Economic Research-Ekonomska Istraživanja

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

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

Shah Fahad, Faisal Alnori, Fang Su & Jian Deng

To cite this article: Shah Fahad, Faisal Alnori, Fang Su & Jian Deng (2022) Adoption of green innovation practices in SMEs sector: evidence from an emerging economy, Economic Research-Ekonomska Istraživanja, 35:1, 5486-5501, DOI: 10.1080/1331677X.2022.2029713

To link to this article: https://doi.org/10.1080/1331677X.2022.2029713

Published online: 07 Feb 2022.

ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
2022, VOL. 35, NO. 1, 5486–5501
https://doi.org/10.1080/1331677X.2022.2029713

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

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

Shah Fahad[a], Faisal Alnori[b], Fang Su[c] and Jian Deng[a]

[a]School of Economics and Management, Leshan Normal University, Leshan, Sichuan, China; [b]Faculty of Economics and Administration, King Abdulaziz University, Jeddah, Saudi Arabia; [c]School of Economics and Management, Shaanxi University of Science & Technology, Xi'an, Shaanxi, China

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.

ARTICLE HISTORY
Received 20 October 2021
Accepted 11 January 2022

KEYWORDS
Analytical Hierarchal Process method (AHP); fuzzy TOPSIS; green innovation; SMEs; Pakistan

JEL CODES
O10; O11; O25

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

CONTACT Jian Deng shah.fahad@mail.xjtu.edu.cn

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; Hung Lau & Wang, 2009; Li & Olorunniwo, 2008; Patil & Kant, 2014; Ravi & Shankar, 2005; Thierry et al., 1995)
	T-2	Lack of R&D capacity	
	T-3	Complex process	
	T-4	Lack of tools	
Marketing	MT-1	Inaccessibility to market	(Fleischmann, 2001; Geyer & Jackson, 2004; Guide & Srivastava, 1997; Jindal & Sangwan, 2011; Hung Lau & Wang, 2009; Li & Olorunniwo, 2008; Ravi & Shankar, 2005; Srivastava, 2008; Stock, 2001)
	MT-2	Lack of customer responsiveness	
	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; Rogers & Tibben-Lembke, 1999)
	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 lack of resources capabilities	
	EC-5	Disposal of perilous wastes costs	
Information	I-1	Problems in access of environmental information	(Abdulrahman et al., 2014; Chung & Zhang, 2011; Ghisetti et al., 2017; Hung Lau & Wang, 2009; Pinget et al., 2015; Zhou et al., 2007)
	I-2	Absence of HR knowledge	
	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	
	L-1	Regulations	(Hutzschenreuter & Horstkotte, 2010; Jindal & Sangwan, 2011; Hung Lau & Wang, 2009; Patil & Kant, 2014)
	L-2	Lack of guidelines and lower support	
	L-3	Low involvement of governmental support	
	L-4	Consultancy to monitor the progress of each industry	

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 practices in SMEs	(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	
S12	Green manufacturing capabilities	(Blok et al., 2015)
S13	Environmental audits of suppliers	(Sarkis, 2001)
S14	Enhanced productivity and firms' performance	(Corral, 2003)
S15	Purchasing environmentally friendly raw materials	(De Medeiros et al., 2014; Kapetanopoulou & Tagaras, 2011; Mathiyazhagan et al., 2014)

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.

