

Evaluation of Automotive Parts Suppliers through Ordinal Priority Approach and TOPSIS

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Abstract: The problem of supplier selection is an important concern for all businesses. Also, as environmental concerns are mounting and socio-economic crises are increasing worldwide, the need for resilient and environment-friendly suppliers is aggravating. Companies are under tremendous pressure to redefine their business practices and operations to achieve sustainability goals while being resilient. The study aims to evaluate the Chinese automotive parts suppliers based on 'gresilience' (green and resilient) criteria. The suppliers are evaluated using the Ordinal Priority Approach (OPA) and TOPSIS models. Also, it is the first time the TOPSIS model has been executed on the OPA-based criteria weights. The results from the two methods were mostly consistent. However, the OPA is flexible and can produce ranking under different assumptions.

Keywords: Supplier selection; automobile industry; Ordinal Priority Approach; TOPSIS; multi-criteria decision analysis

1. Introduction

The global health crisis triggered by the novel coronavirus has generated much skepticism about the future of business operations. It has disrupted supply chains in many industries, challenging businesses across industries to make better decisions. Conventionally, decision-makers only pay attention to purchasing from suppliers that can provide them with materials and services at lower costs, better quality, and shorter delivery times without considering other performance factors such as adaptability, risk management capabilities, and sustainability practices (Kannan *et al.*, 2013). Since supplier selection is such an important part of every business today, increased studies are trying to build a resilient supply chain by incorporating resilience and green criteria into supplier selection using MCDM models. Selecting resilient suppliers has become one of the most important tasks for companies to avoid COVID -19 disruptions like these, as it can be a lever to mitigate such disruptions that eventually affect the long-term profitability of companies. On the other hand, green supplier selection is seen as a unique example of sustainability principles in modern society. The process of green supplier evaluation is a major step toward sustainable network systems. Incorporating environmental factors into traditional supplier evaluation procedures and methods is essential for a sustainable supply chain (Govindan *et al.*, 2015). As new insights into the interactions between business and the environment continue to develop, there is also increasing

consideration of how to integrate sustainable performance into business processes and an extended supply chain (Davis-Sramek *et al.*, 2020).

Now a new question arises: how to select suppliers from the perspective of long-term resilience while reducing negative environmental impacts? This study addresses this critical question by enabling managers to evaluate and select suppliers in the automotive supply industry from the 'gresilience' criteria (green and resilient) perspective. In this study, the Ordinal Priority Approach (OPA) (Ataei *et al.*, 2020) is used to evaluate suppliers in the automotive parts industry of China based on six criteria: speed of recovery, level of recovery, loss of performance during recovery, energy-saving, waste minimization, and green products. The evaluation of the suppliers is based on two different assumptions. In the first assumption, the resilience-based criteria are more important, while in the second assumption, all criteria (greenness and resilience) are considered equally important.

The remaining of the paper is organized as follows: Section 2 presents a comprehensive literature review on green, resilient and gresilient supplier selections. Section 3 presents research methodology, where data collected strategy and the detail about the OPA and TOPSIS is provided. Section 4 presents the results from the two methods. Section 6 concludes the paper and discusses the research limitations and scope of future work.

2. Literature review

2.1 Green supplier selection

Supplier selection is a mechanism that companies use to evaluate and select suppliers. The approach requires companies to evaluate and select their respective suppliers based on their sustainability goals and environmental commitments. Therefore, the selection of green suppliers appears to become one of the most important strategic concerns for companies. Considering this, industries must enhance existing practices that attempt to embrace sustainable initiatives and technologies to promote sustainable business activities (Konys, 2019). Nowadays, companies cannot neglect environmental concerns if they want to remain in business, thanks to the increased regulatory oversight and social awareness about sustainability practices (Lee *et al.*, 2008; Ullah *et al.*, 2022). Environmental sustainability involves the integration of environmental, financial, and social performance, and is a key issue for businesses in the twenty-first century (Ullah *et al.*, 2021; Verghese & Lewis, 2007).

Sustainable supply chain systems have emerged as a means for companies to achieve financial profitability while reducing their carbon footprint and improving environmental and social performance (van Hock & Erasmus, 2000). Environmentally conscious design and manufacturing, for example, is a core strategy that aims to minimize wastages, toxic emissions, and carbon emissions by restructuring the manufacturing and design operations and considering alternative resources (Zhang, 2004).

