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Adoption of green innovation practices in SMEs sector: evidence from an emerging economy

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ABSTRACT
In developing world, awareness and environmental concerns are forcing small and medium-sized enterprises to adopt green practices. Hence it is important to distinguish the major obstacles/barriers which hinders the adoption of green practices in SMEs. This study utilizes a framework (three-phase) to classify the major barriers-obstacles and solutions to eliminate these obstacles in green innovation adoption. In total, twenty-five barriers and fifteen solutions were recognized through review of existing literature and experts opinions. Fuzzy Analytical Hierarchal Process (AHP) was utilized to rank these barriers and Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is employed to give appropriate ranks to strategies/solutions to overcome the identified obstacles. The findings of our study revealed that out of six major barriers, legal barriers were the most critical obstacles in green innovation adoption in Pakistani SMEs. Information barriers were the second critical green innovation adoption obstacles/barriers in SMEs, followed by technical-barriers, managerial-barriers, economic-barriers and market-barriers. These findings will offer insights to SMEs stockholders to overcome and eradicate barriers to green innovation, who intend to adopt green practices instead of conventional ones. Our study analysis will assist SMEs in prioritizing the major factors influencing green innovation adoption.

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1. Introduction
The role of small and medium-sized enterprises (SMEs) is significantly considered in the establishments of businesses around the globe. In a country’s economic growth SMEs play a fundamental role in terms of the creation of employment opportunities, wealth and income creation and poverty alleviation. SMEs are the significant source of competitiveness, wealth, dynamism and enhanced livelihood and they can promote sufficient economic evolution. On the social level, SMEs directly affect poverty
alleviation in comparison with multinational corporations. There is an enhanced usage of material and human possessions in a country’s economic system where SMEs are integrated and successful into the reserved economy (Fahad & Wang, 2018; Leo, 2011). The existence of SMEs in developing regions/countries is still very important and has become preferred in economic entities, studies focusing on SMEs in developing countries are still very limited (Savlovschi & Robu, 2011), and this topic deserves more attention (Kahiya, 2018).

Based on existing literature, SMEs sector accounts for almost seventy percent of total waste emissions. Consequently, due to increased awareness, the government also extended their obligation to SMEs for limiting the environmental impacts. Presently, enterprises are under enormous strain to implement environmentally sustainable processes or products because of augmented knowledge among diverse governments worldwide (Arimura et al., 2011; Ozturk, 2011). According to the IPCC report, main ecological problems such as resource environmental pollution, depletion and global warming are occurring due to manufacturing organizations (Fahad & Wang, 2020; IPCC, 2013). This scenario has led both the governmental organizations and non-governmental organizations to give more consideration to the need of switching from old-style exercises to advanced and green technologies.

SMEs are the most significant contributor to greenhouse gas emissions in every region, with inadequate resources, SMEs fails to engage at the projected level. As a result, institutions focus on developing a new set of green strategies and gaining familiarity with innovative green ideas to assist SMEs in reducing their green gas emissions (Atsuyoshi & Francisco, 2014; Ozturk, 2016). The ideal approaches to reduce pollution from green innovation and green environment is suggested by policymakers and researchers. The introduction of innovative green methods, the regulation of dynamic assets, and the monitoring of pollution and waste created. (Ebrahimi & Mirbargkar, 2017; Ozturk, 2017; Su et al., 2021; Zhang & Walton 2017). Small and medium-sized enterprises are regarded as the strength of the economic growth in Pakistan. They engage up to ninety percent of all private ventures in the industrial sector and nearly seventy eight percent of the off-farm workforce. Besides this, it contributes about 36 percent of the value-added in manufacturing products, around 40 percent of GDP and 30 percent of manufactured product exports.

