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Systematic Approach to Green Supplier Selection Using Multicriteria Methods

Sistemática para a Seleção de Fornecedores Verdes Utilizando Métodos Multicritérios

Sistemática para la Selección de Proveedores Verdes Mediante Métodos Multicriterio

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Abstract

This study aims to propose a systematic approach to supplier selection in the automotive industry by emphasizing the inclusion of environmental criteria alongside the traditional financial and technical criteria. A connection was established between the literature on corporate sustainability practices and multicriteria decision-making methods, with particular emphasis on the Analytic Hierarchy Process (AHP). A qualitative research approach was adopted, consisting of a literature review followed by the identification of interview participants and subject-matter experts, as well as the definition of relevant criteria, subcriteria, and alternatives. The study developed a model that incorporates environmental criteria into the supplier selection process, aligning supplier evaluation with the organization's sustainability objectives. In this context, the proposed model demonstrated the feasibility of integrating sustainable practices into decision-making processes, thereby contributing to more efficient and environmentally responsible management. By incorporating environmental criteria into supplier selection, organizations can respond to the growing demand for sustainable practices while strengthening corporate responsibility. Furthermore, the model may serve as a practical framework for other industries seeking to integrate sustainability into supply chain management. This study contributes to addressing the gap in the literature regarding the integration of environmental criteria into supplier selection in the automotive industry. In addition, it provides a systematic approach that can be adapted and applied across a wide range of industrial settings, offering a foundation for future research in sustainable supply chain management.

Keywords: Analytic Hierarchy Process (AHP), green suppliers, sustainability.

Resumo

O objetivo deste estudo é propor uma sistemática para a seleção de fornecedores na indústria automotiva, enfatizando a consideração de critérios ambientais, além dos critérios financeiros e técnicos tradicionais. Estabeleceu-se uma ligação entre a literatura sobre práticas sustentáveis nas empresas e os métodos de decisão multicritério, com foco particular no Analytic Hierarchy Process (AHP). O método de pesquisa empregado no estudo foi qualitativo e foi realizada uma revisão bibliográfica, seguida pela definição dos *entrevistados e especialistas, com o estabelecimento de critérios, subcritérios e alternativas relevantes. O estudo desenvolveu um modelo que incorpora critérios ambientais no processo de seleção de fornecedores, alinhando-se aos padrões de sustentabilidade desejados pela empresa. Nesse cenário, o modelo demonstrou a viabilidade de integrar práticas sustentáveis no processo de tomada de decisão, contribuindo para uma gestão mais eficiente e ambientalmente responsável. À medida que incorporam critérios ambientais na seleção de fornecedores, as empresas podem atender à crescente demanda por práticas sustentáveis e melhorar sua responsabilidade corporativa. Dessa forma, o modelo pode servir como um guia para outras indústrias que desejam integrar sustentabilidade na gestão da cadeia de suprimentos. Este estudo contribui para preencher a lacuna na literatura sobre a integração de critérios ambientais no processo de seleção de fornecedores na indústria automotiva. Ademais, fornece uma abordagem sistemática, que pode ser adaptada e aplicada em vários contextos industriais, abrindo caminho para futuros estudos na gestão sustentável da cadeia de suprimentos.*

***Palavras-chave**: Analytic Hierarchy Process (AHP), fornecedores verdes, sustentabilidade.*

Resumen

El objetivo de este estudio es proponer una sistemática para la selección de proveedores en la industria automotriz, enfatizando la consideración de criterios ambientales, además de los criterios financieros y técnicos tradicionales. Se estableció una conexión entre la literatura sobre prácticas sostenibles en las empresas y los métodos de toma de decisiones multicriterio, con especial énfasis en el método Analytic Hierarchy Process (AHP). El método de investigación empleado fue de carácter cualitativo e incluyó una revisión bibliográfica, seguida de la definición de los entrevistados y especialistas, así como del establecimiento de criterios, subcriterios y alternativas relevantes. El estudio desarrolló un modelo que incorpora criterios ambientales en el proceso de selección de proveedores, alineándose con los estándares de sostenibilidad deseados por la empresa. En este contexto, el modelo demostró la viabilidad de integrar prácticas sostenibles en el proceso de toma de decisiones, contribuyendo a una gestión más eficiente y ambientalmente responsable. Al incorporar criterios ambientales en la selección de proveedores, las empresas pueden responder a la creciente demanda de prácticas sostenibles y fortalecer su responsabilidad corporativa. De este modo, el modelo puede servir como guía para otras industrias interesadas en integrar la sostenibilidad en la gestión de la cadena de suministro. Este estudio contribuye a reducir la brecha existente en la literatura sobre la integración de criterios ambientales en los procesos de selección de proveedores en la industria automotriz. Además, proporciona un enfoque sistemático que puede adaptarse y aplicarse en diversos contextos industriales, abriendo nuevas oportunidades para futuras investigaciones en la gestión sostenible de la cadena de suministro.

***Palabras clave:** Analytic Hierarchy Process (AHP), proveedores verdes, sostenibilidad.*

Introduction

According to Daudt and Willcox (2018), the automotive market has historically played a significant role in the Brazilian economy, becoming an important contributor to the country's Gross Domestic Product (GDP). In recent years, the sector accounted for 5% of Brazil's GDP and contributed 20% of the Manufacturing Industry GDP, which encompasses the productive sectors involved in transforming raw materials into finished goods and products.

Guerhardt and Vanalle (2017) discuss the crucial role that suppliers and business partners play within the automotive supply chain and how they are expected to deliver high-quality products that meet customer expectations, thereby strengthening the brands they represent. Accordingly, the influence that suppliers exert on organizational performance is widely recognized, and, as a result, the requirements for supplier selection have become increasingly stringent.