In the conventional supplier network practices, the criteria for supplier selection are limited to time, cost, delivery, and quality and have all been considered critical criteria. However, green supplier selection is considered a particular instance of sustainability practices in modern society. This view is like that of Ahi and Searcy (2013). Although there are numerous reports on supplier selection, there is not much on green supplier evaluation and selection that effectively addresses the actual ecological issues (Darnall *et al.*, 2008; Humphreys *et al.*, 2003). Using the Analytic Hierarchy Process (AHP), Noci (1997) developed an eco-friendly vendor-rating framework to assess a company's sustainability impact: green capabilities, current environmental efficiency, suppliers green image, and net life cycle cost.

Green supplier assessment requires monitoring the sustainability impacts of suppliers, asking them to address the environmental impact of their operations, and monitoring the impact of waste within their activities (Darnall *et al.*, 2008; Beamon, 1999). Even with the entire thrust of green distribution networks, some companies might be able to convert environmental investment capital

into economic and social benefits (Laari *et al.*, 2018). Scholars have reportedly developed several criteria and methods for supplier selection that consider underlying environmental threats.

Noci (1997) proposed that green products suppliers' selection consisted of the following three steps: (1) Identifying the green methods that businesses may adopt, (2) Developing a measurement technique to evaluate suppliers' environmental and social performance, and (3) Determining the most appropriate approach for selecting suppliers and ensuring that suppliers can meet the company's social and environmental objectives. Noci (1997) addressed a mechanism for selecting green suppliers. First, firms should evaluate suppliers' current environmental performance; second, firms should evaluate suppliers' sustainable capabilities; third, firms should examine suppliers' commitment to environmental concerns; and finally, firms should monitor the operating efficiency from an investment perspective. Humphreys *et al.* (2003) considered that conventional supplier selection focused solely on quality, flexibility, and other factors. However, as environmental pressures increased, various firms began to pay attention to environmental issues and evaluate suppliers' environmental and social performance. As a result, he argued for a decision-making tool to help companies incorporate environmental principles into the supplier selection process

2.2 Resilient supplier selection

Resilience is an important characteristic of reliable suppliers. Resilience allows a company to look beyond financial stability of their suppliers. A supplier that successfully went through a crisis provides a lot of information to its business partners that the supplier whose ability to cope with crises is unknown. Increasing supply chain resilience and selecting more resilient partners are both efficient approaches to minimize disruptions. Holling (1973) was the first to introduce the concept of resilience, emphasizing that it is the unique ability to absorb change. With time the resilient supply chain developed as a novel idea due to the application of resilience in the supply network (Hosseini & Khalid, 2019; Hosseini *et al.*, 2019). If price, quality, and speed are considered classical criteria for supply chain design, resilience could be one of the attributes for a dynamic supply chain configuration (Betti & Ni, 2020). Behzadi *et al.* (2020) have described resilience as the ability to recover rapidly and easily from supply chain chaos.

Selecting a potential supplier that can provide the most support in the face of disruptive events and reduce the overall risk of supply chain disruption is referred to as resilient supplier selection (Gan *et al.*, 2019; Sahu *et al.*, 2016; Sawik, 2013). For assorted reasons, selecting resilient suppliers is considered a more challenging task than normal selection problems. A supplier's resilience is multidimensional, and evaluating it only using quantitative measures is considered unrealistic. Since several qualitative factors engage in the evaluation process, subjective judgment is constantly present (Pramanik *et al.*, 2017; Hasan *et al.*, 2020).

Ponomarov and Holcomb (2009) describe resilience as the "adaptive capacity of the supply chain to prepare for unforeseen events, adapt to disturbances, and function." Another definition focuses on the ability of an organization to resume normal operations after a disruption (Brandon-Jones *et al.*, 2014; Ivanov & Sokolov, 2013). Currently, there are two ways to increase resilience: (1) strengthening the supply chain (e.g., by adding redundancies, increasing flexibility, and changing organizational culture) (Sheffi & Rice, 2005) and (2) selecting resilient suppliers (before, during, and after disruption) (Hosseini & Khalid, 2019; Hosseini *et al.*, 2019).

