

Application of Circular Economy in Downstream Petroleum Industry: An Interpretative Modelling

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Abstract

In recent years, globalization, the large consumption of resources, increasing pollution, and consequently, the production of waste and greenhouse gases created serious environmental problems. In this regard, the most important philosophy needed by organizations is agreement on creating economic, social and environmental value in the form of the concept of sustainable management. Circular economics is an operational solution to achieve this concept in organizations. This paper attempts to offer multi-level modeling of circular economy barriers in the downstream petroleum industry, emphasizing the rubber and plastics industry. In first, a number of the barrier are extracted from related reviews of the studies. Then, these barriers were validated using experts' opinions in academic and petroleum industry professionals. Then, the fuzzy interpretative structural modeling approach (FISM) was used to determine the relationship between the barriers by considering the linguistic ambiguities of judgments and designing the structural model. The results showed that from the viewpoint of experts, due to the placement of "Obstructing laws and regulations" and "Uncertainty of consumer demand" barriers in the root of the model were the most important barriers of circular economy in the rubber and plastics industry. In the next step, using the MICMAC analysis, the circular economy barriers were put into four clusters. Finally, a discussion and conclusions are presented.

Keywords: Circular Economy, Petroleum Industry, Fuzzy Interpretative Structural Modelling, MICMAC.

Introduction

Rising global warming, industrialization of societies, increasing capacity and demand, and declining non-renewable resources have challenged the manufacturing sector. Thus, natural resources are consumed almost twice as fast as production, which will triple by 2050 (Akhimien, 2020). As the world's population grows from 7.5% to 8.5% by 2030, demand for resources will increase. Competition in the use of resources and stagnation and disruption in their supply in the short term, causes uncertainty and increases costs (Allen, 2013).

Environmental improvements in businesses have encouraged companies to think and act to reduce the negative effects of poor environmental performance on production and consumption. Therefore, to maintain the environment and improve sustainable performance, companies need a new model of economy. A model that rejects linear economics assumptions such as unlimited

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resources and unlimited environmental capacity to absorb waste and environmental pollution (Lieder Rashid, 2016). It's as an efficient tool can reduce environmental impacts and prevent increased costs, delays, and other consequences (Eberhardt, 2019).

Circular economics goal is to use economic prosperity, while maintaining environmental quality and social equity to create sustainable world for future generations (Kirchherr et al., 2017). The implementation of circular economy principles is critical in meeting sustainable development goals (Korhonen et al, 2018; Alamerew& Brissaud, 2020). Qaisdorfer et al (2017) define the circular economy as a regenerator and as a model that reduces waste production and emissions. In other words, a rotating economy seeks to achieve economic benefits, minimize environmental impacts and increase resource efficiency (Kazancoglu, 2018).

The main purpose of circular economics is to distinguish economic growth from natural resource constraints and social impacts (Merli, 2017). This type of economic system is a good opportunity to reduce the use of raw materials, protect material resources and also reduce the impact of carbon. Examining the basics shows that a circular economy will make a significant profit. European Commission in 2014-year study found that the manufacturing sector could generate around € 600 billion a year in profit by using a rotating economy. Arponen et al. (2015) stated in a study that the global economy will benefit from \$1,000 billion annually as a result of implementing the concept of circular economy. However, despite all these potential achievements, the implementation and operation of the rotational economy is always slow.

In a linear economy, they face unsustainable production and consumption patterns. This new concept has greatly reduced this instability in recent years by conserving resources and creating a recovery cycle. Abdul-Hamid et al. (2020) highlighted that the palm oil industry faces many obstacles in adopting CE practices, but the industry is assured that CE practices will improve their reputation. A study by Urbinati et al. (2021) emphasized that the automotive industry is moving towards CE practices in an efficient manner; CE practices lower the production cost. As other industries move to CE practices, the Rubber and plastics industry is also positioned to adopt CE practices. The main drivers of Iran's economy and industry are gas resources and oil reserves, so that currently 28% of GDP, 84% of foreign exchange earnings and 95% of primary energy are supplied from oil and gas. At present, there is a production capacity of 60 million tons of petrochemical products in Iran, of which 7 million tons are related to rubber and plastic products. Wu et al. (2020) indicated that plastic industry is slowly progressing towards CE practices and assured that transition towards CE practices will enhance the industry's performance.