The decision-making process for selecting a strategic supplier is inherently complex because it involves the evaluation of multiple criteria. Duarte (2019) argues that supplier selection may be based on either a single criterion, such as cost, or multiple criteria. In today's context, characterized by decentralized decision-making and a wide variety of available methods, selection criteria are shaped by organizational objectives. Frej (2017) highlights criteria such as price, freight cost, accuracy, on-time delivery, quality, lead time, and flexibility. Araújo et al. (2017) recommend considering quality, cost/price, team resources, financial aspects, organizational management, experience, and lead time. In a literature review, Guerhardt and Vanalle (2017) found that, up to 2012, the criteria most frequently cited for supplier selection were quality, price, and delivery.

More recently, Ganga and Rodrigues (2015) highlighted the growing environmental awareness among both consumers and corporate customers, emphasizing criteria such as low cost, high quality, short lead times, and environmental responsibility. Silva (2016) identified additional sustainability-related criteria, including the development of reusable products, average pollution generation, environmental certification, the use of recyclable packaging materials, and the consumption of resources such as water, energy, and raw materials.

Without discussing specific selection criteria in detail, Corsi et al. (2020) emphasize that organizations must meet consumer expectations and argue that supplier selection plays a crucial role in aligning procurement decisions with organizational strategies. The scientific literature has increasingly addressed these challenges by proposing approaches capable of managing the complexity of supplier selection, particularly in the presence of multiple criteria and the uncertainty associated with them (Duarte, 2019).

Selecting a sourcing option requires balancing several relevant factors (Croom et al., 2000). The importance of these decisions varies according to the size of the purchase or project, making a thorough evaluation of selection criteria essential for well-informed decision-making (Silva, 2016).

According to Monczka et al. (2020), sourcing decision criteria can be classified into two categories: quantitative and qualitative. In this regard, Lima (2019) states that quantitative criteria are based on numerical data, such as price, costs, and delivery capacity, whereas qualitative criteria refer to subjective aspects, including customer relationships, supplier reputation, and innovation capability.

Chart 1 summarizes a set of criteria that extend beyond those traditionally used in supplier selection, including criteria related to environmental issues.

Chart 1

Qualitative and quantitative criteria

PROPOSED BY RELATED CRITERIA	Dweiri et al. (2016)	Awasthi et al. (2018)	Fallahpour et al. (2017)	Jain et al. (2018)	Babbar e Amin (2018)	Osiro et al. (2018)	Cheraghalipour and Farsad (2018)
Price/Cost	X	X	X	X	X	X	X
Quality	X		X	X	X	X	X
Delivery	X		X	X		X	X
Product		X			X	X	
Communication							
Environmental factors		X		X	X	X	X
Social factors		X				X	X
Warranty				X			
Geographic location	X		X	X		X	
Reputation				X			
Service	X				X	X	X
Relationship		X		X		X	
Risks		X			X		
Technology			X			X	X
Flexibility			X			X	
Packaging	X				X		

Source: Prepared by the authors (2024).

As shown above, environmental factors have received increasing attention in the scientific literature in recent years. While some authors emphasize compliance with environmental regulations, others place greater importance on reducing the environmental impact of supply operations.

In this context, the expansion of industrial activities has accelerated environmental change, making the incorporation of environmental factors as strategic elements an important consideration for organizations seeking competitive advantage. Consequently, environmental issues have gained prominence because of the adverse effects of environmental imbalance resulting from human activities (Santos, 2018).

With regard to the environmental factors considered in supplier selection, Chart 2 presents the main criteria identified in the literature. Suppliers meeting these criteria are commonly referred to as green or sustainable suppliers, as environmental considerations assume a central role, or are at least incorporated into, the supplier selection process.

Chart 2

Environmental criteria for green/sustainable supplier selection

Criteria	Definition	Authors
Eco-design	Product design aimed at enabling reuse, recycling, or recovery while minimizing material and energy consumption and avoiding the use of toxic substances.	Rostamzadeh et al. (2015)
Pollution generation	Average measurement of atmospheric pollutant emissions, waste generation, and the presence of other environmentally harmful materials.	Tan et al. (2014)
Environmental management system	Demonstration of sustainability through environmental labels and certifications, such as Leadership in Energy and Environmental Design (LEED), the ISO 14000 family of standards, or the implementation of environmental policies.	Tseng e Chiu (2013)
Environmentally friendly materials	Amount of recyclable materials used in packaging and products.	Büyüközkan and **Çifçi** (2012)
Resource consumption	Indicators of energy, water, and raw material consumption.	Bai and Sarkis (2010)
Reuse, recycling, and waste reduction	Evaluates the supplier's ability to adopt practices and processes that minimize the environmental impact of its activities by promoting material reuse, waste recycling, and the reduction of solid waste generation.	Faisal, Al-Esmael, and Shari (2017)
Green technologies	Evaluates whether the supplier adopts innovative technologies and processes aimed at reducing natural resource consumption, minimizing waste generation, lowering pollutant emissions, and, more broadly, promoting an eco-efficient approach to its operations.	Wang Cheng et al. (2016)

Source: Prepared by the authors (2024).

Environmental regulations, standards, and certifications encourage and recognize organizations' commitment to sustainability by enabling them to assess compliance either voluntarily or in response to legal requirements (Silva, 2016). In this context, green supplier selection has emerged as a practice that extends beyond the traditional criteria of cost and quality by also incorporating environmental and social considerations (Viana and Alencar, 2012). This approach not only helps organizations comply with regulatory requirements and meet consumer expectations but also positions them to achieve competitive advantages and enhance their corporate reputation (Ganga & Rodrigues, 2015).

Within the industrial sector, green procurement involves selecting suppliers that adopt sustainable practices to reduce the environmental impacts of the supply chain. Green supplier selection is a multicriteria decision-making problem that evaluates qualitative and quantitative, subjective and objective environmental aspects, each with different weights and preferences (Silva, 2016). The literature describes a wide range of methods, criteria, and tools to support this process. According to López and Ishizaka (2019), the purpose of multicriteria decision-making is to assist decision-makers when multiple criteria must be considered in evaluating alternative options. Multicriteria decision-making methods play a fundamental role in this context by providing a systematic framework for evaluation and decision-making.

