Multicriteria Decision Support Model for Selection of Express Transport Suppliers

ANA PAULA LOPES
Mathematics Department,
CEOS.PP, ISCAP, Polytechnic of Porto,
Rua Jaime Lopes Amorim, s/n 4465-004 S. Mamede de Infesta,
PORTUGAL

Abstract: - Choosing express logistics service providers is a tough decision that affects costs, the quality of service, delivery reliability, and customer satisfaction. While multicriteria decision-making methods are usually used in supplier selection, most studies focus on traditional criteria such as price and lead time. In this paper, a PROMETHEE-GAIA based decision support model is proposed that incorporates two additional dimensions into traditional logistics performance indicators: sustainability, evaluated through environmental, social, and governance (ESG) alignment, and consumer reputation, measured using indices derived from a public complaint platform. By using quantitative and qualitative criteria, the model gives a more complete and transparent evaluation of providers operating in Courier, Express, and Parcel markets. The model tested with five express transport providers shows that ESG and complaint-based metrics affect supplier rankings and improve decision robustness under sensitivity analysis. The framework improves PROMETHEE applications and offers logistics managers a more general, stakeholder-oriented tool for supplier selection.

Key-Words: - PROMETHEE-GAIA, Multicriteria Decision-Making, Logistics Service Provider, Supplier Selection, Transportation Services, Customer Complaints, Sustainability (ESG), Courier, Express and Parcel (CEP).

Received: July 16, 2025. Revised: October 19, 2025. Accepted: March 8, 2026. Published: June 4, 2026.

1 Introduction

Selecting transport partners in Courier, Express and Parcel (CEP) services involve trade-offs between cost, service quality, risk to the supply chain and customer experience. They play a key role in enabling fast and efficient global connections for businesses and individuals by providing access to the worldwide marketplace, [1], [2].

Recent research has established the value of multicriteria decision-making tools such as AHP, TOPSIS, and PROMETHEE in logistics and supplier selection, [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17]. These approaches present a systematic way of resolving conflicting objectives; however, most companies are still confined to "classic" performance parameters, such as price, lead time, and service quality, [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17]. However, the current logistical environment demands an expanded framework for evaluating performance. Consumers and investors have come to anticipate that all organizations will be committed to their responsibilities in terms of environmental (sustainability) and social issues, [16], [18], [19]; and they also seek to assess how well companies serve their customers by assessing reputation, responsiveness to complaints, and corporate transparency, [20], [21].

In contrast to previous studies on the application of PROMETHEE to problems concerning supplier selection for logistics purposes, this research differs in three major ways: (1) it includes sustainability related to environmental, social and governance issues as criteria in the evaluation of suppliers; (2) it develops a measure of consumers perceptions through the creation of a public complaint index; and (3) it provides greater transparency in all aspects of the methodology, including the establishment of criteria, their normalisation and sensitivity analysis.
These new dimensions have been incorporated into a PROMETHEE-GAIA framework which is intended to provide an integrated socially acceptable and standardised decision support system for logistics managers that is based upon the combination of efficiency and stakeholder expectations.

The applicability of the proposed methodology has been demonstrated by means of a case study comparing the performance of five global courier companies (Fedex, Dhl, Ups, Dpd and Nacex). The results show how the use of ESG and Consumer Perception criteria changes the relative positions of potential suppliers and makes decisions more robust and sustainable, thus giving logistics managers a decision-making tool that is socially acceptable but also operationally reliable.

2 Literature Review

2.1 Supply Chain Management and CEP Services

Supply Chain Management (SCM) is concerned with the development, coordination and integration of all procurement, logistics and distribution related activities within an organization or across organizations, [22], [23]. The primary role of transportation is to provide time and place utility in order to facilitate the most efficient movement of goods from the supplier to the customer, [24], [25]. As E-Commerce continues to expand, so does the need for Express Delivery Services as they now represent a key component of supply chain strategies that can support both business agility and responsiveness to volatile customer demand, [26], [27]. Consequently, the Courier, Express, and Parcel (CEP) sector is ever more recognized as both a strategic enabler and a competitive differentiator in logistics performance.

2.2 Supplier Selection in Logistics

Supplier selection can be divided into two stages: Pre-qualifying and Final Decision, [28]. Risk, flexibility, and strategic alignment were gradually added to the initial approaches focused on cost and quality, [17], [29]. More recent studies have placed a greater emphasis on Sustainable Supplier Selection due to increased pressure from both Regulatory bodies and Stakeholders. Hybrid frameworks that combine AHP, TOPSIS, and PROMETHEE are widely adopted for balancing cost, quality, and environmental performance, [16], [17], [18]. Digitalization and big data analytics also make it possible to monitor and assess predictions in real time, [30], [31]. After 2019, there was a visible increase in fuzzy, AI-based, and hybrid approaches in sustainable supplier selection research, according to bibliometric evaluations, [20], [21].

Despite this evolution, two dimensions remain underexplored in logistics supplier evaluation: (1) consumer perception and reputation metrics – although central to service industries, reputation indicators such as complaint indices are rarely operationalized in MCDM models. (2) holistic ESG integration – while sustainability is increasingly cited, systematic incorporation of environmental, social, and governance (ESG) dimensions into decision support frameworks remains limited, [19], [32].

2.3 Multicriteria Decision-Making (MCDM)

MCDM methods provide organizes frameworks for managing conflicting objectives in supplier selection.

Among the most frequently applied are AHP, TOPSIS, and PROMETHEE, [3], [33]. These methods allow integration of both quantitative and qualitative factors, and PROMETHEE has been widely adopted due to its intuitive preference functions and GAIA visualization, [34], [35]. Recent developments include fuzzy PROMETHEE, [36], machine learning-enhanced PROMETHEE, [37], and hybrid approaches for sustainable sourcing, [38].

However, a review of applications reveals that most PROMETHEE-based studies remain focused on conventional criteria (cost, quality, delivery), [16], [17], [18]. Very few studies explicitly include consumer reputation or ESG criteria in supplier evaluation. This research addresses this gap by combining PROMETHEE-GAIA with novel, stakeholder-sensitive criteria - sustainability and complaint indices - thus extending its applicability in the express logistics sector.