Several studies have attempted to investigate the SMEs operations (Kandasamy et al., 2015; Kongolo, 2010) and their importance (Eze & Okpala, 2015; Harrison & Baldock, 2015). However, studies specifically focusing on SMEs green innovation barriers and their solution are still in dearth. There is still a robust need to scrutinize the present state of the SMEs sector in developing countries like Pakistan and the barriers associated with it that hurdle SMEs to adopt green innovation. It is therefore essential to examine the necessary factors/barriers and their solutions to be executed to preclude them from worst occurring. To fill the existing research gap, we firstly employ Fuzzy AHP to obtain the comparative weights of obstacles/barriers, for which 25 barriers were selected based on existing literature and expert opinions. Secondly, this study uses Fuzzy TOPSIS approaches to obtain the prioritize solutions, for which 15 solutions are presented.
2. Relevant studies

Environmental and green innovations are often described interchangeably, that are the best measures to lessen environmental risk and pollution reduction. According to the researcher (Chen, 2008), green innovation practices can be divided into green system innovation, managerial innovation and green process innovation. Green innovation is considered as an updated process or service that leads to a reduction in environmental shocks (De Marchi, 2012). In the implementation of green innovation, there are always several hinders, that limit the SMEs sector in various aspects. Table 1 summarizes an extensive literature that focused on the identification of major barriers in SMEs green innovation adoption. Based on expert opinions and existing literature, 25 sub-obstacles and 15 strategies to eliminate those obstacles were identified as shown in Tables 2 and 3.

Based on expert opinions and existing literature, 25 sub-obstacles/barriers, and 15 strategies/solutions to overcome those barriers were identified as illustrated in Tables 2 and 3.

Table 1. Relevant literature.

| Findings                                                                 | Type                      | Reference(s)               |
|--------------------------------------------------------------------------|---------------------------|----------------------------|
| This study investigated the SMEs management systems in the European Union, the authors identified barriers and opportunities by studying 33 studies including implementation, support and guidance, resources and perception. | Review                    | (Hillary, 2004)            |
| This study focused on SMEs drivers and obstacles to green innovation in Australia. The barriers reported by authors were lack of knowledge about the environment and availability of resources. | Review                    | (Walker et al., 2008)     |
| The authors conducted a study in Netherland and investigated environmental leaders about recommendations for green innovation. The authors reported 26 barriers including the availability of resources, increased costs and sustainable products. | Survey analysis           | (Runhaar et al., 2008)    |
| This study was conducted in Japan, and the authors mainly reported green innovation approaches. The main barriers the authors identified are regulations, economic barriers, technological barriers, lack of market demand and managerial obstacles. | Survey analysis           | (Arundel & Kemp, 2009)    |
| The authors identified main obstacles to green innovation in European union SMEs, such as technical capabilities, market barriers, knowledge barriers and uncertain returns. | PCA analysis              | (Marin et al., 2015)      |
| This study reported the barriers such as financial barriers, knowledge obstacles and market obstacles to green innovation in French SMEs. | Multinominal logit estimation and regression | (Pinget et al., 2015) |
| The authors analyzed a case study in Slovenia regarding green innovation obstacles in SMEs sector, the main obstacles were internal barrier (cost) and external barrier (legislations). | Case study                | (Hojnik & Ruzzier, 2016)  |
| The main barrier reported by the authors in European union was lack of public funding in SMEs. | Logit regression          | (Cecere et al., 2020)     |
| Authors reported main obstacles/barriers in Malaysia were the product, Environmental resources, government support and perception and attitude barriers to green innovations SMEs. | PLS analysis              | (Abdullah et al., 2016)   |
| This study analyzed the impact of financial barriers SMEs green innovation adoption. Authors reported that financial barriers green innovation adoption was sometimes neglected in SMEs. and they are mostly neglected by SMEs. | SEM analysis              | (Ghisetti et al., 2017)   |

Source: authors compilation.
### Table 2. Main and sub-barriers.

