International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 03 | Mar 2021 www.irjet.net p-ISSN: 2395-0072

ANALYZING THE BARRIERS FOR THE SHIFTING TOWARDS CIRCULAR ECONOMY IN MANUFACTURING CONTEXT: A DEMATEL APPROACH

Aamir Ul Islam[1], Naveen Kumar[2]

[1]PG Scholar, Department of Mechanical Engineering, Yamuna Institute of Engineering and Technology, Gadholi-133103, India
[2]Assistant Professor, Department of Mechanical Engineering, Yamuna Institute of Engineering and Technology, Gadholi-133103, India

---

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 have 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 maximizes 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 barriers towards the adoption of circular economy. Further, these barriers are categorised into two groups utilising the decision-making trial and evaluation laboratory (DEMATEL). The result of this study explored that most influential are 'government policies for cleaner production' and 'urbanisation' while 'enhanced material and energy efficiency' and 'improving product quality' is the most influenced barriers. This study can be support the policy makers to develop the strategies in adoption of circular economy.

Keywords: Circular Economy; Barriers; DEMATEL; Supply Chain Management.

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 putting 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 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 is to limit the extraction of raw materials and 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 switching of a linear economy to a CE is a very challenging task and demands motivational factors. These barriers facilitate in the adoption of the CE which makes it necessary for the identification and evaluation of the barriers before the adoption of the CE. With the use of DEMATEL, this study acknowledges the position of each barrier in the CE system along with their degree of effectiveness on the system and on the other barriers. With the help of experts, the results obtained by the DEMATEL provides the major dominant barriers [16]. The focus is put on these influential barriers to make better the overall system. The other benefits of this technique are that the DEMATEL technique is suitable with limited data, [9]. Understanding the barriers 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 barriers of the CE, explore the causal relationships among the barriers.

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

2. Literature review

A CE approach is to facilitate growth and at the same time minimise resource usage by closing all resource loops and reconnecting them at various nodes, thereby reducing and ultimately eliminating waste [17]. 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, barriers, and practices that affect the adoption of the CE through supply chain perspective. Sun et al. [10] assessed the concepts, practices and assessment tools of CE in china. Geng et al. [11] evaluated the advancement and extent of adoption of the CE in China. Kirchherr et al. [7] examined the various conceptualizations of the CE to clarify the present interpretation of CE concepts by analysing 114 definitions. Lewandowski [12] 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 [13] 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 et al. [14] analysed the various conceptions of bio treatment such as bio refineries and waste management that encourage the adoption of the CE. Ghisellini [5] analysed the changes involved with interlinking the systems of environment and economy.

3. Barriers towards the adoption of the Circular Economy

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

Table 1: Barriers towards the adoption of circular economy

BARRIERS	DESCRIPTION	REFERENCES
Br001.Ineffective implementation of Circular economic laws	The proposed Laws related to Circular Economy are weak and there are inadequate tools which can help to maintain the effectiveness of the law or regulation in the Circular supply chain	Su et al. [18], Zhijun and Nailing [24]
Br002. Lack of public awareness	It includes the dearth of awareness and sense of perseverance by public	Su et al. [18], Lieder [8], Liu et al. [20], Geng [15], Bakker et al. [25]
Br003. Weak economic incentives	Weak economic incentives act as hindrance to enterprises in the transition towards circular economy	Su et al. [18], Geng [15]
Br004. Lack of reliable information to public	The lack of reliable information about Circular Economy makes it uneasy for the people reuse/recycle/ remanufacture products.	Su et al. [18], Liu et al. [20]
Br005. Lack of proper vision in regards of circular economy with supply chain	The vision in regards of the goals, objectives related to the espousal of the Circular economy are unclear.	Pan et al. [21]
Br006. Lack of skills by employees in Circular economy	The poor skill development of the employees in the enterprises make the transition towards circular economy difficult.	Bakker et al. [16]
Br007. Inadequate leadership and poor management towards Circular economy	The inadequacy in the leadership and management develops the probability of lack of interest on circular economy adoption.	Liu and Bai [22]
Br008. Lack of	The life of the products gets reduced due to	Scheinberg et al.

business models	the lack of Circular business models, as the processes through business models may not be available.	[23], Lewandowski [17]
Br009. Consumer perception towards the reclaimed product	Negative perception of consumers about the reused products which question the quality, health and safety of the refurbished products	Genovese et al. [25], Zhijun and Nailing [24]
Br010. Lack of technology transfers	The lack of technology transfers result in the inefficient tackling of societal problems like of ecological degradations, resources depletion, climate change. "In this the technology is transferred from the inventor (developed nation) to a secondary user (developing country) to develop efficacy towards circular economy".	Geng [15]

4. Research Methodology

The aim of this paper is to investigate the barriers of the circular economy through causal relationship. After finding the barriers through literature review and expert's input, the barriers are examined using DEMATEL Technique.

