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**(Research Paper)**

## **Prioritizing and Analyzing Supplier Development Activities in the Automotive Industry**

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### **Abstract**

**Purpose:** Supplier development (SD) activities are crucial in the automotive industry as they enhance the capabilities and performance of suppliers, ensuring a more efficient, reliable, and competitive supply chain. This paper aims to prioritize activities related to SD using the Best-Worst Method (BWM).

**Design/methodology/approach:** Three fundamental stages were conducted in this study. First, relevant studies were synthesized. SD activities were identified, and finally, through calculation of the CVR, 30 activities were classified into four categories. In the second stage, using the Best-Worst Method, a linear optimization model was formulated for the activities in each category. By solving these models, the weights of the identified activities for each of the four categories were obtained separately.

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**Findings:** The main findings reveal that the highest priority activities identified by experts include “Evaluation of tangible supplier capabilities and feedback”, “Training and updating the supplier”, “Creating collaborative communications or partnerships”, and “Sharing environmental, ethical, and social responsibility information”. In the third stage, the obtained prioritization in each category was shared with experts, and their suggestions regarding the findings were documented and interpreted. The results indicate a strong preference for activities that support collaboration and capability enhancement over those focused on competition.

**Practical implications:** The identified activities in this paper are comprehensive and can be utilized by the automotive industries of various countries. Additionally, the approach used, due to its novelty, simplicity of calculations, practicality, and compatibility with managers' subjective judgments, is expected to be well-received by researchers and especially by managers in the automotive industry and even other industries.

**Originality/value:** This study underscores the importance of a structured approach to prioritizing SD activities within supply chains.

**Keywords:** Supplier Relationship Management, SD Activities, BWM, Automotive Industry

## 1. Introduction

In the ever-evolving landscape of global business, effective management of the supply chain has become increasingly critical for firms. The supply chain, encompassing the flow of goods, services, and information from raw material suppliers to customers, represents a complex network that significantly impacts a firm's operational efficiency, financial performance, and competitive advantage ([Tran et al., 2021](#); [Karamoozian et al., 2024](#); [Zhang et al., 2024](#)). In order to establish efficacious strategic supplier relationships, organizations must concentrate on SRM, which includes the processes of supplier selection, supplier segmentation, and SD ([Coşkun et al., 2022](#)).

The term “Supplier Development” was first used by [Leenders \(1966\)](#) to describe efforts by manufacturers to increase the number of viable suppliers and improve their performance ([Resende et al., 2023](#)). SD is defined as the efforts of a buying firm to improve the performance and/or capabilities of the supplier to meet the buying firm's supply needs ([Bai & Satir, 2020](#)). It is known as a systematic approach to leverage capacity and capability improvements across the supply chain ([Saghiri & Wilding, 2021](#)). SD has historically been a practice intricately linked with the automotive sector, where outsourcing of components and subassemblies is a tradition ([Batson, 2008](#)). The complexity of automobiles necessitates a substantial degree of collaboration with suppliers for assembly purposes ([Akman, 2015](#)). This is underscored by the fact that a significant portion of a vehicle's production cost (up to 75%) is attributable to parts obtained from external suppliers ([Chavhan et al., 2018](#)). The implementation of SD initiatives is thus crucial in the automotive sector, where managing

supplier relationships and ensuring the quality of outsourced components are essential for maintaining competitive advantage and operational efficiency.

Firms can employ a set of activities to develop the capabilities of their suppliers. These activities range from low-involvement activities, such as evaluating, providing feedback, and incentivizing suppliers, to much more elaborate and resource-intensive activities, such as investing in production equipment and training supplier staff ([Feng et al., 2024](#)). In previous studies, various terms have been employed to discuss SD activities, «criteria» ([Govindan et al., 2010](#); [Dalvi & Kant, 2015](#)), «elements» ([Krause & Ellram, 1997](#); [Abdullah & Maharjan, 2003](#)), «factors» ([Chavhan et al., 2018](#); [Chidambaranathan et al., 2009](#); [Routroy & Pradhan, 2013](#)), «activities» ([Lloyd et al., 1994](#); [Wagner & Krause, 2009](#); [Dalvi & Kant, 2016](#)), «programs» ([Saghiri and Wilding, 2021](#); [Akman, 2015](#); [Resende et al., 2023](#)), «practices» ([Yawar & Kauppi, 2018](#); [Chavhan, 2012](#); [Sancha et al., 2015](#)), «initiatives» ([Sánchez-Rodríguez et al., 2005](#)), «efforts» ([Marksberry, 2012](#); [Karamoozian et al., 2024](#)), «strategies» ([Rezaei et al., 2015](#); [Zhang et al., 2024](#); [Karamoozian et al., 2024](#)) and «enablers» ([Sunil Kumar & Routroy, 2014](#); [Dalvi & Kant, 2017](#)). Therefore, integrating them into the terms of activities related to SD and categorizing them can be a necessity at present. Given that companies are willing to take measures to facilitate the development of their suppliers, the identified activities can help companies in this regard. Also, each of the studies has studied one or more categories of tangible capabilities, intangible capabilities, relationships and environmental capabilities, and none of them has studied all of these categories together based on activities related to SD. The increase in SD studies in the last two decades, and especially the current decade, has been significant compared to previous decades, which has led to the emergence and introduction of new activities for SD. Therefore, identifying and categorizing activities related to SD can be useful for researchers in this field. In this paper, we prioritize SD-related activities using the BWM. This prioritization can lay the foundation for formulating automotive industry policies for SD and, based on this prioritization, we will offer suggestions for the development of suppliers in the automotive industry.

## 2. Literature review

This section commences with an overview of the theoretical background of SD, followed by a summary of studies related to SD in Section 2.1. Next, a categorization of activities related to SD is provided in Section 2.2.

