Investigation of Drivers Towards Adoption of Circular Economy: A DEMATEL Approach

Annayath Maqbool, Shahbaz Khan, Abid Haleem and Mohd Imran Khan

Abstract The increased population, scarcity of resources and environmental consciousness put the tremendous stress on the organisations to fulfil the demand in sustainable way. The current linear model is based on the take-make-use-destroy model, which has many limitations in terms of resource utilisation and environmental impact. To overcome such limitation, circular economy is proposed. The main aim of circular economy is to create a circular system that maximises the resource value and enhances the material and product. However, the adoption of the circular economy is challenging and required some essential/motivational factor. This study is identifying the ten major drivers towards the adoption of circular economy. Further, these drivers are categorised into two groups utilising the decision-making trial and evaluation laboratory (DEMATEL). The result of this study explored that most influential drivers are 'government policies for cleaner production' and 'urbanisation', while 'enhanced material and energy efficiency' and 'improving product quality' are the most influenced. This study can support the policy makers to develop the strategies in the adoption of circular economy.

Keywords Circular economy · Drivers · DEMATEL · Supply chain management

A. Maqbool · S. Khan · A. Haleem (✉) · M. I. Khan
Department of Mechanical Engineering, Jamia Millia Islamia, New Delhi 110025, India
e-mail: ahaleem@jmi.ac.in

A. Maqbool
e-mail: anayatmir56@gmail.com

S. Khan
e-mail: shahbaz.me12@gmail.com

M. I. Khan
e-mail: imrankhan@st.jmi.ac.in

H. Kumar and P. K. Jain (eds.), *Recent Advances in Mechanical Engineering*,
Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-981-15-1071-7_14

1 Introduction

The population of the world has been predicted to be about 9 billion by 2050 and 10.1 billion by 2100 [1]. This massive population growth puts tremendous stress on the environment and the resource [2]. So, there is the requirement of more extraction of raw materials and consequently more waste.

The current economic model is linear in nature [3] and aims at producing products from raw material, sold and dumped as waste after serving the purpose of use [4]. This economic model is called the take-make-use-destroy model [5]. This linear model is not sustainable in the long run as this model continuously destroys the limited natural resources [6]. The adoption of the circular economy (CE) can surmount the limitations of the linear model of the economy. A CE as described by the authors of [7] is 'an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations'.

The aim of the CE was to limit the extraction of raw materials and the production of waste by recovering and reusing as many of the materials possible. The CE has many significant advantages over the traditional economy as it is evident in literature through various studies and researches [8]. The linear economy flow model is causing several serious environmental impacts such as global warming and natural resource depletion. Unlike linear economy practices, CE-oriented approach focuses on reuse, remanufacturing, refurbishment, repair of products by cascading and upgrading. CE also emphasise on the exploitation of renewable energies such as solar, wind and biomass energy throughout the product value chain.

The switching of a linear economy to a CE is a very challenging task and demands motivational factors. These drivers facilitate in the adoption of the CE which makes it necessary for the identification and evaluation of the drivers before the adoption of the CE. With the use of DEMATEL, this study acknowledges the position of each driver in the CE system along with their degree of effectiveness on the system and on the other drivers. With the help of experts, the results obtained by the DEMATEL provide the major dominant drivers [9]. The focus is put on these influential drivers to make better the overall system. The other benefits of this technique are that the DEMATEL technique is suitable with limited data, [10]. Understanding the drivers and their driving potential will be beneficial in formulating the strategies in order to decrease the effect of barriers. In this paper, the objective of research is to find the drivers of the CE and explore the causal relationships among the drivers.

The remaining paper is structured as follows: Sect. 2 reviews the literature on the CE. Section 3 identifies the significant drivers of the CE. Section 4 presents the research methodology of the paper. The results are illustrated in Sect. 5. Sections 6, 7 and 8 present the discussions, implications and conclusions, respectively.

2 Literature Review

A CE approach is to facilitate growth and, at the same, time minimises resource usage by closing all resource loops and reconnecting them at various nodes, thereby reducing and ultimately eliminating waste [11].

To reveal the current status of adoption of the CE, various research scholars have generally reviewed the concepts of CE. Ghisellini et al. [5] first reviewed the CE and compared CE adoption and practices of China with Europe, Japan and the world. Govindan et al. [8] presented a comprehensive review of barriers, drivers and practices that affect the adoption of the CE through supply chain perspective.