A deeper commitment to sustainability goals and developing resilient organizations has been identified as an essential component to help firms overcome future disruption (McKenzie, 2020). Sheffi and Rice (2005) defined supply chain resilience as "the inherent ability of a supply chain to maintain or restore its steady flow behavior so that it can resume regular operations after a disruption." Since vendor or supplier selection is a vital aspect of supply chain systems, many research publications attempt to build a more resilient supply chain by incorporating resilience into vendor or supplier selection using MCDM algorithms. With time, scholars found that resilience alone is not enough to express the performance of a supplier, especially as the negative affects of industrial activities on environment became more known. Thus, the concept of "gresilience" emerged.

2.3 Gresilient supplier selection

Today, a company's ability to redefine its existing distribution networks to go green while improving resilience to sudden disruptions is a key competitive advantage. The sophistication of strategic sourcing has grown and requires the development of novel approaches. Many scholars consider supplier selection's green and resilience aspects as separate perspectives, but merging the green aspect of strategic sourcing with the resilient aspect of strategic sourcing can result in lasting distribution networks (Fahimnia *et al.*, 2018). Resilient supplier selection aims to avoid or minimize predicted or unforeseen chaos, or at least reduce its negative influence on the environment. Consequently, resilience and greenness are the ultimate goals of healthy supply chain management (Mohammed *et al.*, 2021). Yavari and Zaker (2019) developed a two-layer network structure model to improve the resilient-green closed-loop supply chain for disrupting the power grid in the consumer goods supply chain, to achieve low cost and low carbon emission in the supply chain. However, the term "resilient-green" has been applied to supply chain design in various industries, while there is little relevant research for supplier selection. Ivanov *et al.* (2017) investigated the intersection of sustainability and resilience in supply networks to design a resilient supply chain while reducing uncertainty and improving sustainability. From the perspective of sustainability and resilience, Giannakis and Papadopoulos (2016) and Ivanov *et al.* (2017) argued that modeling and developing decision support systems can help enhance the development of environmentally sustainable and robust supply chains.

Supplier selection is a decision process that can significantly improve the supply chain surplus by preparing a firm future supply disruptions. Disruption would be detrimental to the goal of green development, so further studies on resilient-green supply chains are needed. Many studies have emphasized the importance of green and resilient suppliers for the long-term sustainability of companies. In addition, some recent attempts have merged them informally under the term "gresilience." The concept of gresilience is important for companies seeking a long-term relationship with their suppliers and environmentally friendly customers. Mohammed *et al.* (2021) proposed the concept of "gresilience" by describing the development of a unified green and resilient (Gresilient) supplier selection and contracting strategy that considers traditional, green, and resilient factors. Later, Mahmoudi *et al.* (2021a) proposed its first definition. They defined gresilience as the ability of an environmentally sustainable supply chain to recover from a disruption to its original or more desirable (improved) state in a timely and cost-effective manner (Mahmoudi *et al.*, 2021a). A keen supply selection is fundamental to the prosperity of any business; the global health crisis has proven that proper product outsourcing is critical for any organization. Resilience and environmental friendliness have already been associated with supply chain management.

Sustainable supply chain governance is affected by frequent unavoidable disruptions, so a robust supply chain framework is needed to address these dynamics. Considering sustainable development, Ivanov (2018) argued that key challenges include supply chain resilience and optimized distribution network structure following disruptions. Notwithstanding the need for proper integration of the elements of a gresilient framework into business operations, previous research does not adequately address some issues related to purchasing. Therefore, it is argued that integrating gresilience into the supplier selection framework can help managers deal with these constraints and other issues.