### 2.1 Related work

SD is a strategic approach intended to improve suppliers' performance and capabilities in order to enhance supply chain efficiency and competitiveness. Considering the present conditions of external suppliers supplying the components and semi-finished goods due to the decrease in vertically integrated manufacturing systems, this concept has gained importance

([Benton et al., 2020](#)). SD involves a variety of activities, among these activities are technical assistance, financial support for suppliers, and training, with long-term collaborative buyer-supplier relationships as principal objectives. The SD concept usually refers to knowledge management activities. By sharing their knowledge and expertise, buyers can help suppliers improve their technology and product development capabilities, which improves supply chain performance ([Chen et al., 2015](#)). Most efforts on SD also address social issues within the supply chain. Using socially targeted capability development initiatives, businesses can enhance the social sustainability of their supply chains ([Habek and Lavios, 2021](#)). In the investigations conducted between the years 2015 and 2024 regarding SD, significant strides have been made towards examining different dimensions of this concept. A summary of related activities undertaken during these years is presented in Table 1.

**Table 1. Summary of related studies.**

Author(s)	Contribution	Industry/Industries
<a href="#">Ghijsen et al. (2010)</a>	Examined the relationship between SD strategies and their satisfaction and commitment	Automotive industry
<a href="#">Govindan et al. (2010)</a>	Identified the criteria related to SD through a literature review	Automotive industry
<a href="#">Wagner (2011)</a>	Evaluated the state of the supplier-buyer relationship before engaging in joint activities	High-tech, automotive, construction, chemical, pharmaceutical, food and textile industries
<a href="#">Arroyo-López et al. (2012)</a>	Examined the impact of SD on the short-term and long-term performance	Automotive industry
<a href="#">Kumar et al. (2012)</a>	Examined the barriers to SD based on the characteristics of the buyer and supplier	Automotive, electronics, metal, construction, apparel, textile and chemical industries
<a href="#">Blonska et al. (2013)</a>	Analyzed the effect of SD on the benefits of relationships, considering the role of relational capital	Metals and electronics industries
<a href="#">Praxmarer-Carus et al. (2013)</a>	Investigated the implications of a supplier's perceived proportion of expenses and revenues associated with supplier development on supplier satisfaction	Automotive, pharmaceutical and engineering industries
<a href="#">Blome et al. (2014)</a>	Examined SD in consideration of the environment	Automotive, communications, food and pharmaceutical industries
<a href="#">Khan and Nicholson (2014)</a>	Introduced a three-step process for implementing SD	Automotive industry
<a href="#">Kumar and Routroy (2014)</a>	Identified the factors that affect the effectiveness of SD	Automotive industry
<a href="#">Akman (2015)</a>	Identified the suppliers that should be involved in green SD by evaluating and segmenting the suppliers	Automotive industry
<a href="#">Rezaei et al. (2015)</a>	Linked SD to supplier segmentation	High-tech industry
<a href="#">Sancha et al. (2015)</a>	Investigated the impact of social SD practices on the suppliers' social performance	Manufacturing industry
<a href="#">Awasthi and Kannan (2016)</a>	Evaluated green SD programs	Automotive industry
<a href="#">Friedl and Wagner (2016)</a>	Described the importance of joint SD with other buyers	Automotive, high-tech and aerospace industries
<a href="#">Salimian et al. (2017)</a>	Explored the relationship between SD and internal quality performance	Automotive, plastic and electronics industries

Author(s)	Contribution	Industry/Industries
<a href="#">Yawar and Kauppi (2018)</a>	Demonstrated that both private and public companies employ similar SD practices to create capabilities	Dairy industry
<a href="#">Glavec-Geo (2019)</a>	Demonstrated that SD is an important tool for purchasing companies, through which they can increase supplier satisfaction	Buying firms
<a href="#">Bai and Satir (2020)</a>	Identified and analyzed barriers to green SD	Manufacturing industry
<a href="#">Benton et al. (2020)</a>	Explored the influence of SD programs on supplier performance	Automotive industry
<a href="#">Fan et al. (2021)</a>	Identified sustainable SD incentives that contribute to customer satisfaction as well as to the company's future sales	Various industries
<a href="#">Saghiri and Wilding (2021)</a>	Investigated the mediating role of five supply-side factors in the relationship between SD and supplier performance	Various industries
<a href="#">Tran et al. (2021)</a>	Examined the relationship between SD incentives, relational norms and supplier opportunism	Food industry
<a href="#">Coşkun et al. (2022)</a>	Developed a framework for sustainable supplier evaluation and development	Chemical industry
<a href="#">Burgess et al. (2023)</a>	Conducted a systematic review of seventy-eight studies on supply chain quality management practices	Food industry
<a href="#">Resende et al. (2023)</a>	Reviewed decision-making models for formulating and evaluating SDPs	Automotive industry
<a href="#">Feng et al. (2024)</a>	Examined SD and integration in electric vehicle supply chains with power battery recycling dynamics	Automotive industry
<a href="#">Karamoozian et al. (2024)</a>	Explored the effects of epidemic outbreaks on automotive supply chain performance	Automotive industry

## 2.2 SD Activities

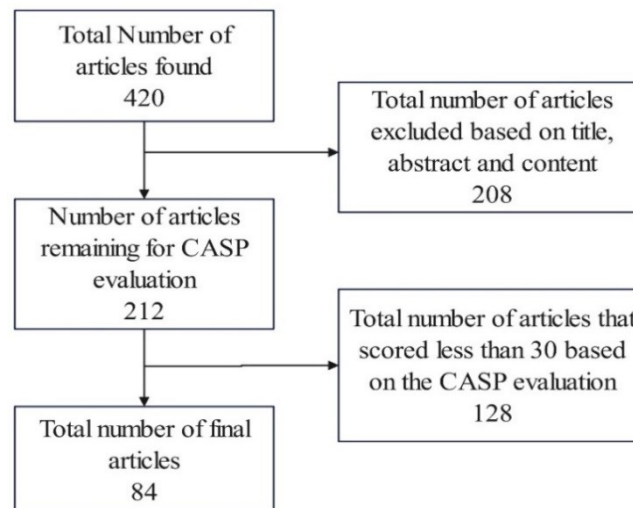
To identify supplier development activities, a meta-synthesis approach is employed. Meta-synthesis necessitates the investigator to perform a comprehensive and profound examination and integrate results from related qualitative inquiries. By examining the findings of primary research articles, researchers reveal and create terms that provide a more comprehensive representation of the phenomenon under study. Similar to a systematic approach, the use of meta-synthesis results in an outcome that is greater than the sum of its parts. In summary, the steps and methods of conducting meta-synthesis in this research are as follows:

Step 1- Formulating the research question: According to the meta-synthesis method, formulating the research question should focus on "what," "who," "when," and "how." The research question in the meta-synthesis section of this study was: What are the activities related to supplier development?