Sun et al. [12] assessed the concepts, practices and assessment tools of CE in china. Geng et al. [13] evaluated the advancement and extent of adoption of the CE in China. Kirchherr et al. [7] examined the various conceptualisations of the CE to clarify the present interpretation of CE concepts by analysing 114 definitions. Lewandowski [14] assessed the current business models of circular to find out gaps that continued to be in the literature and presented a proposal for a new structure for better adoption of the CE. Ellen McArthur Foundation [15] presented a study that provides a toolkit for the policymakers who want to design a policy to step up the changes towards the CE. Liguori and Faraco [16] analysed the various conceptions of biotreatment such as biorefineries and waste management that encourage the adoption of the CE. Ghisellini et al. [5] analysed the changes involved with interlinking the systems of environment and economy.

3 Drivers Towards the Adoption of the Circular Economy

Drivers are the motivational requirement for the effective adoption of CE in a supply chain. For the successful implementation, these drivers are identified and investigated, and Table 1 describes the selected drivers.

4 Research Methodology

The paper aims to investigate the drivers of the CE through causal relationship. After finding the drivers through literature review and expert's input, the drivers are examined using DEMATEL technique [27].

DEMATEL is the MCDM technique which was proposed and developed by the Battle Memorial Institute of Geneva during the period of 1972 and 1976. DEMATEL technique is summarised in the following steps.

Table 1 Drivers towards the adoption of circular economy

Drivers	Description	References
Government policies for cleaner production (D_01)	Governments of almost every country made laws and policies for the promotion of cleaner production, consumption and waste management for the protection of resources health and safety. These laws act as drivers for the implementation of CE	[17–21]
Economic growth through adoption of CE (D_02)	With the adoption of circular economic activities, i.e. reduce, reuse and recycle, remanufacturing effectively helps in generating long-term profitability	[2, 19, 22]
Environmental protection laws (D_03)	The amount of waste produced could result in the generation of greenhouse gases and lead to global warming. Due to these climatic changes, air quality and water quality will be degraded, and landscapes may be lost forever. Therefore, it becomes necessary for the implementation of laws for environmental protection which is possible by the adoption of the CE	[19–21, 23, 24]
Demand for renewable energy (D_04)	The renewable resources need to be secured as the demand for these resources is increasing	[24, 25]
Urbanisation (D_05)	As people are moving towards the big cities, they require more development in the form of roads, bridges, dams, sewage and the need for transport thus put more pressure on the environment	[26]
Consumer awareness (D_06)	For the effective execution of the CE, consumer awareness is necessary	[19]
Enhanced material and energy efficiency (D_07)	Through the strategic adoption of CE, effectiveness of materials and energy use will be increased	[12]

(continued)

Table 1 (continued)

Drivers	Description	References
Improving product quality (D_08)	Product quality will be increased by adopting the CE in the supply chain	[19]
Cost reduction and financial profitability (D_09)	The product cost is reduced due to the use of recycled materials and alternative energy utilisation	Recommended by expert
The scarcity of resources (D_10)	Major resources such as raw materials and conventional energy sources are limited; these materials need to be preserved for future use	Recommended by expert

Step I: Construction of direct influence matrix

A questionnaire is used to collect the response experts about the effect of one factor over another factor. The pairwise comparison values between factor 'i' and 'j', by kth expert, were expressed using a five-point linear scale ranging between 0 and 4; the numerals are used to indicate the strength of a relationship (please see Table 2).

The notation of x_{ij} indicates the influence of variable i on variable j. The elements of diagonal (i.e. $i = j$) of the direct relation matrix are zero. For every expert, a non-negative $n \times n$ matrix is acquired as $X^k = x_{ij}^k$ where k represents the kth experts ($1 \leq k \leq H$). The direct relation matrix is acquired from each expert (number of expert is H) in the form of $X^1, X^2, X^3 \ldots X^H$.

Step II: Construct an overall direct relation matrix from H experts, the average matrix $A = [a_{ij}]$ can be acquired from the Expression [1]:

$$a_{ij} = \frac{\sum_{k=1}^{H} x_{ij}^k}{H} \tag{1}$$

Step III: Construct a normalised initial direct relation matrix, B from Expressions (2) and (3).

Table 2 Scale and their interpretation

Scale	Interpretation
0	No influence
1	Very low influence
2	Medium influence
3	High influence
4	Very high influence

$$B = A \cdot S \tag{2}$$

$$\text{where } S = \frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}} \tag{3}$$

The elements of matrix B lie between zero and one.

Step IV: Construct the total relation matrix 'T' from Expression (4)

$$T = B \cdot (I - B)^{-1} \tag{4}$$

where 'I' is the identity matrix.