| Barriers     | Code | Sub-barriers                                                                 | References                                                                                     |
|--------------|------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Technical    | T-1  | Lack of new technologies                                                    | (Gunasekaran & Spalanzani, 2012; Hutzschenreuter & Horstkotte, 2010; Jindal & Sangwan, 2011;  |
|              | T-2  | Lack of R&D capacity                                                        | Hung Lau & Wang, 2009; Li & Olorunniwo, 2008; Patil & Kant, 2014; Ravi & Shankar, 2005;    |
|              | T-3  | Complex process                                                            | Thierry et al., 1995)                                                                         |
|              | T-4  | Lack of tools                                                               |                                                                                               |
| Marketing    | MT-1 | Inaccessibility to market                                                   | (Fleischmann, 2001; Geyer & Jackson, 2004; Jindal & Sangwan, 2011; Hung Lau & Wang, 2009;  |
|              | MT-2 | Lack of customer responsiveness                                            | Rogers & Tibben-Lemkte, 1999)                                                                |
|              | MT-3 | Customers’ requirements regulations                                         |                                                                                               |
| Economic     | EC-1 | Unavailability of loans                                                     | (Hicks et al., 2005; Jindal & Sangwan, 2011; Hung Lau & Wang, 2009; Presley et al., 2007;  |
|              | EC-2 | Poor financial resources and lack of staff                                  |                                                                                               |
|              | EC-3 | Less return of investment and high costs                                   |                                                                                               |
|              | EC-4 | High hazard waste disposition costs                                        |                                                                                               |
| Information  | I-1  | Lack of HR knowledge                                                       | (Abdulrahman et al., 2014; Chung & Zhang, 2011; Ghisetti et al., 2017; Hung Lau & Wang, 2009;  |
|              | I-2  | Problems in access of environmental information                             | Zhou et al., 2007)                                                                            |
|              | I-3  | Advice from stakeholders and use of information                             |                                                                                               |
|              | I-4  | Lack of ability                                                             |                                                                                               |
| Managerial   | ML-1 | Lack of human resources                                                     | (Hung Lau & Wang, 2009; Li & Olorunniwo, 2008; Ravi & Shankar, 2005; Srivastava, 2008)       |
|              | ML-2 | Lack of capability to innovate                                              |                                                                                               |
|              | ML-3 | Lack of trainings                                                           |                                                                                               |
| Legal        | ML-4 | Owners’ governance issues                                                   | (Hutzschenreuter & Horstkotte, 2010; Jindal & Sangwan, 2011; Hung Lau & Wang, 2009; Patil &  |
|              |      | Regulations                                                                 | Kant, 2014)                                                                                   |
|              | L-1  | Lack of guidelines and lower support                                        |                                                                                               |
|              | L-2  | Low involvement of governmental support                                     |                                                                                               |
|              | L-3  | Consultancy to monitor the progress of each industry                        |                                                                                               |
|              | L-4  |                                                                                                                         |

Source: authors compilation.

### Table 3. List of 15 essential strategies.

| NO | Strategies                                                                 | References                                                                                     |
|----|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| S1 | State/establishment institutions need to subsidize SMEs to produce green products | (Dat et al., 2012)                                                                           |
| S2 | Enhance R&D exercises                                                     | (Efendigil et al., 2008)                                                                      |
| S3 | Proper discloser of information                                           | (Hung Lau & Wang, 2009)                                                                       |
| S4 | Conducting training programs regarding green innovation                   | (Somsuk & Laosirihongthong, 2017)                                                            |
| S5 | adopt the advance financial mods of financing                            | (Vanhaverbeke, 2006)                                                                         |
| S6 | A concrete SME policy                                                     | (Horbach et al., 2012)                                                                        |
| S7 | Pakistan should have a strategy to provide suppliers for foreign-financed projects | (Eltayeb et al., 2011)                                                                       |
| S8 | Relationships with environmental and social groups                        | (Friedman & Miles, 2002)                                                                      |
| S9 | Provide training to businessmen about green purchasing for SMEs           | (Arundel & Kemp, 2009)                                                                       |
| S10| Increase awareness programs regarding green innovation in SMEs            | (Vanhaverbeke, 2006)                                                                         |
| S11| Easy access to finances from institutions                                 | (Blok et al., 2015)                                                                           |
| S12| Green manufacturing capabilities                                          | (Sarkis, 2001)                                                                               |
| S13| Environmental audits of suppliers                                        | (Corral, 2003)                                                                               |
| S14| Enhanced productivity and firms’ performance                              | (De Medeiros et al., 2014; Kapetanopoulou & Tagaras, 2011; Mathiyazhagan et al., 2014)      |
| S15| Purchasing environmentally friendly raw materials                          |                                                                                               |

Source: authors compilation.
SMEs in general, face several obstacles in the implementation of green innovation due to adequate resources. Existing literature has suggested several solutions/strategies to overcome the obstacles/barriers. According to Kiss et al. (2013), policies designed by the state regarding the adoption of green innovation might be more beneficial. Based on existing literature and expert opinions, several strategies are identified as presented in Table 3.

