Environment, Development and Sustainability (2022) 24:1897–1927
https://doi.org/10.1007/s10668-021-01513-x

Assessing the prioritization of barriers toward green innovation: small and medium enterprises Nexus

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Received: 7 September 2020 / Accepted: 8 May 2021 / Published online: 25 May 2021

Abstract
Over recent years, there was a substantial rise globally in the importance of the environmental agenda for SMEs. The customer becomes now conscious of their consumer choices' environmental consequences. This research has also identified obstacles to introducing green business activities in small- and medium-sized enterprises and increase sustainable development. The green innovation barriers refer to green products, processes, and management; therefore, it is important to minimize restrictions on clean technology implementation in small- and medium-sized enterprises. This study uses an integrated decision process to define primary barriers, sub-obstacles, and approaches to addressing those obstacles to Saudi Arabia's green innovation practices. Through extensive literature review and twelve experts' opinions, six key barriers, twenty-five sub-barriers, and plans to reduce obstacles were identified. Using the fuzzy analytical hierarchy process (FAHP), key barriers and sub-barriers are assessed. The methodology used to rank strategies is the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS). Five Saudi Arabia SMEs are involved in the study of the proposed integrated decision model. The FAHP reports that the key obstacles to introducing green practices in SMEs are "political obstacles" The FTOPSIS, therefore suggesting that "developing research methods to deliver green innovation in small- and medium-sized enterprises" is the best approach to addressing barriers in green innovation adoption in SMEs.

Keywords SMEs · Barriers · Green innovation · Sustainable development · FAHP · FTOPSIS · Saudi Arabia

1 Introduction

Consumers and customers are currently very much aware of environmental protection. Strict environmental policies to mitigate emissions are often implemented by states, which are enhanced by businesses, such as small- and medium-sized enterprises (SMEs) (Mohsin 2020b; Mohsin et al. 2018, 2021). Whatever their size (small and medium), these industries

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play a fundamental role in economic development. Besides, some are responsible for the degradation of the community. However, the SMEs' contributions to environmental degradation are ignored at the regional and national levels due to their scale (Sun et al. 2020b, c, d). Literature has shown that SMEs account for around 70% of the industry's overall waste and environmental emissions. After that, the awareness was increased due to the pressure imposed by the various stakeholders, and the government also extended the responsibility to the SMEs to limit the environmental impact (Wasif Rasheed and Anser 2017; Xu et al. 2020b; Ahmad et al. 2020).

A few international-level agreements also call on SMEs to reduce the pollution caused by the industries to protect the environmental assets and minimize climate change challenges (Baloch et al. 2020, 2021). In 2015, several countries at the Paris agreement agreed to strictly follow the agreement's targets of reducing carbon emissions (Iqbal et al. 2021; Zhang et al. 2021) to secure the atmosphere (Ikram et al. 2019a; Sun et al. 2019; Ikram et al. 2019b). As previously reported, SMEs could be the biggest contributor to greenhouse gas emissions; because of the minimum resources, the SMEs cannot participate at the expected level. Accordingly, institutions are concentrating on detailing a new arrangement of strategies and acquaintance of creative thoughts with assisting SMEs to lessen their level of emission (Mohsin et al. 2019, 2020a, 2021). The policymakers and researchers suggest the best strategies for SMEs to decrease pollution from the 'Innovation for Green' environment. Environment and green procurement mean the introduction and innovative production objects, processes, or methods, resources that also regulate the use of productive resources and monitor waste and pollution generated on Earth (Yang et al. 2021; He et al. 2020; Mohsin et al. 2020b). Green innovation can be the solution to sustain or address to overcome SMEs' environmental issues. Implementing good environmental friendliness will boost SMEs' competitive advantage and benefit the long run (6). Though there are so many problems and hurdles to implementing green innovation for SMEs, SMEs must tackle to evaluate these various obstacles adequately to effectively execute sustainable innovations (Sun et al. 2020a). In this regard, researchers design the goals of our report, i.e., (i) recognizing green innovation obstacles in small- and medium-sized enterprises; (ii) prioritizing or ranking defined barriers; (iii) seeking solutions to those obstacles; and (iv) prioritizing and ranking solution (Alemzero et al. 2020a; Sun et al. 2020b; Alemzeroet al. 2020b).

To accomplish the aims of this report, researchers have divided this research study into three phases. In the first phase, authors notify different blockades through a very comprehensive literature survey to execute the green practices for the welfare of SMEs. After that, the authors classify the blockades into other significant categories. Researchers finally got the solution of these blockades from the expert's feedback through a comprehensive literature study. In this second level, researchers follow the practical approach by applying the fuzzy analytical hierarchy process (FAHP) to consider the main burdens of blockades to the extent green innovation can be impeded. Later on, they have used the identical process of (FAHP) to calculate the importance weights of the sub-blockades. They multiply the necessary weights with their specific significant blockade category weights to get the global sub-blockades weights. In the third and last phase, researchers have used the sub-blockade global consequences by using fuzzy technology to get the solution for the SMEs to prefer the same ideal solution (FTOPSIS) (Agyekum et al. 2021).

Singh et al.'s 2020 research framework addressed the role of green absorptive potential in moderating the relationship between organizational factors and green innovation; their conclusions lack multi-dimensional and comprehensive organizational factors. The scope and width of judgment on green technologies are referred to as green strategic orientation at the strategic level. As a result, political factors such as bank loan unavailability, financial barriers, and senior management cognition and green strategic direction have been ignored to investigate the moderating effect of green innovation capacity on organizational factors and green innovation in SMEs. The above is a synopsis of recent literature on green innovation. However, there is a geographic variation of green technology innovation supply and demand, and spillover consequences cannot be underestimated. Consequently, from the viewpoint of AHP and fuzzy-TOPSIS results, this analysis will have an in-depth interpretation of the impacts of green technology advancement on Saudi Arabia's green innovation.

This study is unique because the SMEs' sector of the Saudi Arab is understudied so (i) this study will fill this gap, and this is the first study which identifies and ranks several challenges in the implementation of the environmental innovation of SMEs in Saudi Arab, (ii) this study also gives solutions, which can strategically address many different barriers. Green innovation has huge importance, but despite that, it is not that much researched and explored. Furthermore, the solution and barriers of the SMEs sector's green innovation greatly depend on the related background and history of the specific region or country. It is therefore essential that work is carried out to a specific region or nation. (iii) This research study's framework can be very important and helpful for the policymakers and researchers; they can further extend their research on this topic. (iv) Finally, we have looked at six key barriers, twenty-five sub-barriers, and plan to reduce obstacles by using the FAHP process; consequently, it is certain how suppliers can change their green innovation plans in reaction to consumer or partnership characteristics. We have developed a policy framework based on findings.

The study is further divided into the following divisions: Section 2 discusses the literature review and discusses implementing obstacles to environmentally sustainable innovation in the Saudi Arab context. Section 3 describes the aim and important methods which are used in this study. Section 4 discusses the results of the study, and Sect. 5 presents the conclusion of this research study.