3 Methodology

3.1 Research Design

This study adopts a decision-analytic modeling approach. A set of six evaluation criteria was defined, combining quantitative and qualitative measures. Data were obtained from real-world express transport providers and normalized for comparability. To obtain the ranking, PROMETHEE II was used; to visualize the results, GAIA was employed; and to test for robustness by analyzing how sensitive the results are to changes in the input parameters, a sensitivity analysis was performed. Due to the emphasis on methodological transparency, as a means of achieving replication.

3.2 Selection of Alternatives

Five international express logistics providers (DHL, UPS, NACEX, DPD, FedEx) were selected due to their market presence in Portugal. Although the sample is limited, it reflects a relevant subset of global CEP operators. The aim is not statistical generalization but methodological demonstration; thus, the sample size reflects a focused but representative subset of market leaders.

3.3 Decision Criteria and Data Sources

Six decision criteria were defined, integrating both operational and stakeholder-oriented factors.

3.3.1 Price per kg

This is a quantitative criterion, and the objective is to minimize it. It refers to the cost the organization must incur for transporting goods, calculated in €/kg. There are four geographic location zones where the provider can deliver to from the organization's facility. They include Portugal (PT), Spain (ES), Europe 1 (EUR1), and Europe 2 (EUR2). The provider price tables (2024) were used to normalize the prices per kilogram in euros with respect to each zone (PT, ES, EUR1, EUR2) and within weight ranges for express transport providers. Typically, express transport companies have segmented price tables based on both weight ranges and delivery zone for the services they provide (Table 1). In this study, there are five weight ranges for which we established price tables. These ranges are:]0, 5] Kg,]5, 10] Kg,]10, 20] Kg,]20, 30] Kg, and more than 30 kilograms.

Table 1. Price Table by Weight Range and Destination Zone

Organization	*Code*	*Zone*	*Weight Range (kg)*	*Price (€)*	*Additional (€)*
C1	PT]0, 5]	PT	0-5	8,00	
	PT]5,10]	PT	6-10	10,00	
	PT]10, 20]	PT	11-20	14,00	
	PT]20, 30]	PT	20-30	17,00	
	PT]30, +00[	PT	+30	21,00	0,40
	ES]0, 5]	ES	0-5	9,00	
	ES]5, 10]	ES	6-10	11,00	
	ES]10, 20]	ES	11-20	15,00	
	ES]20, 30]	ES	20-30	18,00	
	ES]30, +00[	ES	+30	23,00	0,48
	EUR 1]0, 5]	EUR 1	0-5	11,20	
	EUR 1]5, 10]	EUR 1	6-10	14,00	
	EUR 1]10, 20]	EUR 1	11-20	25,00	
	EUR 1]20, 30]	EUR 1	20-30	30,00	
	EUR 1]30, +00[	EUR 1	+30	35,00	0,60
	EUR 2]0, 5]	EUR 2	0-5	13,44	
	EUR 2]5, 10]	EUR 2	6-10	16,80	
	EUR 2]10, 20]	EUR 2	11-20	30,00	
	EUR 2]20, 30]	EUR 2	20-30	36,00	
	EUR 2]30, +00[	EUR 2	+30	42,00	0,82

Source: Created by the author - Official price tables (2024)

To allow for comparison among several service providers due to differences in how service providers structure their pricing, it may be required to restructure or normalize the pricing data presented in the price tables. By restructuring or normalizing the pricing data, service providers will be able to compare fairly and accurately service offerings.

To determine the price per kilogram (€/kg), a simple formula was used: the total price to be paid for each zone was divided by the corresponding total weight (in kg) transported to that zone. This calculation allows for the normalization of costs across different providers and destinations, enabling a fair comparison of transport efficiency per unit of weight (Table 2).

Table 2. Cost per Zone

Zone	*Price per kg (€)*
PT	0,89 €
ES	0,93 €
EUR 1	1,45 €
EUR 2	1,80 €

Source: Created by the author

This price-per-kilogram metric is an important quantitative criterion in the supplier evaluation model, particularly in multicriteria decision-making (MCDM) contexts involving logistics providers, [30]. By standardizing cost values across regions and providers, decision-makers can better compare pricing structures relative to the service offered.

3.3.2 Lead Time

Lead time is a quantitative criterion to be minimized. The lead time (measured in days) is the total amount of time from the moment the shipment is picked up at the origin by the carrier until it reaches its destination. This information must be provided by the transport supplier during the negotiation process.

Lead times differ based on the geographical zone and the structure of the transport provider. While some companies may rely on subcontracting strategies to extend their operational reach, others may have more reliable timelines thanks to their own global networks. In such cases, although the provider may offer broader coverage, the use of third parties often results in longer lead times. Some suppliers specialize in specific geographic niches and may outperform global players in those regions, [17], [30], [38].

3.3.3 Payment Terms

This is also a quantitative criterion measured in days. It refers to the time the client is allowed to take to settle payment for transportation services. Longer payment terms can act as a form of financing offered by the provider. Therefore, from the client's perspective, this criterion is to be maximized. More favorable payment terms can improve cash flow and reduce financial pressure for the contracting organization, [39].

3.3.4 Service Quality

Service quality is a qualitative criterion that must be assessed based on predefined minimum standards established by the organization. As this is a subjective dimension, it requires quantification to allow for objective comparison and decision-making. A 5-point Likert scale is used, where: 1 = Very Poor; 2 = Poor; 3 = Acceptable; 4 = Good and 5 = Excellent.

To determine the quality score, the organization may evaluate several factors, including delivery success rates; internal knowledge and client-specific experience; evaluations by regulatory bodies; degree of control over the transportation network (owned vs. subcontracted), and relevance to the company's operational context.

It is important to note that a transport supplier's service quality may vary depending on the sector or type of goods handled. A provider may perform excellently in one industry but poorly in another [16], [40].

3.3.5 Sustainability (ESG Alignment)

Sustainability is a qualitative criterion that evaluates the current and planned investments or actions aimed of the supplier demonstrating a balance between economic development, social responsibility, and environmental protection. The assessment can include the use of electric or low-emission vehicles, carbon offsetting programs, ethical labour practices, certifications (e.g., ISO 14001, Eco Vadis) and participation in circular logistics initiatives.