For these reasons, there has been increasing interest in effective tools and techniques capable of considering multiple aspects and characteristics when selecting suppliers from a set of potential alternatives. Multicriteria decision-making is a field of operations research that seeks optimal solutions to complex problems involving multiple, and often conflicting, indicators and criteria. As previously discussed, its primary objective is to support decision-makers in selecting the most appropriate alternative when multiple evaluation criteria must be considered (López & Ishizaka, 2019).

In recent years, the automotive industry has faced increasing pressure to adopt more sustainable practices. Traditionally focused on economic and technical parameters within its supply chain, the sector has increasingly recognized the importance of integrating environmental criteria into its operations. Nevertheless, many manufacturers continue to face challenges in balancing these emerging requirements with their established procurement practices.

The research problem addressed in this study is the limited incorporation of environmental criteria into supplier selection within the automotive industry, where decision-making remains predominantly based on economic and technical considerations. Given the sustainability gap in the sector, there is a clear need for a model that integrates environmental criteria into the supplier selection process. Accordingly, this study seeks to provide a solution that addresses both the traditional requirements of the automotive industry and environmental considerations, thereby promoting sustainable practices aligned with corporate responsibility.

The aim of this study is to establish a systematic approach for supplier selection in an automobile manufacturing company that incorporates green/sustainable criteria by applying a multicriteria decision-making method.

Investigated Context

The organizational context of this study is an automotive manufacturer of passenger vehicles located in the Southern Fluminense region of Brazil. Like many organizations in this sector, the company faces ongoing challenges in its supplier selection process. Every new project or specific organizational need — whether driven by regulatory requirements, technical modifications, or unexpected disruptions — requires a supplier selection process. This process involves an open market consultation to identify and select the proposal that best satisfies the organization's technical and economic requirements.

The department responsible for leading this process is the Purchasing and Supply Chain Department. Its role is to consolidate the input provided by the various organizational units and, based on these specifications, solicit proposals from qualified suppliers. This process is carefully structured to ensure that all submitted proposals are evaluated fairly and consistently. Ultimately, the department is responsible for consolidating the evaluation results and reporting to senior management the proposal that best meets the predefined selection criteria.

At present, supplier selection decisions are primarily based on economic and technical considerations. Consequently, factors such as cost, quality, and suppliers' technical capabilities receive the greatest emphasis. Environmental criteria, although increasingly recognized in light of the growing demand for sustainability, are often overlooked. This is primarily due to limited familiarity with these criteria and uncertainty regarding their relevance and the weight they should carry in the decision-making process.

Therefore, there is a clear need for a supplier selection model that effectively integrates environmental criteria. Such a model would not only satisfy the traditional requirements of the automotive industry but also promote sustainable practices aligned with corporate responsibility expectations. Furthermore, integrating environmental considerations into supplier selection would enable the company not only to adapt to evolving regulatory requirements but also to contribute to the sustainability of the automotive sector as a whole.

Diagnosis of the Problem Situation

This study is applied research based on a real-world case involving an automobile manufacturer located in the Southern Fluminense region of Brazil. Every new project, technical or safety-related modification, or risk of supply disruption resulting from production constraints requires the selection of a supplier for a specific component or family of components.

To diagnose the problem, a literature review was first conducted by combining the keywords supplier selection and selection methods, together with terms such as criterion or environmental criterion, in a search performed in the scielo database. The results revealed a predominance of multicriteria decision-making methods among the applications reported in the retrieved studies. More specifically, 91% of the studies addressing supplier selection employed either the Analytic Hierarchy Process (AHP) or the Analytic Network Process (ANP). Similarly, 76% of the studies that investigated environmental criteria in conjunction with supplier selection methods adopted these analytical approaches.

The multicriteria decision-making method selected for this study was the AHP. The AHP provides a hierarchical framework for evaluating relevant criteria by considering not only cost but also quality, reliability, and, increasingly, environmental commitment (Romero, 2021). Guarnieri (2015) found that 25% of the reviewed studies employed either the AHP or the ANP because of their ease of application to supplier selection problems. The AHP stands out for its ability to hierarchically structure criteria and subcriteria, providing a realistic representation of the complexity involved in supplier selection. Its flexibility and effectiveness across a wide range of applications have established it as one of the leading tools for optimizing decision-making processes (Zanghelini, 2018).

Following the principles proposed by Saaty (1987), the systematic decision-making framework comprises the following steps:

a) Hierarchy construction: organizing the elements of the model into a hierarchical structure;

b) Pairwise comparison: assessing the relative importance of criteria and subcriteria;