Step 2- Systematic literature review: At this stage, the investigator meticulously conducts a comprehensive review of scholarly articles published in diverse academic journals. Relevant keywords are identified. For each specified article, a full-text version is retrieved.

In this study, the keyword "supplier development" is used to search for related articles, resulting in 420 articles.

Step 3- Evaluating and choosing appropriate articles: In this phase, the researcher dismisses a multitude of publications during each evaluation, which are subsequently omitted from the meta-synthesis process. Articles are screened by examining the title, abstract, and full content, and assessing the methodological quality, leading to the exclusion of some articles. The instrument frequently employed for assessing the quality of principal qualitative research investigations is the "Critical Appraisal Skills Programme" (CASP). This instrument consists of 10 questions that assist the investigator in ascertaining the precision, validity, and relevance of qualitative research inquiries: (1) research objectives, (2) justification for methodology, (3) research framework, (4) sampling technique, (5) data acquisition, (6) reflexivity, which encompasses the relationship between the investigator and participants, (7) ethical considerations, (8) accuracy of data analysis, (9) clear and explicit presentation of findings, and (10) research significance. At this juncture, the investigator allocates a score from 1 to 5 to each of these questions (1= poor, 2= average, 3= good, 4= very good, and 5= excellent), then creates a form to evaluate the results by summing the scores for each article. Articles with a total score of less than 30 are eliminated. In this study, 208 articles were excluded based on their title, abstract and their content, and 128 based on CASP evaluation. Supplier development activities are identified based on the remaining 84 articles. The process of evaluating and selecting suitable articles is shown in Fig. 1.



**Fig. 1. The process of evaluating and selecting suitable articles.**

Step 4- Extracting Results: The investigator continuously reads the chosen and finalized manuscripts multiple times to derive findings from them. Coding is a process through which phenomena are identified, grouped, named, described, and analyzed within the data. The coding procedure is delineated into three phases: open coding, axial coding, and selective coding. Through coding, concepts, categories, and themes or dimensions are

formed. Concepts constitute the most basic unit of analysis and are derived from the conceptual understanding of the data. Categories represent a higher level of concepts, showcasing the similarities and differences among them. Themes or dimensions illustrate the relationships between categories and their related concepts, as well as the differences and similarities among categories at a generalized level. In this study, the Atlas.ti software is used for coding and identifying concepts.

Step 5- Analyzing and Integrating Qualitative Findings: During the analysis, the investigator looks for themes that emerge across the articles included in the meta-synthesis. [Sandelowski and Barroso \(2006\)](#) refer to this as "thematic analysis." The researcher identifies and specifies themes or contexts, and once these contexts are recognized and defined, the researcher forms a classification, placing similar and pertinent classifications under a theme that best describes them. Themes provide a foundation for creating "explanations and models, theories, or working hypotheses." In this study, all identified activities from the reviewed studies are initially considered as codes after integration and adjustment; then, based on the meaning and concept of each of these codes, they are categorized under a similar concept. Identified supplier development activities are presented in Table 2.

**Table 2. SD activities extracted from the literature.**

Aspects	Related activities	References
Tangible	Evaluation of tangible supplier capabilities and feedback	<a href="#">Narasimhan et al. (2008)</a> ; <a href="#">Bai et al. (2021)</a>
	Establishing up-to-date quality standards	<a href="#">Chavhan (2012)</a> ; <a href="#">Shahzad et al. (2016)</a> ; <a href="#">Coşkun et al. (2022)</a>
	Reducing the number of suppliers	<a href="#">Sánchez-Rodríguez et al. (2005)</a> ; <a href="#">Chavhan (2012)</a> ; <a href="#">Dalvi and Kant (2017)</a> ; <a href="#">Veldman et al. (2022)</a>
	Segmentation of suppliers for their development	<a href="#">Akman (2015)</a> ; <a href="#">Rezaei et al. (2015)</a> ; <a href="#">Taghipour et al. (2022)</a>
	Creation of incentives based on design improvements	<a href="#">Narasimhan et al. (2008)</a> ; <a href="#">Huo et al. (2022)</a>
	Direct involvement in supplier operations	<a href="#">Salimian et al. (2017)</a> ; <a href="#">Tseng et al. (2022)</a>
Intangible	Evaluation of intangible supplier capabilities and feedback	<a href="#">Wagner and Krause (2009)</a> ; <a href="#">Saunila et al. (2021)</a> ; <a href="#">Pigola et al. (2022)</a>
	Training and updating the supplier	<a href="#">Shahzad et al. (2016)</a> ; <a href="#">Salimian et al. (2017)</a> ; <a href="#">Park et al. (2023)</a>
	Joint establishment of a supplier development group	<a href="#">Chidambaranathan et al. (2009)</a> ; <a href="#">Marksberry (2012)</a> ; <a href="#">Park et al. (2023)</a>
	Creation of knowledge networks	<a href="#">Khan and Nicholson (2014)</a> ; <a href="#">Cheng et al. (2022)</a>
	Obtaining financial and non-financial commitments	<a href="#">Friedl and Wagner (2016)</a> ; <a href="#">Saghiri and Wilding (2021)</a>
	Creating mechanisms for mutual trust	<a href="#">Khan and Nicholson (2014)</a> ; <a href="#">Chen et al. (2016)</a> ; <a href="#">Wang et al. (2023)</a>
Relational	Raising performance expectations from the supplier	<a href="#">Abdullah and Maharjan (2003)</a> ; <a href="#">Marksberry (2012)</a> ; <a href="#">Rezaei et al. (2015)</a> ; <a href="#">Chen et al. (2015)</a>
	Evaluation of supplier relationships and feedback	<a href="#">Govindan et al. (2010)</a> ; <a href="#">Saghiri and Wilding (2021)</a> ; <a href="#">Basana et al. (2024)</a>