According to the above, this study seeks to provide a fuzzy interpretive model of the barriers of circular economy in the downstream petroleum industry with special emphasis on the rubber and plastics industry. These industries have played an important role in improving living standards around the world. So, the main question of this research is: what are the barriers of circular economic that are considered to enhance the environmental performance of the downstream petroleum industry, and how do they interact with each other?

The rest of the present research is organized in four sections: The second part reviews the theoretical and experimental foundations of circular economics. In the following, the effective barriers will be identified. In the third section, the research methodology is introduced. Then, fuzzy interpretive analyzes will be performed. In the fourth section, the research findings are presented. Finally, results and suggestions for managers and future studies are presented.

Literature review

The environment provides materials, water, and energy as inputs for production. Then, these resources are converted into consumer products and services, and waste is generated. If waste generation exceeds the absorption capacity of the system, the ability of the environment to

provide resources is disrupted, which leads to a reduction in resources. Circular economics is a closed system. In a closed system, the environment is part of the system, and the extraction of resources is based on performance. In this economy, waste is the source of new resources through recycling (McDonough and Braungart, 2013).

Boulding first introduced the concept of rotational economics in 1966 with his paper "The Earth Economy of the Future". Then, in 1989, Pierce and Turner developed (1989) the concept under the title Environmental Economics in *The Economics of Natural Resources and the Environment*. Its practical applications in economic systems have been shaped by the concepts of industrial ecology, clean production, and the idea of cradle to cradle, all of which agree on a closed loop. The circular economy promotes competitive advantage, sustainable economic growth, and job creation (European Union, 2015). This economy is considered a system of resource recovery. It reuses improving the system's economic performance by promoting sustainable resource performance, reducing environmental pollution and costs, and improving waste recycling (Grafstrom and Aasma, 2021). The framework of the circular economy is shown figure 1.

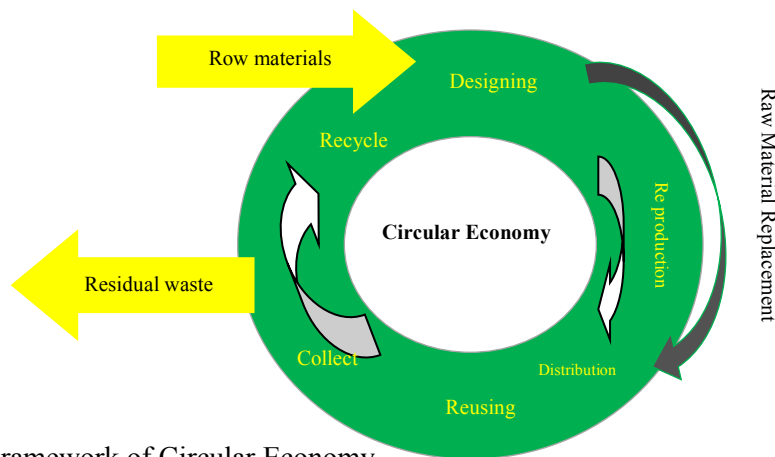


Figure 1. Framework of Circular Economy

The circular economy focuses on efficient use of materials, waste reduction, and material recycling, and improves the Earth's ecosystem through profitable business models and creates hidden job opportunities (Kirchherr, 2017). It emphasizes the use of healthy raw materials and the elimination of harmful substances, reducing waste production, reusable and recyclable materials, renewable energy, water management (wastewater treatment and increasing its quality for reuse and reducing water consumption) and social awareness. In 2018, the EU introduced industry performance indicators to the circular economy in the four areas of production and consumption, waste management, second-hand raw materials, and competitiveness and innovation. Masi et al (2018) state that circular economy is a kind of economic system that shows a paradigm shift in how human society relates to nature and aims to prevent resource depletion, renewable energy use, and materials, and facilitate sustainable development. Achieving a circular model requires environmental innovation and a review of laws, production and consumption in society. In recent years, various studies have contributed to the literature on circular economics, some of which are listed in next:

Bjornbet et al. (2021), by conducting a study entitled *The role of circular economy in manufacturing industries*, tried to understand and establish the relationship between circular economy and sustainable development. The results showed that the improvement of sustainable performance of organizations would be achieved through the implementation of a circular economy with emphasis on environmental, social, and economic dimensions. Grafstrom and Aasma (2021) conducted a study to identify barriers to circular economics. The results showed that technological, organizational, market and cultural barriers are key barriers to implementing

the circular economy. In a study, Kumar et al. (2021) identified barriers to the circular economy and fourth generation industry in India's multinational corporate supply chain. The results showed that the lack of government support and incentives for sustainability and the lack of specific policies and protocols for the circular economy are the most important obstacles. Moreno et al. (2021), in a study, identified the performance indicators of the circular economy in Spanish companies. The results showed that the indicators of green purchasing management and waste management, recycling and recycling, and use of green energy are the most important performance indicators. Prada et al. (2021) presented a study on driving the circular economy through public environmental and energy research and development from SMEs in the European Union. the study showed that public environmental and energy research and development negatively affects the level of SMEs' investment in CE activities. In a study, Abokersh et al. (2021) identified a framework for sustainable evaluation of thermal energy storage in circular economy. The study concludes that the integration of reusing and recycling at the initial design should be sought in order to achieve a more environmentally sustainable and circular outcome. Karayılan et al. (2021) conducted a study prospective evaluation of circular economy practices within plastic packaging value chain through optimization of life cycle impacts and circularity. The results show that if better upcycling options including industrial symbiosis can be identified and established in the future, in addition to the composting as a viable End of Life option, plastic packaging value chain can create higher environmental benefits.

Barros et al. (2020) conducted a study entitled Circular Economy as a Stimulus for Sustainable Business. The results of the study showed organizations to achieve sustainable business management in each of the main areas of their business should focus on the components of the circular economy. Keulen et al. (2020) in a study, identified the enablers as well as the barriers to the circular economy in the coffee product value chain in the Netherlands. The results showed that incoherence in government policies and lack of standard circular design are the main obstacles. Also, having a common awareness and vision and designing integrated business models are important enablers in implementing a circular economy. In a study, Singh et al. (2020) identified and examined the barriers to the circular economy in the mining sector of India with a hierarchical analysis process approach. The study results showed that the factors of government laws and policies are the main obstacles in implementing the circular economy approach in the mining sector. In a study, Rivera et al. (2020) identified the social indicators of circular economies using the fuzzy Delphi approach. The results showed that from the perspective of experts, the components of customer health and safety, increasing employment, and food security are among the most important indicators in the social dimension of the circular economy. Feng and Gang (2020) presented a study on integrating entropy weighting method and multi-objective planning model for supplier selection and order allocation in the circular economy. This study was conducted in two phases: selecting a green supplier and allocating an order for an automotive company. The study results indicate the effectiveness of the proposed approach to achieve the research objectives.

A careful study of the existing literature shows that there is very little knowledge of circular economics and the barriers to its implementation in the industry. Therefore, identifying the main barriers can be very important. But in a dynamic environment, there are interactive relationships between these barriers that identifying those relationships can be crucial in implementing them. The present study was conducted to cover the shortcomings of previous research. It can be said that this study is innovative in terms of identifying barriers and determining their interpretive structure to understand the synergy of the interaction between them in the rubber and plastics industry. In other words, this study incorporates these ideas and examines the barriers to transition to a circular economy for downstream petrochemical industries.