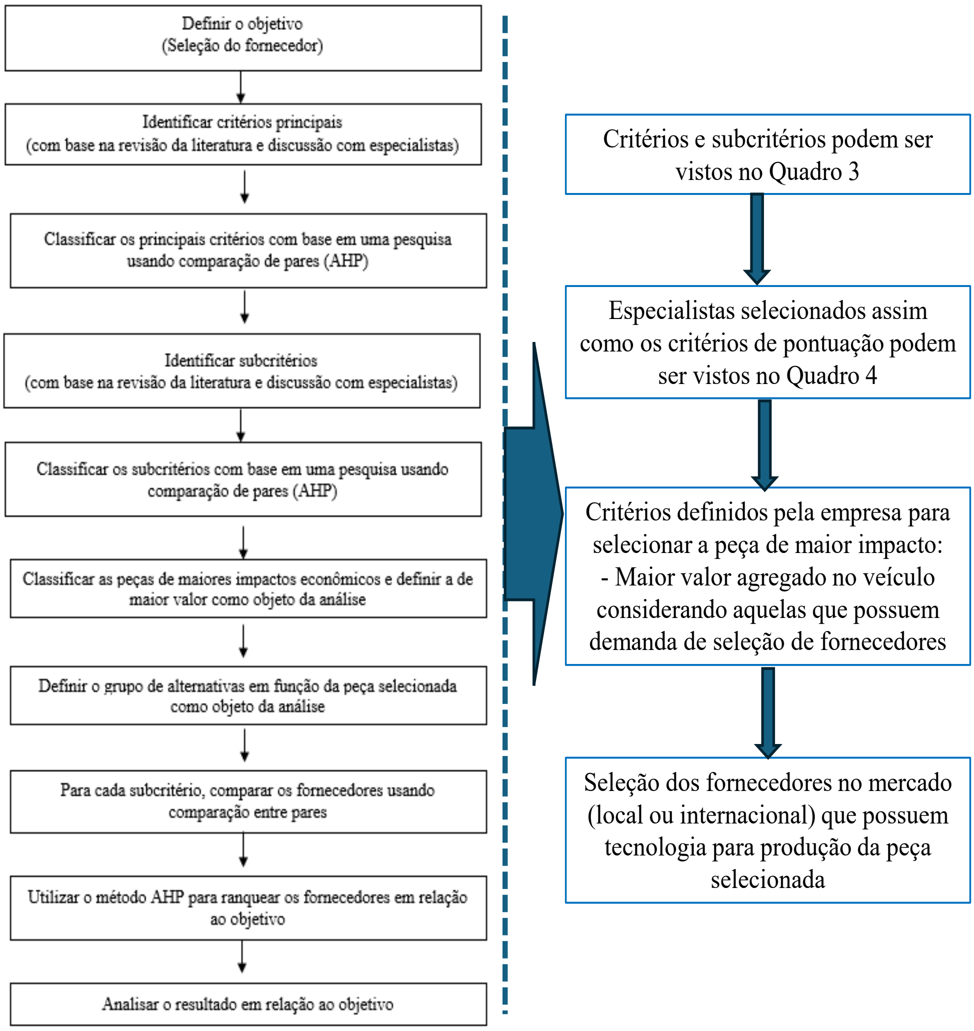
c) Calculation of relative weights and aggregation of preferences: determining weights based on pairwise comparisons and calculating the overall priority scores;

d) Analysis and interpretation: analyzing the results to support the decision-maker's final decision.

Figure 1 illustrates the decision-support framework adopted for implementing the AHP.

Figure 1

Decision-support framework based on the AHP



Source: Prepared by the authors (2024).

The following sections describe each stage of the methodology, emphasizing the data collection procedures and the information obtained.

Data Collection and Processing

Data collection was conducted in three stages: (i) collection of data for evaluating the criteria and subcriteria to be used and determining their respective weights; (ii) collection of data for defining the commodity or component to which the model would be applied; and (iii) collection of comparative data for evaluating the alternatives with respect to each criterion.

Based on the literature, together with internal reports and key performance indicators (KPIs) from an automobile manufacturer, two primary criteria were initially identified through a brainstorming session involving four employees from the purchasing department, each holding different organizational roles. The environmental criterion was subsequently incorporated as the primary distinguishing feature of the present study, resulting in the final set of three main criteria. Chart 3 presents the criteria and subcriteria included in the proposed model.

Chart 3

Criteria and subcriteria

Criteria	Subcriteria	Attributes
Economic	**Component price**	Final component price, considering all direct and indirect production costs, investment amortization, engineering costs, and development expenses. Final transportation costs are excluded.
	Logistics cost	Transportation and handling costs incurred until the component reaches the vehicle assembly line.
	Cost reduction performance	Supplier's capability and track record in proposing ideas and improvements to reduce costs and prices throughout the supply period.
	Financial stability	Ability to maintain stable operations and fulfill long-term contractual commitments.
Technical	**Quality**	Failure rate (PPM), commitment to quality, continuous improvement programs, corrective and preventive action methodologies, inspection and control procedures, implemented ISO management systems, and rejection rates.
	Reliability	Compliance with delivery schedules, commitment to deadlines, delivery delays, operational efficiency, delivery lead time, number of on-time shipments, and waiting time.
	Capacity	Available production capacity to meet the required production volume.
	Flexibility	Ability to accommodate volume fluctuations, resolve operational issues, adapt production equipment, and introduce new products or production volumes in terms of time and cost.
Environmental	**Certifications**	Compliance with mandatory local, national, and international regulations.
	Internal and external environmental policies	Environmental training and awareness programs, leadership commitment to supporting environmental improvement initiatives, and monitoring and control of resource consumption and emissions.
	Green processes	Use of recycled and non-toxic materials, reusable packaging, renewable energy sources, and waste generation indicators.

Source: Prepared by the authors (2024).

Data for evaluating the criteria and subcriteria were collected through a questionnaire administered to specialists with different professional responsibilities. Chart 4 lists the participants involved in the study.

Chart 4

Expert participants

Interviewee	Position	Experience	Weight
E1	Project manager	> 20 years	20%
E2	Project manager	> 20 years	20%
E3	Buyer	> 15 years	10%
E4	Purchasing manager	> 20 years	50%

Source: Prepared by the authors (2024).

As shown in Chart 4, four specialists directly involved in decisions related to the research topic participated in the evaluation process. Although the number of specialists may represent a limitation, this constraint is mitigated by the fact that these professionals are the individuals who effectively influence the organization's decision-making process.

Each specialist was assigned a predefined weight based on their level of experience and the relevance of their organizational role to the decision-making process. Thus, although specialists E1 and E2 had professional experience comparable to that of E4, specialist E4 received a higher weight because of their strategic position within the purchasing department, which provides broader and more critical knowledge for establishing organizational priorities. This weighting scheme more accurately reflects the actual influence of each participant on the decision-making process.

To consolidate the individual judgments, the Aggregation of Individual Priorities (AIP) method, using a weighted variant, was adopted. After collecting the specialists' individual judgments, this approach enabled the weighting and harmonization of their different perspectives while ensuring that the final results reflected the predefined importance assigned to each participant according to the relevance of their organizational responsibilities.