2 Literature review

In reality, green innovation will reduce specific environmental threats, such as CO_2 emissions or other climate change impacts and product use. Environmental design is generally defined as environmental system innovation, sustainable processes, and eco-design practice (Anser et al. 2020a, g, h, j, k). There are many definitions of green innovation provided by many researchers in the past years. In this study, researchers have used environmental innovation and green innovation; these two terms are interchangeable (Anser et al. 2020g h; Khalid et al. 2020) and forwarded the description of ecosystem innovation. Similarly, Anser et al. 2020a, b, c, d, e, f, g, h, i, j, k, in this study, define the term sustainable innovations as a highly developed item. The service of the procedure is very approachable toward the environment and can reduce environmental risks. Asif et al. 2020; Sarker et al. 2020; Iram et al. 2020; Tehreem et al. 2020 describe green innovation. Though, in many cases, the application of eco-friendly innovation is frequently confronted with many hurdles. Specifically, the SMEs have lingered behind with regard to embracing the green practices (Yousaf et al. 2020; Tehreem et al. 2020; Wasif Rasheed and Anser 2017; Xu et al. 2020b). Broad investigations uncovered many boundaries of SMEs to practice green innovation. The authors summarized a few current studies in Table 1, which identify different barriers and hurdles to environmental innovation and green practices (Liu et al. 2020; Lin et al. 2020b; Jun et al. 2020).

By considering the relevant and current studies, researchers got feedback from the experts to finalize different barriers/hurdles concerning Saudi Arabs, since no research study has been led to conclude the barriers/ hurdles for the SMEs within the Saudi Arab toward clean new technology. Concerning Saudi Arabia, twenty-four barriers/hurdles were confirmed. They are further subdivided into six categories, i.e., market barrier (MB), economic barrier (EB), technical barrier (TB), information barrier (IB), political barrier (PB), and managerial barrier (MAB). In Table 2, there are a list of respective categories of selected sub-barriers. Similarly, in Table 3 of this study, ten strategic solutions were finalized to these barriers; after conducting a thorough survey of literature, these solutions were finalized.

3 Research framework

The proposed research framework is a hybrid style (Fuzzy AHP & Fuzzy TOPSIS) that was applied in the Saudi Arabia. The proposed methodology of this research study is presented in Fig. 1. To find out the barriers that can delay the implementation of green innovation practices for SEMs is the main theme of this research study that can provide the solution to get rid of sustainable green business obstacles to action in SMEs. For examining the results, five experienced and professional (managers) experts were contacted to evaluate and identify the essential and main barriers of green innovation in the SME sector. Webmail service was used to contact the experts, and the questionnaire survey instrument was distributed to get feedback.

The major barriers and sub-barriers were analyzed by using the fuzzy AHP method of sustainable innovation in SMEs. After that, the obstacles, which found in the fuzzy method, were incorporated into the fuzzy TOPSIS method to get the green innovation barriers.

Figure 1 explains the pictorial process of the method that has been used in the study. It can be seen from Fig. 1 that the first step is the identification of main criteria and sub-criteria and then calculates the weight of each criterion through FAHP, and finally, the third step the practical application of the fuzzy TOPSIS method is to generate the results.

3.1 Fuzzy AHP method

The analytical hierarchy method (AHP) is a commonly used methodology to address complex decisions, though, in the literature, the AHP is very much criticized because of its unbalanced judgment scale and the absence of the ability to integrate uncertainty and vagueness in the complex decision (Zhou 2019a, b; de Lima Silva and de Almeida Filho 2020; Zhou et al. 2018; Xu et al. 2020a). Addressing such AHP deficiencies, different researchers incorporate fuzzy with AHP to frame FAHP. FAHP effectively deals with any uncertainty involving in the decision making and therefore has been used in a variety of fields, including the energy sector ((Lei et al. 2020; Xu et al. 2019a, b, the health sector (Singh and Prasher 2019), supply chain (Patil and Kant 2014), risk evaluation (Fattahi and Khalilzadeh 2018), corporate social responsibility (Moktadir et al. 2018), and others (Calabrese et al. 2019; Wu et al. 2019). This research analysis contains the following paths:

Let a matrix be $H = (h_{ij})_{n\times m}$. Let a fuzzy number be $F_{ij} = (a_{ij}, b_{ij}, c_{ij})$;

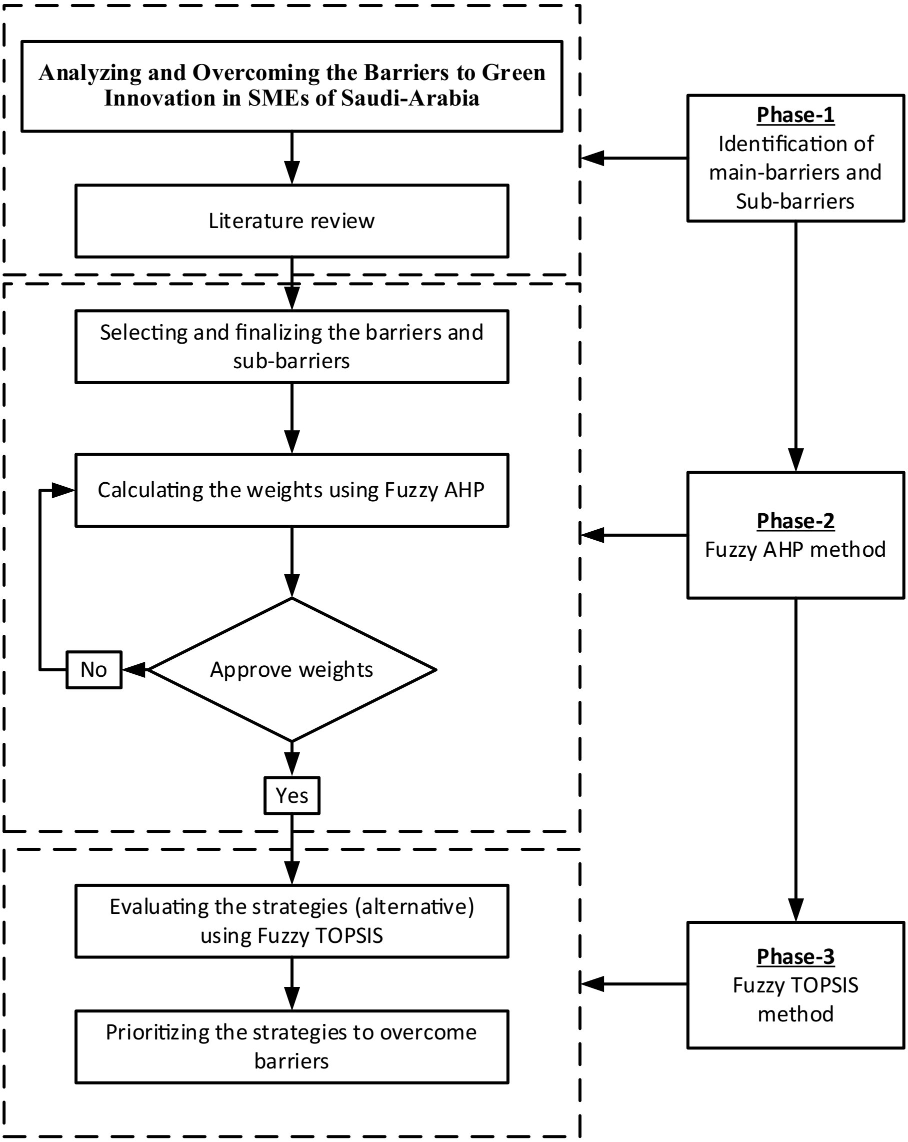


Fig. 1 The research framework of the study

1. Using fuzzy numbers, formulate paired matrices.
2. Use Eqs. (1, 2, 3, and 4) to obtain the results of fuzzy synthetic degree value (SEV_i):