3. Study framework

This study utilized the application of two combined frameworks (FAHP and FTOPSIS) from the perspective of Pakistani SMEs. This paper is based on the 15 Pakistani SMEs and on consultation of 14 experts for assigning weights to respective barriers and solutions to maintain validity and consistency of resulted weights. The engagement of experts in the implementation of decision methods (multi-criteria) such as Fuzzy AHP and TOPSIS approaches is very essential. Without expert opinions, weights assignment may have uncertainty and could be conflicting. The proposed framework of this study is shown in Figure 1.

4. Fuzzy analytic hierarchy process (FAHP)

The process of constructing a FAHP approach is followed by an established comparison matrix, combining numerous decisions, assessing the reliability of fuzzy weights.
According to (Saaty, 1996) AHP constructs an issue in a hierarchical order, dropping in subsequent stages from an objective to criteria, sub-criteria, and alternative solutions. The hierarchy offers the professionals/experts with an inclusive perspective of complicated interactions and assists them in determining whether the aspects of the same level are equivalent or otherwise. Components are then matched pairwise to determine their weights. Conversely, the substance of AHP, pairwise comparison, presents imprecision since it needs experts’ judgment. In practice, professionals/experts may sometimes be unable to allocate the precise numbers to their preferences because of incomplete information (Chan & Kumar, 2007; Xu & Liao, 2014).

To deal with AHP’s imprecision, precise values are altered with fuzzy sets that comprise linguistic expressions in fuzzy AHP. This ensures ambiguous decisions by allocating degrees of association to specific values to define the degrees, which these numbers relate to an affirmation. The addition of fuzzy sets to AHP, on the other hand, complicates the calculation process because distinct fuzzy sets exist and the affiliated processes are complicated. FAHP has become a popular approach for dealing with difficult decisions. (Kubler et al., 2016). We applied the following fuzzy approach in this study:

In the first step, we construct the paired matrices by using fuzzy numbers. In the second step, by using Equations (1)–(4), we obtained fuzzy synthetic extent values ($SEV_i$):

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

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

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

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

In the step 3, by using equation 5 to get possibility degree $SEV_j = (a_j, b_j, c_j) \geq SEV_i = (a_i, b_i, c_i)$:

$$V( SEV_j \geq SEV_i ) = ( SEV_i \cap SEV_j ) = c_j \begin{cases} 1, & \text{if } b_j \geq b_i \\ 0, & \text{if } a_i \geq c_j \\ \frac{a_i - c_j}{(b_j - c_j) - (b_i - a_i)}, & \text{otherwise} \end{cases}$$
\( d \) denotes the intersection between \( c_{ij} \) and \( c_{ij} \), \( (SEV_i \geq SEV_j) \) and \( (SEV_j \geq SEV_i) \) values are compared with \( SEV_i \) and \( SEV_j \).

In step 4, get the lowest possible degree \( d(i) \) of \( (SEV_j \geq SEV_i) \): and \( ij = 1, 2, 3, 4, 5, \ldots, k \).

\[
(\text{SEV} \geq \text{SEV}_1, \text{SEV}_2, \ldots, \text{SEV}_k),
\]
for \( i = 1, 2, 3, 4, 5, \ldots, k \)

\[
= \{(\text{SEV} \geq \text{SEV}_1) \text{ and } (\text{SEV} \geq \text{SEV}_2) \text{ and } (\text{SEV} \geq \text{SEV}_k)\}
\]

\[
= \min (\text{SEV} \geq \text{SEV}_i)
\]
for \( i = 1, 2, 3, 4, 5, \ldots, k \)

\[
d'(B_i) = \min (\text{SEV}_j \geq \text{SEV}_i),
\]
for \( i = 1, 2, 3, 4, 5, \ldots, k \)

\[
W' = (d'(H_1), d'(H_2), d'(H_3), \ldots, d'(H_n))^T
\]

\( H_i (i = 1, 2, \ldots, n) \) signifies \( n \) components:

In Step 5, standardized vector is as below:

\[
W = (d(H_1), d(H_2), d'(H_3), \ldots, d'(H_n))^T
\]

### 4.1. Fuzzy TOPSIS – (technique for order of preference by similarity ideal solution)

Boran (2017) introduced the TOPSIS approach in 1981, which constructs the association of negative and positive solutions. In this study, we utilized TOPSIS approach to reduce the ambiguity in decisions and obtain consistent results. The fuzzy set theory provides the inestimable problem and information under uncertain environment (Xu et al., 2019). This method is useful for evaluating and ranking alternative solutions by utilizing fuzzy linguistics. As a result, we examined the alternative solutions for each criterion by using TFNs (Triangular fuzzy numbers) as shown in Table 4.