This criterion reflects the organization's compliance with the global sustainability goals and ESG (Environmental, Social, and Governance) policies, [19], [32].

3.3.6 Consumer Complaint Index

This is a quantitative criterion that measures the supplier's customer satisfaction index based on complaints registered on *Portal da Queixa*, a public and free-access online complaint platform. The index is from 0 to 100, which indicates the brand's ability to respond and solve user complaints. A higher index denotes better reputation and customer service performance.

This criterion can be particularly useful in understanding the supplier's sensitivity to consumer feedback and its commitment to resolving service issues.

3.4 Weight Assignment

As [34], emphasize, assigning weights to criteria is one of the most challenging steps in a multicriteria decision-making process. These weights reflect the decision-maker's preferences, values, and organizational priorities, [34]. To support this process, a tool was developed that calculates the relative weight of the "Price" and "Lead Time" criteria by considering both the transport volumes per destination and the strategic relevance of each region. This approach ensures that criteria with direct operational impact are weighted proportionally to their relevance in the logistics flow. The weight considered for each criterion is: Price (25%), Lead Time (25%), Payment Term (11%), Service Quality (12%), Sustainability (13%), and Complaint Portal Satisfaction Index (14%). The highest weights were assigned to the price and lead time criteria due to their direct influence on operational performance and competitiveness in the express transportation sector. Such weighting strategies are consistent with best practices in supplier selection literature, which emphasize aligning the criteria with both quantitative logistics performance indicators and qualitative strategic goals, [16], [17], [19].

3.5 Preference Function Selection

PROMETHEE requires defining how differences between alternatives are interpreted. Selection followed, [34] and was validated through PROMETHEE Decision Lab Assistant. Functions were selected according to the criterion type:

- **V-shape function** for Price and Lead Time (captures sensitivity to incremental changes).
- **Usual function** for Payment Terms (binary distinction between "better" and "worse").
- **Level function** for Service Quality and Sustainability (stepwise subjective scales).
- **Linear function** for Complaint Index (continuous perception of differences).

Thresholds (indifference, preference) were calibrated from industry practice (e.g., ±1 day in lead time = meaningful; ±5 points in complaint index = noticeable).

3.6 Validation and Robustness Checks

- **Internal validation:** consistency checks performed by recalculating weights with alternative aggregation (entropy method). Results showed consistent ordering.
- **Sensitivity analysis:** Visual Stability Intervals (VSI) tested robustness under ±20% weight variations for each criterion.
- **External validation:** DHL's leadership and FedEx's inferior positioning were consistent with external evaluations when results were compared to independent logistics rankings for plausibility.

3.6.1 Supplementary Statistical Validation

To strengthen the methodological robustness of the proposed multicriteria decision support model, a set of complementary statistical analyses was conducted before the application of the PROMETHEE-GAIA method. These analyses are not designed to provide a basis for probabilistic inferences at a population level; however they will be useful to demonstrate the validity of the internal consistency, structural relevance and justifications of the evaluation criteria that are being utilized within the decision model.

First, one way analysis of variance (ANOVA) was performed on the quantitative cost and lead times for each of the four destination zones (Portugal, Spain, Europe 1 and Europe 2), to determine if there is statistical significance with respect to the difference across these destinations. The null hypothesis assumes equality of mean values across zones. Rejection of the null hypothesis supports the treatment of each destination zone as a distinct evaluation dimension and justifies the adopted normalization procedures and differentiated weighting strategy for cost and time-related criteria.

Second, chi-square tests of independence were used on qualitative and categorical criteria to validate how they are structurally incorporated into the multicriteria framework. For the service quality criterion, contingency tables crossing transport providers with Likert-scale quality levels were analyzed to determine whether there is a systematic association between specific suppliers and the quality assessments or if these quality assessments are randomly distributed among all available suppliers. A similar approach was applied to the sustainability (ESG alignment) criteria by considering the presence or absence of key environmental, social and governance practices. These tests support the ordinal score assignment from qualitative judgment to be evaluable through PROMETHEE method.

Finally, Spearman's rank correlation coefficient was employed to assess the stability of supplier rankings before and after the inclusion of sustainability and consumer complaint indices. This research gives more information on how sensitive the decision outcome is to non-traditional performance dimensions and quantifies the extent to which stakeholder-oriented criteria affect the final ranking.

These additional statistical procedures increase the transparency and internal validity of the dataset and reinforce the credibility of the decision model, while preserving the essentially non-probabilistic and preference-based character of the PROMETHEE-GAIA methodology.

4 Results and Discussion

This section presents and discusses the results of the multicriteria decision making (MCDM) analysis, conducted through the PROMETHEE-GAIA methodology. The results express the performances of the logistics service providers under evaluation on the decision criteria defined, considering quantitative and qualitative factors. The results show the performance of the logistics service providers under assessment related to the defined decision criteria, both quantitative and qualitative aspects were considered. The PROMETHEE II ranking shows a clear ordering of the alternatives by aggregating the preference flows, while the GAIA plane gives a visual representation that helps to understand the trade-offs and conflicts between the criteria. Sensitivity analyses were also performed to test the robustness of the rankings under different weight scenarios. The discussion combines these findings with the knowledge from literature and the operational setting of the express logistics sector and indicates practical implications for decision makers.

4.1 PROMETHEE II Ranking Results

The PROMETHEE II analysis yielded a complete ranking of the five evaluated transportation service providers based on their aggregated preference flow (Phi) (Figure 1). Results show DHL as the top ranked alternative with highest net flow (Φ = 0.1449), indicating strong overall performance across the weighted criteria. UPS follows with a moderate positive net flow (Φ = 0.0733), suggesting competitive performance but with some trade-offs in specific areas. DPD is ranked third (Φ = 0.0426) with a positive net flow but is a little lower than UPS. FedEx shows negative net flows of -0.2695, indicating that it is less preferred compared than the other providers under the current weighting scheme. The positive outranking flows (Phi$^+$) represent the degree to which each alternative outranks others, with DHL again leading (Φ^+ = 0.4265). The negative outranking flows (Phi$^-$) reflect the degree to which each alternative is outranked by others; FedEx has the highest Phi$^-$ value (0.4684), suggesting relatively poor performance across several criteria.