$$\mathrm{SEV}_i = \sum_{j=1}^{m} F_{ij} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} F_{ij}\right]^{-1} \tag{1}$$

$$\text{s.t} \sum_{j=1}^{m} F_{ij} = \left(\sum_{j=1}^{m} a_{ij}, \sum_{j=1}^{m} b_{ij}, \sum_{j=1}^{m} c_{ij} \right) \text{for } i = 1{,}2,3{,}4,5, \ldots, n(2) \tag{2}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} F_{ij} = \left(\sum_{i=1}^{n} \sum_{j=1}^{m} a_{ij}, \sum_{i=1}^{n} \sum_{j=1}^{m} b_{ij}, \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} \right) \tag{3}$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} F_{ij} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij}}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} b_{ij}}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} a_{ij}} \right) \tag{4}$$

3. Use Eq. (5) to obtain a degree of possibility $SEV_j = (a_j, b_j, c_j) \geq SEV_i = (a_i, b_i, c_i)$:

$$V\left(SEV_j \geq SEV_i\right) = \left(SEV_i \cap SEV_j\right) = c_{s_j}(d) = \begin{cases} 1, \text{if } b_j \geq b_i \\ 0, \text{if } a_i \geq c_j \\ \frac{a_i - c_j}{(b_j - c_j) - (b_i - a_i)}, \text{otherwise} \end{cases} \tag{5}$$

   where (d) is the intersection between c_{s_j} and c_{s_i};$(SEV_i \geq SEV_j)$ and $(SEV_j \geq SEV_i)$ values are compared with SEV_i and SEV_j.
4. Obtain minimum possibility degree $d(i)$ of $(SEV_j \geq SEV_i)$: where $ij = 1{,}2,3{,}4,5, \ldots, k$.

$$\begin{gathered} \left(SEV \geq SEV_1, SEV_2, \ldots, SEV_k\right), \\ \text{for } i = 1{,}2,3{,}4,5, \ldots, k \\ = \left[\left(SEV \geq SEV_1\right) \text{ and } \left(SEV \geq SEV_2\right) \text{ and} \ldots \left(SEV \geq SEV_k\right)\right] = \min\left(SEV \geq SEV_i\right) \\ \text{for } i = 1{,}2,3{,}4,5, \ldots, k \end{gathered} \tag{6}$$

   Let

$$d'\left(B_i\right) = \min \left(SEV_j \geq SEV_i\right), \text{for } i = 1{,}2,3{,}4,5, \ldots, k$$

   then the weight vector is

$$W' = \left(d'\left(H_1\right), d'\left(H_2\right), d'\left(H_3\right), \ldots, d'\left(H_n\right)\right)^T \tag{7}$$

   where H_1 $(i = 1{,}2,3{,}4,5, \ldots, n)$ represents n elements:
5. Vector is normalized as follows:

$$W = \left(d\left(H_1\right), d\left(H_2\right), d'\left(H_3\right), \ldots, d\left(H_n\right)\right)^T \tag{8}$$

   where W is a non-fuzzy weight.

3.2 FTOPSIS method

Hwang and Yoon developed the TOPSIS method in 1981 (90). TOPSIS method developed the common idea or relationship, which can be positive or negative to get a suitable way out. In this research, the fuzzy-based TOPSIS method is adopted to minimize the problem of uncertainty in decisions and can get reliable and more consistent results. The set theory of fuzzy can help to get the immeasurable and incomplete information in the fuzzy environment (91). To rank and evaluate the alternatives of the linguistic variables, this method is more preferable. So, to analyze each criterion's alternatives, the triangular fuzzy numbers (TFNs) were used in this study. Uncertain problems can be reduced with the help of linguistic variables in terms of a quantitative approach. The linguistic terms can be interpreted with TFN in so many aspects; Table 4 indicates the linguistic influences in the current research study (Table 5).

The following measures display TFN-based linguistic variables:

Step I: Let $\tilde{A} = \left(a_1, a_2, a_3\right)$, $\tilde{B} = \left(b_1, b_2, b_3\right)$ are the two fuzzy numbers, so the math relationship is as follows:

$$\tilde{A} + \tilde{B} = \left(a_1, a_2, a_3\right) + \left(b_1, b_2, b_3\right) = \left(a_1 + b_1, a_2 + b_2, a_3 + b_3\right) \tag{9}$$

$$\tilde{A} \times \tilde{B} = \left(a_1, a_2, a_3\right) \times \left(b_1, b_2, b_3\right) = \left(a_1 b_1, a_2 b_2, a_3 b_3\right) \tag{10}$$

Step II: Let $\tilde{A}_i = (a_{i1}, a_{i2}, a_{i3})$ be a TFN for $i \in I$. Afterward, the normalized fuzzy number of each $\tilde{A}_i$ is shown as:

$$\tilde{R} = [r_{ij}]_{m \times n} \tag{11}$$

where $i = 1,2,3,\dots,m$ and $j = 1,2,3,\dots,n$

The fuzzy standardization approach is viewed as a constructive optimal solution, i.e., benefits criteria:

$$r_{ij} = (\frac{a_{1ij}}{a^*_{3j}}, \frac{a_{2ij}}{a^*_{3j}}, \frac{a_{3ij}}{a^*_{3j}}) \tag{12}$$

where $a^*_{3j} = \max a_{3ij}$ is a benefit-type criterion?

The fuzzy normalization approach is presented as the negative optimal solution (i.e., costs' criteria):

$$r_{ij} = (\frac{a^-_{1j}}{a_{3ij}}, \frac{a^-_{1j}}{a_{2ij}}, \frac{a^-_{1j}}{a_{1ij}}) \tag{13}$$

$a^-_{1j} = min a_{1ij}$ is cost-type criteria.

Step III: Construct the fuzzy-weighted normalized decision matrix.

$$\tilde{V} = [v_{ij}]_{m \times n} \tag{14}$$

$i = 1,2,3,\dots,m$ and $j = 1,2,3,\dots,n$

Here, $v_{ij} = r_{ij} \times w_j$

Step IV: Determine the distance between fuzzy ideal (d^+_i) and fuzzy negative ($d^-_i The$) ideal solution.

$$d^*_i = (v^*_1, v^*_2, v^*_3, \dots, v^*_n) \tag{15}$$

where $V^*_j = (1,1,1)$ $j = 1,2,3,\dots,n$

$$d^-_i = (v^-_1, v^-_2, v^-_3, \dots, v^-_n) \tag{16}$$

where $V^-_j = (0,0,0)$ $j = 1,2,3,\dots,n$

Here, the distance between $\tilde{A} = \left(a_1, a_2, a_3\right), \tilde{B} = \left(a_1, a_2, a_3\right)$ is presented as:

$$d\left(\tilde{A}, \tilde{B}\right) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \tag{17}$$

Step V: Develope the closeness constant $\left(CC_i\right)$ of each alternate:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \tag{18}$$

Step VI: Rate and select the right equivalents. It will include the rating of equivalents about an optimal and unfavorable best way by using the FTOPSIS process steps.