Aspects	Related activities	References
	Timely sharing of information	<a href="#">Abdullah and Maharjan (2003)</a> ; <a href="#">Chen et al. (2016)</a> ; <a href="#">Dalvi and Kant (2017)</a> ; <a href="#">Schmidt et al. (2022)</a>
	Conclusion of long-term contracts with suppliers	<a href="#">Narasimhan et al. (2008)</a> ; <a href="#">Dalvi and Kant (2017)</a> ; <a href="#">Liem et al. (2020)</a> ; <a href="#">Bhattacharyya et al. (2023)</a>
	Coordinating processes, goals, and actions	<a href="#">Govindan et al. (2010)</a> ; <a href="#">Smals et al. (2022)</a>
	Setting challenging long-term goals jointly	<a href="#">Wagner and Krause (2009)</a> ; <a href="#">Dalvi and Kant (2017)</a> ; <a href="#">Liem et al. (2020)</a>
	Creating collaborative communications or partnerships	<a href="#">Govindan et al. (2010)</a> ; <a href="#">Basana et al. (2024)</a>
	Utilizing appropriate communication tools	<a href="#">Lloyd et al. (1994)</a> ; <a href="#">Nguyen et al. (2020)</a>
	Developing collaborative strategies at the supply chain level	<a href="#">Salimian et al. (2017)</a> ; <a href="#">Yonghui (2023)</a>
	Promoting a competitive culture among supply chains	<a href="#">Chebichii et al. (2023)</a> ; <a href="#">Queiroz et al. (2023)</a>
	Making the supply chain accountable	<a href="#">Wang et al. (2010)</a> ; <a href="#">Taghipour et al. (2022)</a>
Environmental	Performance evaluation of supplier's environmental impact	<a href="#">Akman (2015)</a> ; <a href="#">Queiroz et al. (2023)</a>
	Sharing environmental, ethical, and social responsibility information	<a href="#">Routroy &amp; Pradhan (2013)</a> ; <a href="#">Qu et al. (2022)</a>
	Obtaining environmental and social certifications	<a href="#">Fu et al. (2012)</a> ; <a href="#">Sancha et al. (2015)</a>
	Creating initiatives to enhance living standards in target communities	<a href="#">Habeek and Lavios (2021)</a> ; <a href="#">Li et al. (2022)</a>
	Green and environmentally conscious procurement	<a href="#">Blome et al. (2014)</a> ; <a href="#">Awasthi and Kannan (2016)</a> ; <a href="#">Ghosh et al. (2021)</a>
	Reverse logistics activities	<a href="#">Blome et al. (2014)</a> ; <a href="#">Awasthi and Kannan (2016)</a>
	Joint efforts to improve sustainability performance	<a href="#">Fu et al. (2012)</a> ; <a href="#">Sancha et al. (2015)</a> ; <a href="#">Taghipour et al. (2022)</a>

### 3. Methodology

In our study on SD activities, we considered two dimensions: the development of internal capabilities and the development of external capabilities. The internal dimension encompasses activities related to the development of both tangible and intangible capabilities, while the external dimension includes activities associated with the development of relational and environmental capabilities.

Internal capability development of the supplier includes the development of all elements within the supplier's company. These elements are under the control of the supplier but their development may require efforts from the supplier, the buyer, or both. We have categorized these into tangible and intangible aspects, identifying several activities aimed at development within each category. Activities related to the development of tangible capabilities are those that enable the supplier to improve in terms of physical capabilities, having the most significant impact on the development of the supply function within the supplier. On the other hand, activities associated with the development of intangible capabilities are those that

enable the supplier to advance in terms of non-physical capabilities, facilitating the supplier's non-physical development for advancement.

External capability development of the supplier pertains to the supplier's interaction with the external environment. Unlike the internal dimension, elements of this dimension are not entirely under the control of the supplier. However, similar to internal development, their enhancement may require initiatives by the supplier, the buyer, or both. This dimension is divided into two categories: relational and environmental. Activities related to the development of relationships are connected with the exchange of information and interactions between the supplier and supply chain partners. Meanwhile, activities related to the development of environmental capabilities indicate the supplier's attention to the environment, customers, and society. The implementation of these activities leads to the development of sustainable capabilities and social responsibility within the supplier firm.

The BWM is used for evaluating various criteria when one needs to make decisions that involve multiple factors. It is considered more precise and yields better results than some of the older methods. The main advantage of BWM over other methods is that it simplifies the decision-making process. By asking for fewer comparisons, it eases the mental load on the person making the decision and lowers the chances of making contradictory choices. Its systematic way of figuring out priorities also means that it captures what the decision-maker truly thinks is most important in a clearer and more precise way. Presented here is an outline of the methodology for BWM to ascertain the relative importance of various activities ([Rezaei, 2015](#)):

Step 1: The decision-maker (DM) identifies a set of activities  $\{A_1, A_2, \dots, A_n\}$ . In our case, we have identified 30 activities related to SD. These activities fall into four categories: tangible, intangible, relational and environmental. In this study, the activities of each group are examined separately.

Step 2. The DM selects the best and the worst activities within each group. The best activity denotes the most preferable or the most significant activity, and the worst activity is the least significant.