Step V: Evaluate the causal parameters through Expressions (5) and (6):

$$R_i = \sum_{j=1}^{n} t_{ij} \text{ for all } i \tag{5}$$

$$C_j = \sum_{i=1}^{n} t_{ij} \text{ for all } j \tag{6}$$

where R_i indicates the sum of rows and C_j indicates the sum of columns.

Step VI: Construct a cause and effect diagram using the data of $(R + C)$ and $(R–C)$ given in Table 6, computed from Eqs. (7) and (8):

$$P_i = R_i + C_j | i = j \tag{7}$$

$$E_i = R_i - C_j | i = j \tag{8}$$

The difference $(R_i - C_i)$ indicates the net influence that variable i adds to the system. Furthermore, if the value of $(Ri - Ci)$ is positive, variable i is a net cause, and if the value of $(Ri - Ci)$ is negative, variable i is a net receiver.

5 Results

The drivers towards the adoption of the CE are obtained through literature review. After discussing, the drivers with a five-member experts' group for the deeper insights and ten drivers were finalised on the recommendations of experts (Table 1). After

finalising the drivers, the decision makers were asked to assess the direct relation among the drivers of the CE on the scale of 0–4 (Table 2). The overall direct relation matrix is calculated using Expression 1 (Table 3).

Then, the normalised direct relation matrix (B) is computed from Expressions (2) and (3) as shown in Table 4.

After that, this matrix is changed into total relation matrix (T) using Expression (4) as shown in Table 5.

In matrix T, the summation of rows and columns is denoted by R and C, respectively, using Expression (5).

Where R_i denotes the total influence of driver 'i' to the other drivers, and Ci denotes net effect on driver 'j' from other drivers. Following the computations of values R and C for every row and column, the prominence (P_i) and net effect (E_i) is computed utilising the Expressions (7) and (8) as shown in Table 6. The net cause/effect of each driver is determined through 'E_i (i.e. $R - C$)'. If the value E_i is positive, then the driver produces the net cause, and if negative, then the driver is the net effect. Figure 1 shows the plots of $R + C$ and $R - C$, which thereby depicts the causal relationship among the drivers of the CE. We have discussed these results with experts for further insights.

6 Discussion on Results

In this research, the relationship among the various factors was investigated by using DEMATEL, which crammed the space left by conventional models that have only considered the direct effects of a factor [28].

The results that show the driver effects on the system alongside on each other are shown in Table 5. Based on the '$R + C$' values, the importance order of the drivers is D_05 > D_01 > D_10 > D_06 > D_09 > D_08 > D_02 > D_03 > D_07 > D_04. Thus, from the '$R - C$' values, the drivers are classified into cause and effect groups. The drivers 'government policies for cleaner production (D_01)', 'urbanisation (D_05)', 'consumer awareness (D_06)', 'cost reduction and financial profitability (D_09)' and 'scarcity of resources (D_10)' having the positive values of $R - C$ are categorised under cause group. The drivers 'economic growth through adoption of CE (D_02)', 'environmental protection laws (D_03)', 'demand for renewable energy (D_04)', 'enhanced material and energy efficiency (D_07) and 'improving the product quality (D_08)' having the negative values of $R - C$ are categorised under effect group.

The categorisation of drivers into cause and effect groups will facilitate the experts to recognise the cause group drivers, which are necessary to be controlled [29]. The matter of fact is that the variables in the influential group are hard to transform while the variables in the influenced group can be easily transformed [30]. The drivers who need improvement on priority basis will be recognised by the decision makers with the help of prioritisation of drivers while focusing on that driver will improve the other drivers as well as the whole system [31].

Table 3 Overall direct relation matrix as obtained through expert inputs

Drivers	D_01	D_02	D_03	D_04	D_05	D_06	D_07	D_08	D_09	D_10
D_01	0	3.6	3.8	3.4	3.6	3.6	3.8	4	3.4	3.4
D_02	1.6	0	1.6	1.4	2	2.4	2.4	2	3	2
D_03	3.2	2.4	0	1.6	2	2.8	1.4	1.6	1.4	2.4
D_04	1.4	1.6	1.6	0	2.8	1.4	1.6	2.4	2	1.4
D_05	3.4	3.2	3.8	3.8	0	3.4	3.8	3.8	3.2	4
D_06	3	2.4	2.8	2.8	3	0	3	3.4	3.2	3.6
D_07	2	1.6	1.6	1.6	1.6	2.4	0	1.6	1.4	1.6
D_08	1.6	2	1.6	2.4	2	2.4	1.6	0	2	2
D_09	3.4	3.6	3.2	3	3	2.8	3	3	0	3.2
D_10	3.4	3.2	3	3.2	4	3.4	3	3.4	3.2	0