4 Results and discussion

The research used a hybrid analysis system for evaluating obstacles to sustainable practices services in SMEs, i.e., fuzzy AHP and fuzzy TOPSIS. Also, this study has proposed various strategies for overcoming the barriers to the sustainable design of SME environmentally friendly business activities. Saudi Arabia is doing a very kind of study introducing green business activities in SMEs. Therefore, the research offers stakeholder groups, decision makers, and authorities a framework for evaluating the integrated decision-making process to solve challenges in Saudi Arabia and effectively implementing environmentally friendly innovation in SMEs. Saudi Arabia has proven and recordable oil reserves of 266.4 billion barrels, accounting for about 22% of global funds. The world produces over 7.5 billion standard cubic feet of natural gas every day and has over 8588 billion m3 reserves. With natural resource supply worth US$75.5 trillion, US$45.5 trillion, and US$34.4 trillion, respectively, Russia is in the first place, the USA is in second place, and the Saudi economy is in third place. The GDP of the Kingdom of Saudi Arabia is about US$795.58 billion, and it is mainly fueled by oil and natural gas production. Saudi Arabia is positioning itself as a technology infrastructure superpower center, with sales reaching US$36 billion in 2017 and projected to top US$40 billion in the coming years. Government actions in numerous fields, such as electricity, telecom, and finance, have led to this technical development. The country's vision 2030, which aims to expand the number of multinational businesses, prioritizes the e-government program. The telecom industry in the region expanded by 55%, and the information technology field now accounts for more than 515 of the overall Middle East economy. The country is working hard to grow the ICT industry to international standards to excel in technology infrastructure in the Middle East by 2030.

4.1 The primary obstacles of fuzzy AHP results

Fuzzy AHP program has identified the main barrier outcomes. Six significant obstacles to green product innovation have been identified by expert assessment and research. The weights and main-barrier rankings are shown in Fig. 2. The results reveal that the most significant barrier that prevents green innovation from being implemented in SMEs is political barriers (PB) (0.191). The remaining major barriers are numbered as follows: 0.000—weight management barriers (MABs), 0.0000—weight technical barriers (TBs), 0.0000—weight barriers to knowledge (IBs), 0.0000—weight economic barriers (EBs), and 0.0000—weight business barriers (MBs).

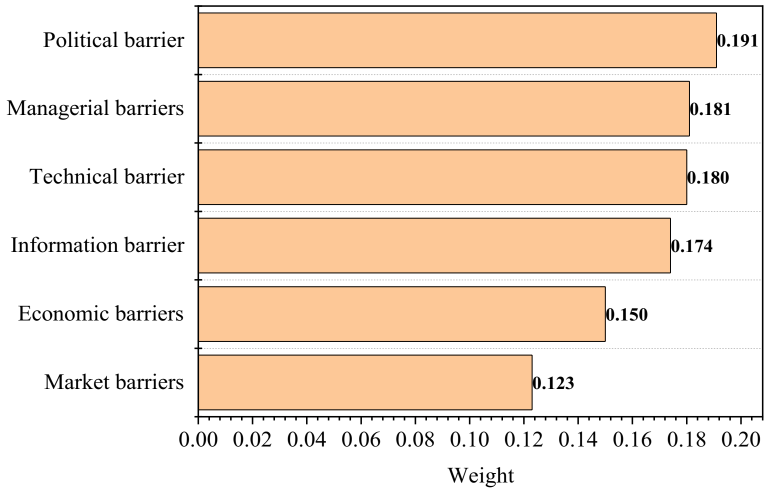


Fig. 2 Ranking of key obstacles with the objective

The findings are similar to the past study by Abdel-Basset et al. 2019. The less technological know-how results in negative effects on the organization's green innovation activities. The business or organization profit from ample R&D, financial capital, and sustainable development and introduce green products of innovation. Environmental resources are important for any SME to sustain themselves in the long term. Economic obstacles include scarcity of technology or a dynamic market for green technologies (Pinget et al. 2015).

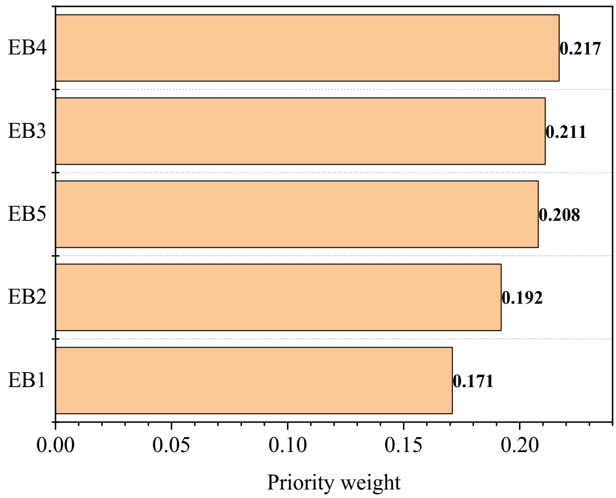


Fig. 3 Weights and sub-barrier rankings for economic barriers (EBs)

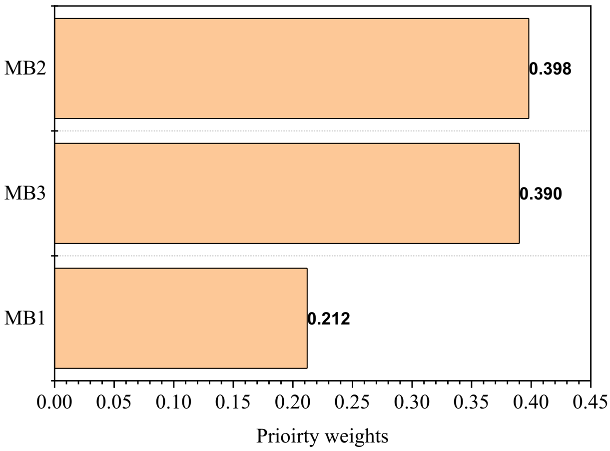


Fig. 4 Weights and sub-barrier rating for market (MB) barriers

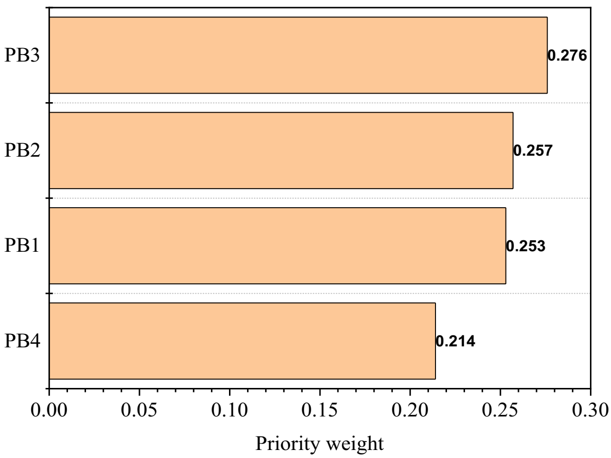


Fig. 5 Weights and sub-barrier ranking regarding the political barriers (PBs)

4.2 The sub-barrier results of Fuzzy AHP

Figure 3 displays the list of weights and sub-barriers concerning economic barriers (EBs). Priority was given to the lack of subsidies and financial benefits (EB3), bank loan unavailability (EB1), and less payoff (EB1), as the most prominent sub-barriers. While high green system costs (EB4) and high waste disposal costs (EB5) are the least important sub-barriers to green innovation, the results show that the lack of subsidies and financial rewards (EB3) is a key sub-barrier.