PROMETHEE Flow Table

Rank	action		Phi	Phi+	Phi-
1	DHL		0,1449	0,4265	0,2815
2	UPS		0,0733	0,3204	0,2471
3	DPD		0,0426	0,3238	0,2812
4	NACEX		0,0087	0,3218	0,3131
5	FEDEX		-0,2695	0,1989	0,4684

Fig. 1. Screenshot of the PROMETHEE II Flow Table showing net preference flows (Phi), positive flows (Phi$^+$), and negative flows (Phi$^-$) for each logistics provider

Source: Created by the author

The results obtained offer clear guidance to decision makers, identifying DHL as the most suitable logistics partner, according to the developed evaluation model and the trade-off among the factors considered (cost, service quality, lead time, payment terms, sustainability and customer satisfaction). The relatively small differences among the mid-ranked alternatives further imply that small changes in the weights of the criteria would lead to a change in the ranking, which is further investigated in the sensitivity analysis. The relatively small differences between the options in the middle ranks also suggest that small changes in the criteria's weights could lead to changes in the ranked order. This is further addressed in the sensitivity analysis.

4.2 GAIA Plane Analysis

The GAIA (Geometrical Analysis for Interactive Aid) plane offers a visual representation of the performance of each alternative relative to the defined decision criteria. As shown in Figure 2, the decision axis (represented by the red vector) reflects the aggregated direction of the decision-maker's preferences, derived from the weighted criteria. DHL, positioned in the same direction as the decision axis and far from the cluster of other providers, emerges as the most aligned with the ideal profile. This confirms its top ranking in the PROMETHEE II analysis.

In contrast, FEDEX and DPD appear in the opposite direction of the decision axis, indicating weak alignment with the prioritized criteria, especially on price and service performance. NACEX, while relatively distant from the decision axis, is positioned not near the origin, suggesting a more neutral performance with no extreme strengths or weaknesses.

The proximity of UPS to the central cluster, particularly near criteria such as quality, lead time in Spain, and complaint index, suggests that its performance is balanced and generally aligned with core expectations, albeit with lower impact than DHL. Notably, DHL stands out positively on lead time in EUR2 and sustainability, while FEDEX and DPD seem more closely aligned with price EUR2 and price ES, although at the cost of underperforming in other areas.

The GAIA plane explains 88,7% of the decision problem's variability in the two principal dimensions (U-V), indicating a high-quality representation of the multicriteria space and enhancing the reliability of the visual interpretation.

Fig. 2. GAIA Plane illustrating the relative positioning of logistics providers and decision criteria in a reduced-dimensional space

Source: Created by the author

These insights from the GAIA analysis confirm the PROMETHEE II ranking and provide decision-makers with a detailed understanding of the trade-offs and strengths of each supplier.

5 Sensitivity Analysis

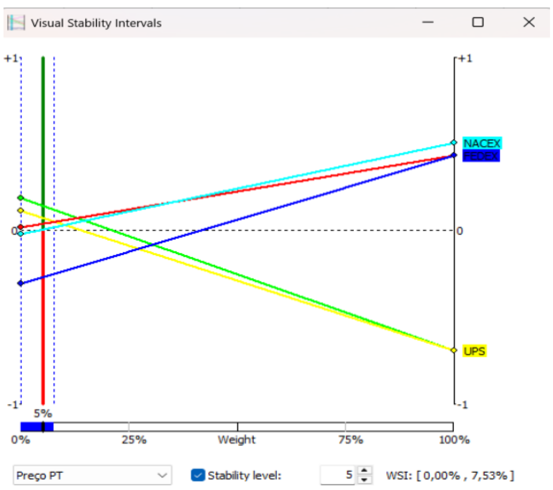
Sensitivity analysis was performed for each of the ten decision criteria to evaluate the robustness of the ranking results using the Visual Stability Intervals (VSI) tool of the PROMETHEE software. This analysis evaluates the sensitivity of the ranking of the alternatives to variations in the weight of each criterion and therefore provides insight into the stability of the decision.

The sensitivity analysis of the four price-related criteria (Figure 3), Price PT, Price ES, Price EUR1, and Price EUR2, reveals that these factors have a strong influence on the ranking of logistics service providers, yet exhibit limited stability when compared to other criteria.

Price PT and Price ES both present narrow Weight Stability Intervals (WSI), with stability ranges of [0.00%, 7.53%] and [0.00%, 11.13%], respectively. This means that even small changes in the weight assigned to these criteria could significantly alter the ranking of alternatives. Notably, UPS's ranking is highly sensitive to changes in these weights, indicating a fragile position under cost-based evaluation.

Price EUR1 and Price EUR2 offer slightly broader stability ranges [4.17%, 11.06%] and [2.40%, 8.69%], which still implies moderate sensitivity. Concerning the relative positioning, the weight of these criteria increases as the better the relative position of the provider becomes, which is an indicator of the higher strength of FedEx and DPD in the European pricing context. Overall, the results highlight the importance of the pricing criteria in the supplier selection process. Given the low-to-moderate robustness of the findings, any change in the weight of these factors, due to budgetary reasons or strategic reordering, should be re-assessed through further multicriteria analysis to prevent undesired modifications of the supplier ranking.

The results collectively highlight the high influence of pricing criteria on supplier selection process. Because of their low to moderate robustness, any change in the weight allocation for cost-related factors (either due to budget changes or strategic re-prioritization) should be carefully re-evaluated with updated multicriteria analysis to avoid unintended changes in supplier ranking.