Table 4 Normalised direct relation matrix (*B*)

Drivers	D_01	D_02	D_03	D_04	D_05	D_06	D_07	D_08	D_09	D_10
D_01	0.000	0.110	0.117	0.104	0.110	0.110	0.117	0.123	0.104	0.104
D_02	0.049	0.000	0.049	0.043	0.061	0.074	0.074	0.061	0.092	0.061
D_03	0.098	0.074	0.000	0.049	0.061	0.086	0.043	0.049	0.043	0.074
D_04	0.043	0.049	0.049	0.000	0.086	0.043	0.049	0.074	0.061	0.043
D_05	0.104	0.098	0.117	0.117	0.000	0.104	0.117	0.117	0.098	0.123
D_06	0.092	0.074	0.086	0.086	0.092	0.000	0.092	0.104	0.098	0.110
D_07	0.061	0.049	0.049	0.049	0.049	0.074	0.000	0.049	0.043	0.049
D_08	0.049	0.061	0.049	0.074	0.061	0.074	0.049	0.000	0.061	0.061
D_09	0.104	0.110	0.098	0.092	0.092	0.086	0.092	0.092	0.000	0.098
D_10	0.104	0.098	0.092	0.098	0.123	0.104	0.092	0.104	0.098	0.000

Table 5 Total relation matrix (T)

Drivers	D_01	D_02	D_03	D_04	D_05	D_06	D_07	D_08	D_09	D_10
D_01	0.255	0.361	0.360	0.352	0.365	0.372	0.366	0.388	0.348	0.356
D_02	0.201	0.157	0.200	0.196	0.217	0.232	0.226	0.225	0.237	0.215
D_03	0.250	0.233	0.161	0.209	0.225	0.250	0.207	0.223	0.202	0.234
D_04	0.176	0.185	0.182	0.137	0.219	0.185	0.185	0.216	0.192	0.180
D_05	0.349	0.349	0.359	0.362	0.265	0.365	0.365	0.382	0.341	0.370
D_06	0.305	0.294	0.299	0.302	0.314	0.235	0.310	0.335	0.308	0.326
D_07	0.187	0.179	0.176	0.178	0.182	0.206	0.133	0.188	0.170	0.180
D_08	0.192	0.206	0.192	0.216	0.210	0.223	0.196	0.159	0.203	0.207
D_09	0.320	0.331	0.315	0.312	0.319	0.319	0.315	0.330	0.224	0.321
D_10	0.334	0.335	0.324	0.332	0.359	0.350	0.330	0.357	0.328	0.247

Table 6 Prominence (P_i) and net effect (E_i)

Drivers	R	C	$R + C$	$R - C$
D_01	3.524	2.569	6.093	0.955
D_02	2.105	2.630	4.734	−0.525
D_03	2.194	2.568	4.763	−0.374
D_04	1.857	2.595	4.452	−0.737
D_05	3.506	2.673	6.179	0.833
D_06	3.026	2.737	5.763	0.289
D_07	1.779	2.633	4.412	−0.854
D_08	2.004	2.803	4.807	−0.799
D_09	3.106	2.554	5.659	0.552
D_10	3.296	2.636	5.932	0.660