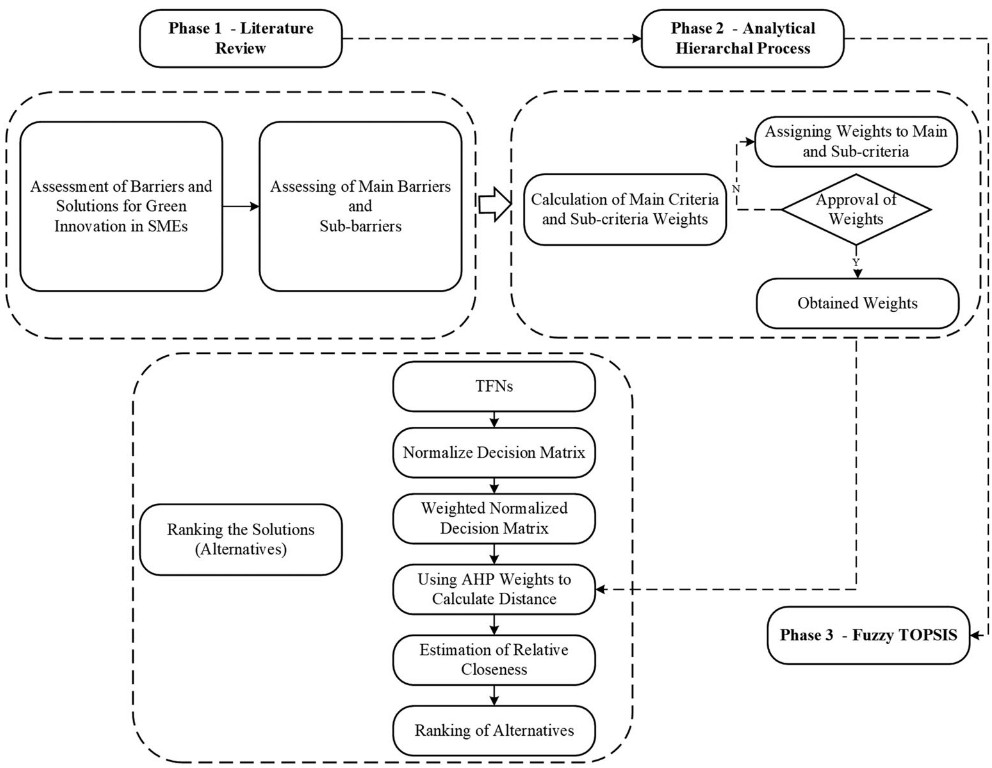

Figure 1. Study framework.
Source: authors compilation.

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) :

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

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

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

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

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

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

d denotes the intersection between c_{s_j} andc_{s_i}, $(SEV_i \geq SEV_j)$ 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 $ij = 1, 2, 3, 4, 5, \ldots, k$.

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

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

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

H_1 $(i = 1, 2, \ldots., n)$ signifies n components:

In Step 5, standardized vector is as below:

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

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 $\tilde{A} = (a_1, a_2, a_3)$, $\tilde{B} = (b_1, b_2, b_3)$ are the 2 uncertain numbers, and the association is as follows:

Table 4. Represent the TFNs (Triangular fuzzy numbers) scale.

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.

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

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

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:

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

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

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

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

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:

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

$a^-_{1j} = min\ a_{1ij}$ denotes the cost type standard.

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

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

$i = 1, 2, 3, \ldots, m$ 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.

$$\begin{aligned} d_i^* &= (v_1^*, v_2^*, v_3^*, \ldots, v_n^*) \\ V_j^* &= (1, 1, 1) j = 1, 2, 3, \ldots, n \end{aligned} \tag{15}$$

$$\begin{aligned} d_i^- &= (v_1^-, v_2^-, v_3^-, \ldots, v_n^-) \\ V_j^- &= (0, 0, 0) j = 1, 2, 3, \ldots, n \end{aligned} \tag{16}$$

Here, the distance between$\sim$ $A = (a_1, a_2, a_3)$, $\sim B = (a_1, a_2, a_3)$ is presented as:

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

In step 5, we construct the closeness coefficient (CC_i) of each alternate:

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

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

Table 5. Ranking of main/major barriers.