The resulting AIP priority vector is calculated as the weighted sum of the individual eigenvector matrices, as expressed in Equation (1).

$$Vetor\ Resultado\ AIP = \sum_{i=1}^{n} (Autovetor_i\ x\ Peso_i) \quad (1)$$

Where:
• is the number of interviewees;
• is the eigenvector matrix of interviewee ;
• is the weight assigned to interviewee .

The summation represents the weighted combination of the individual eigenvectors, reflecting each participant's contribution to the final priority vector.

Defining the commodity or component is a fundamental step in determining the set of suppliers to be evaluated. In this study, the component was selected specifically for the case study to illustrate the implementation of the proposed methodology, based on the information available in the company's internal management reports. Accordingly, the selected component was the highest-cost item identified for the only vehicle model included within the scope of the study.

The highest-value component in Model A is the instrument panel, commonly referred to as the dashboard. This component is located at the front of the vehicle interior and houses the steering wheel, infotainment system, control switches, air-conditioning system, instrument cluster, and other assemblies. It is a large injection-molded plastic component that, in addition to its commercial relevance because of its high cost, has significant logistical implications due to its transport volume and considerable quality implications because it is a highly visible component from the customer's perspective.

To define the alternatives, a set of prequalified suppliers with the technological capability to manufacture this component was evaluated. These suppliers specialize in the injection molding of medium- and large-scale plastic components with complex geometries and possess complementary technologies, such as localized weakening processes designed to accommodate airbag deployment. The domestic market currently includes four major suppliers with the technological expertise and production capacity required to manufacture this type of component. In addition, international suppliers may also be considered as potential alternatives.

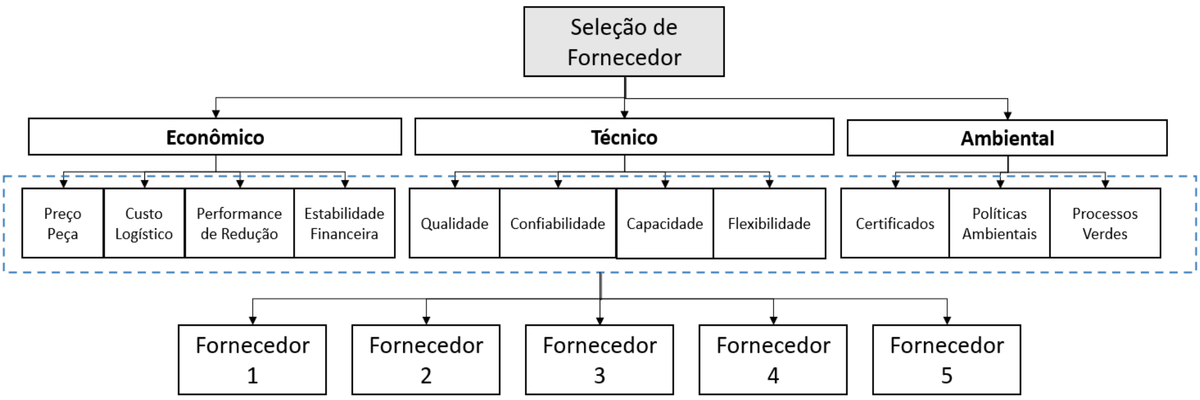
The final stage consists of an interview with the Purchasing Manager, who also participated in the first stage of the study and received the highest decision-making weight. This specialist is responsible for evaluating the competing suppliers with respect to each criterion.

Analysis and Proposed Innovation/Intervention

After defining the criteria, subcriteria, and alternatives, the hierarchical structure of the decision problem was established. For confidentiality reasons, the suppliers were identified by numbers rather than by their actual names, as shown in Figure 2.

Figure 2

Hierarchical structure of the decision problem



Source: Prepared by the authors (2024).

As previously explained, the vehicle instrument panel was selected as the component to be subjected to the supplier selection process. In addition to representing a high-value component, it also has a substantial impact on transportation costs and product quality. This selection enabled the identification of the suppliers capable of manufacturing the component, thereby defining the alternatives considered in the decision problem. Of the five suppliers evaluated, four are domestic suppliers and one is an international supplier.

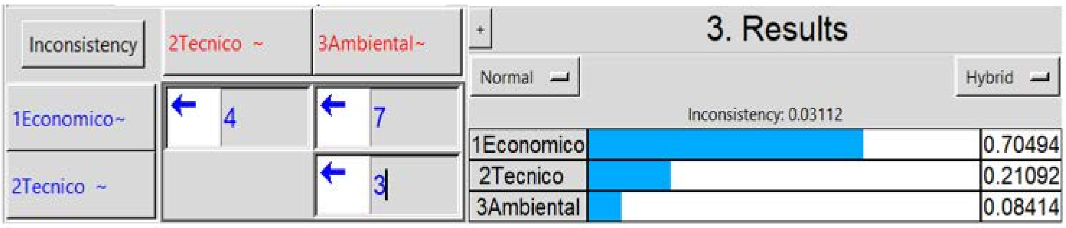
Application of the Method

Once the hierarchical structure of the problem had been established, the specialists were interviewed to determine the relative importance of each criterion and subcriterion. Based on the individual responses, a weighted average was calculated using the predefined weights assigned to each specialist. These weighted judgments were then aggregated to determine the final priority weights.

To process the specialists' individual responses, the data were entered into the Super Decisions software, which was used to calculate the normalized eigenvector of each participant's pairwise comparison matrix. Figure 3 illustrates an example of the judgment matrix provided by Interviewee 1 (E1) and the corresponding normalized eigenvector generated by the software.

Figure 3

Judgment matrix and eigenvector of interviewee 1 (E1)



Source: Prepared by the authors (2024).

The same procedure was applied to all specialists. After entering each participant's judgment matrix into Super Decisions, the normalized eigenvectors were obtained, as presented in Table 1. It can also be observed that the Consistency Ratio (CR) was below 0.10 for all evaluations.