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

Step I. Construction of Direct Relation matrix

The views of experts about the effect of one factor over another factor are collected through the questionnaire. The pairwise comparison values between factor 'i' and 'j', by k^{th} expert, were expressed using a five-point linear scale ranging between 0 and 4, the numerals used to indicate the strength of a relationship (Please see table 2).

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

"The notation of x_{ij}indicates that the influence of variable *i* on variable *j*. The diagonal element (i.e. *i=j*) of the direct inflectional matrix is zero. A non-negative n×n matrix is acquired for each expert as $X^k = [x_{ij}^k]$ where k represents the k^{th} experts (1≤k≤H). The direct relation matrix is acquired from each expert (no. of expert is H) in the form of X^1, X^2, X^3…. X^{H}".

Step II: "Construct an overall direct-relation matrix from *H* experts, the average matrix *A* = [*aij*] can be acquired from the expression (1)":

$$a_{ij}=\frac{\sum_{k=1}^{H} x_{ij}^k}{H} \quad (1)$$

Step III: "Construct a normalized initial direct-relation matrix, *B* from expression (2) & (3)".

$$B=A \bullet S \quad (2)$$

Where $$S=\frac{1}{max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}} \quad (3)$$

every element in matrix *B* lies between zero and one.

Step IV: "Construct the Total relation matrix "T" from expression (4)"

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

Where "I" is the identity matrix.

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

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

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

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

Step VI: "Construct a causal and effect diagram using the dataset consisting of prominence (Pi) and net effect (Ei) from equations (7) and (8)":

$P_i= R_i + C_j \mid i=j$ (7)

$E_i= R_i - C_j \mid i=j$ (8)

"The difference ($R_i - C_i$) indicates the net influence that variable I contributes to the system. Moreover, if ($Ri - Ci$) is positive, variable i is a net cause, while variable i is a net receiver or result if ($Ri - Ci$) is negative".

5. Results

The barriers towards the adoption of the circular economy are obtained through literature review. After discussing the barriers with a five-member experts' group for the deeper insights and ten barriers were finalised on the recommendations of experts (Table 1). After finalising the barriers, the experts were asked to evaluate the direct influence among the barriers of the circular economy on the scale of 0-4 (Table 2). The overall direct relation matrix is calculated using expression 1 shown in Table 3.

Table 3: Overall direct relation matrix as obtained through expert inputs

Barriers	Br001	Br002	Br003	Br004	Br005	Br006	Br007	Br008	Br009	Br010
Br001	0.00	2.60	2.80	2.40	2.60	2.60	2.80	3.00	2.40	2.40
Br002	1.20	0.00	1.20	1.00	1.40	1.60	1.60	1.40	2.00	1.40
Br003	2.20	1.60	0.00	1.20	1.40	1.80	1.00	1.20	1.00	1.60
Br004	1.00	1.20	1.20	0.00	1.80	1.00	1.20	1.60	1.40	1.00
Br005	2.40	2.20	2.80	2.80	0.00	2.40	2.80	2.80	2.20	3.00
Br006	2.00	1.60	1.80	1.80	2.00	0.00	2.00	2.40	2.20	2.60
Br007	1.40	1.20	1.00	1.20	1.20	1.60	0.00	1.20	1.00	1.20
Br008	1.20	1.40	1.00	1.60	1.40	1.60	1.20	0.00	1.40	1.40
Br009	2.40	2.60	2.20	2.00	2.00	1.80	2.00	2.00	0.00	2.20
Br010	2.40	2.20	2.00	2.20	3.00	2.40	2.00	2.40	2.20	0.00

Further, the Normalized direct-relation matrix (B) is developed using Equation (2) and (3) shown in Table 4.