Step 3. The DM conducts a pairwise comparison between the best activity and the other activities. This step seeks to assess the relative importance of the most critical activity in comparison to other activities. The decision-maker assigns a value from 1 to 9 to indicate the level of preference. The outcomes of these comparisons are represented as follows:

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn}),$$

Where  $a_{Bj}$  represents the preference of the best activity B over activity j, and  $a_{BB} = 1$ .

Step 4. In this step, the decision-maker evaluates the relative importance of each activity compared to the worst activity, assigning a value from 1 to 9 (1: equally important, 9: extremely more important). The results of these comparisons are represented as follows:

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T,$$

Where  $a_{jW}$  indicates the preference of the activity  $j$  over the worst activity  $W$ , and  $a_{WW} = 1$ .

Step 5. In each group, we determine the optimal weights for the activities. Calculating the optimal weights ( $w_1^*, w_2^*, \dots, w_n^*$ ) For each pair of  $w_B/w_j$  and  $w_j/w_W$ , the optimal weight should meet the requirement that  $w_B/w_j = a_{Bj}$  and  $w_j/w_W = a_{jW}$ . To meet the conditions, the maximum absolute differences  $|\frac{w_B}{w_j} - a_{Bj}|$  and  $|\frac{w_j}{w_W} - a_{jW}|$  for all  $j$  is minimized. Additionally, considering the non-negativity constraint and sum condition of the weights, the following problem can be formulated as equation (1):

$$\min \max_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\} \quad (1)$$

s.t.

$$\sum_j w_j = 1,$$

$$w_j \geq 0, \text{ for all } j$$

Hence, problem (1) can be transferred to equation (2):

$$\min \xi \quad (2)$$

s.t.

$$\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi, \text{ for all } j$$

$$\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi, \text{ for all } j$$

$$\sum_j w_j = 1,$$

$$w_j \geq 0, \text{ for all } j$$

The linear model of the above function was also presented ([Rezaei, 2016](#)). In this article, the weights are obtained using the linear model as represented in equation (3).

$$\min \xi \quad (3)$$

s.t.

$$|w_B - a_{Bj}w_j| \leq \xi, \text{ for all } j$$

$$|w_j - a_{jW}w_W| \leq \xi, \text{ for all } j$$

$$\sum_j w_j = 1,$$

$$w_j \geq 0, \text{ for all } j$$

To complete steps 2, 3 and 4, we established a panel of eight automotive industry experts (holding a total of four virtual meetings with them over 30 days). The experts were selected through snowball and purposive sampling methods. Through their feedback, we were able to reach a consensus. In the next step, the obtained prioritization results in each category are presented to 10 experts from the automotive industry. Their opinions and suggestions regarding the findings are then collected and analyzed through interviews, providing validation and deeper insights into the findings. The same sampling method was used for

selecting experts at this stage. The experts were engaged in the planning unit, had a minimum of 5 years of work experience, and held at least a master's degree. Fig. 2 represents the steps undertaken in this article for the identification and better understanding of SD activities.

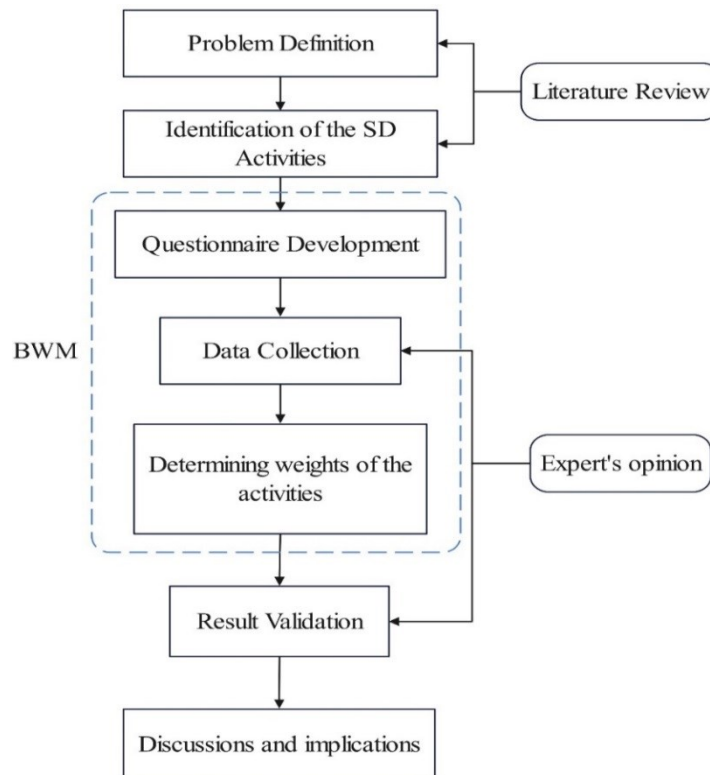


Fig. 2. Flowchart of the study methodology

## 4. Findings

### 4.1 Prioritization results

In this section, we present the results from the application of BWM for the analysis of the collected data, categorized by different SD aspects.

#### 4.1.1 Results related to the first aspect (tangible)

These abbreviations are used for the following tangible SD activities: Evaluation of tangible supplier capabilities and feedback (T1), Establishing up-to-date quality standards (T2), Reducing the number of suppliers (T3), Segmentation of suppliers for their development (T4), Creation of incentives based on design improvements (T5) and Direct involvement in supplier operations (T6).

Experts were asked to select the best and worst activity among the six activities related to the first aspect. The result of this survey was the selection of "Evaluation of tangible supplier capabilities and feedback" as the best activity and "Reducing the number of suppliers" as the worst activity. Subsequently, the best activity was compared to the other activities, and the other activities were compared to the worst activity. Based on these comparisons, a linear programming model was formulated and solved. The weights of the activities were obtained as shown in Table (3).