TFN-based Linguistic variables are based on six steps:

In the first step, we assume \( A = (a_1, a_2, a_3) \), \( B = (b_1, b_2, b_3) \) are the 2 uncertain numbers, and the association is as follows:

| S.No | Responsive linguistics (RL) | TFNs |
|------|--------------------------|------|
| One  | Very Low                 | (1-2-3) |
| Two  | Low                      | (2-3-4) |
| Three| Modest low               | (3-4-5) |
| Four | Moderate                 | (4-5-6) |
| Five | Average                  | (5-6-7) |
| Six  | Reasonable Average       | (6-7-8) |
| Seven| Improved                 | (7-8-9) |

Source: Han and Trimi, (2018), authors compilation.
\[ \tilde{A} + \tilde{B} = (a_1, a_2, a_3) + (b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \]  
(9)

\[ \tilde{A} \times \tilde{B} = (a_1, a_2, a_3) \times (b_1, b_2, b_3) = (a_1b_1, a_2b_2, a_3b_3) \]  
(10)

In the second step, we assume \( \tilde{A}_i \) is equal to \( (a_{i1}, a_{i2}, a_{i3}) \) be a T.F.Ns for \( i \in I \).

Subsequently, the normalization of uncertain number of each \( \tilde{A}_i \) is as follows:

\[ \tilde{R} = [r_{ij}]_{m \times n} \]  
(11)

\( i = 1, 2, 3, \ldots, m \) and \( j = 1, 2, 3, \ldots, n \)

The normalization technique is seen as a positive strategy, based on positive considerations:

\[ r_{ij} = \left( \frac{a_{1ij}}{a_{3j}}, \frac{a_{2ij}}{a_{3j}}, \frac{a_{3ij}}{a_{3j}} \right) \]  
(12)

Where \( a_{3j} = \max a_{3ij} \) is it an advantage sort criterion?

For the adverse ideal solution, for instance ‘costs criterion’, the following approach is presented:

\[ r_{ij} = \left( \frac{a_{1i-}}{a_{3ij}}, \frac{a_{2i-}}{a_{2ij}}, \frac{a_{3i-}}{a_{1ij}} \right) \]  
(13)

\( a_{i-} = \min a_{1ij} \) denotes the cost type standard.

In this third step, we applied the hypothesis of the fuzzy standardized matrix.

\[ \tilde{V} = [v_{ij}]_{m \times n} \]  
(14)

\( i = 1, 2, 3, \ldots, m \) and \( j = 1, 2, 3, \ldots, n \)

And \( v_{ij} = r_{ij} \times w_j \)

In step four, we establish the distances between uncertain ideal (\( d_i^+ \)) and uncertain adverse (\( d_i^- \)) ideal solution.

\[ d_i^+ = (v_{i1}^+, v_{i2}^+, v_{i3}^+, \ldots, v_{in}^+) \]

\[ V_j^+ = (1, 1, 1) j = 1, 2, 3, \ldots, n \]  
(15)

\[ d_i^- = (v_{i1}^-, v_{i2}^-, v_{i3}^-, \ldots, v_{in}^-) \]

\[ V_j^- = (0, 0, 0) j = 1, 2, 3, \ldots, n \]  
(16)

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

\[ d(\tilde{A}, \tilde{B}) = \sqrt{\frac{1}{3} [(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2]} \]  
(17)
In step 5, we construct the closeness coefficient \( CC_i \) of each alternate:

\[
CC_i = \frac{d_i^+}{d_i^+ + d_i^-}
\]

where \( i = 1, 2, \ldots, m \); \( d_i^+ \) is the known distance from uncertain constructive solution/strategy; and \( d_i^- \) shows the distance from the uncertain adverse strategy/solution.