Main barriers	Sub-barriers	Code	Rank	Main criteria weights	Priority weights of sub-criteria	Global weights of sub-criteria
Economic barriers	Unavailability of loans	EC-1	4th	0.143	0.196	0.028028
	Limited financial and staff resources and environmental legislation	EC-2	2nd		0.206	0.029458
	Less return of investment and high costs	EC-3	1st		0.218	0.031174
	lack of resources capabilities	EC-4	5th		0.182	0.026026
	Disposal of perilous wastes costs	EC-5	3rd		0.198	0.028314
Marketing barriers	Inaccessibility to market	MT-1	3rd	0.139	0.278	0.038642
	Lack of customer responsiveness	MT-2	1st		0.366	0.050874
	Customers' requirements regulations	MT-3	2nd		0.356	0.049484
Legal barriers	Regulations	L-1	2nd	0.185	0.255	0.047175
	Lack of guidelines and lower support	L-2	3rd		0.241	0.044585
	Low involvement of governmental support	L-3	1st		0.286	0.05291
	Consultancy to monitor progress of each industry	L-4	4th		0.219	0.040515
Information barrier	Problems in access of environmental information	I-1	1st	0.180	0.253	0.04554
	Absence of HR knowledge	I-2	4th		0.247	0.04446
	Advice from stakeholders and use of information	I-3	2nd		0.25	0.045
	Lack of ability	I-4	3rd		0.249	0.04482
Technical barrier	Lack of new technologies	T-1	3rd	0.179	0.235	0.042065
	Lack of R&D capacity	T-2	1st		0.258	0.046182
	Complex process	T-3	2nd		0.277	0.049583
	Lack of tools	T-4	4th		0.23	0.04117
Managerial barriers	Lack of HR	ML-1	4th	0.175	0.188	0.0329
	Lack of capability to innovate	ML-2	1st		0.281	0.049175
	Lack of training	ML-3	2nd		0.291	0.050925
	Owners' governance issues	ML-4	3rd		0.24	0.042

Source: authors compilation.

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

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*	*0.637*	*0.849*	*1.137*	*0.555*	*0.714*	*0.991*	*0.616*	*0.819*	*1.158*	*0.726*	*0.975*	*1.337*
MT	0.786	1.052	1.438	1	1	1	0.605	0.834	1.188	0.58	0.765	1.081	0.565	0.732	1.035	0.566	0.765	1.109
L	0.879	1.176	1.568	0.41	1.198	1.65	1	1	1	0.739	1.044	1.449	0.847	1.138	1.544	0.863	1.206	1.621
I	1.0084	1.399	1.799	0.924	1.306	1.723	0.69	0.957	1.353	1	1	1	0.746	0.971	1.283	0.668	0.917	1.263
T	0.863	1.219	1.621	0.965	1.364	1.767	0.647	0.878	1.179	0.863	1.147	1.502	1	1	1	0.649	0.91	1.272
ML	0.748	1.025	1.377	0.901	1.306	1.767	0.616	0.829	1.158	0.791	1.09	1.496	0.786	1.098	1.541	1	1	1

Source: authors compilation.

overall three sub-criterions 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.

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.

Disclosure statement

The authors declare no conflict of interest.

Funding

Not applicable

ORCID

Shah Fahad http://orcid.org/0000-0002-7080-3031
Fang Su http://orcid.org/0000-0002-6319-5103

References

Abdullah, M., Zailani, S., Iranmanesh, M., & Jayaraman, K. (2016). Barriers to green innovation initiatives among manufacturers: The Malaysian case. *Review of Managerial Science*, *10*(4), 683–709. 10.1007/s11846-015-0173-9

Abdulrahman, M. D., Gunasekaran, A., & Subramanian, N. (2014). Critical barriers in implementing reverse logistics in the Chinese manufacturing sectors. *International Journal of Production Economics*, *147*, 460–471. doi:10.1016/j.ijpe.2012.08.003.

Arimura, T. H., Darnall, N., & Katayama, H. (2011). Is ISO 14001 a gateway to more advanced voluntary action? The case of green supply chain management. *Journal of Environmental Economics and Management*, *61*(2), 170–182.