**Table 3. Weights of the tangible activities**

Rank	Weight	Activity
1	0.49	T <sub>1</sub>
2	0.159	T <sub>6</sub>
3	0.127	T <sub>2</sub>
4	0.106	T <sub>5</sub>
5	0.08	T <sub>4</sub>
6	0.038	T <sub>3</sub>

As observed in Table (3), "Evaluation of tangible supplier capabilities and feedback" has the highest weight (0.49). As the degree of preference for the best activity (in this case, Evaluation of tangible supplier capabilities and feedback) over other activities increases, the weight of the best activity (here, Evaluation of tangible supplier capabilities and feedback) will also increase. Conversely, the activity "Reducing the number of suppliers" has the least importance (0.038). As the degree of preference for other activities over the worst activity (T3) increases, the weight of the worst activity (T3) will decrease.

Given the above points, it can be said that the experts have assigned a high degree of preference to "the Evaluation of tangible supplier capabilities and feedback" activity compared to other activities, as the weight of this activity is significantly higher than the others (see Table 3). Additionally, considering the relatively similar weights of the four activities (Direct involvement in supplier operations, establishing up-to-date quality standards, Creation of incentives based on design improvements, and Segmentation of suppliers for their development) it can be inferred that the experts have given these activities relatively equal preference. However, they have assigned a significantly higher degree of preference to these activities compared to the worst activity (Reducing the number of suppliers).

#### 4.1.2 Results related to the second aspect (intangible)

These abbreviations are used for the following intangible SD activities: Evaluation of intangible supplier capabilities and feedback (I1), Training and updating the supplier (I2), Joint establishment of an SD group (I3), Creation of knowledge networks (I4), Obtaining financial and non-financial commitments (I5) Creating mechanisms for mutual trust (I6) and Raising performance expectations from the supplier (I7).

Experts selected "Training and updating the supplier" as the best activity and "Obtaining financial and non-financial commitments" as the worst activity. The weights of the activities were obtained as shown in Table (4).

**Table 4. Weights of the intangible activities**

Rank	Weight	Activity/Activities
1	0.423	I <sub>2</sub>
2	0.137	I <sub>1</sub> , I <sub>4</sub>
3	0.11	I <sub>6</sub>
4	0.078	I <sub>3</sub> , I <sub>7</sub>
5	0.037	I <sub>5</sub>

As observed in Table (4), "Training and updating the supplier" has the highest weight (0.423). Conversely, the activity "Obtaining financial and non-financial commitments" has the least importance (0.037).

Considering the above points, it can be said that experts have assigned a relatively high priority to "training and updating the suppliers" compared to other activities. This is because the weight of the activity for "training and updating the suppliers" shows a relatively significant difference compared to other activities. However, this difference is less than the difference in the weights of other activities compared to the "Evaluation of tangible supplier capabilities and feedback in the tangible" category. Another noteworthy point is that given the relatively equal weights of the activities for "Evaluation of intangible supplier capabilities and feedback", "Creation of knowledge networks", "Joint establishment of an SD group", "Creating mechanisms for mutual trust" and "Raising performance expectations from the supplier", and the fact that the activity of "Obtaining financial and non-financial commitments" has a relatively lower weight compared to these five activities, it can be said that experts have assigned a relatively equal priority to these five activities compared to each other, but a high priority for these five activities compared to the worst activity of "Obtaining financial and non-financial commitments".

#### 4.1.3 Results related to the third aspect (relational)

These abbreviations are used for the following intangible SD activities: Evaluation of supplier relationships and feedback (R1), Timely sharing of information (R2), Conclusion of long-term contracts with suppliers (R3), Coordinating processes, goals, and actions (R4), Setting challenging long-term goals jointly (R5) Creating collaborative communications or partnerships (R6), Utilizing appropriate communication tools (R7), Developing collaborative strategies at the supply chain level (R8), Promoting a competitive culture among supply chains (R9), and Making the supply chain accountable (R10).

Experts were asked to select the best and worst activity among these ten activities. The result of this survey was the selection of "Creating collaborative communications or partnerships" as the best activity and "Promoting a competitive culture among supply chains" as the worst activity. The weights of the activities were obtained as shown in Table (5).

**Table 5. Weights of the relational activities.**

Rank	Weight	Activity/ Activities
1	0.339	R <sub>6</sub>
2	0.144	R <sub>2</sub>
3	0.108	R <sub>1</sub>
4	0.072	R <sub>3</sub> , R <sub>7</sub>
5	0.062	R <sub>4</sub> , R <sub>5</sub> , R <sub>10</sub>
6	0.054	R <sub>8</sub>
7	0.027	R <sub>9</sub>

As observed in Table (5), "Creating collaborative communications or partnerships" has the highest weight (0.338). The activity "Promoting a competitive culture among supply chains" has the least importance (0.027).

Considering the above points, it can be said that experts have assigned a relatively high priority to "Creating collaborative communications or partnerships" compared to other activities. This is because the weight of the activity "Creating collaborative communications or partnerships" shows a relatively significant difference compared to other activities, while the weights of the other 9 activities do not differ much from each other. This indicates that experts have assigned a relatively equal priority to these nine activities compared to each other. However, the activity "Promoting a competitive culture among supply chains" has the lowest weight, indicating a lower priority compared to other activities. The activities "Creating collaborative communications or partnerships", "Evaluation of supplier relationships and feedback" and "Timely sharing of information" have accounted for more than 58% of the importance. Based on these results, automotive industry manufacturers should pay special attention to these 3 activities.

#### 4.1.4 Results related to the fourth aspect (environmental)

These abbreviations are used for the following intangible SD activities: Performance evaluation of supplier's environmental impact (E1), Sharing environmental, ethical, and social responsibility information (E2), Obtaining environmental and social certifications (E3), Creating initiatives to enhance living standards in target communities (E4), Green and environmentally conscious procurement (E5) Reverse logistics activities (E6) and Joint efforts to improve sustainability performance (E7).

The experts selected "Sharing environmental, ethical, and social responsibility information" as the best activity and "Creating initiatives to enhance living standards in target communities" as the worst activity. The weights of the activities were obtained as shown in Table (6).