Table 4: Normalized direct-relation matrix (B)

Barriers	Br001	Br002	Br003	Br004	Br005	Br006	Br007	Br008	Br009	Br010
Br001	0.00	0.11	0.12	0.10	0.11	0.11	0.12	0.13	0.10	0.10
Br002	0.05	0.00	0.05	0.04	0.06	0.07	0.07	0.06	0.08	0.06
Br003	0.09	0.07	0.00	0.05	0.06	0.08	0.04	0.05	0.04	0.07
Br004	0.04	0.05	0.05	0.00	0.08	0.04	0.05	0.07	0.06	0.04
Br005	0.10	0.09	0.12	0.12	0.00	0.10	0.12	0.12	0.09	0.13
Br006	0.08	0.07	0.08	0.08	0.08	0.00	0.08	0.10	0.09	0.11
Br007	0.06	0.05	0.04	0.05	0.05	0.07	0.00	0.05	0.04	0.05
Br008	0.05	0.06	0.04	0.07	0.06	0.07	0.05	0.00	0.06	0.06
Br009	0.10	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.00	0.09
Br010	0.10	0.09	0.08	0.09	0.13	0.10	0.08	0.10	0.09	0.00

After that, this matrix is transformed into Total-Relation Matrix (T) using Equation (4) and shown in table 5.

Table 5: Total-Relation Matrix (T)

Barriers	Br001	Br002	Br003	Br004	Br0005	Br006	Br007	Br008	Br009	Br010
Br001	0.23	0.33	0.33	0.32	0.34	0.34	0.34	0.37	0.32	0.33
Br002	0.18	0.14	0.18	0.17	0.19	0.20	0.20	0.20	0.21	0.19
Br003	0.22	0.20	0.14	0.19	0.20	0.21	0.18	0.20	0.18	0.21
Br004	0.16	0.17	0.16	0.12	0.19	0.16	0.17	0.19	0.17	0.16
Br005	0.32	0.32	0.33	0.33	0.24	0.33	0.34	0.36	0.31	0.35
Br006	0.26	0.25	0.25	0.26	0.27	0.19	0.27	0.30	0.27	0.29
Br007	0.17	0.16	0.15	0.16	0.17	0.18	0.12	0.18	0.15	0.17
Br008	0.17	0.18	0.16	0.19	0.19	0.19	0.18	0.14	0.18	0.19
Br009	0.28	0.30	0.27	0.27	0.28	0.27	0.27	0.29	0.19	0.28
Br010	0.30	0.30	0.29	0.30	0.33	0.31	0.29	0.32	0.29	0.22

In matrix *T*, the summation of rows and column are represented by R and C respectively using equation (5).

Table 6: The prominence (Pi) and net effect (Ei)

Barriers	R	C	R+C	R-C
Br001	3.23	2.30	5.54	0.93
Br002	1.86	2.35	4.21	-0.49
Br003	1.93	2.27	4.20	-0.35
Br004	1.66	2.31	3.96	-0.65
Br005	3.21	2.38	5.60	0.83
Br006	2.62	2.38	5.00	0.23
Br007	1.61	2.36	3.97	-0.74
Br008	1.77	2.55	4.32	-0.77
Br009	2.70	2.25	4.95	0.45
Br010	2.94	2.38	5.33	0.56

- Where, Ri denotes the total effect of barrier to the other barriers, and Ci denotes net effect on barrier j from other barriers. After the Calculation of R and C for every row and column, the prominence (Pi) and net effect (Ei) is calculated using expressions (7) and (8) shown in Table 6. The net cause/effect of each barrier are determined through "Ei (i.e. R-C)". If Ei is positive, then the barrier is considered to produce the net cause and if negative then the barrier is the net effect. Figure 1 shows the plots of R+C and R-C, which thereby depicts the causal relationship among the barriers of the circular economy. We have discussed these results with experts for further insights.