In the sixth step, it provided the ranking of equivalents positive and negative solutions.

5. Results and discussion

In this paper, we utilized two combinations (FAHP and FTOPSIS) to determine the barriers to sustainable operation in the field of SMEs. Various methods for addressing the limitations to ecologically responsible SME business and sustainable design for economic actions have been offered in this study.

5.1. Results of AHP and TOPSIS

By the comparison of SMEs green innovation barriers, it is difficult to ascertain which barriers are more important than others, but using the Fuzzy AHP method formed it more comprehensible and useful for decision-makers. The Fuzzy AHP technique was utilized to identify the main obstacles to the implementation of green practices in Pakistani SMEs. This study identified six major obstacles, including market barriers, economic barriers, political barriers, technical barriers, information barriers and managerial barriers, based on the expert assessment and previous literature. According to our research findings, in Pakistani SMEs. In the prioritization of green innovation barriers, we observed the legal barriers with the highest weightage value of (0.185) that were the most critical obstacles to green innovation implementation in Pakistani SMEs. Information barriers with (0.180) were the second critical barrier in SMEs, followed by technical barriers with (0.179), managerial obstacles/barriers (0.175), economic barriers (0.143) and market barriers (0.139) as shown in Table 5. Our results indicated that legal obstacles are the leading obstacles in the implementation of green innovation in Pakistani SMEs. Based on the ranking of sub-criterion weights of legal barriers, sub-criterion (L-3) ‘Low involvement of governmental support’ was considered as highest-ranked sub-weight followed by the other sub-weights ranked as L-3 > L-1 > L-2 > L-4, L-1 denotes regulations, L-2 represents lack of guidelines and lower support where L-4 shows lack of consultancy to monitor the progress of each industry. Our results are consistent with the previous study of (Lin & Ho, 2008) who reported similar findings. Similarly, information barrier sub-criteria, (I-1) ‘problems in access of environmental information’ was the highest weightage barrier and (I-2) ‘absence of HR knowledge’ was the lowest weightage barrier, overall weightage barriers were ranked in the order of I-1 > I-3 > I-4 > I-2, I-3 shows the advice from stakeholders and use of information, where I-4 represents lack of ability. Our findings support the study findings of (Perron et al., 2006). Technical barriers sub-criterion weights are ranked as T-2 > T-3 > T-1 > T-4. This sub-criterion result indicates
that ‘lack of R&D capacity’ is the highest-ranked barrier in the implementation of green innovation in this category (technical barriers), followed by T-3, complex process, T-1 lack of new technologies and T-4 lack of tools. These results are in line with the findings of (Le Pochat et al., 2007), who reported similar results. Our study results also support the findings of (Walker et al., 2008), who reported that being less technologically aware hurts the operation of green innovation in any organization. Likewise ranking of managerial barriers are ranked in descending order as ML-2 > ML-3 > ML-4 > ML-1, which indicates (ML-2) ‘lack of capability to innovate’ among all the other barriers was ranked highest for green innovation in Pakistani SMEs sector followed by ML-3, ML-4 and ML-1, ML-3 shows lack of trainings; ML-4 denotes owners’ governance issues and ML-1 denotes lack of HR. Our results supports the findings of (Ebinger et al., 2006), who reported the similar results. Economic barriers sub-criteria weights are ranked as EC-3 > EC-2 > EC-5 > EC-4 > EC-1 in descending order, that indicates that ‘less return of investment and high costs’ is the top ranking barrier in the implementation of green innovation in SMEs. EC-2 represents poor financial resources and lack of staff, EC-5 shows disposal of perilous wastes costs, EC-4 lack of resources capabilities and EC-1 represents unavailability of loans. Our results findings are in line with (Govindan et al., 2014), who reported similar results. The rating of market barriers are ranked as MT2 > MT3 > MT1 (as shown in Table 5), which shows that “lack of customer responsiveness” has the highest ranking among
overall three sub-criteria of market barriers followed by MT-3 (customer requirements regulations) and MT-1 (inaccessibility to market). Our results are in line with the study of (Govindan et al., 2014; Noci & Verganti, 1999). Table 7 illustrates the paired comparison matrix of major barriers.