Figure 4 shows sub-barrier scores like business barriers (MB). The market incapacity (MB1) of 0.0000 weights and the inadequacy of knowledge and understanding (MB3) of 0.00000 weights were therefore classified as major sub-barriers from the MB point of view. Open market doors are required to access green capital to generate green products and increase consumer sensitivity, knowledge and awareness of the green products (Li et al. 2021). So this is important to give.

Figure 5 shows the classification of sub-barriers around political barriers (PBs).

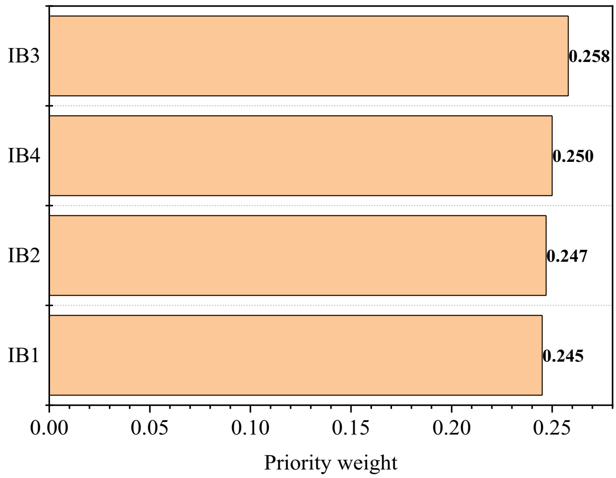
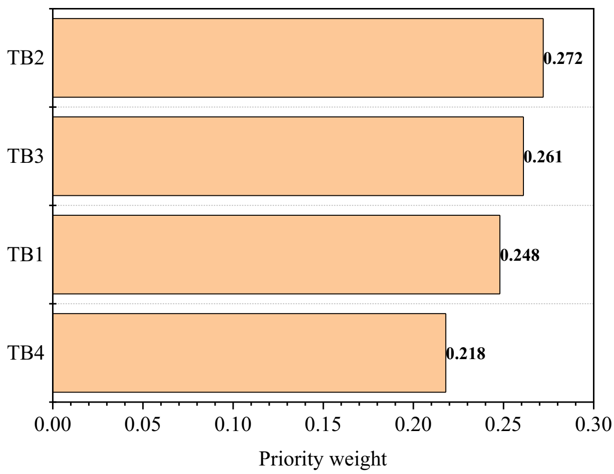


Fig. 6 Weights and classification of sub-barriers about information barriers (IBs)

The findings show that an absence of govt update policy (PB2), 0.390 in weight, is a major obstacle to green innovation for Saudi Arabia's small- and medium-sized enterprises. The second significant sub-barrier while environmental policy (PB3) enforcement and lack of training and advisory programs (PB4) are the least important sub-barriers. The government is expected to make green innovation.

Figure 6 demonstrates the classification of sub-barriers as regards knowledge barriers (IB). Results show that the scarcity of technical data (IB3) is a crucial 0.0000 weight substrate, accompanied by negative attitude (IB1), inadequate information (IB2), and inability (IB4) accordingly. The shortage of technical expertise means that green innovations cannot turn small- and medium-sized companies into sustainable innovation activities. At the same time, there is no knowledge of sustainable rules and policies among employers and contractors. Consequently, it cannot determine the environmental points of view.

Fig. 7 Weights and ranking of sub-barriers concerning the technical barriers (TBs)



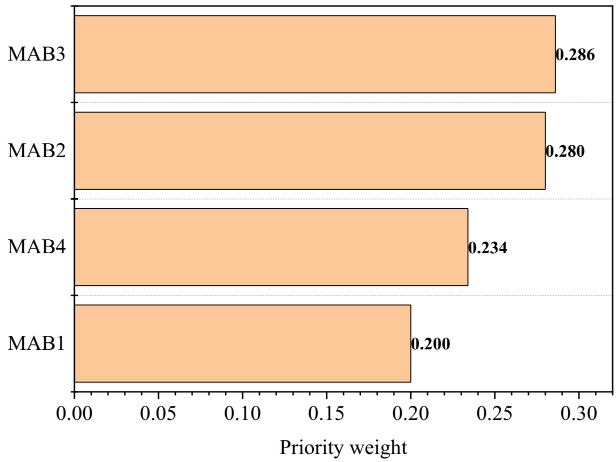


Fig. 8 Weights and ranking of sub-barriers concerning the managerial barriers (MAB)

Figure 7 presents the sub-barrier classification relating to technical barriers (TB). From the TB perspective, the 0.00000—weight lack of R&D capability (TB2)—has been described as the biggest sub-barrier to green growth in SME innovation. Whereas technical and market uncertainty (TB1) is defined as a small- and medium-sized enterprises, Saudi Arabia is a developing nation with limited technical capital, and hence, the government needs huge efforts to include green light.

Figure 8 displays rankings of sub-barriers including barriers to management (MAB). Among SMEs, resistance to sustainable methods (MAB3) weighing 0.0000 is already described as a much more prevalent green technology barrier within the managerial barrier (MAB). The remaining problems were rated as shown in a scarcity of involvement (MAB2), insufficient resources (MAB1), and absence of incentive systems (MAB4).

4.3 The cumulative performance of the subcarriers

The weights of twenty-five subcarriers were measured in this subsection, irrespective of their groping. The final ranking of these general sub-barriers is shown in Fig. 3. The findings showed that the environment policy (PB3) of 0.0527 weights was the main effective sub-barrier, accompanied by dedication (MAB2) of 0.0518 weight and green procurement (MAB3) of 0.0507 weight. The following sub-barriers were identified: Considered sub-barriers in Saudi Arabia's SMEs are impeding green innovation growth. Turn to Appendix B for a detailed analysis of key obstacles to green practices in small- and medium-sized enterprises.