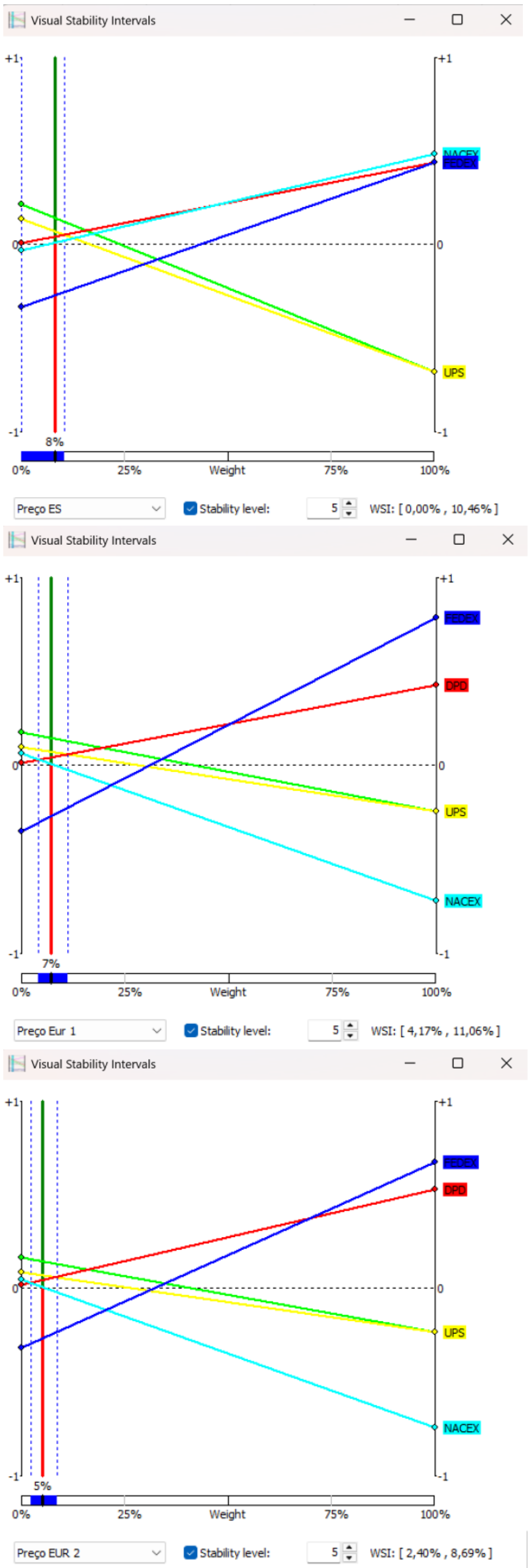


Fig. 3. Sensitivity analysis of cost-related criteria (Price PT, Price ES, Price EUR1, and Price EUR2), showing the stability intervals (WSI) for each criterion

Source: Created by the author

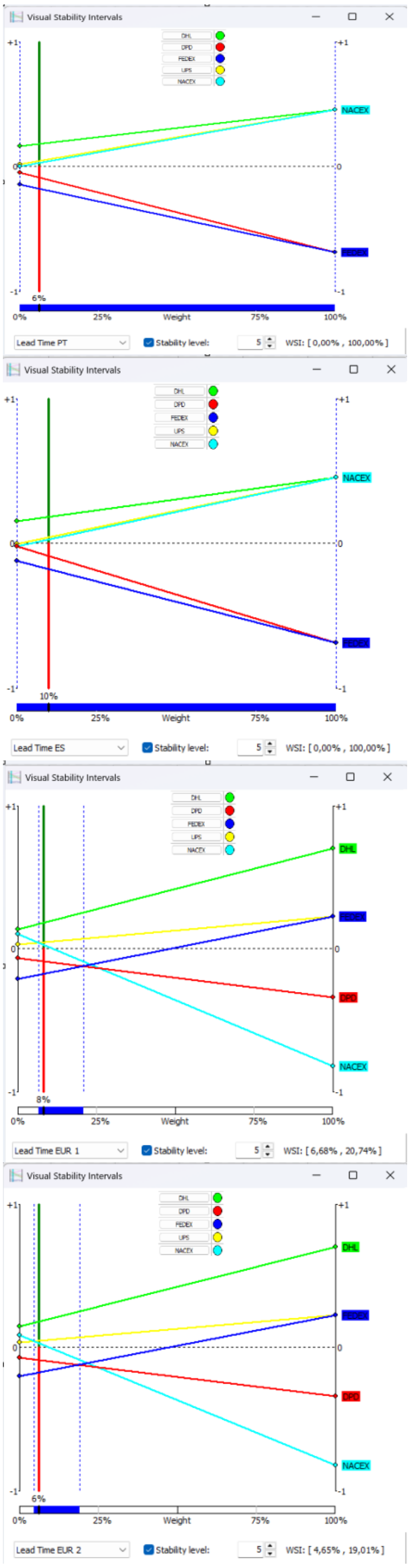


Fig. 4. Visual Stability Intervals (VSI) for lead time-related criteria, showing the impact of weight variation on ranking stability across domestic (PT, ES) and European (EUR1, EUR2) zones
Source: Created by the author

Sensitivity Analysis of the Lead Time Criteria Lead Time PT, Lead Time ES, Lead Time EUR1, Lead Time EUR2 (Figure 4) shows a high degree of stability, which supports the robustness of the decision model in time-based performance evaluations.

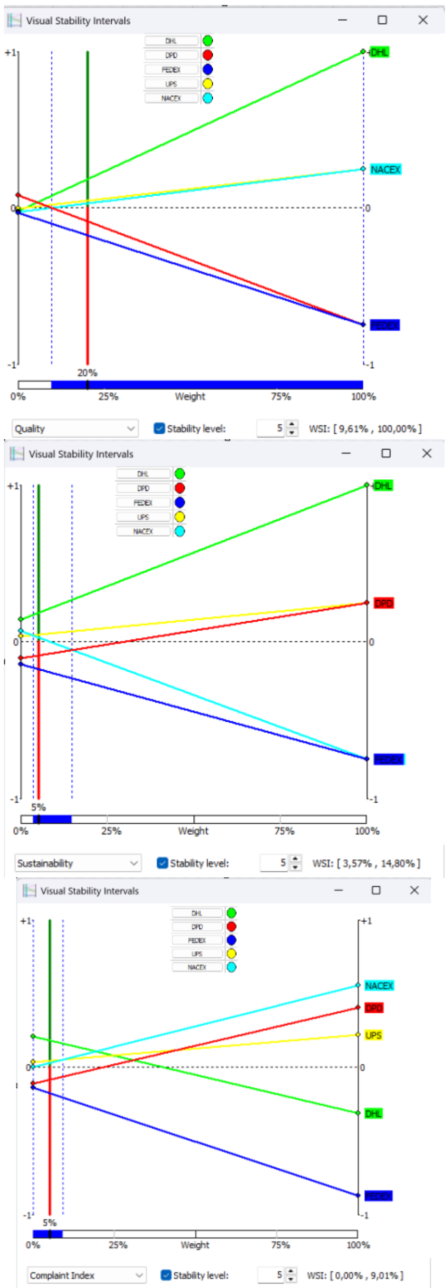
Maximum stability is observed for both Lead Time PT and Lead Time ES, with Weight Stability Intervals (WSI) ranging from 0.00% to 100.00%. This implies that any variation of weight given to these criteria, from 0% to 100%, would not change the ranking of the alternatives. Therefore, these criteria are viewed as being very robust and non-disruptive, thus providing reliable components for the model, even in extreme prioritization situations. Lead Time EUR1 and Lead Time EUR2 show moderate-to-high stability, with WSI ranges of [6.68%, 20.74%] and [4.65%, 19.01%], respectively. While not as robust as their domestic counterparts, these criteria still tolerate a reasonable range of weight variation without causing rank inversions. In these scenarios, DHL consistently improves its position as the weight of lead time increases, whereas NACEX tends to lose ground, indicating that time performance in European zones is a relative strength of DHL and a weakness for NACEX.