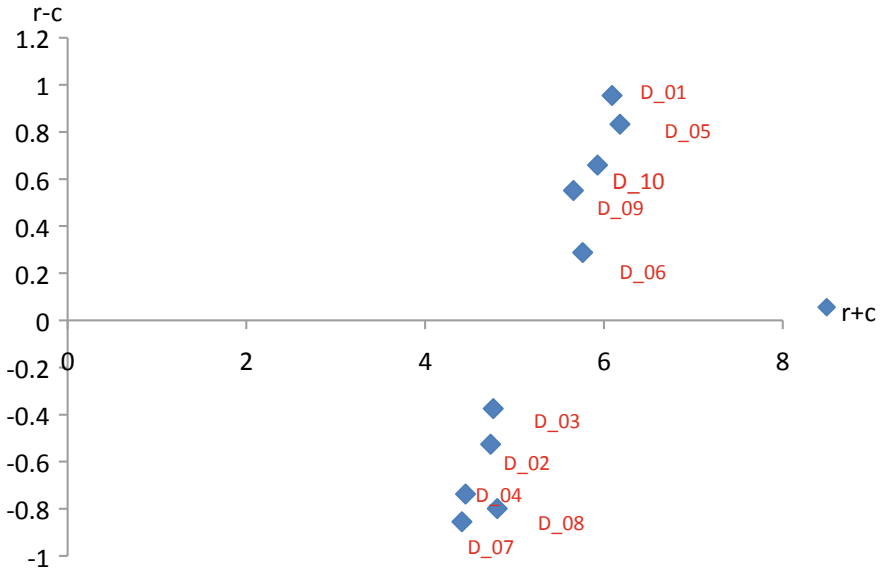

Fig. 1 Cause and effect diagram

6.1 Influential Drivers

Among the influential drivers, the 'government policies for cleaner production (D_01)' has been identified as the most influential driver. This is justified because the government laws are vital for adopting and implementing CE practices in the supply chain. The second most influential driver is 'urbanisation (D_05)'; the developmental changes necessitated by the shifting of people towards cities put pressure on the environment and hence demand a change. The adoption of the CE addresses this

demand. The next influential driver is 'scarcity of resources (D_10)', as the natural resources such as water, non-renewable energy and raw material are limited. Growing population stresses the limited availability of resources and leads to non-sustainable development. The CE reduces the need for new raw materials by reusing existing materials. 'Cost reduction and financial profitability (D_09)' is another influential driver for the implementation of the CE practices. The least influential driver identified is 'consumer awareness (D_06)' which is significant for the adoption of the CE.

6.2 Influenced Drivers

The most influenced driver identified is 'improving the product quality (D_08)'. It can be influenced by consumer awareness (D_06). The next most influenced driver identified is 'enhanced material and energy efficiency (D_07)'; it is influenced by 'scarcity of the resource (D_10)' and 'government policies for cleaner production (D_01)'. The next influenced driver is 'demand for renewable energy (D_04)'; it could be influenced by 'consumers awareness (D_06)' and 'environmental protection laws (D_03)'. The least influenced drivers are 'economic growth through adoption of the CE (D_02)' and 'environmental protection laws (D_03)'.

7 Implications

This research can be useful for the successful implementation of the CE. The decision makers can get help from identified interrelationships between drivers. The categorisation of the drivers into an influential and influenced group may help the policymakers to develop the policies for the adoption of the CE. The organisation needs to primarily focus on the influential group drivers for the successful adoption of the CE. This study can be beneficial for the academia to develop the understanding of the drivers of the CE and interrelationship among them.

8 Conclusion

The drivers of the successful implementation of the CE practices are recognised through the systematic literature review and affirmed through expert's opinion. After finalising the drivers, the relationship among the identified driver is determined using the DEMATEL approach. These drivers are classified into 'influenced' and 'influential' groups. The results of this study are discussed with the experts, and helpful cognisance is given in the discussion section. Finally, the research implication of this

paper is provided. The result of this study suggested that most influential are 'government policies for cleaner production' and 'urbanisation'. The most influenced drivers are 'enhanced material and energy efficiency' and 'improving product quality'. The influential drivers are the major focus while drafting the policies to implement the CE. This study also has some limitations such as the expert's opinion may be biased and subjective. To overcome such limitations, DEMATEL can be integrated with fuzzy and grey theory in future studies. Further, these drivers can be evaluated using the other MCDM technique such as fuzzy AHP, TOPSIS and BWM techniques.

