis further confirmed that the decision outcomes remain robust even under moderate variations in criteria importance. However, the AHP method has limitations—it depends on expert pairwise comparisons, which can introduce subjectivity or bias if not backed by enough data or cross-functional validation. The accuracy of results may also suffer from inconsistencies in judgments when dealing with many criteria.

Overall, the findings reaffirm that data-driven, structured evaluation methods enhance transparency and strategic alignment in supplier selection. Future research can extend this model by incorporating digital supplier scorecards, real-time performance analytics, and carbon footprint tracking to support next-generation, sustainable automotive supply chains.

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