Overall, the lead time group contributes meaningfully to the model and maintains strong structural integrity. These results validate the strategic importance of incorporating delivery speed as a stable and reliable criterion in logistics provider selection.

The final set of criteria includes a mix of financial, subjective, and reputation-based dimensions. The results of the sensitivity analysis (Figure 5) reveal varying degrees of influence on the stability of the overall provider ranking:

- Quality stands out with an extremely wide stability range ([9.61%, 100.00%]), indicating that the ranking remains highly stable across a broad spectrum of weight allocations. This robustness confirms DHL's consistent advantage in service quality, with its ranking improving steadily as the weight of this criterion increases. This makes quality a strategically safe criterion to emphasize without risking ranking volatility.
- Sustainability also demonstrates moderate stability, with a WSI range of [3.57%, 14.80%]. While not as dominant in the overall decision model, it offers flexibility and can be given more prominence without significantly affecting the ranking structure. Again, DHL is the most benefitted when sustainability is prioritized, which shows that it is in line with ESG values.

- By contrast, the Complaint Index has a tight stability interval ([0.00%, 9.01%]) indicating that small changes in weights can change the ranking. This implies that the model is sensitive to customer satisfaction metrics and decisions based on this criterion should be taken with caution. Notably, FedEx shows the worst performance in this area.
- Payment Terms, with a WSI of [0.38%, 12.88%], also have limited stability. Providers like DPD and NACEX gain a relative advantage when this criterion is emphasized, while DHL's position declines, showing that payment flexibility is not its strength. Therefore, organizations with strict cash-flow concerns may need to reweigh this criterion carefully.



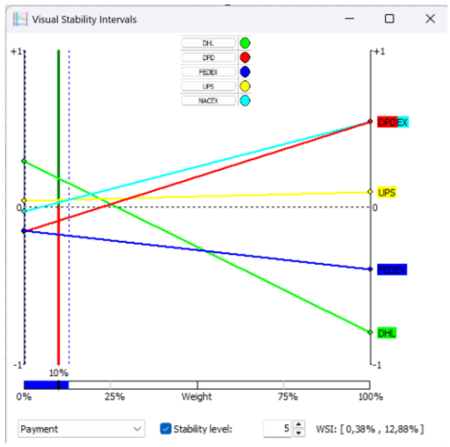


Fig. 5. Visual Stability Intervals (VSI) for Payment, Quality, Sustainability, and Complaint Index criteria, illustrating their respective influence on ranking sensitivity

Source: Created by the author

These findings reinforce the model strength in qualitative terms (particularly quality), but also highlight risks of volatility related to customer perception and financial flexibility.

The sensitivity analysis conducted across all 12 evaluation criteria provides a robust assessment of the decision model's stability and highlights the relative impact of each criterion on the final supplier ranking. The analysis revealed three distinct groups of criteria based on their weight stability intervals (WSI):

- Highly Stable Criteria: Lead Time PT, Lead Time ES, and Quality exhibited the widest WSI ranges - up to 100% - demonstrating strong robustness. This means that the overall supplier ranking remains unaffected even under extreme changes in the weight assigned to these criteria. These results confirm the reliability of the model when prioritizing core service dimensions such as delivery performance and perceived quality.
- Moderately Stable Criteria: Lead Time EUR1, Lead Time EUR2, Price EUR1, Price EUR2, and Sustainability showed moderate stability. While their influence on the ranking is more sensitive to weight adjustments than the first group, they still tolerate reasonable variations without significantly disrupting the order of preference. These criteria reflect operational efficiency and strategic alignment with sustainable practices, particularly relevant in a European logistics context.
- Less Stable Criteria: Price PT, Price ES, Payment Terms, and Complaint Index presented narrow WSI ranges, indicating a high sensitivity to weight changes. A slight adjustment in these factors may result in rank inversion or changes in the top suppliers. These criteria should be examined with

caution in future decision cycles, especially when the organization anticipates changes in budget constraints, financial policies or customer satisfaction goals.
Therefore, the sensitivity analysis indicates that the model is structurally sound and robust to decision-making for most strategic criteria. It also emphasizes the importance of proper weights assignment, particularly in the context of cost and customer perception factors, as these can excessively affect the supplier selection decision.

6 Conclusion

This paper contributes to the supplier selection literature by moving beyond conventional applications of PROMETHEE-GAIA and incorporating two novel dimensions, sustainability (ESG alignment) and consumer reputation metrics derived from complaint platforms. While PROMETHEE has been previously applied to logistics, our framework shows how the incorporation of such non-traditional, stakeholder-driven criteria changes the ranking of the suppliers and improves managerial decision-making.

The results confirm that DHL is performing consistently well in all aspects, especially cost and delivery times. Also, it is performing well with regards to sustainability and reputation. However, the performance of the other service provider's is negatively affected by an apparent trade-off. Sensitivity analysis further validates the robustness of the model, showing that the inclusion of ESG and customer perception metrics influences ranking stability.