Table 1

Individual eigenvectors for the criteria

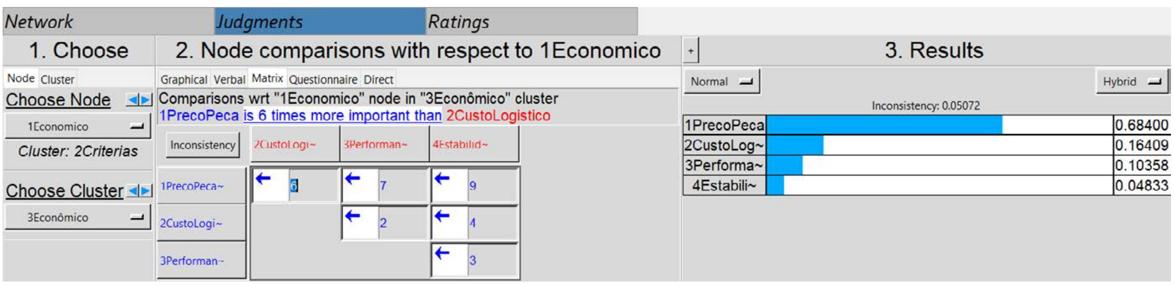
	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4
Economic	0.70494	0.59173	0.61441	0.54693
Technical	0.21092	0.33322	0.26837	0.34454
Environmental	0.08414	0.07506	0.11722	0.10852
Consistency ratio (CR)	0.03112	0.01361	0.07069	0.05156

Source: Prepared by the authors (2024).

The same procedure was performed for all subcriteria, with the individual judgments processed separately. As an example, Figure 4 presents the pairwise comparison matrix and normalized eigenvector obtained for the Component Price subcriterion from E2.

Figure 4

Judgment matrix and eigenvector E2 for the component price subcriterion



Source: Prepared by the authors (2024).

After processing all individual judgment matrices, the complete set of normalized eigenvectors for each interviewee and each subcriterion was obtained, as shown in Table 2. All evaluations yielded a Consistency Ratio (CR) below 0.10.

Table 2

Individual eigenvectors for the subcriteria

Criteria	Subcriteria	E1	E2	E3	E4
Economic	Component Price	0.69612	0.68400	0.69681	0.70001
	Logistics Cost	0.10126	0.16409	0.11981	0.14274
	Cost Reduction Performance	0.15107	0.10358	0.08434	0.07863
	Financial Stability	0.05155	0.04833	0.09903	0.07863
Technical	Quality	0.71251	0.68400	0.64889	0.72067
	Reliability	0.07660	0.04833	0.06675	0.06218
	Capacity	0.07660	0.10358	0.17704	0.10698
	Flexibility	0.13429	0.16409	0.10732	0.11017
Environmental	Certifications	0.80000	0.77858	0.70852	0.63699
	Environmental Policies	0.10000	0.07860	0.06033	0.10473
	Green Processes	0.10000	0.14282	0.23115	0.25828

Source: Prepared by the authors (2024).

The convergence of the specialists' judgments regarding subcriteria such as Component Price, Quality, and Certifications demonstrates remarkable consistency in their perceptions of the importance of these factors in supplier selection. In particular, the Certifications subcriterion was unanimously regarded as critical because of its direct relationship with legal and regulatory compliance. This finding underscores the importance of certifications in supplier selection decisions and reflects a shared understanding of the need to comply with applicable regulations and standards.

Conversely, the differences observed in the weights assigned to the Green Processes and Environmental Policies subcriteria reveal important nuances in how sustainability is perceived. Most interviewees assigned greater importance to Green Processes, associating them with cost reductions and direct economic benefits. However, one interviewee assigned equal importance to both subcriteria, suggesting a more balanced evaluation of environmental and economic considerations. These differences highlight the complexity of balancing environmental and economic priorities in supplier selection decisions.

After obtaining the priority vectors for each interviewee, Equation (3) was used to calculate the aggregated priority vector. The resulting weights are presented in Table 3.

Table 3

Eigenvectors after aggregation of individual judgments

Criteria	Weight	Subcriteria	Weight
Economic	59.4%	Component Price	69.6%
		Logistics Cost	13.6%
		Cost Reduction Performance	9.9%
		Financial Stability	6.9%
Technical	30.8%	Quality	70.4%
		Reliability	6.3%
		Capacity	10.7%
		Flexibility	12.6%
Environmental	9.8%	Certifications	70.5%
		Environmental Policies	9.4%
		Green Processes	20.1%

Source: Prepared by the authors (2024).

Table 3 presents the consolidated results obtained from the weighted aggregation of the criteria and subcriteria. The table provides a clear visual representation of the relative importance of each component within the decision-making process.

Evaluation of the Alternatives

At this stage, Interviewee 4 (E4), whose contribution carried the greatest decision weight, evaluated the five suppliers with respect to each subcriterion based on the company's internal management reports, which documented each supplier's performance for the corresponding evaluation criteria. Although a multicriteria approach involving multiple specialists was adopted, the individual judgments were weighted to reflect each participant's actual influence on the organizational decision-making process. Consequently, E4 received the highest weight because this participant served as the primary decision-maker and possessed strategic information, including access to management reports, an integrated organizational perspective, and final responsibility for the purchasing decision. The remaining specialists contributed complementary technical expertise.

Table 4 presents the priority vectors for the alternatives (Suppliers — Fx), providing an evaluation from the perspective of each subcriterion.