3. Research methodology

3.1 Sample and framework

Suppliers' data were collected from a procurement manager at a medium-sized Chinese company founded seven years ago that trades automotive parts not only to local companies but also to foreign companies, which account for two-thirds of its annual sales. The company is located in Nanjing, China. For the sake of convenience, the suppliers are defined as follows: first supplier (A1), second supplier (A2), third supplier (A3), and fourth supplier (A4). An expert from the

company's procurement department was asked to evaluate the suppliers based on the following six criteria: speed of recovery (C1), level of recovery (C2), performance loss during recovery (C3), energy-saving (C4), waste minimization (C5), and green products (C6). Thus, C1, C2, and C3 correspond to resilience and C4, C5, and C6 to greenness. The evaluation of the suppliers is based on two different assumptions. In the first assumption, resilience criteria are considered (1st priority), and green criteria are considered (2nd priority), while in the second assumption, both resilience and green criteria are considered equally important (1st priority). The supplier selection framework is shown in Figure 1. In the current study, the Ordinal Priority Approach (OPA) is used to evaluate the Chinese automotive suppliers based on resilience criteria. TOPSIS method is used for comparative analysis.

3.2 Ordinal Priority Approach

Multiple criteria decision-making (MCDM) is a critical problem in today's business world. Experts, criteria, and alternatives are the backbone of any decision-making process. In 2020, Amin Mahmoudi and colleagues (Ataei *et al.*, 2020) proposed the Ordinal Priority Approach (OPA), a linear programming-based model for multiple criteria decision-making. Later, it was extended to Grey OPA (Mahmoudi *et al.*, 2021b), Fuzzy OPA (Mahmoudi *et al.*, 2021a; Pamucar *et al.*, 2022), Robust OPA (Mahmoudi *et al.*, 2022), Neutrosophic OPA (Abdel-Basset *et al.*, 2022) and DEA-OPA (Mahmoudi *et al.*, 2021c). Shajedul (2021) used the OPA to evaluate sustainable technologies in the agricultural sector. Quartey-Papafio *et al.* (2021) used the OPA for supplier selection in the healthcare sector. Mahmoudi *et al.* (2020) used the OPA-based framework for project selection. Sadeghi *et al.* (2022) used the OPA to evaluate distributed ledger technologies for the construction industry. Mahmoudi and Javed (2021) used the OPA for weighing and ranking of sub-contractors in the construction industry. The literature identifies several benefits of the OPA. For instance, the OPA does not require a pairwise decision matrix. It uses a simple but powerful linear programming approach to solve MCDM problems without requiring normalization of the data and can work even when the data is incomplete. In the current study, the Ordinary Priority Approach (OPA) is used to determine the weights for suppliers and criteria. Eq. (1) shows the model OPA, which can be solved using appropriate software. In the current study, the OPA Solver (v1.00) was used to run the model. The OPA model is shown below.

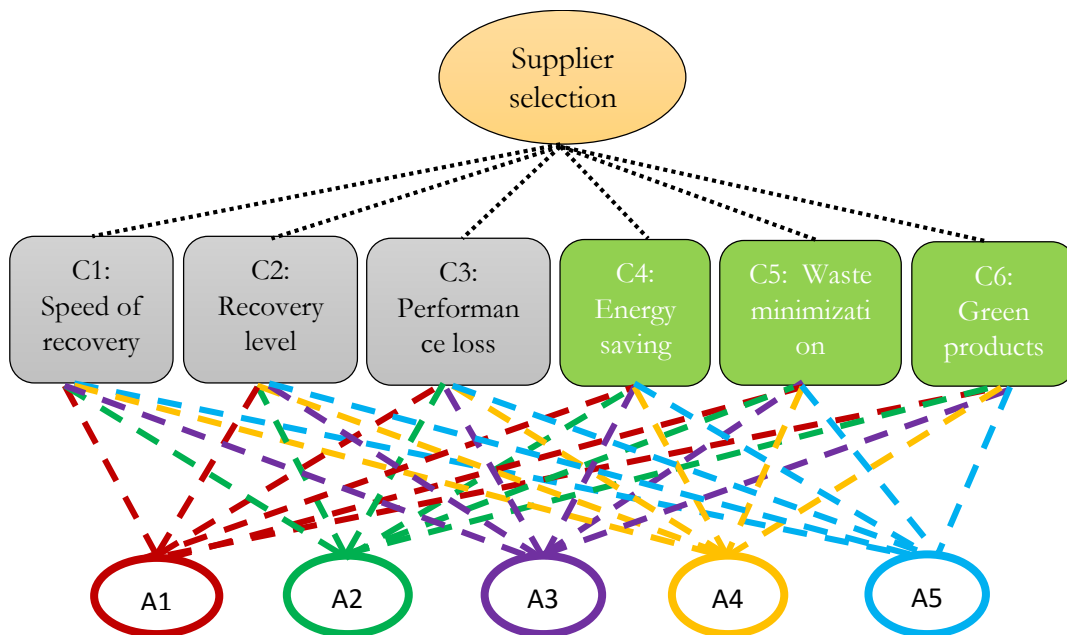


Figure 1. The supplier selection framework of five automotive parts suppliers against six criteria