From a theoretical standpoint, this research extends PROMETHEE-based studies by embedding social and environmental evaluation into quantitative MCDM structures, thereby responding to the emerging demands of sustainable and consumer-centric supply chains. In practice, it provides managers with a transparent and flexible tool for supplier selection in dynamic markets. In future research, this approach could be extended by incorporating real-time complaint analytics (e.g. natural language processing of consumer feedback) or by integrating AI-enhanced preference modelling to further enhance decision support in uncertain and dynamic environments.

Future research may further enhance decision support in uncertain and dynamic environments by extending this approach to include real-time complaint analytics (e.g. natural language processing of consumer feedback), or by integrating AI-enhanced preference modelling.

References:

[1] L. Dablanc, "Goods transport in large European cities: Difficult to organize, difficult to modernize," *Transp Res Part A Policy Pract*, vol. 41, no. 3, pp. 280-285, 2007, https://doi.org/10.1016/j.tra.2006.05.005.

[2] A. Hübner, H. Kuhn, and J. Wollenburg, "Last mile fulfilment and distribution in omni-channel grocery retailing: A strategic planning framework," *International Journal of Retail and Distribution Management*, vol. 44, no. 3, 2016, https://doi.org/10.1108/IJRDM-11-2014-0154.

[3] M. Behzadian, R. B. Kazemzadeh, A. Albadvi, and M. Aghdasi, "PROMETHEE: A comprehensive literature review on methodologies and applications," *Eur J Oper Res*, vol. 200, no. 1, pp. 198–215, 2010, https://doi.org/10.1016/j.ejor.2009.01.021.

[4] L. Oubahman and S. Duleba, "Review of PROMETHEE method in transportation," Production Engineering Archives, vol. 27, no. 1, pp. 69-74, 2021, https://doi.org/10.30657/pea.2021.27.9.

[5] A. Albadvi, S. K. Chaharsooghi, and A. Esfahanipour, "Decision making in stock trading: An application of PROMETHEE," *Eur J Oper Res*, vol. 177, no. 2, pp. 673–683, 2007, https://doi.org/10.1016/j.ejor.2005.11.022.

[6] B. Elevli, "Logistics freight center locations decision by using Fuzzy-PROMETHEE," *Transport*, vol.29, no.4, pp. 412-418, 2014, https://doi.org/10.3846/16484142.2014.983966.

[7] M. A. M. Isa, N. S. Saharudin, N. B. Anuar, and N. F. Mahad, "The application of AHP-PROMETHEE II for supplier selection," in *Journal of Physics: Conference Series*, 1988, vol. 1988, no. 012062, 2021. https://doi.org/10.1088/1742-6596/1988/1/012062.

[8] J. Trujillo-Díaz, "Sorting methodology using PROMETHEE method to consolidate, load and transport goods," in *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2017, [Online]. https://ieomsociety.org/bogota2017/papers/6.pdf (Access Date: November 2, 2025).

[9] B. Sennaroglu and G. Varlik Celebi, "A military airport location selection by AHP integrated PROMETHEE and VIKOR

methods," *Transp Res D Transp Environ*, vol.59, pp. 160-173, 2018, https://doi.org/10.1016/j.trd.2017.12.022.

[10] H. R. Rezaei-kelidbari, M. Homayounfar, and S. F. A. Foumani, "A Combined Group EA-PROMETHEE Method for a Supplier Selection Problem," *Iranian Journal of Optimization*, vol. 8, no. 2, pp. 87–100, 2016.

[11] N. Agrawal, "Multi-criteria decision-making toward supplier selection: exploration of PROMETHEE II method," *Benchmarking*, vol. 29, no. 7, pp. 2122-2146, 2021, https://doi.org/10.1108/BIJ-02-2021-0071.

[12] A. P. Lopes and N. Rodriguez-Lopez, "A decision support tool for supplier evaluation and selection," *Sustainability (Switzerland)*, vol. 13, no. 22, p. 12387, 2021, https://doi.org/10.3390/su132212387.

[13] R. R. Pinho and A. P. Lopes, "Multicriteria Decision Support Model for Selection of Tinplate Suppliers," 2020, ISBN: 9781799822165. https://doi.org/10.4018/978-1-7998-2216-5.ch006.

[14] T. Nie and H. Yu, "Research on Green Suppliers Selection Based on Hesitant Fuzzy Linguistic PROMETHEE Method," in *2020 IEEE 3rd International Conference on Automation, Electronics and Electrical Engineering, AUTEEE 2020*, pp. 77-81, 2020. https://doi.org/10.1109/AUTEEE50969.2020.9315537.

[15] C. N. Wang, V. T. Hoang Viet, T. P. Ho, V. T. Nguyen, and V. T. Nguyen, "Multi-criteria decision model for the selection of suppliers in the textile industry," *Symmetry (Basel)*, vol. 12, no. 6, p. 979, 2020. https://doi.org/10.3390/SYM12060979.

[16] K. Govindan, S. Rajendran, J. Sarkis, and P. Murugesan, "Multi criteria decision making approaches for green supplier evaluation and selection: a literature review," *J Clean Prod*, vol. 98, pp. 66–83, Jul. 2015, https://doi.org/10.1016/j.jclepro.2013.06.046

[17] J. Chai, J. N. K. Liu, and E. W. T. Ngai, "Application of decision-making techniques in supplier selection: A systematic review of literature," *Expert Syst Appl*, vol. 40, no. 10, pp. 3872-3885, 2013, https://doi.org/10.1016/j.eswa.2012.12.040.

[18] S. S. Sithi, Mst. A. Ara, A. T. Dhrubo, A. H. Rony, and Md. A. Shabur, "Sustainable supplier selection in the textile industry using triple bottom line and SWARA-TOPSIS approaches," in *Discover Sustainability*, vol. 6, no. 344, p. 344, 2025. https://doi.org/10.1007/s43621-025-01206-9.

[19] R. Kumar and D. Pamucar, "A Comprehensive and Systematic Review of Multi-Criteria Decision-Making (MCDM) Methods to Solve Decision-Making Problems: Two Decades from 2004 to 2024," *Spectrum of Decision Making and Applications*, vol. 2, no. 1, pp. 178–197, 2025. https://doi.org/10.31181/sdmap21202524.