- **Discussion on Results**

Final results that show the influence levels of each barrier in the system as well as on each other are presented in Table 5. Based on the "R+C" values, the importance order of the barriers is Br005>Br001>Br010> Br006> Br009> Br008> Br002> Br003> Br007> Br004. Thus, from the "R-C" values, the factors are divided into two groups as cause and effect groups. The barriers 'Ineffective implementation of Circular economic laws (Br001)', 'Lack of public awareness (Br005)', 'Lack of skills by employees in Circular economy (Br006)', 'Consumer perception towards the reclaimed product (Br009)' and 'Lack of technology transfers (Br010)' having the positive values of R-C. These barriers are categorized under cause group. The barriers 'Lack of proper vision in regards of circular economy with supply chain (Br002)','Weak economic incentives(Br003)', 'Lack of reliable information to public(Br004)', 'Inadequate leadership and poor(Br007) and 'Lack of business model**s**(Br008)' having thenegative values of R-C are categorized under effect group".

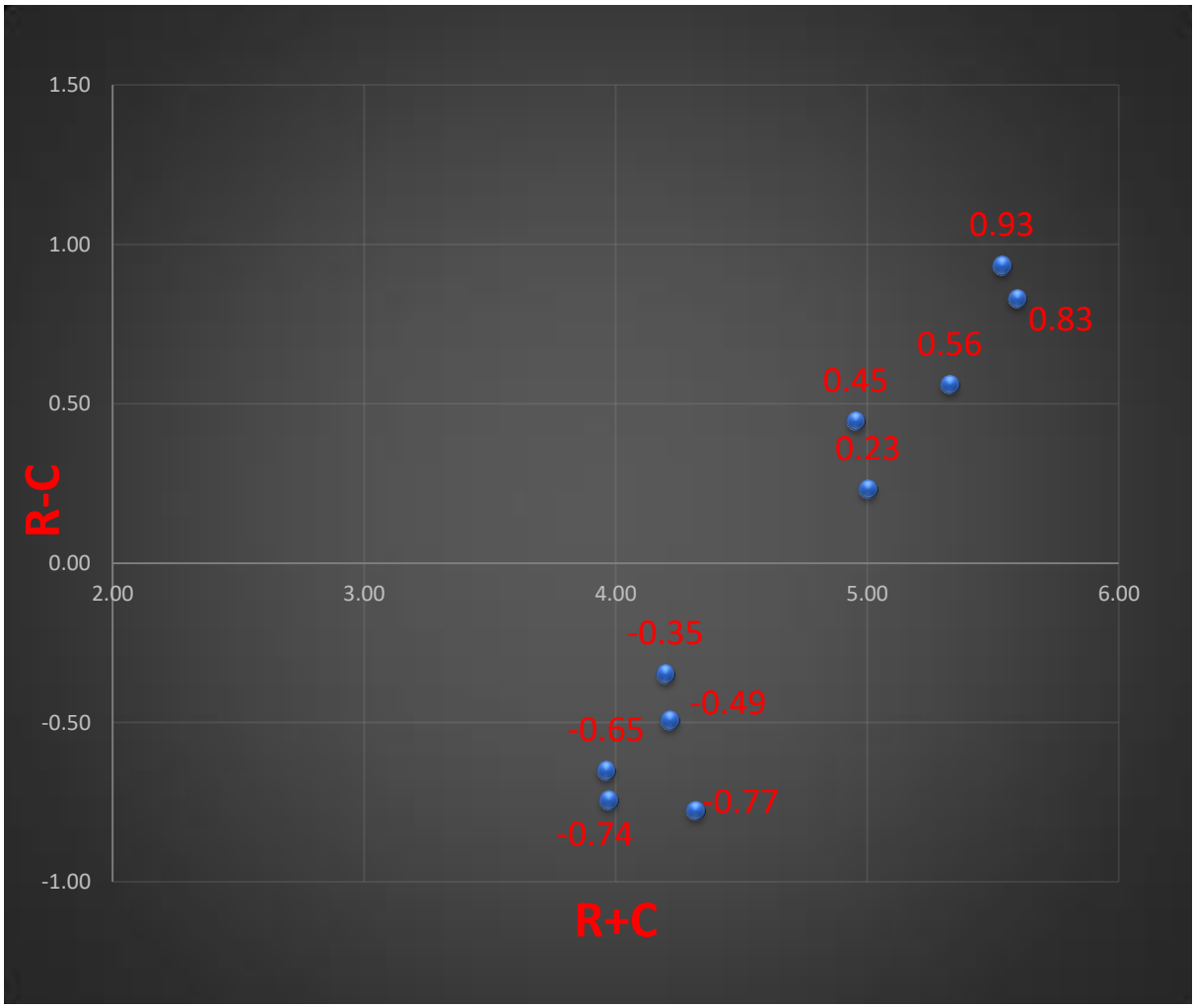

Fig. 9. Cause and Effect Diagram.