Arundel, A., & Kemp, R. (2009). Measuring eco-innovation.

Atsuyoshi, M., & Francisco, J. V. (2014). *Public spending and growth: the role of government accountability*. Discussion Papers 2014/18, University of Nottingham, Centre for Finance, Credit and Macroeconomics (CFCM).

Blok, V., Long, T. B., Gaziulusoy, A. I., Ciliz, N., Lozano, R., Huisingh, D., Csutora, M., & Boks, C. (2015). From best practices to bridges for a more sustainable future: Advances and challenges in the transition to global sustainable production and consumption: Introduction to the ERSCP stream of the Special volume. *Journal of Cleaner Production*, *108*, 19–30. doi:10.1016/j.jclepro.2015.04.119]

Boran, K. (2017). An evaluation of power plants in Turkey: Fuzzy TOPSIS method. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(2), 119–125. doi:10.1080/15567249.2015.1050561.

Cecere, G., Corrocher, N., & Mancusi, M. L. (2020). Financial constraints and public funding of eco-innovation: empirical evidence from European SMEs. *Small Business Economics*, *54*(1), 285–302. doi:10.1007/s11187-018-0090-9.

Chan, F. T. S., & Kumar, N. (2007). Global supplier development considering risk factors using fuzzy extended AHP-based approach. *Omega*, *35*, 417–431.

Chung, S.-S., & Zhang, C. (2011). An evaluation of legislative measures on electrical and electronic waste in the People's Republic of China. *Waste Management (New York, N.Y.)*, *31*(12), 2638–2646. doi:10.1016/j.wasman.2011.07.010.

Corral, C. M. (2003). Sustainable production and consumption systems—cooperation for change: assessing and simulating the willingness of the firm to adopt/develop cleaner technologies. The case of the In-Bond industry in northern Mexico. *Journal of Cleaner Production*, *11*, 411–426.

Dat, L. Q., Linh, D. T. T., Chou, S.-Y., & Vincent, F. Y. (2012). Optimizing reverse logistic costs for recycling end-of-life electrical and electronic products. *Expert Systems with Applications*, *39*(7), 6380–6387. doi:10.1016/j.eswa.2011.12.031.

De Marchi, V. (2012). Environmental innovation and R&D cooperation: empirical evidence from Spanish manufacturing firms. *Research Policy*, *41*(3), 614–623.

De Medeiros, J. F., Ribeiro, J. L. D., & Cortimiglia, M. N. (2014). Success factors for environmentally sustainable product innovation: A systematic literature review. *Journal of Cleaner Production*, *65*, 76–86. doi:10.1016/j.jclepro.2013.08.035.

Ebinger, F., Goldbach, M., & Schneidewind, U. (2006). Greening supply chains: a competence-based perspective. In *Greening the Supply Chain* (pp. 251–269). Springer. https://doi.org/10.1007/1-84628-299-3_14

Ebrahimi, P., & Mirbargkar, S. M. (2017). Green entrepreneurship and green innovation for SME development in market turbulence. *Eurasian Business Review*, *7*, 203–228.

Efendigil, T., Önüt, S., & Kongar, E. (2008). A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness. *Computers & Industrial Engineering*, *54*(2), 269–287. doi:10.1016/j.cie.2007.07.009.

Eltayeb, T. K., Zailani, S., & Ramayah, T. (2011). Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. *Resources, Conservation and Recycling*, *55*(5), 495–506. doi:10.1016/j.resconrec.2010.09.003.

Eze, T., & Okpala, C. (2015). Quantitative analysis of the impact of small and medium scale enterprises on the growth of Nigerian economy: (1993–2011). *International Journal of Development and Emerging Economics*, *3*(1), 26–38.