4.4 Fuzzy TOPSIS results

This study proposed various strategies to solve green innovation's major obstacles in Saudi Arabia's small- and medium-sized enterprises. The Soft TOPSIS approach has been used to define green engineering approaches and rank them in this sense. This process study

Table 1 Relevant studies

Year	Country/area	Results	Methodology	References
2018	India	The research reveals problems and proposed approaches to these obstacles. Seven big obstacles were identified in the study, twenty-six as sub-barriers, and twenty methods to overcome them	BWM / FTOPSIS	(Gupta and Barua 2018a)
2018	India	This study explored the role of obstacles to managing the green supply chain in Indian clothing SMEs. This listed 36 barriers to the activities in the green supply chain. For those thirty-six barriers, ten were classified as significant. Obstacles of greatest effect were found to be lacking in growing demands, diverse, sustainable processes, or network architecture	Literature review and interview questions sample	(Majumdar and Sinha 2018)
2018	India	The research found obstacles to sustainable design for small and medium businesses and large companies. Monetary benefits, sustainable policy enforcement, advertising, development, and implementation participation, as well as other related obstacles to sustainable manufacturing, have been identified	Structural analysis of perception	(Seth et al. 2018)
2018	India	The research structure for defining ’SMEs’ obstacles in the green supply chain management. The research, therefore, offers to recommend a sustainable clothing supply chain to overcome these barriers	Structural analysis of perception	(Panigrahi and Rao 2018)
2017	General	During the past two decades, the work has been carried out to establish green innovation determinants. The analysis identified 23 factors and was divided into 7 classes of structural framework showing the connection among factors and approaches to overcoming sustainable; innovative technology obstacles in the manufacturing of SMEs were also discussed	Literature review	(de Jesus Pacheco et al. 2017)
2017	European Union	The research explored the impact of budgetary constraints on sustainable production policies in response to small- and medium-sized enterprises; researchers find that economic obstacles are still a significant obstacle to transformative sustainability. Researchers have found that SMEs largely ignore financial burdens, although they are essential and much more important throughout the financial system. The researchers have tried to address financial obstacles to green innovation with other policies	Equation modeling	(Ghisetti et al. 2017)

Table 1 (continued)

Year	Country/area	Results	Methodology	References
2015	France	The study identified obstacles to SME research and development. The analysis contained a selection of 435 SMEs how small- and medium-sized businesses view these barriers. The most important were listed as barriers to information, obstacles, and financial challenges linked to the business. The researchers noted that these obstacles threaten SMEs that are more committed to green innovation than those that do not follow sustainable initiatives	Regression analysis	(Pinget et al. 2015)
2015	Malaysia	This research paper has shown observations on obstacles that discourage SMEs from implementing green production processes. The authors have used Delphi test approaches to reach a well-founded conclusion on finding and overcoming obstacles. The study offers guidance for SMEs looking to transform traditional practices into green practices	Delphi survey	(Ghazilla et al. 2015)

Table 2 List of main barriers and sub-barriers

Main barrier	Sub-barriers	Code number	Reference
Economic barriers (EBs)	Scarce bank loans	(1)	(Cecere et al. 2018; Mathiyazhagan et al. 2013)
	Least payoff	(2)	(Govindan et al. 2014; Matus et al. 2012)
	Very short financial incentives	(3)	
	The high cost of the green system	(4)	(Hillary 2004)
	Hazardous waste cost	(5)	(Govindan et al. 2014, (Mathiyazhagan et al. 2013)
Market barriers (MBs)	Market out of reach	(1)	(Gupta and Barua 2018a)
	Customers' low responsiveness	(2)	(Ashford 1993; Dhull and Narwal 2016; Silva et al. 2008)
	Trust issues	(3)	(Govindan et al. 2014; Mathiyazhagan et al. 2013; Walker et al. 2008; Revell and Rutherfoord 2003)
Political barrier (PB)	Unclear green policies	(1)	(Zhu et al. 2012a b; Runhaar et al. 2008; Brammer et al. 2012)
	No policy for green technology	(2)	(Blok et al. 2015)
	No policy implementation	(3)	(Zhu et al. 2012a b; Blok et al. 2015; AlKhidir and Zailani 2009; Runhaar et al. 2008)
	No counseling programs	(4)	(Ashford 1993; Urban and Naidoo 2012)
Information barrier (IB)	No information about green products	(1)	(Dhull and Narwal 2016; Mudgal et al. 2010; Chen et al. 2006; Min and Galle 2001)
	Less familiarity with green innovation	(2)	(Runhaar et al. 2008; Mudgal et al. 2010; Mathiyazhagan et al. 2013; Mangla et al. 2017; Longoni et al. 2014; Simpson et al. 2004; Shen and Tam 2002; Horbach et al. 2012)
	Less technological information	(3)	(Mangla et al. 2017; Woolman and Veshagh 2006)
	Rare green innovation opportunities	(4)	(Govindan et al. 2014; Theyel 2000; Runhaar et al. 2008)
Technical barrier (TB)	Market uncertainty	(1)	(Jinzhou 2011; Rao and Holt 2005)
	Minimum R&D	(2)	(Lai et al. 2003),
	Complex designing process	(3)	(Perron 2005; Beamon 1999; Russel 2017)
	Least technologies	(4)	(Del Río et al. 2010)
Managerial barriers (MAB)	Short of staff	(1)	(Lin and Ho 2008; Collins et al. 2007)
	Scarce commitment	(2)	(Ravi and Shankar 2005; Ashford 1993; Zhu et al. 2012a b
	Reluctant green practices	(3)	(Ashford 1993; Zhu et al. 2012a b; Jones et al. 2011; Lin and Ho 2008)
	No reward systems	(4)	(Madrid-Guijarro et al. 2009; Zhu et al. 2012)

created a fluid assessment matrix with the TFN level. The total overview of the fuzzy TOPSIS system is given in Appendix-A. The main results show that research development practices for green practices in small and medium enterprises (S1) are considered the top green innovation approach for small- and medium-sized enterprises growth. Thus, green product design (S6) R&D activities and the successful development of sustainable new policies to mitigate environmental destruction (S5) are also the second and third major sustainable practice techniques designed to address barriers in small- and medium-sized enterprises.

Table 6 presents the prioritizing order of strategies to overcome the barriers to green innovation in SMEs.

Each of the strategies to overcome barriers in green innovation practices is discussed below:

4.4.1. Creation of scientific activities to implement renewable technologies in SMEs (S1): first ranked

The S1 was given priority as the first ranked strategy to overcome the main barriers to green innovation development in Saudi Arabia's SMEs.

4.4.2. Transform research and development (R&D) standards for green product production (S6): second ranked

The S6 has emerged as the second most effective approach for addressing obstacles to renewable innovation in SMEs.

4.4.3. Government's design of effective green policies to reduce environmental degradation (S5): third ranked

The S5 rated third-most effective technique in addressing SMEs' obstacles to green innovation.

4.4.4. Develop Environmental Management Systems for SME monitoring (S3): fourth ranked

The S3 has emerged as the fourth significant strategy for overcoming the barriers to green innovation and SME growth.

4.4.5. Establishment of an eco-logistics center for SMEs (S4): fifth ranked

The PS4 has been ranked as a fifth vital strategy for SMEs to overcome green innovation barriers.

4.4.6. The state will provide SMEs with subsidies and opportunities to manufacture green goods (S9): sixth ranked

The S9 is ranked as the sixth crucial strategy for implementing green innovation practices in Saudi Arabia's SMEs.

4.4.7. Involving all the players in resource protection and procurement programs (S10): seventh ranked

The S10 strategy for overcoming the barriers in green innovation practices was ranked seventh.

4.4.8. Education businessmen in sustainability practices and renewable procurement for SMEs (S7): eighth ranked 4.4.8. Education businessmen in sustainability practices and renewable procurement for SMEs (S7): eighth ranked

The S7 has been rated eighth in importance for green innovation creation in Saudi Arabia's SMEs.