$$\begin{aligned}
 & \text{Max } Z \\
 & \text{s. t.} \\
 & Z \leq j \left(r(W_{jk}^r - W_{jk}^{r+1}) \right) \quad \forall j, k \text{ and } r \\
 & Z \leq jmW_{jk}^m \quad \forall j \text{ and } k \\
 & \sum_{j=1}^n \sum_{k=1}^m W_{jk} = 1 \\
 & W_{jk} \geq 0 \quad \forall j \text{ and } k
 \end{aligned} \tag{1}$$

Equations (2) and (3) should be applied to determine weights for suppliers and criteria, respectively,

$$W_k = \sum_{j=1}^n W_{jk} \quad \forall k \tag{2}$$

$$W_j = \sum_{k=1}^m W_{jk} \quad \forall j \tag{3}$$

For the sake of completion, it is reported that j and k represent the indexes of the criteria and alternatives, respectively, whereas n and m represent the total number of criteria and alternatives. W_{jk}^r represent the weight(s) of k^{th} alternative based on j^{th} criterion and r^{th} rank, and j and k represent the rank of criterion and alternative (Quartey-Papafio *et al.*, 2021)

3.3 TOPSIS

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was proposed by Hwang and Yoon (1981). It is one of the most popular MCDM models. It has seen applications in various fields. For instance, Nazari *et al.* (2018) used it for photovoltaic power plant selection sites in Iran. Later, Liu *et al.* (2019) proposed the entropy-based TOPSIS model to measure the maturity of the carbon market in China. Mahmoudi *et al.* (2020) used it in their work on project selection. Ikram *et al.* (2020) used it in their study involving prioritization of barriers to integrated management system implementation. James *et al.* (2021) used the TOPSIS model to select the best bus chassis for bus fleet operators in India. Thio (2021) used TOPSIS to rank site selection criteria for marine cultivation in Indonesia. Kaul and Bhattacharjee (2022) used the Fuzzy TOPSIS model to evaluate the performance of lean green strategies in a healthcare products manufacturing company. Salookolaei and Nasab (2020) used the Fuzzy TOPSIS for evaluating projects. Zare *et al.* (2018) used the grey TOPSIS model for computerised management system selection. In the current study, the following steps (Hwang & Yoon, 1981) were used to run TOPSIS.

Step 1: The current approach assesses the decision matrix in Eq. (1), which consists of m alternatives and n criteria. If A_i represents the i^{th} supplier, and x_{ij} denotes the numerical result of the i^{th} supplier with respect to the j^{th} criterion, then the decision matrix D is,

$$D = \begin{matrix} & \begin{matrix} C_1 & C_2 & \dots & C_j & \dots & C_n \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{matrix} & \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1j} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2j} & \dots & x_{2n} \\ \vdots & \vdots & \dots & \vdots & \dots & \dots \\ x_{i1} & x_{i2} & \dots & x_{ij} & \dots & x_{in} \\ \vdots & \vdots & \dots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mj} & \dots & x_{mn} \end{bmatrix} \end{matrix} \tag{4}$$

Step 2: A normalized decision matrix is constructed in this step as expressed by Eq. (5).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \tag{5}$$

Step 3: The criteria weights w obtained through the OPA model in Eq. (3) is applied at this step.

$$w = (w_1, w_2, \dots, w_j, \dots, w_n), \sum_{j=1}^n w_j = 1, \tag{6}$$

Step 4: The weighted normalized decision matrix V is formulated as shown in Eq. (7),

$$V = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \dots & w_j r_{1j} & \dots & w_n r_{1n} \\ \vdots & \vdots & & \vdots & & \vdots \\ w_1 r_{i1} & w_2 r_{i2} & \dots & w_j r_{ij} & \dots & w_n r_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \dots & w_j r_{mj} & \dots & w_n r_{mn} \end{bmatrix} \tag{7}$$