[20] K. Khulud, I. Masudin, F. Zulfikarijah, D. P. Restuputri, and A. Haris, "Sustainable Supplier Selection through Multi-Criteria Decision Making (MCDM) Approach: A Bibliometric Analysis," vol. 7, no. 4, p.96, 2023. https://doi.org/10.3390/logistics7040096.

[21] H. Neji, M. Rekik, L. Souifi, and I. Rodriguez, "A Systematic Review of Sustainable Supplier Selection Using Advanced Artificial Intelligence Methods," in *Proceedings of the 17th International Conference on Agents and Artificial Intelligence*, SCITEPRESS - Science and Technology Publications, vol. 3, pp. 451–460, 2025. https://doi.org/10.5220/0013149900003890.

[22] Council of Supply Chain Management Professionals (CSCMP), "Supply Chain Management Terms and Glossary", [Online]. https://www.cisco-eagle.com/uploads/cscmp/cscmp-glossary.pdf (Access Date: February 16, 2026).

[23] John T. Mentzer, William DeWitt, James S. Keebler, Soonhong Min, Nancy W. Nix, Carlo D. Smith, Zach G. Zacharia, "Defining Supply Chain Management," *Journal of Business Logistics*, vol. 22, no. 2, pp. 1-25, 2001, https://doi.org/10.1002/j.2158-1592.2001.tb00001.x.

[24] A. Rushton, P. Croucher, and P. Baker, "The handbook of logistics and distribution management,", 4th Edition, 2010, [Online]. https://ftp.idu.ac.id/wp-content/uploads/ebook/ip/DISTRIBUSI%20LOGISTIK/epdf.pub_the-handbook-of-logistics-and-distribution-managem.pdf (Access Date: February 16, 2026).

[25] P. Schönsleben, Handbook Integral Logistics Management: Operations and Supply Chain

Management Within and Across Companies: Sixth Edition. *Springer*, 2023. https://doi.org/10.1007/978-3-662-65625-9.

[26] CBInsights Research Brief, "Retail's Adapt-Or-Die Moment: How Artificial Intelligence Is Reshaping Commerce," Retail Tech Report. Retrieved from CBInsights, [Online]. https://www.cbinsights.com/research/artificial-intelligence-reshaping-commerce/ (Access Date: February 16, 2026).

[27] S. Chopra, "Supply Chain Management: Strategy, Planning, and Operation, Global Edition," 7th Edition, Pearson, 2020. ISBN: 9781292257891.

[28] L. de Boer, E. Labro, and P. Morlacchi, "A review of methods supporting supplier selection," *European Journal of Purchasing and Supply Management*, vol. 7, no. 2, pp. 75–89, 2001. https://doi.org/10.1016/S0969-7012(00)00028-9.

[29] N. Slack, S. Chambers, R. Johnston, and A. Betts, "Operations Management,", Pearson, 6th Edition, 2021, [Online]. https://www.pearson.com/se/Nordics-Higher-Education/subject-catalogue/decision-science/slack-operations-and-process-management-6e.html (Access Date: February 16, 2026).

[30] J. Mageto, "Big data analytics in sustainable supply chain management: A focus on manufacturing supply chains," vol. 13, no. 13, p. 7101, 2021. https://doi.org/10.3390/su13137101.

[31] K. Hu and L. Kong, "Supplier Selection Criteria under Heterogeneous Sourcing Needs: Evidence from an Online Marketplace for Selling Production Capacity," *SSRN Electronic Journal*, 2023, https://doi.org/10.2139/ssrn.4420456.

[32] V. Patil, T. Tan, S. Rispens, S. Dabadghao, and E. Demerouti, "Supplier sustainability: A comprehensive review and future research directions," *Sustainable Manufacturing and Service Economics*, vol. 1, 2022. https://doi.org/10.1016/j.smse.2022.100003.

[33] J. Figueira, S. Greco, and M. Ehrgott, *Multiple Criteria Decision Analysis: State of the Art Surveys*, 2005. https://doi.org/10.1007/b100605.

[34] J. P. Brans and Y. De Smet, Multiple Criteria Decision Analysis "*PROMETHEE methods*", vol. 233, pp 187-219, 2016. https://doi.org/10.1007/978-1-4939-3094-4_6.

[35] C.-L. Hwang and K. Yoon, "Methods for Multiple Attribute Decision Making," vol. 186, pp. 58-191, 1981. https://doi.org/10.1007/978-3-642-48318-9_3.

[36] N. Ullah, M. Azam, M. Abbas, W. Hussain, A. Birhanu, and K. A. Gepreel, "A novel decision-making approach for the selection of best deep learning techniques under logarithmic fractional fuzzy set information," *Sci Rep*, vol. 15, p. 20598, Jul. 2025. https://doi.org/10.1038/s41598-025-03389-7.

[37] A. Abdulla and G. Baryannis, "A hybrid multi-criteria decision-making and machine learning approach for explainable supplier selection," *Supply Chain Analytics*, vol. 7, p. 100074, 2024, https://doi.org/10.1016/j.sca.2024.100074.

[38] Bojan Matić, Stanislav Jovanović, Dillip Kumar Das, Edmundas Kazimieras Zavadskas, Željko Stević, Siniša Sremac, Milan Marinković , "A new hybrid MCDM model: Sustainable supplier selection in a construction company," *Symmetry (Basel)*, vol. 11, no. 3, p. 353, 2019, https://doi.org/10.3390/sym11030353.

[39] S. K. Mangla, P. Kumar, and M. K. Barua, "Risk analysis in green supply chain using fuzzy AHP approach: A case study," *Resour Conserv Recycl*, vol. 104 (B), 2015, https://doi.org/10.1016/j.resconrec.2015.01.001.

[40] D. A. Garvin, "What Does 'Product Quality' Really Mean?", *Sloan Manage Review*, Cambridge, vol. 26, no. 1, pp 25-43, 1984, [Online]. https://sloanreview.mit.edu/article/what-does-product-quality-really-mean/ (Access Date: February 16, 2026).

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

Ana Paula Lopes solely conceived and designed the study, collected and analyzed the data, developed and applied the decision-support methodology, interpreted the results, and wrote and revised the manuscript. No other individuals contributed to the conception, analysis, or writing of this article. The author assumes full responsibility for the integrity and originality of the work.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.