Fahad, S., & Wang, J. (2018). Farmers' risk perception, vulnerability, and adaptation to climate change in rural Pakistan. *Land Use Policy*, *79*, 301–309. doi:10.1016/j.landusepol.2018.08.018]

Fahad, S., & Wang, J. (2020). Climate change, vulnerability, and its impacts in rural Pakistan: A review. *Environmental Science and Pollution Research International*, *27*(2), 1334–1338. https://doi.org/10.1007/s11356-019-06878-1

Fleischmann, M. (2001). Reverse Logistics Network Structures and Design. (No. ERS-2001-52-LIS). ERIM Report Series Research in Management, Erasmus Research Institute of Management (ERIM), Erasmus University and the Erasmus School of Economics (ESE), Erasmus University Rotterdam.

Friedman, A. L., & Miles, S. (2002). SMEs and the environment: evaluating dissemination routes and handholding levels. *Business Strategy and the Environment*, *11*(5), 324–341. doi:10.1002/bse.335.

Geyer, R., & Jackson, T. (2004). Supply loops and their constraints: The industrial ecology of recycling and reuse. *California Management Review*, *46*(2), 55–73. doi:10.2307/41166210.

Ghisetti, C., Mancinelli, S., Mazzanti, M., & Zoli, M. (2017). Financial barriers and environmental innovations: evidence from EU manufacturing firms. *Climate Policy*, *17*(sup1), S131–S147. doi:10.1080/14693062.2016.1242057.

Govindan, K., Kaliyan, M., Kannan, D., & Haq, A. N. (2014). Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Economics*, *147*, 555–568. doi:10.1016/j.ijpe.2013.08.018.

Guide, V. D. R., & Srivastava, R. (1997). Buffering from material recovery uncertainty in a recoverable manufacturing environment. *The Journal of the Operational Research Society* , *48*(5), 519–529. doi:10.2307/3010510.

Gunasekaran, A., & Spalanzani, A. (2012). Sustainability of manufacturing and services: Investigations for research and applications. *International Journal of Production Economics, 140*(1), 35–47. doi:10.1016/j.ijpe.2011.05.011.

Han, H., & Trimi, S. (2018). A fuzzy TOPSIS method for performance evaluation of reverse logistics in social commerce platforms. *Expert Systems with Applications*, *103*, 133–145. doi:10.1016/j.eswa.2018.03.003.

Harrison, R. T., & Baldock, R. (2015). Financing SME growth in the UK: Meeting the challenges after the global financial crisis. *Venture Capital*, *17*(1–2), 1–6. https://doi.org/10.1080/13691066.2015.1050241

Hicks, C., Dietmar, R., & Eugster, M. (2005). The recycling and disposal of electrical and electronic waste in China—legislative and market responses. *Environmental Impact Assessment Review*, *25*(5), 459–471. doi:10.1016/j.eiar.2005.04.007.

Hillary, R. (2004). Environmental management systems and the smaller enterprise. *Journal of Cleaner Production*, *12*(6), 561–569. doi:10.1016/j.jclepro.2003.08.006.

Hojnik, J., & Ruzzier, M. (2016). Drivers of and barriers to eco-innovation: a case study. *International Journal of Sustainable Economy*, *8*(4), 273–294. doi:10.1504/IJSE.2016.079433.

Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact—The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, *78*, 112–122. doi:10.1016/j.ecolecon.2012.04.005.

Hung Lau, K., & Wang, Y. (2009). Reverse logistics in the electronic industry of China: A case study. *Supply Chain Management*, *14*(6), 447–465. https://doi.org/10.1108/13598540910995228

Hutzschenreuter, T., & Horstkotte, J. (2010). Knowledge transfer to partners: a firm level perspective. *Journal of Knowledge Management*, *14*(3), 428–448. doi:10.1108/13673271011050148.

Jindal, A., & Sangwan, K. S. (2011). *Development of an interpretive structural model of barriers to reverse logistics implementation in Indian industry, Glocalized solutions for sustainability in manufacturing* (pp. 448–453). Springer.