As a second-least effective approach to address the obstacles to renewable engineering, the S2 was prioritized

4.4.10. Human resources preparation for ecological sustainability programs (S8): tenth ranked

The S8 was ranked as the least important strategy for overcoming obstacles in developing green innovation practices.

Table 3 List of strategic solutions

Strategy	Strategy(S) code number	Reference
Design of research activities to implement green innovation in SMEs	(1)	(Dangelico 2016; Horbach et al. 2012; Dangelico 2016)
To coordinate awareness-raising and training activities in public institutions awareness of green innovation in SMEs	(2)	(Solazzo et al. 2016; Mathiyazhagan et al. 2014)
Creation of environmental management systems to track SME systems	(3)	(Zhu et al. 2012a b, (Somsuk and Laosirihongthong 2017; Lee et al. 2014; Johnstone and Hascic 2008)
Establishment of green logistics facility for SMEs	(4)	(Somsuk and Laosirihongthong 2017; Jabbour et al. 2015; Kannan et al. 2014; Zhu et al. 2012)
Develop successful Government green policies to reduce environmental degradation	(5)	(Govindan et al. 2016; Kiss et al. 2013; Arundel and Kemp 2009)
Strengthen research and development activities for clean goods	(6)	(Govindan et al. 2014; Govindan et al. 2016),
Education entrepreneurs about sustainability and green systems for SMEs	(7)	(Gupta and Barua 2017; Mathiyazhagan et al. 2014)
Human resource preparation for green sustainability programs	(8)	(Gupta and Barua 2018b; De Medeiros et al. 2014; Bliesner et al. 2014; Hanim Mohamad Zailani 2012; Corral 2003)
SMEs should receive subsidies and incentives from the government to manufacture green goods	(9)	
Involving all the players in environmental protection and procurement programs	(10)	(Somsuk and Laosirihongthong 2017; Lee et al. 2014; Eltayeb et al. 2011; Awasthi et al. 2010; Zhu et al. 2012)

Table 4 Responsive linguistics scale (Han and Trimi 2018)

No	Responsive linguistics	TFNs
1	Too low (TL)	(1,2,3)
2	Low (L)	(2,3,4)
3	Moderate low (ML)	(3,4,5)
4	Moderate (M)	(4,5,6)
5	Standard (S)	(5,6,7)
6	Moderate standard (MS)	(6,7,8)
7	Better (B)	(7,8,9)

4.5 Discussion

As the world's biggest oil producer with a GDP of $684 billion and 16% of global petroleum reserves, Saudi Arabia plays a vital position in OPEC's economic policies. According to Forbes magazine, petroleum goods account for 87% of expenditure income, 42% of total GDP, and 90% of total exports. According to the IMF, Saudi Arabia will have a budget deficit of 7.8% in 2019 due to lower oil prices, although non-oil exports will rise at a pace of 2.6 percent. These facts are intriguing and shocking, but they do point to a vulnerability in the economy's dependency on oil exports. The key justification for preferring Saudi Arabia is to investigate its reaction to the 2014 oil price crisis; would the Saudi Government restructure its economic dynamics? We attempt to recommend substantial steps to monitor the economic degradation mechanism in light of the emerging financial problems that the Saudi Government is facing. However, the current study adds to the established literature in a variety of ways: first, according to our research, this paper is the first to look at the effect of non-petroleum exports on Saudi Arabia's economy, utilizing the principles and ideas of the export drove development hypothesis. One possible reason derives from the reality that Saudi Arabia's economy is almost exclusively based on oil, which induces environmental destruction and impedes overall economic growth.

Green technology advancement tends to affect total factor efficiency, according to these reports, and can be clarified in three ways. To start, companies participate in green technology advancement practices that are inspired by the core principle of benefit maximization Singh et al. (2020) showed that green technology engineering would create a rewarding impact and raise business income in Italian manufacturing in the face of environmental regulation. The green technology innovation may boost global business competitiveness, utilizing EU members as an illustration, while green technology advancement improved industrial total factor efficiency by enhancing factory cleanliness and technical processes. Second, social regulators and governments create sustainable development strategies that help develop green technology innovation. Green technology innovation, according to Huang and Li (2017), is a major driver of green economic growth, with environmental protection policies stimulating green technology innovation as a particular impact direction. By monitoring and corporating green innovation practices, alleviating knowledge asymmetry, and reducing corporate green funding stresses, Xie et al. (2019) believed that media environmental security supervision could improve the impacts of green technology innovation. Finally, externalities hinder the success of green technology advancement. Green technology advancement, according to El-Kassar and Singh (2019), has two externalities. In the one side, corporations have incurred the risks of green engineering in return for the

Table 5 Weight and average sub-barrier rating

Primary obstacle	Weight of primary obstacle	Sub-obstacles	Number of codes	Sub-carrier priority weights	Global sub-barrier weight	Ranking
Economic obstacles (EB)	0.15	Bank loans are inaccessible	(1)	0.171	0.0257	24
		Less pay	(2)	0.192	0.0288	22
		Lack of subventions and	(3)	0.211	0.0317	20
		Opportunities High costs of a Green Program High costs of disposing of hazardous waste	(4)	0.217	0.0326	19
			(5)	0.208	0.0312	21
Market complications (MBs)	0.123	Incapable of market access	(1)	0.212	0.0261	23
		Lack of response from customers	(2)	0.398	0.0490	6
		Untrustworthy	(3)	0.39	0.0480	8
Political challenges (PB)	0.191	Broad green approaches	(1)	0.253	0.0483	7
		Implementation of green policy	(2)	0.257	0.0491	4
		Lack of government policy on green technology upgrades	(3)	0.276	0.0527	1
		Lack of educational services and outsourcing	(4)	0.214	0.0409	16
Information obstruction (IB)	0.174	Lack of general understanding	(1)	0.245	0.0426	14
		Lack of perspective	(2)	0.247	0.0430	13
		Lack of information on infrastructure	(3)	0.258	0.0449	10
		Knowledge deficit Knowledge deficit	(4)	0.25	0.0435	12
Technical barrier (TB)	0.18	Uncertainty over technology and the market	(1)	0.248	0.0446	11
		Lack of research and development capacity	(2)	0.272	0.0490	5
		Lack of research and development capacity	(3)	0.261	0.0470	9
		No technologies	(4)	0.218	0.0392	17

Table 5 (continued)

Primary obstacle	Weight of primary obstacle	Sub-obstacles	Number of codes	Sub-carrier priority weights	Global sub-barrier weight	Ranking
Managerial hurdles (MB)	0.181	Human capital deficit	(1)	0.2	0.0362	18
		Engagement difference	(2)	0.286	0.0518	2
		Unwillingness to switch to green practices	(3)	0.28	0.0507	3
		Few remuneration schemes	(4)	0.234	0.0424	15

Table 6 Ranking of strategies to overcome barriers to green innovation in SMEs of Saudi-Arabia