Methodology

In order to achieve the present research objectives, at first, literature in the context of circular economy is reviewed. After the identification of components, a fuzzy ISM method is implemented to make an interactive model. In the end, MICMAC analysis is calculated. The procedure of this research is shown in figure 2.

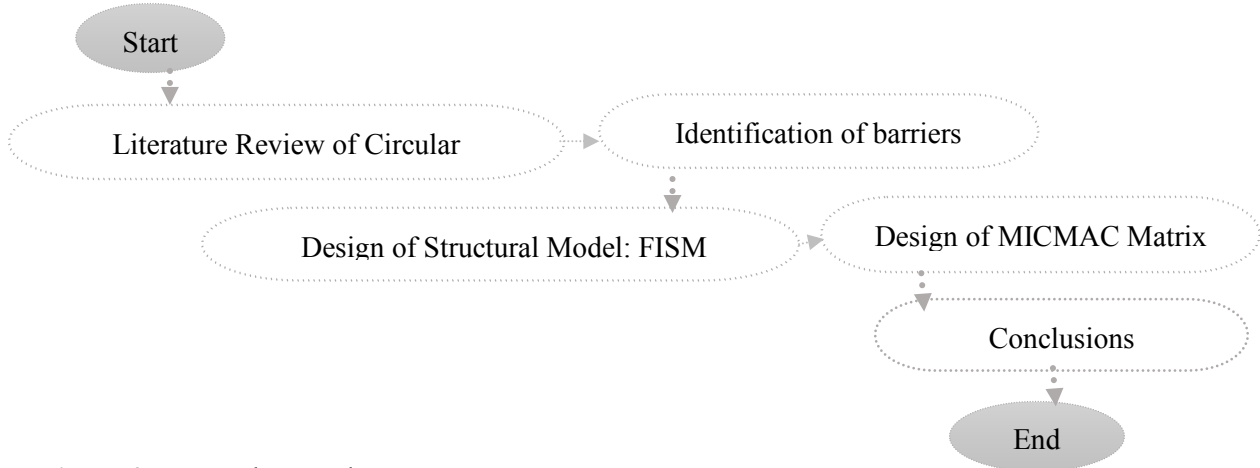


Figure 2. Research procedure

In this paper, the barriers of the circular economy were exploited through the study of thematic literature. Thus, using the textual content analysis approach, the practices are eliminated with low frequency. The final barriers of circular economy are shown in table 1.

Table 1. Key barriers to the circular economy in the literature

Key barriers to circular economy	Reference
Lack of circular economy culture	Karuppiah et al. (2021); Urbinati et al. (2021)
Lack of collaboration among supply chain partners	Moktadir et al. (2020); Yadav et al. (2020)
Lack of guidelines for re-manufacturing products	Fatimah et al. (2020); Pieroni et al. (2021)
Lack of financial assistance from government	Gupta et al. (2019); Corona et al. (2019)
Obstructing laws and regulations	Karuppiah et al. (2021); Kirchherr et al. (2018)
challenges in the safe return of waste to the biosphere	Yadav et al. (2020); Dantas et al. (2020)
Lack of reverse logistics facilities	Korhonen et al. (2018); Kirchherr et al. (2018)
High upfront investment cost	Moktadir et al. (2020); Corona et al. (2019)
Lack of technologies and technical skills	Yadav et al. (2020); Ribeiro et al. (2016)
Cheap virgin material	Karuppiah et al. (2021); Kirchherr et al. 2018
stakeholders with short term agendas	Grafstrom &Aasma (2021);Kapoor et al. (2020)
Uncertainty of consumer demand	Tura et al. (2019); Grafstrom &Aasma(2021)
Lack of market mechanisms for waste recovery	Grafstrom &Aasma (2021); Tura et al. (2019)
Lack of social awareness	Schroeder et al. (2019); Grafstrom &Aasma (2021)

In continue, the steps describe the Interpretive Structural Modelling(ISM) approach. It is a tool operation research that offers a graphical structure of complex systems (Watson, 1978). This model was introduced by Warfield in 1974 for the first time (Warfield, 1974). This model is capable of showing the complicated problems in graphical form and reducing the complication. The ISM recognizes the internal relationships among variables and analyzes the effect of one variable on the other variables. The classic approach of ISM merely discusses the relationship between elements shown by a two-value spectrum of 0 or 1. At the same time, the effect intensity of one variable on the other is not considered (Pramod & Banwet. 2015).