Kandasamy, S., Chay Yoke, C., Leng Yean, U., Peck Ling, T., Wei Fong, P., & Nai-Chiek, A. (2015). Contribution of SMEs to economic development of ASEAN countries: the three focus areas. *Global Journal of Business and Social Science Review*, *3*(3), 1–13.

Kapetanopoulou, P., & Tagaras, G. (2011). Drivers and obstacles of product recovery activities in the Greek industry. *International Journal of Operations & Production Management*, *31*(2), 148–166. doi:10.1108/01443571111104746.

Kiss, B., Manchón, C. G., & Neij, L., (2013). The role of policy instruments in supporting the development of mineral wool insulation in Germany, Sweden and the United Kingdom. *Journal of Cleaner Production*, *48*, 187–199.

Kubler, S., Robert, J., Derigent, W., Voisin, A., & le Traon, Y. (2016). A state-of the-art survey & testbed of Fuzzy AHP (FAHP) applications. *Expert Systems with Applications*, *65*, 398–422.

Le Pochat, S., Bertoluci, G., & Froelich, D. (2007). Integrating ecodesign by conducting changes in SMEs. *Journal of Cleaner Production*, *15*(7), 671–680. doi:10.1016/j.jclepro.2006.01.004.

Leo, B. (2011). New SME Financial Access Initiatives: Private Foundations' Path to Donor Partnerships. Center for Global Development Working Paper.

Li, X., & Olorunniwo, F. (2008). An exploration of reverse logistics practices in three companies. *Supply Chain Management: An International Journal*, *13*(5), 381–386. doi:10.1108/13598540810894979.

Lin, C.-Y., & Ho, Y.-H. (2008). An empirical study on logistics service providers' intention to adopt green innovations. *Journal of Technology Management & Innovation*, *3*, 17–26.

Marin, G., Marzucchi, A., & Zoboli, R. (2015). SMEs and barriers to Eco-innovation in the EU: exploring different firm profiles. *Journal of Evolutionary Economics*, *25*(3), 671–705. doi:10.1007/s00191-015-0407-7.

Mathiyazhagan, K., Govindan, K., & Noorul Haq, A. (2014). Pressure analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Research*, *52*(1), 188–202. doi:10.1080/00207543.2013.831190.

Noci, G., & Verganti, R. (1999). Managing 'green'product innovation in small firms. *R&d Management*, *29*(1), 3–15. doi:10.1111/1467-9310.00112]

Ozturk, I. (2011). The Macroeconomic Effects of IMF Programs in Mena Countries. *African Journal of Business Management*, *5*(11), 4379–4387.

Ozturk, I. (2016). The Relationships among Tourism Development, Energy demand and Growth Factors in Developed and Developing Countries. *International Journal of Sustainable Development & World Ecology*, *23*(2), 122–131. https://doi.org/10.1080/13504509.2015.1092000

Ozturk, I. (2017). The Dynamic Relationship between Agricultural Sustainability and Food Energy-Water Poverty in a Panel of Selected Sub-Saharan African Countries. *Energy Policy*, *107*, 289–299. doi:10.1016/j.enpol.2017.04.048.

Patil, S. K., & Kant, R. (2014). A fuzzy AHP-TOPSIS framework for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers. *Expert Systems with Applications*, *41*(2), 679–693. doi:10.1016/j.eswa.2013.07.093.

Perron, G. M., Côté, R. P., & Duffy, J. F. (2006). Improving environmental awareness training in business. *Journal of Cleaner Production*, *14*(6-7), 551–562. doi:10.1016/j.jclepro.2005.07.006.

Pinget, A., Bocquet, R., & Mothe, C. (2015). Barriers to environmental innovation in SMEs: Empirical evidence from French firms. *M@n@gement*, *18*(2), 132–155. doi:10.3917/mana.182.0132.