Code	Strategy	(d_a^+)	(d_a^-)	CCi	Rank
S1	Developing research practices for implementing green innovation in SMEs	0	13.7843	1	1
S2	Organizing knowledge-raising and training activities at public agencies to increase the awareness of green technologies among SMEs	12.4739	1.292	0.0939	9
S3	Develop environmental management systems for SME monitoring	5.2914	8.5194	0.6169	3
S4	Establishment of green logistics facilities for SMEs	7.3449	6.4403	0.4672	5
S5	Government-led implementation of ambitious green policies to minimize environmental degradation	5.2037	8.6026	0.6231	4
S6	Strengthen research and development (R&D) activities for renewable goods	1.9161	11.8882	0.8612	2
S7	Education businessmen in sustainability practices and renewable procurement for SMEs	11.8829	1.9131	0.1387	8
S8	Training of human resources to green innovation	13.2332	0.5574	0.0404	10
S9	The state will offer discounts and opportunities for green goods to SMEs	9.4487	4.3623	0.3159	6
S10	Involving all players in and purchasing sustainable protection programs	10.599	3.2115	0.2325	7

related gains. On the other hand, pollution charges were not included in manufacturing and operation costs, and businesses were not granted motivation to innovate.

Environmental problems are posed by both end-users and business clients when the planet confronts significant environmental challenges such as climate change, air contamination, and ozone depletion. As a consequence, suppliers' green engineering initiatives have improved. According to previous studies, this sort of effort helps boost product and firm efficiency. We discovered that suppliers' green improvement activities typically result in beneficial partnership results by evaluating organizational customers' data. Customers would be more pleased with the partnership and have a greater confidence in the relationship's profitability as they understand their suppliers' contribution to green innovation activities. Green creativity on the part of vendors does not necessarily result in meaningful consumer reviews or assessments.

As a consequence, we attempted to recognize consumer and partnership contingencies impacting supplier green innovation's positive effects. The results of a supplier's green innovation were considered to be affected by at least four variables. First, if consumers engage in the supplier's invention phase, it contributes to better relational results. Second, since consumers and suppliers hold the same philosophy and principles and participate in improved knowledge sharing, partnerships marked by near-informal links (high relational embeddedness) are more likely to benefit from supplier green innovation activities. Fourth, consumers who are fearful of taking chances may not be involved in green technologies. This is because the efficiency, compatibility, and financial returns of new green goods are always unpredictable.

5 Conclusion and policy implications

In Saudi Arabia, the introduction of green engineering processes, operations or recycling of waste materials, and renewable manufacturing items are only in the beginning process. Because of the inadequate scale, the Saudi Arabic SMEs are lagging. A variety of countries are currently changing their SMEs and introducing green engineering activities that will allow them to overcome the barrier. As far as our best knowledge is concerned, this is the first study to evaluate the hurdles/barriers and overwhelm with best green innovation strategies in Saudi Arabia's SMEs from these barriers. So, the comprehensive decision for developing the framework for green innovation practices has been used for SMEs to understand the extent of these barriers.

To address the analysis void, the hybrid decisions were suggested to help the context of current analysis study researchers, i.e., AHP with fuzzy technique and TOPSIS with fuzzy techniques. This can identify and assess the key obstacles to green innovation adoption and recommend various approaches to overcome these obstacles. The researchers suggested this research study's structure for Saudi Arabia's SMEs with help from the previous literature review and five experts who were very qualified and experienced. Main six barriers were present in this study, and twenty-four sub-barriers were recognized; alongside this, ten tactics were established to overcome the introduction of green innovation in Saudi Arabia's SMEs from these barriers.

The main barriers and sub-barriers have been analyzed and placed using the AHP technique. The results show that the most imperative obstructions are political barriers (PBs). The soft TOPSIS approach was then used to prioritize certain approaches that can address such obstacles. To achieve green innovation, some research approaches in small- and medium-sized companies (small- and medium-sized enterprises) were created (small businesses, size 1), and some very successful strategies were laid out, amongst others, to optimize research and development practices to produce green goods (six). By analyzing those strategies, it will be of great help to managers and policymakers.

This is a comprehensive analysis, and there are also certain drawbacks to this research that can be studied in the future. This study was conducted in Saudi Arabia in green innovation SMEs. This research would also help to equate the results of Saudi Arabian small- and medium-sized companies with those in other countries. Also, in every nation, the execution of green innovation activities in SMEs has its own and varied barriers. This study utilized the TOPSIS-fuzzy AHP and fuzzy strategies; however, MCDM methods such as the VIKOR, ANP, the WASPS, and ELECTRE can be used to compare the findings, to recognize improvements, and to reduce the effect of major obstacles and subsidies in the implementation of green innovation practices. A large number of SMEs are being studied and explored to validate the updated findings. Ultimately, this research study is used only to examine green innovation approaches and obstacles in the small- and medium-sized enterprises market, so more work on this subject can be carried out in a broader context.

5.1 Policy implications

Some policy consequences are suggested to accelerate green innovation and environmentally sustainable economic development. Second, to produce more spatial impact, more focus should be given to geographic direct and spillover effects. Advanced technology, foreign direct investment, environmental regulation instruments, skills, and other services are widely disseminated due to the accumulation and diffusion impact, resulting in a spatially high-quality growth trend assisted by "multi-poles."

Second, it is more crucial and urgent to accelerate the transition and implementation of technological advancement production. Rapidly increasing creativity would not substantially contribute to green innovation development in the eastern and central regions. This likely is because they cannot be adequately adapted to commercial practices. It is important to experience a change in these fields. Consequently, the government could adopt policies that enable companies to grow green technology creativity while simultaneously eliminating structural obstacles. On the one side, promoting technology research and development within companies is significant. On the other side, high-tech industries must be brought into China to have the resources to advance technologically. In the western zone, manufacturing technology is relatively obsolete. The central government must establish policies that enable businesses in the region of the west to collaborate with Saudi Arabia businesses.

Chief managers, industry experts, and politicians will all profit from the results of our analysis. Our research platform seeks to provide recommendations to major industrial organizations on the effect of sustainability policy and green innovation on environmental efficiency execution. General managers and politicians are increasingly focusing on environmental efficiency; in the meantime, they will use the study context of environmental performance in developing markets to mitigate waste, noise, air pollutants, preserve water, conserve electricity, and non-renewable capital, all of which contribute to better environmental results. Consequently, general managers of major industrial firms cannot neglect CSR when assessing environmental efficiency, as many reports have demonstrated that CSR increases operational performance dramatically.

The research suggests three useful implications based on the extensive analytical analysis. To continue, policymakers and economists should concentrate on Saudi Government's economic dependency on oil and petroleum products, which may be minimized. Promoting the non-oil export sector, on the other side, may assist in the achievement of the sustainable development goals (SDGs) and be advantageous to the world. Second, it is more than important for Saudi Arabia to introduce tourism improvements and new policies that will encourage religious and cultural tourists' arrival. As a consequence, the Saudi Government will be willing to concentrate further on economic and institutional reforms.

Last but not least, the Saudi Government could support clean energies and advanced technology investments. Renewable infrastructure projects will help to minimize dependency on fossil fuels while still preserving the atmosphere. Furthermore, ambitious policies on the overall energy balance will assist in industrial and institutional change, eventually resulting in long-term economic development.

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