Step 5: The value of the positive (A^+) and negative ideal vector (A^-) is calculated in Eq. (8).

$$A^+ = \{v_1^+, v_2^+, \dots, v_j^+, \dots, v_n^+\}, \quad A^- = \{v_1^-, v_2^-, \dots, v_j^-, \dots, v_n^-\} \tag{8}$$

Step 6: The separation measure of each alternative from positive to negative ideal one is given by Eq. (9).

$$S_{i+} = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2}, \quad S_{i-} = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}, i = 1, 2, \dots, m \tag{9}$$

Step 7: The relative closeness to the ideal solution can be determined by Eq. (10). A higher value of C_{i+} implies, the supplier is better.

$$C_{i+} = \frac{S_{i-}}{S_{i+} + S_{i-}}, \quad 0 < C_{i*} < 1, \quad i = 1, 2, \dots, m \tag{10}$$

Step 8: Ranking of the alternatives (suppliers in the current study) is made at this step.

4. Results and discussion

The current research exposes a combination of the OPA-TOPSIS Approaches, which allows companies and managers to develop a decision-making tool to evaluate suppliers meritoriously. The current study sets a coherent substance for business managers to assess their decision process profoundly and eventually minimize the probability of a poor decision-making process.

The study used the data listed in Table 1 to run the Ordinal Priority Approach (OPA) model, as shown in Eq. (1). To determine the weights of the suppliers and the criteria, this research made use of Eqs. (2) - (3), respectively. Two assumptions were considered during the data analysis, one

Table 1. The decision matrix

Assumption 1 (H_1)	1	1	1	2	2	2
Assumption 2 (H_2)	1	1	1	1	1	1
	C1	C2	C3	C4	C5	C6
A1	1	1	4	1	2	3
A2	3	3	1	2	3	2
A3	2	1	3	2	2	1
A4	4	4	2	2	1	3
A5	1	2	3	2	1	2

where both the resilience and green criteria are unequally weighted (H1) and the latter where the resilience and green criteria are equally weighted (H2). In H1, the resilience criteria have the first priority (1), and the green criteria have the second priority (2), and in H2, both the resilience and green criteria have the first priority (1). Table 1 shows the decision matrix, and Table 2 shows the results, i.e., the weighting and ranking of the criteria and suppliers.

As can be seen in Figure 2, the third supplier (A3) turned out to be the best among all other suppliers, and A4 turned out to be the relatively worst supplier in both assumptions. Consequently, the procurement manager of the trading company is more likely to benefit from a close relationship with the supplier (A3) in case of future supply chain disruptions. Supplier (A4) should be considered as a last resort rather than a reliable supplier.

The results are considered reliable if multiple decision-making models produce comparable rankings. Therefore, after applying the OPA, TOPSIS was applied. Since TOPSIS can't estimate the weights of criteria, the weights earlier calculated through the OPA were used in both scenarios (H1 and H2). Table 3 shows the ranking and relative closeness of the ideal suppliers measured through the TOPSIS approach. Besides, the decision matrix in Table 1 contains the input data used to obtain the results in Table 3. However, it is worth mentioning that the criteria weigh vectors for the assumptions (H1 and H2) are extracted from the OPA model since the TOPSIS model cannot determine the weights of the criteria.

The TOPSIS approach indicates that suppliers A3, A5, and A1 have the most consistent performance in H1 relatively, with relative closeness values of 0.657, 0.635, and 0.579, respectively. Moreover, the results also indicate that in H2, suppliers A3, A5, and A1 remain the top-performing suppliers, with relative closeness values of 0.658, 0.625, and 0.524, respectively. Table 4 shows the comparative analysis of the rankings obtained through the two models. One can see from the table that the OPA and TOPSIS models present the respective ranking of the suppliers under the considered assumptions (H1 and H2). The comparative analysis shows that except for suppliers