Presley, A., Meade, L., & Sarkis, J. (2007). A strategic sustainability justification methodology for organizational decisions: a reverse logistics illustration. *International Journal of Production Research*, *45*(18-19), 4595–4620. doi:10.1080/00207540701440220.

Ravi, V., & Shankar, R. (2005). Analysis of interactions among the barriers of reverse logistics. *Technological Forecasting and Social Change*, *72*(8), 1011–1029. doi:10.1016/j.techfore.2004.07.002.

Rogers, D. S., & Tibben-Lembke, R. S. (1999). *Going backwards: Reverse logistics trends and practices*. Reverse Logistics Executive Council.

Runhaar, H., Tigchelaar, C., & Vermeulen, W. J. (2008). Environmental leaders: making a difference. A typology of environmental leaders and recommendations for a differentiated policy approach. *Business Strategy and the Environment*, *17*(3), 160–178. doi:10.1002/bse.520.

Saaty, T. L. (1996). *Decision Making with Dependence and Feedback: The Analytic Network Process*. Pittsburgh: RWS Publications.

Sarkis, J. (2001). Manufacturing's role in corporate environmental sustainability-Concerns for the new millennium. *International Journal of Operations & Production Management*, *21*(5/6), 666–686. doi:10.1108/01443570110390390.

Savlovschi, L. I., & Robu, N. R. (2011). The role of SMEs in modern economy. *Economia, Seria Management*, *14*, 277–281.

Somsuk, N., & Laosirihongthong, T. (2017). Prioritization of applicable drivers for green supply chain management implementation toward sustainability in Thailand. *International Journal of Sustainable Development & World Ecology*, *24*(2), 175–191. doi:10.1080/13504509.2016.1187210.

Srivastava, S. K. (2008). Network design for reverse logistics. *Omega*, *36*(4), 535–548. doi:10.1016/j.omega.2006.11.012.

Stock, J. R. (2001). The 7 deadly sins of reverse logistics. *Material Handling Management*, *56*, MHS5–MHS5.

Su, F., Liang, X., Cai, S., Chen, S., & Fahad, S. (2021). Assessment of parent-subsidiary companies' geographical distance effect on corporate social responsibility: a case of A-share listed companies. *Economic Research-EKONOMSKA Istraživanja*, 1–25. https://doi.org/10.1080/1331677X.2021.2019597

Thierry, M., Salomon, M., Van Nunen, J., & Van Wassenhove, L. (1995). Strategic issues in product recovery management. *California Management Review*, *37*(2), 114–136. doi:10.2307/41165792.

Vanhaverbeke, W. (2006). The interorganizational context of open innovation. *Open Innovation: Researching a New Paradigm*, 205–219. http://www.openinnovation.net/Book/NewParadigm/Chapters/

Walker, H., Di Sisto, L., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of Purchasing and Supply Management*, *14*(1), 69–85. doi:10.1016/j.pursup.2008.01.007.

Xu, L., Wang, Y., Shah, S. A. A., Zameer, H., Solangi, Y. A., Walasai, G. D., & Siyal, Z. A. (2019). Economic viability and environmental efficiency analysis of hydrogen production processes for the decarbonization of energy systems. *Processes*, *7*, 494. doi:10.3390/pr7080494

Xu, Z., & Liao, H. (2014). Intuitionistic Fuzzy analytic hierarchy process. *IEEE Transactions on Fuzzy Systems*, *22*, 749–761.

Zhang, J. A., & Walton, S. (2017). Eco-innovation and business performance: the moderating effects of environmental orientation and resource commitment in green-oriented SMEs. *R&D Management in SMEs*, *47*, E26–E39.

Zhou, L., Naim, M. M., & Wang, Y. (2007). Soft systems analysis of reverse logistics battery recycling in China. *International Journal of Logistics Research and Applications*, *10*(1), 57–70. doi:10.1080/13675560600717847.