**Table 6. Weights of the environmental activities**

Rank	Weight	Activity
1	0.414	E <sub>2</sub>
2	0.168	E <sub>1</sub>
3	0.126	E <sub>3</sub>
4	0.101	E <sub>5</sub>
5	0.084	E <sub>7</sub>
6	0.072	E <sub>6</sub>
7	0.036	E <sub>4</sub>

As observed in Table (6), "Sharing environmental, ethical, and social responsibility information" has the highest weight (0.413). Conversely, the activity "Creating initiatives to enhance living standards in target communities" has the least importance (0.035).

Considering the above points, it can be said that in pairwise comparisons, experts have assigned a very high priority to the activities of "Performance evaluation of supplier's environmental impact", "Sharing environmental, ethical, and social responsibility information" and "Obtaining environmental and social certifications". These activities have accounted for more than 70% of the importance, with the activity "Sharing environmental, ethical, and social responsibility information" alone accounting for more than 41% of the importance and taking the highest priority. The activity "Creating initiatives to enhance living standards in target communities" has had the lowest weight and has taken the seventh priority. Based on these results, automotive industry manufacturers should pay special attention to the activities of "Performance evaluation of supplier's environmental impact", "Sharing environmental, ethical, and social responsibility information" and "Obtaining environmental and social certifications".

#### 4.2 Validation of results

Validation of outcomes derived from multi-criteria models constitutes the concluding stage before the execution of a definitive decision. Therefore, after prioritizing the activities related to SD in each category using the Best-Worst Method (BWM), the findings were shared with industry experts to evaluate their validity. The following questions were used for this assessment:

**Question 1. "Our findings regarding the tangible aspect are summarized in Table (3). What are your thoughts on this prioritization?"**

Due to tangible interactions from the beginning of the manufacturer-supplier relationship to its end, the manufacturer continuously evaluates the supplier and provides necessary feedback, thus giving greater weight to this activity. Experts highlighted the value of direct involvement in supplier operations. They primarily believe that close collaboration and hands-on engagement are critical. These practices help build strong relationships and ensure that suppliers align with our quality and performance standards. This approach not only fosters trust but also enables quicker problem-solving and innovation. Regarding establishing up-to-date quality standards, Incentivizing Innovation and Segmentation, experts agree on their fundamental role. While segmenting suppliers for targeted development is ranked lower, experts still recognize its importance. However, its lower ranking suggests that while valuable, it may not have an immediate impact compared to direct evaluation and involvement. Regarding the reduction of supplier base, experts opined that in the automotive industry, the relationships between producers and suppliers are typically long-term and robust. Additionally, the number and diversity of suppliers for various parts are limited; therefore, reducing or eliminating suppliers is exceedingly challenging and sometimes impossible. Some experts argue that the low ranking of segmentation and consolidation overlooks their long-term benefits. While these activities may not have immediate impacts,

they can lead to more sustainable SD and optimization of operations over time. They assert that "balancing immediate tangible improvements with long-term strategic goals is essential for holistic SD."

**Question 2. "Our findings regarding the intangible aspect are summarized in Table (4). What are your thoughts on this prioritization?"**

In the realm of intangibles, rapid environmental changes and technological advancements underscore the importance of training and updating supplier information for their development; most experts deem these updates and training essential. Experts believe that evaluating intangible supplier capabilities and feedback, creating knowledge networks, and establishing mechanisms for mutual trust essentially constitute an SD program, which necessitates three phases: formulation, implementation, and control, with outcomes becoming evident in the long term. The joint establishment of an SD group and raising performance expectations from the supplier require collaboration between the supplier and the producer. However, since these activities have been evaluated from the producer's perspective, their significance for the producer may have been diminished. Dissenting views suggest, "Without adequate support and development, merely raising expectations could lead to supplier stress and potential underperformance." Regarding the acquisition of financial and non-financial commitments, experts state that, due to the previously mentioned difficulties, obtaining such commitments from suppliers would be arduous. They believe that an overemphasis on any single activity could lead to gaps in SD, highlighting the need for a well-rounded strategy that addresses both immediate and long-term goals.

**Question 3. "Our findings regarding the relational aspect are summarized in Table (5). What are your thoughts on this prioritization?"**

In terms of relationships, experts referred to the same rationale associated with reducing the supplier base and obtaining financial and non-financial commitments for creating collaborative communications or partnerships, which has taken the top priority. This high ranking reflects the strategic importance of collaboration in achieving long-term success and resilience in the supply chain. Experts asserted that the most critical output of the evaluation, which must be communicated to suppliers, is the timely sharing of information, hence two activities are approximately of equal and high importance. The activities of concluding long-term contracts with suppliers, utilizing appropriate communication tools, coordinating processes, aligning goals and actions, and jointly setting challenging long-term objectives are all subsumed under strategic planning and have been accorded nearly equal importance. This finding indicates that the experts exercised due diligence in completing the questionnaire. These activities are seen as foundational for establishing and maintaining robust supplier relationships. Some experts argued, "Over-coordination can lead to inefficiencies and bureaucratic delays. Setting overly challenging goals might also create undue pressure and strain relationships. A more flexible and adaptive approach could be more beneficial."

Regarding the activities of making the supply chain accountable, developing collaborative strategies at the supply chain level, and promoting a competitive culture, experts interpreted that all these activities require coordination among all members of the supply chain, thus diminishing their importance relative to other activities.