In this research, the relationship among the various factors were investigated by using DEMATEL, "which filled the gap left by traditional models that set strategies by only considering direct effects or single directions of criteria. The categorisation of barriers into cause and effect groups will facilitate the decision makers to recognise the group of barriers (cause group) which are necessary to be controlled [26]. The matter of fact is that the factors in the influential group are difficult to move while factors in the influenced group are easily moved [27, 28]. The barriers who need improvement on priority basis will be recognised by the decision makers with the help of prioritisation of barriers while focusing on that barrier will improve the other barriers as well as the whole system [10].

6. Influential Barriers

Among the influential barriers the 'Ineffective implementation of Circular economic laws (Br001)' has been identified as the most influential barrier. This is justified because the government regulations are vital for the circular economy in supply chains and the laws and policies made by the governmental institutions will serve as a base for the implementation of the circular economy. The second most influential barrier is 'Lack of public awareness (Br005)', the developmental changes necessitated by the shifting of people towards cities put pressure on the environment and hence demands a change. The implementation of the circular economy addresses this demand. The next influential barrier is 'lack of technology transfers (Br010)', as the resources (raw materials, water, energy, and fertile land) are limited, but due to the growing population, the demand is increasing. The circular economy decreases the need for new raw materials by reusing existing materials. 'Consumer perception towards the reclaimed product (Br009)' is another influential barrier for the implementation of the circular economy. The least influential barrier identified is 'Lack of skills by employees in Circular economy (Br006)' which is necessary for the adoption of the circular economy.

7. Influenced Barriers

The most influenced barrier identified is 'Lack of business model**s** (Br008)'. It can be influenced by 'Lack of skills by employees in Circular economy (Br006)'. The next most influenced barrier identified is 'Inadequate leadership and poor(Br007)', it is influenced by 'Lack of technology transfers(Br010)' and 'Ineffective implementation of Circular economic laws (Br001), The next influenced barrier is 'Lack of reliable information to public(Br004)', it could be influenced by 'Lack of skills by employees in Circular economy (Br6)' and 'Weak economic incentives(Br003)'. The least influenced barriers are 'Lack of proper vision in regards of circular economy with supply chain (Br002)' and 'Weak economic incentives (Br003)'.

8. Implications

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

9. Conclusion

The barriers of the successful implementation of the circular economy are identified through the literature review and validated through expert's opinion. After finalising the barriers, the interrelationship among the barrier is determined using the DEMATEL approach. These barriers are categorised into two groups namely "influenced" and "influential" group. The result is discussed with the expert, and useful insight is provided in the discussion section. Finally, the implication of this study is provided. The result of this study suggested that most influential are 'implementation of Circular economic laws (Br001)' and Lack of public awareness (Br005). The most influenced barriers are "Lack of business model**s** (Br008)" and Inadequate leadership and poor (Br007). The influential barriers are the major focus while drafting the policies to implement the circular economy. 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 barriers can be evaluated using the other MCDM technique such as fuzzy AHP, TOPSIS, and BWM techniques.

REFRENCES

[1]. Bastein, T., E. Roelofs, E. Rietveld, and A. Hoogendoorn. 2013. Opportunities for a Circular Economy in the Netherlands. TNO, Report commissioned by the Netherlands Ministry of Infrastructure and Environment.

[2]. Franklin-Johnson, E., F. Figge, and L. Canning. 2016. "Resource Duration as a Managerial Indicator for Circular Economy Performance." Journal of Cleaner Production 133: 589–598.