Table 4

Priority vectors of the alternatives under each subcriterion

	Economic				**Technical**				**Environmental**		
	Component Price	**Logistics Cost**	**Cost Reduction Performance**	**Financial Stability**	**Quality**	**Reliability**	**Capacity**	**Flexibility**	**Certifications**	**Environmental Processes**	**Green Processes**
F1	0.12293	0.38801	0.05850	0.30055	0.21030	0.45799	0.16772	0.06801	0.12278	0.40363	0.17153
F2	0.22044	0.17409	0.31762	0.30055	0.56004	0.10416	0.16772	0.52326	0.07272	0.24575	0.17153
F3	0.03257	0.07107	0.50033	0.08910	0.13225	0.12152	0.58148	0.25966	0.44289	0.21989	0.08895
F4	0.08508	0.33317	0.08181	0.02634	0.05884	0.02911	0.04154	0.11418	0.07272	0.05197	0.08895
F5	0.53899	0.03366	0.04173	0.28346	0.03856	0.28722	0.04154	0.03490	0.28889	0.07876	0.47904

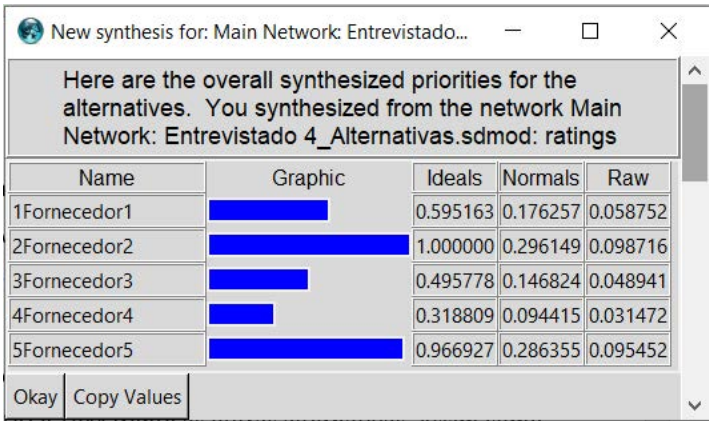
Source: Prepared by the authors (2024).

Table 4 highlights the performance differences between the international supplier (F5) and the domestic suppliers, illustrating the complexity of the supplier selection process. Although the international supplier demonstrates superior performance regarding component price and financial stability, it faces disadvantages in logistics and quality because of the transportation challenges associated with delivering the components. In addition, international suppliers exhibit strong performance in legal compliance and green technologies, largely driven by stricter environmental regulations in Europe. However, their comparatively lower performance in environmental policies reveals a gap in the adoption of practices considered essential within the customer organization's operating context.

After aggregating all priority vectors together with the priority vectors of the alternatives, the data were entered into the Super Decisions software to calculate the overall priorities and rank the suppliers according to the established criteria and subcriteria. Figure 5 presents the overall ranking generated by Super Decisions.

Figure 5

Overall priority ranking of the alternatives



Source: Prepared by the authors (2024).

The results indicate that Supplier 2 was identified as the most suitable alternative, followed by Supplier 5. Although Supplier 5, an international supplier, performed less favorably than Supplier 2 across most subcriteria, it achieved superior performance in the Component Price subcriterion, which carries the greatest weight in the supplier selection process. Nevertheless, when the complete set of subcriteria is considered, Supplier 2 achieves the highest overall ranking.

Systematic Framework for Developing the Supplier Selection Model

Although the academic literature has consistently demonstrated the effectiveness of multicriteria decision-making techniques for supplier selection, a gap remains between theory and organizational practice. This discrepancy may be attributed to several barriers, including organizations' limited familiarity with these methodologies, the complexity of their practical implementation, and organizational resistance to change. In addition, organizations face the challenge of selecting suppliers that satisfy environmental requirements, as integrating sustainable practices further increases the complexity of the decision-making process.

To address these challenges, this study proposes the systematic framework illustrated in Figure 6, which supports the structuring of the decision problem and the development of multicriteria decision models. By providing a systematic and accessible methodological approach, the framework not only facilitates the supplier selection process but also enables broader consideration of environmental, social, and economic dimensions.

The proposed supplier selection framework comprises five structured phases, consistent with the organization of this study. These phases were carefully designed to guide the decision-making process in a systematic, efficient manner from the initial literature review to the validation of the final results.

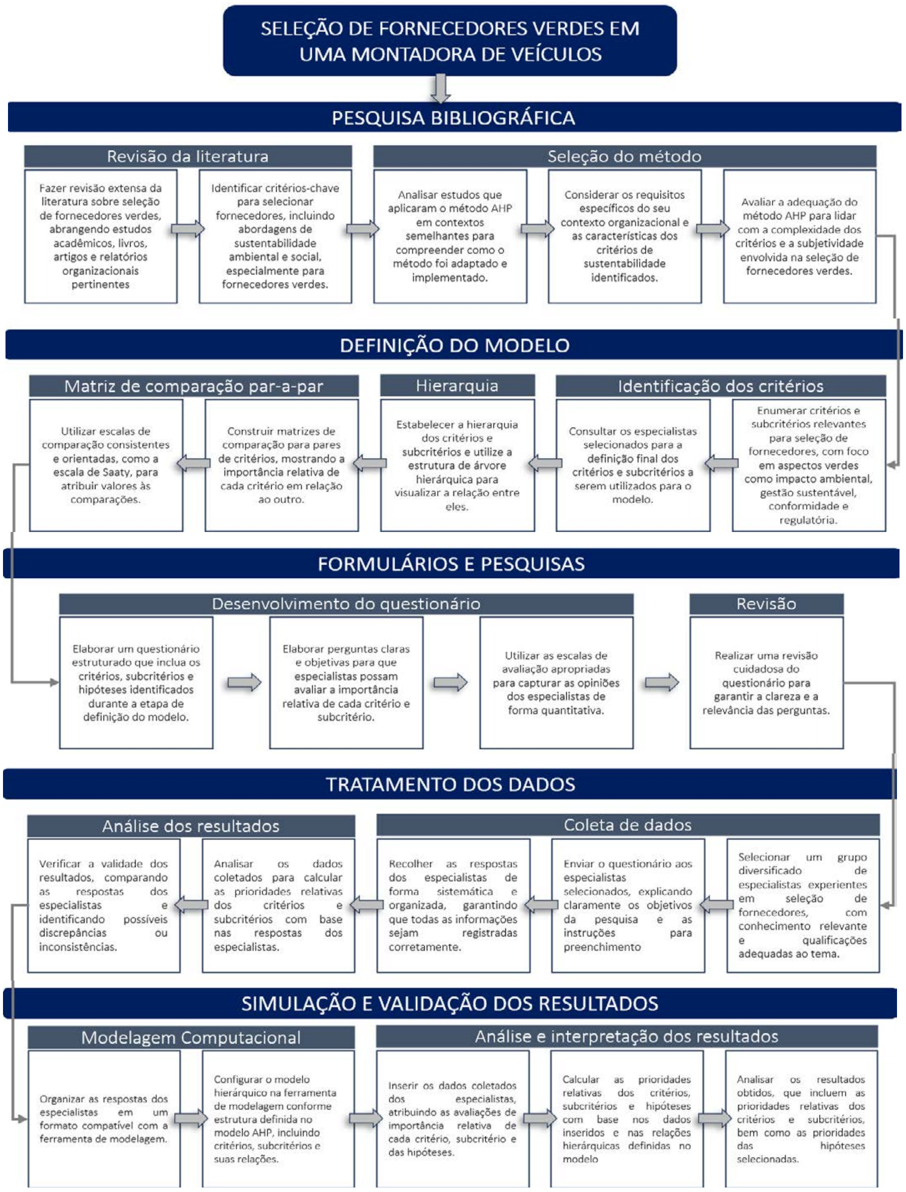
The first phase, Literature Review, consists of a comprehensive review of the relevant literature to establish the theoretical foundation for the supplier selection process and identify best practices and available analytical techniques. The second phase, Model Definition, focuses on establishing the relevant evaluation criteria and parameters, as well as defining the multicriteria decision-making model to be applied.