Some measures have been proposed to overcome the aforementioned barriers, and it is difficult to determine which measure is more important to overcome the barrier; however, prioritizing the proposed measure may be more advantageous for decision-makers. The measures/solutions were ranked based on the highest closeness coefficient value, indicating that the solution, i.e., state/establishment institutions need to subsidize SMEs to produce green products, is the top priority strategy to eliminate the barriers. The solution “Collaborations with social and environmental groups” is coming at the last priority solution to overcome green innovation obstacles/barriers. However, other solutions ranking are S1-S14-S5-S6-S4-S2-S13-S15-S7-S12-S3-S8-S10-S9-S11 in descending orders. In order to eliminate the barriers/obstacles in the adoption of green innovation, Pakistani SMEs need to prioritize the implementation of these solutions as shown in Table 6.

### Table 6. Ranking of solutions/strategies.

| Solutions | $d^+$ | $d^-$ | (CCI) | Final Ranking |
|-----------|-------|-------|-------|---------------|
| S1        | 0.2027 | 17.4396 | 0.9885 | 1             |
| S2        | 14.6808 | 2.9747  | 0.1685 | 14            |
| S3        | 6.4811  | 11.1668 | 0.6328 | 5             |
| S4        | 8.7364  | 8.9194  | 0.5052 | 6             |
| S5        | 6.1388  | 11.5145 | 0.6523 | 4             |
| S6        | 2.2391  | 15.4256 | 0.8732 | 2             |
| S7        | 13.7668 | 3.8656  | 0.2192 | 13            |
| S8        | 15.0514 | 2.5245  | 0.1436 | 15            |
| S9        | 10.2802 | 7.3666  | 0.4174 | 7             |
| S10       | 12.4175 | 5.2015  | 0.2952 | 12            |
| S11       | 5.8444  | 11.8221 | 0.6692 | 3             |
| S12       | 10.9721 | 6.6644  | 0.3779 | 8             |
| S13       | 11.134  | 6.4966  | 0.3685 | 10            |
| S14       | 11.0857 | 6.5753  | 0.3723 | 9             |
| S15       | 11.1765 | 6.4647  | 0.3665 | 11            |

Source: authors compilation.

### Table 7. Table Paired comparison matrix of main/major barriers.

|          | EC | MT | L   | I   | T   | ML  |
|----------|----|----|-----|-----|-----|-----|
| EC       | 1  | 1  | 1   | 0.695 | 0.95 | 1.272 |
| MT       | 0.786 | 1.052 | 1.438 | 1    | 1   | 0.605 |
| L        | 0.879 | 1.176 | 1.568 | 0.41 | 1.198 | 1.65 |
| I        | 1   | 1   | 1   | 0.605 | 0.834 | 1.188 |
| T        | 1   | 1   | 1   | 0.605 | 0.834 | 1.188 |
| ML       | 1   | 1   | 1   | 0.605 | 0.834 | 1.188 |

Source: authors compilation.

6. Conclusion

In the recent era, it is very hard to force SMEs to adopt sustainable green innovation practices because of various types of barriers associated with it. It is challenging to assume all the strategies at once; therefore, it is essential to prioritize the strategies for further implementation to eliminate the obstacles/barriers in the adoption of
green innovation measures. We specifically used a multicriteria method of decision method to prioritize the strategies/solutions to eliminate the SMEs obstacles in Pakistan. Barriers/obstacles were chosen based on existing literature and published reports, and linguistic ranks were designated to each criterion with the assistance of a decision-making team. In this study, we identified 25 barriers and presented 15 solutions based on existing literature and the evaluation process. We utilized FAHP method to establish the barriers relative weights and FTOPSIS approach to prioritizing the strategies/solutions. Our results revealed that out of six major barriers, legal barriers were the most critical obstacles in green innovation adoption in Pakistani SMEs. Information-barriers were the second critical green innovation adoption obstacles/barriers in SMEs, followed by technical-barriers, managerial-barriers, economic-barriers and market-barriers. Based on the ranking of sub-criterion weights of legal barriers, sub-criterion (L3) “low involvement of governmental support” was considered as the highest ranked sub-weight in legal barriers. Solutions prioritization would be beneficial for policymakers to implement the solutions to overcome the obstacles in green innovation adoption in the SMEs sector.

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