[3]. MacArthur, E. 2015. Towards a Circular Economy: Business Rationale for an AcceleratedTransition.https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf

[4]. Jawahir, I. S., and R. Bradley. 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., C. Cialani, and S. Ulgiati. 2016. "A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems." Journal of Cleaner Production 114: 11–32.
[6]. Kok, L., G. Wurpel, and A. Ten Wolde. 2013. Unleashing the Power of the Circular Economy. Report by IMSA Amsterdam for Circle Economy.
[7]. Julian Kirchherr, Denise Reike, Marko Hekkert 2017 "Review Conceptualizing the circular economy: An analysis of 114 definitions" Resources, Conservation & Recycling 127 (2017) 221–232.
[8]. Lieder, M., and A. Rashid. 2016. "Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry." Journal of Cleaner Production 115: 36–51.
[9]. MacArthur, E. 2013. "Towards the Circular Economy." Journal of Industrial Ecology 23–44
[10]. Kannan Govindan & Mia Hasanagic (2018) A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective, International Journal of Production Research, 56:1-2, 278-311
[11]. Papanek, V., & Lazarus, E. L. (2005). Design for the Real World: Human Ecology and Social Change Ed. 2.
[12]. Avital, M., Andersson, M., Nickerson, J., Sundararajan, A., Van Alstyne, M., & Verhoeven, D. (2014, January). The collaborative economy
[13]. Bocken, N. M., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308-320
[14]. Moreno, M., Delos Rios, C., Rowe, Z., & Charnley, F. (2016). A conceptual framework for circular design. *Sustainability*, *8*(9), 937.
[15]. Zhu, Q., Geng, Y., & Lai, K. H. (2010). Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and performance implications. *Journal of Environmental Management*, *91*(6), 1324-1331
[16]. Bocken, N. M., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308-320
[17]. Cong, L., Zhao, F., & Sutherland, J. W. (2019). A design method to improve end-of-use product value recovery for circular economy. *Journal of Mechanical Design*, *141*(4), 044502Korhonen, J., Honkasalo, A., Seppala, J., 2018. Circular economy: the concept and its limitations. Ecological Economics. 143, 37e46.
[18]. Su, B., A. Heshmati, Y. Geng, and X. Yu. 2013. "A Review of the Circular Economy in China: Moving from Rhetoric to Implementation." Journal of Cleaner Production 42: 215–227.
[19]. Scheinberg, A., J. Nesić, R. Savain, P. Luppi, P. Sinnott, F. Petean, and F. Pop. 2016. "From Collision to Collaboration – Integrating Informal Recyclers and Re-use Operators in Europe: A Review." Waste Management & Research 34 (9): 820–839.
[20]. Batista, L., Bourlakis, M., Liu, Y., Smart, P., &Sohal, A. (2018). Supply chain operations for a circular economy. *Production Planning & Control*, *29*(6), 419-424.
[21]. Pan, S. Y., M. A. Du, I. T. Huang, I. H. Liu, E. E. Chang, and P. C. Chiang. 2015. "Strategies on Implementation of Waste-to-Energy (WTE) Supply Chain for Circular Economy System: A Review." Journal of Cleaner Production 108: 409–421.
[22]. Liu, Y., and Y. Bai. 2014. "An Exploration of Firms' Awareness and Behavior of Developing Circular Economy: An Empirical Research in China." Resources, Conservation and Recycling 87: 145–152.
[23]. Scheinberg, A., J. Nesić, R. Savain, P. Luppi, P. Sinnott, F. Petean, and F. Pop. 2016. "From Collision to Collaboration – Integrating Informal Recyclers and Re-use Operators in Europe: A Review." Waste Management & Research 34 (9): 820–839.
[24]. Zhijun, F., and Y. Nailing. 2007. "Putting a Circular Economy into Practice in China." Sustainability Science 2 (1): 95–101.
[25]. Genovese, A., A. A. Acquaye, A. Figueroa, and S. L. Koh. 2015. "Sustainable Supply Chain Management and the Transition towards a Circular Economy: Evidence and Some Applications." Omega 66: 344–357.
[26]. Wu, W.W., Lee, Y.T., 2007. Developing global managers' competencies using the fuzzy DEMATEL method. Expert Syst. Appl. 32 (2), 499–507.
[27]. Asif, F. M., Roci, M., Lieder, M., Rashid, A., Štimulak, M., Halvordsson, E., & de Bruijckere, R. (2018). A practical ICT framework for transition to circular manufacturing systems. *Procedia CIRP*, *72*, 598-602.
[28]. Maqbool, A. , Khan, N.Z. (2020). Analyzing barriers for implementation of public health and social measures to prevent the transmission of COVID-19 disease using DEMATEL method, Diabetes & Metabolic Syndrome: Clinical Research & Reviews, Volume 14, Issue 5,Pages 887-892, https://doi.org/10.1016/j.dsx.2020.06.024.