Table 2. The evaluation of criteria and suppliers using the OPA

	C1	C2	C3	C4	C5	C6	A1	A2	A3	A4	A5
Weight*	0.223	0.223	0.175	0.108	0.12	0.151	0.229	0.181	0.235	0.139	0.217
Rank*	1	1	3	6	5	4	2	4	1	5	3
	C1	C2	C3	C4	C5	C6	A1	A2	A3	A4	A5
Weight**	0.162	0.162	0.127	0.157	0.175	0.218	0.214	0.175	0.245	0.148	0.218
Rank**	3	3	6	5	2	1	3	4	1	5	2

*Assumption 1 (H1): Resilience criteria > Green criteria
 **Assumption 2 (H2): Resilience criteria = Green criteria

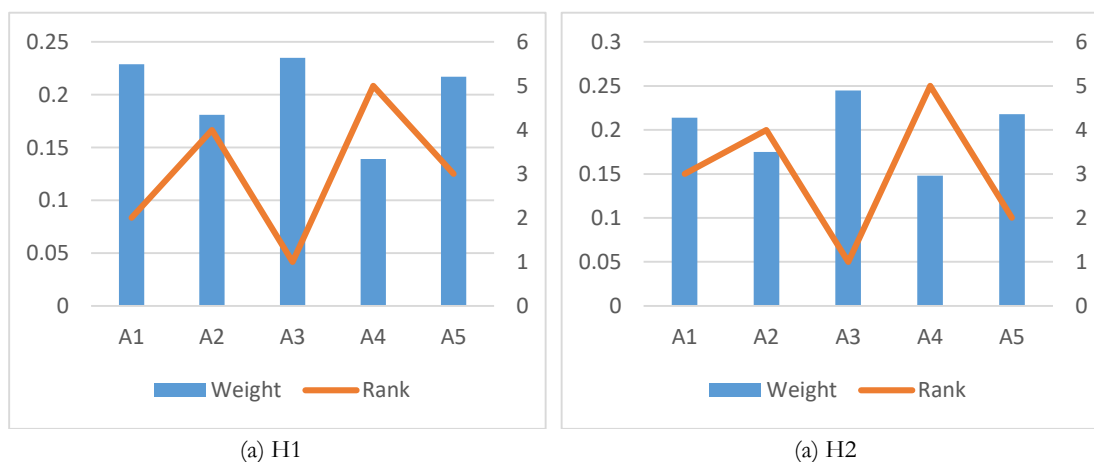


Figure 2. Weights and ranking of the suppliers in two scenarios

Table 3. Relative closeness and ranking of the suppliers through TOPSIS

	A1	A2	A3	A4	A5
Separation Measure (Si+)*	0.103	0.102	0.072	0.151	0.074
Separation Measure (Si-)*	0.141	0.104	0.132	0.068	0.129
Relative Closeness (Ci+)*	0.579	0.504	0.647	0.312	0.635
Rank*	3	4	1	5	2
Separation Measure (Si+)**	0.097	0.092	0.059	0.125	0.064
Separation Measure (Si-)**	0.106	0.081	0.114	0.065	0.106
Relative Closeness (Ci+)**	0.524	0.468	0.658	0.340	0.625
Rank**	3	4	1	5	2
*Assumption 1 (H1): Resilience criteria > Green criteria **Assumption 2 (H2): Resilience criteria = Green criteria					

Table 4. Comparative analyses of the rankings from the OPA and TOPSIS

Supplier	H1		H2	
	OPA	TOPSIS	OPA	TOPSIS
A1	2	3	3	3
A2	4	4	4	4
A3	1	1	1	1
A4	5	5	5	5
A5	3	2	2	2

A1 and A5 in the first assumption (H1) of both models, the OPA and TOPSIS methods have the same relative ranking of the suppliers. Thus, the comparative analyses indicate that the OPA and TOPSIS models are reliable tools for evaluating the suppliers as their results are comparable.