**Question 4. “Our findings regarding the environmental aspect are summarized in Table (6). What are your thoughts on this prioritization?”**

In the environmental context, experts referred to the same rationale related to the relational aspect for the high priority given to sharing environmental, ethical, and social responsibility information and performance evaluation of suppliers' environmental impact. This prioritization underscores the strategic importance of transparency and continuous monitoring in promoting sustainability and ethical practices throughout the supply chain. Experts asserted that sharing such information and evaluating performance is important for building trust, ensuring compliance with environmental standards, and identifying areas for improvement. Obtaining environmental and social certifications has been ranked third, but experts highlighted its high importance due to its prerequisite nature. To obtain these certifications, suppliers must have executed activities of green and environmentally conscious procurement, joint efforts to improve sustainability performance, reverse logistics activities, and creating initiatives to enhance living standards in target communities to a standard and acceptable level. This requirement elevates the importance of this activity compared to the mentioned four activities, as it signifies formal recognition of a supplier's commitment to comprehensive environmental practices. Green and environmentally conscious procurement is essential for integrating environmental considerations into procurement decisions, reducing overall environmental impact. Experts agreed that while this practice is important, its implementation is often contingent on achieving certification standards. Joint efforts to improve sustainability performance are critical for innovation and shared benefits, though they are ranked lower due to the challenges of coordination and alignment of goals. Experts suggested that while collaborative initiatives are valuable, they are often necessary steps towards obtaining certifications. Creating initiatives to enhance living standards in target communities is ranked lowest, indicating that while social responsibility is important, it is often seen as a supporting activity rather than a primary focus. However, experts argue that improving living standards contributes to the social pillar of sustainability and is a necessary component for obtaining environmental certifications.

## **5. Discussion**

This study presents a comprehensive analysis of SD activities using the Best-Worst Method across four key dimensions: tangible, intangible, relational, and environmental. The findings indicate that the most critical activities for SD include “Evaluation of tangible supplier capabilities and feedback,” “Training and updating the supplier,” “Creating

collaborative communications or partnerships,” and “Sharing environmental, ethical, and social responsibility information.” These results provide valuable insights into prioritizing SD initiatives, which can enhance operational efficiency and foster stronger supplier relationships. The emphasis on evaluating supplier capabilities and providing training aligns with recent literature highlighting the importance of SD in attaining competitive advantage. For instance, studies by [Saunila et al. 2021](#) and [Du et al. 2023](#) highlight that effective capability evaluation improves supplier performance and innovation. Likewise, the prioritization of training is consistent with findings from [Chen et al. \(2021\)](#), who argue that continuous training is crucial for sustaining supplier competitiveness in rapidly evolving markets. However, the study's finding that "Reducing the number of suppliers" is considered the least important activity conflicts with some previous studies that advocate for supplier consolidation as a means to improve cooperation and reduce complexity ([Connor et al., 2020](#); [Zhou et al., 2020](#)). This divergence may be due to different contextual factors such as industry characteristics or organizational strategies that influence supplier management perceptions. The results suggest a clear preference for activities that promote collaboration and communication over those that emphasize competition or reduction in supplier numbers. The high weight assigned to “Evaluation of tangible supplier capabilities and feedback” indicates a recognition among experts of its critical role in ensuring that suppliers meet quality standards and contribute effectively to supply chain goals. This finding is consistent with theories of relational governance, which propose that strong relationships between buyers and suppliers lead to better performance outcomes ([Gulati, 1998](#)). In terms of relational activities, our emphasis on "Creating collaborative communications or partnerships" is consistent with findings from [Vachon and Klassen \(2006\)](#), who assert that collaboration improves supply chain performance. However, the low priority assigned to "Promoting a competitive culture among supply chains" suggests a shift towards cooperative strategies rather than competitive ones, which is supported by recent literature advocating for collaborative supply chain networks ([Zhu & Sarkis, 2004](#)). Interestingly, the activity “Creating initiatives to enhance living standards in target communities” was rated lowest in the environmental category. This may reflect a pragmatic focus on immediate operational improvements rather than broader social impacts, suggesting a potential misalignment between theoretical ideals of corporate social responsibility and practical implementation strategies.

## 6. Conclusions

This article is conducted in three stages; the first stage involves a literature review, where relevant articles and studies are collected and appropriate studies are selected using meta-synthesis. Subsequently, through an in-depth examination of the selected texts and coding with ATLAS.ti software, activities related to SD are identified. The identified activities,

which numbered over 62, are reviewed by the research team, and after combining and adjusting them, they are categorized into four categories: tangible capability development, intangible capability development, relational development, and environmental capability development. To validate the content of the activities and the categorization, experts from the automotive industry are consulted. After gathering the experts' opinions and calculating the CVR, 30 final activities are determined. The distribution of tangible, intangible, relationship, and environmental categories among these 30 activities was, respectively, six activities, seven activities, 10 activities, and seven activities. In the second stage, we seek to determine the weights of each of the activities. For this purpose, one of the best and most recent methods known as BWM is used. This method was invented by [Rezaei in 2015](#), which significantly reduces pairwise comparisons and, consequently, the calculations compared to the AHP method, and also significantly improves consistency in judgments. To determine the weights of the activities within each category using the BWM method, pairwise comparison matrices are separately developed for the activities of each category and presented to experts in the automotive industry and academia. After collecting the experts' opinions, a linear optimization model based on the BWM method is formulated for the activities of each category. The linear optimization models are solved using Excel software, and optimal weights for the different activities are obtained. The findings of the activity weights determination show that the highest priority activities identified by experts include "Evaluation of tangible supplier capabilities and feedback" (tangible), "Training and updating the supplier" (intangible), "Creating collaborative communications or partnerships" (relational), and "Sharing environmental, ethical, and social responsibility information" (environmental). In the third stage, the prioritizations obtained for each category are shared with industry experts, and they are asked to provide their opinions and suggestions on them. This study offers practical guidance for supply chain managers aiming to enhance SD practices. By prioritizing collaboration and capability enhancement over competitive practices, organizations can align their operations more closely with strategic goals. In conclusion, this study underscores the importance of a structured approach to prioritizing SD activities within supply chains. By addressing both theoretical implications and practical applications, it lays the groundwork for future studies that can further refine our understanding of effective supplier management strategies. This study, like other studies, has some limitations. The reliance on expert opinions may introduce bias; experts may have different interpretations of what constitutes effective SD activities. Additionally, this study's context (focused primarily on the automotive industry) limits the generalizability of the findings to other sectors. Future research should explore the impact of contextual factors such as industry type on the prioritization of SD activities.

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