References

1. Bastein T, Roelofs E, Rietveld E, Hoogendoorn A (2013) Opportunities for a circular economy in The Netherlands. TNO, Report commissioned by the Netherlands Ministry of Infrastructure and Environment
2. Franklin-Johnson E, Figge F, Canning L (2016) Resource duration as a managerial indicator for circular economy performance. J Clean Prod 133:589–598
3. MacArthur E (2015) Towards a circular economy: business rationale for an accelerated transition. Accessed November, 2018. https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdfFoundation_9-Dec-2015.pdf
4. Jawahir IS, Bradley R (2016) Technological elements of circular economy and the principles of 6R-based closed-loop material flow in sustainable manufacturing. Procedia CIRP 40:103–108
5. Ghisellini P, Cialani C, Ulgiati S (2016) A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J Cleaner Prod 114: 11–32
6. Kok L, Wurpel G, Ten Wolde A (2013) Unleashing the power of the circular economy. Report by IMSA Amsterdam for Circle Economy
7. Kirchherr Julian, Reike Denise, Hekkert Marko (2017) Review conceptualizing the circular economy: an analysis of 114 definitions. Resour Conserv Recycl 127(2017):221–232
8. Govindan K, Hasanagic M (2018) A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. Int J Prod Res 56(1–2):278–311
9. Khan S, Imran Khan M, Haleem A (2018a) Towards effective management of cold chain: A DEMATEL approach. In: IOP conference series: materials science and engineering, vol 404, pp 012019
10. Chang B, Chang CW, Wu CH (2011) Fuzzy DEMATEL method for developing supplier selection criteria. Expert Syst Appl 38(3):1850–1858
11. McKinsey & Company (2016, October) The circular economy: moving from theory to practice. Special edition. Accessed November 2018. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability%20and%20Resource%20Productivity/Our%20Insights/The%20circular%20economy%20Moving%20from%20theory%20to%20practice/The%20circular%20economy%20Moving%20from%20theory%20to%20practice.ashx
12. Sun B, Heshmati A, Geng Y, Yu X (2013) A review of the circular economy in China: moving from rhetoric to implementation. J Cleaner Prod 42:215–227
13. Geng Y, Zhu Q, Doberstein B, Fujita T (2009) Implementing China's circular economy concept at the regional level: a review of progress in Dalian, China. Waste Manag 29(2):996–1002
14. Lewandowski M (2016) Designing the business models for circular economy—towards the conceptual framework. Sustainability 8(1):43
15. Ellen MacArthur Foundation (2015) Delivering the circular economy, a toolkit for policymakers. Ellen MacArthurFoundation, Cowes
16. Liguori R, Faraco V (2016) Biological processes for advancing lignocellulosic waste biorefinery by advocating circular economy. Bioresorc Technol 215:13–20

17. Park J, Sarkis J, Wu Z (2010) Creating integrated business and environmental value within the context of China's circular economy and ecological modernization. J Clean Prod 18(15):1494–1501
18. Xinan L, Yanfu L (2011) Driving forces on China's circular economy: from Government's perspectives. Energy Procedia 5:297–301
19. Ilić M, Nikolić M (2016) Drivers for development of circular economy—a case study of Serbia. Habitat Int 56:191–200
20. Hazen BT, Mollenkopf DA, Wang Y (2017) Remanufacturing for the circular economy: an examination of consumer switching behavior. Bus Strategy Environ 26(4):451–464
21. Quina MJ, Soares MA, Quinta-Ferreira R (2017) Applications of industrial eggshell as a valuable anthropogenic resource. Resour Conserv Recycl 123:176–186
22. Geng Y, Zhu Q, Doberstein B, Fujita T (2008) Implementing China's circular economy concept at the regional level: a review of progress in Dalian, China. Waste Manag 29(2):996–1002
23. Pringle T, Barwood M, Rahimifard S (2016) The challenges in achieving a circular economy within leather recycling. Procedia CIRP 48:544–549
24. Clark JH, Farmer TJ, Herrero-Davila L, Sherwood J (2016) Circular economy design considerations for research and process development in the chemical sciences. Green Chem 18(14):3914–3934
25. Schiller G, Müller F, Ortlepp R (2017) Mapping the anthropogenic stock in Germany: metabolic evidence for a circular economy. Resour Conserv Recycl 123:93–107
26. Sun L, Li H, Dong L, Fang K, Ren J, Geng Y, Fujii M, Zhang W, Zhang N, Muduli K, Barve A (2013) Establishment of a sustainable development framework in small-scale mining supply chains in India. Int J Intell Enterp 2(1):84–100
27. Khan, S., Imran Khan M., Haleem, A., (2018b) Facilitating fair trade practices as a development strategy. In: IOP conference series: materials science and engineering, vol 404, pp 012009
28. Horng J-S, Liu C-H, Chou SF, Tsai C-Y (2013) Creativity as a critical criterion for future restaurant space design: developing a novel model with DEMATEL application. Int. J. Hosp. Manag. 33:96–105
29. Lin Y-T, Yang Y-H, Kang J-S, Yu H-C (2011) Using DEMATEL method to explore the core competences and causal effect of the IC design service company: an empirical case study. Expert Syst Appl 38:6262–6268
30. Wu WW, Lee YT (2007) Developing global managers' competencies using the fuzzy DEMATEL method. Expert Syst Appl 32(2):499–507
31. Govindan K, Muduli K, Devika K, Barve A (2016) Investigation of the influential strength of factors on adoption of green supply chain management practices: an Indian mining scenario. Resour. Conserv Recycl 107(2016):185–194