In recent years, organizations' environmental performance has gained extensive attention from governments, scholars, and environmentally conscious people. Therefore, resilient supply chain networks have become a growing concern for industry decision-makers as they become more conscious of potential chaos in the business environment. In this study, the evaluation and selection of suppliers were based on two different assumptions. First, the resilience and green criteria are unequally weighted (H1), and second, they are equally weighted (H2). Additionally, the research used the OPA and TOPSIS to evaluate supplier selection attributes in the automotive parts industry. TOPSIS is an established model, while the OPA is an innovative technology. The findings show that under both assumptions (H1 and H2) that suppliers A3, A5, and A1 are the top-performing suppliers relative to the others. Therefore, the local Chinese company managers should maintain a closer relationship with these suppliers. As the study proves, they are the most reliable suppliers that could overcome supply chain disruptions. However, the remaining suppliers are not as reliable as the top three performers. Thus, the manager should pay close attention to their business relationship and should consider asking them to improve their performance within a given timeframe or terminate their partnership.

Furthermore, the TOPSIS results in table 3 show that in either of the assumptions (H1 and H2), suppliers A3, A5, and A1 are the top-performing suppliers relative to the remaining suppliers. Therefore, confirming the earlier findings of the OPA model. Throughout the study, suppliers A3, A5, and A1 have demonstrated a consistent performance with relative closeness to the ideal suppliers higher than the remaining peers. Thus, the probability of better coping with uncertainties around today's changing business environment is relatively high.

Because of this study, the procurement manager at the Chinese trading company now understands the crucial importance of adopting a resilient supplier selection for the well-being of their future business operations. It gives the Chinese company and other companies within the same industry a comprehensive view of the most crucial factors to consider within the realm of the

unpredictable business environment. Thus, this study may greatly aid the less performing suppliers from this study to adapt to the changing market environment.

5. Conclusion

Supplier selection is an important process in automotive industries as it guarantees the quality of the material and services needed to produce automobiles and its components. Inadequate procurement of materials can jeopardize companies' economic performance and lead to a decline in sales and profitability. The current study argues that synthesizing green and resilient criteria into *gresilience* is a timely initiative, especially as the customers are becoming increasingly concerned about the environment and the businesses are becoming increasingly concerned about their partners' resilience. Primarily, after the COVID-19 pandemic, when supply chains were disrupted around the world, the focus on being green and resilient was much heard. The current study followed a unified framework of green and resilience (*gresilient*) criteria to execute the suppliers in a Chinese automotive parts industry using the OPA and TOPSIS models. The OPA approach was chosen because of its convenience in determining the weighting of suppliers and criteria since it does not require a pairwise decision matrix, or normalized decision matrix, and more importantly, it allows decision-makers to incorporate their own industry knowledge into the mathematical model. Also, the key rationale for using the TOPSIS approach in this study is its ability to evaluate the relative closeness to positive and negative ideal solutions. The rankings obtained from the two models were mostly consistent.

The study suggests to the trading companies, the procurement manager should establish exclusive stakeholder relationship strategies and management strategies to help manage their suppliers as business partners rather than just a supplier, which will not only reshape their business operations but also build resilient value chains to cope with the changing business environment. Furthermore, it is vital for companies to engage in addressing the looming environmental issues and evaluate suppliers' environmental and social performance. As society becomes more environmentally conscious, implementing a thorough green and resilient supplier selection criteria will pay exponential dividends in the future business environment. The current research will help scholars and industry leaders to solve real-world related complex decisions and promote sustainable practices.

In the future more extensive studies involving uncertainty, and advanced versions of the OPA, and TOPSIS can be undertaken. Also, more criteria can be included. Meanwhile, a more specific *gresilience*-based supplier selection framework for the automotive industry can be proposed. Time was a major constraint during the execution of this study; thus, group decision-making problem was not studied. In the future, group decision-making can also be involved by seeking input from multiple experts in the procurement department. Also, how the TOPSIS model runs on the OPA-based criteria weights may differ from the TOPSIS model run on the criteria weights estimated through other approaches is yet to be seen. Even though, in just a few years the OPA has emerged as a promising alternative decision-making model, as can be seen from the increasing number of publications involving the OPA, its validity will only be confirmed as it sees application in new and diverse problems. In the future, its validity should be confirmed through extensive comparative analyses with the established models like the Grey Relational Analysis and Analytic Hierarchy Process. Also, how the supplier passion (Nawaz *et al.*, 2021) can affect the supplier *gresilience*, or vice versa, is an interesting area of further research.

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