The third phase, Questionnaires and Surveys, involves designing and administering data collection instruments, such as questionnaires and interviews, to obtain relevant information from potential suppliers. During the fourth phase, Data Processing, the collected data are analyzed and organized to support the decision-making process. Finally, in the fifth phase, Simulation and Validation of Results, the proposed model is tested, and the resulting outcomes are compared and validated to ensure the robustness and reliability of the supplier selection process.

This methodological framework provides a clear and sequential approach, facilitating the implementation of the proposed systematic framework while ensuring results that are consistent with the organization's strategic objectives.

Figure 6

Systematic framework for green supplier selection in an automobile manufacturer



Source: Prepared by the authors (2024).

Conclusions

This study achieved its objective of proposing a systematic framework for green supplier selection in scenarios involving a substantial number of potential suppliers. Under such conditions, it is essential that supplier selection extends beyond the traditional economic and technical criteria by meaningfully incorporating environmental considerations.

Following a comprehensive review of the academic literature, this study examined the theories related to supplier selection, quantitative decision-making methods, and environmental criteria. This review made it possible to identify gaps in the existing body of knowledge and to develop a conceptual framework to guide the research.

Furthermore, this study established green and sustainability-related criteria for supplier selection in the automotive industry. By integrating these criteria into a supplier selection model based on a multicriteria decision-making method, the study advances a more comprehensive approach to supply chain management.

However, it is important to note that only a modest difference was observed between the two highest-ranked suppliers — one domestic and one international. This finding raises an important issue: although domestic and international suppliers achieved similar overall results, the environmental impact associated with transporting imported components must also be taken into account. Therefore, supplier selection that is genuinely aligned with sustainability principles requires improved measurement of emissions not only within suppliers' internal operations but also throughout the transportation processes associated with international suppliers. Such an approach would provide a more comprehensive and accurate assessment of suppliers' environmental performance, thereby supporting more informed and responsible decision-making.

The findings also highlight the importance of adopting an integrated approach to green supplier selection that simultaneously considers environmental, economic, social, and ethical dimensions. Achieving sustainability throughout the supply chain requires a comprehensive evaluation encompassing environmental performance, social responsibility, corporate governance, and community impact. Expanding the scope of supplier assessment to include multiple selection criteria therefore promotes stronger alignment with sustainability principles, contributing to a more resilient and sustainable automotive industry over the long term.

The systematic framework developed in this study represents a significant theoretical contribution by providing a clear sequence of steps for developing a decision-support tool that can be readily applied to green supplier selection. Its practical contribution is equally relevant, as it provides organizations with a tool that enables practical and efficient analysis during the supplier nomination process, allowing the adaptation of relevant variables and the development of customized models for specific procurement scenarios. This approach can be replicated within the same automobile manufacturer and repeatedly applied to different components or component families, thereby supporting a sustainable and effective supplier selection process.

Although the study achieved its proposed objective, several limitations should be acknowledged. First, this is a single-case study conducted within one automobile manufacturer, which limits the generalizability of the findings. Second, the environmental assessment relies primarily on declarative and documentary indicators rather than independently audited environmental metrics or Life Cycle Assessment (LCA). Another limitation concerns the inherently subjective nature of the AHP method, which depends on experts' pairwise judgments and may therefore be influenced by individual biases, even when differentiated weights are assigned to the participants. Finally, the proposed model was applied to only one component family and implemented using a specific software package (Super Decisions), which may require adaptations for application in different organizational contexts.

This study identifies three directions for future research aimed at expanding and improving the green supplier selection process. First, future studies should consider incorporating suppliers' social impact variables to promote a more comprehensive sustainability assessment. Second, the proposed framework should be tested across different component groups or product families to evaluate its adaptability and effectiveness in a broader range of contexts within the automotive industry. Third, although Super Decisions is freely available online, its adoption in corporate environments remains limited because of unfamiliarity with the software and the technical expertise required for its use. Consequently, future research should explore the development of models based on more widely adopted business tools, such as Microsoft Excel, to facilitate the practical implementation of green supplier selection methods during supplier nomination processes.

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