The fuzzy interpretive structural model (FISM) approach was used in the present paper to remove this defection. The steps of FISM were taken in order to design the structural model the barriers of circular economy as shown in figure 3.

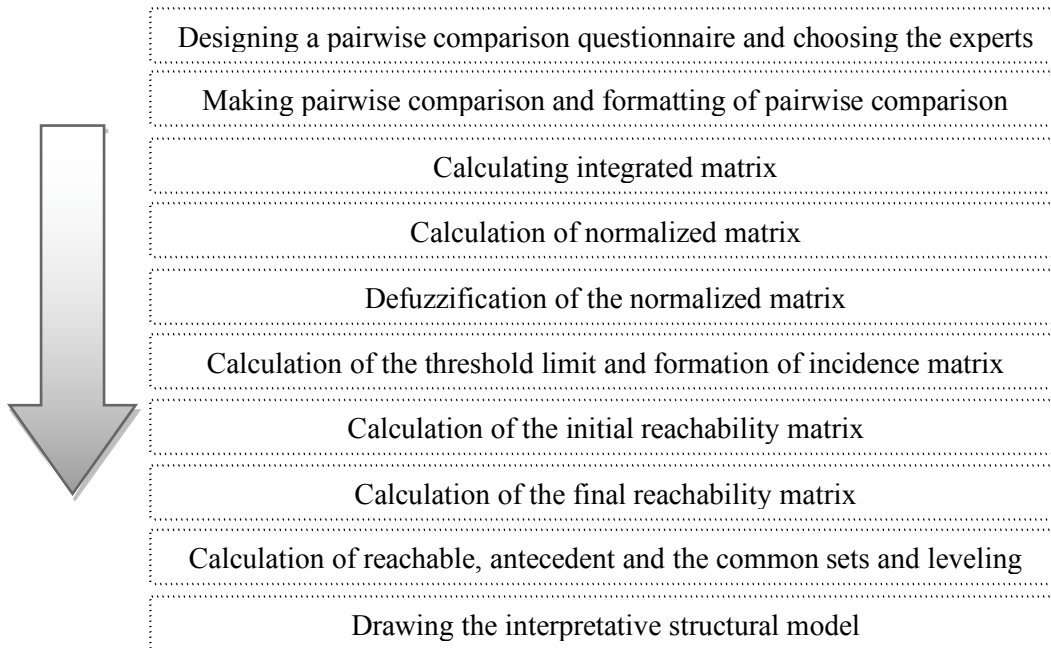


Figure 3: Steps of FISM

As shown in the above figure, the a pairwise comparison questionnaire is designed, and then respondents are selected to purposive sampling method. In this research, a number of 14 experts from the rubber and plastics industry and the university have been chosen based on theoretical domination, practical experience, and the availability of population. In the next step, after filling out the questionnaire by respondents, the pairwise comparison matrixes are formed. Then, linguistic variables are converted into fuzzy numbers for doing calculations. Linguistic variables, symbols and fuzzy numbers are shown in table 2. Thus, the pairwise comparison matrix is formed, as shown in figure 4.

Table2. Linguistic Variables and Fuzzy Numbers (Akyuz & Celik, 2015)

Linguistic Variables	Symbol	Fuzzy Number		
No effect	no	0	0	0.25
Little effect	l	0	0.25	0.5
Medium effect	m	0.25	0.5	0.75
High effect	v	0.5	0.75	1
Very high effect	vh	0.75	1	1

$$D = \begin{bmatrix} P_1 & P_2 & \dots & P_n \\ P_1 & - & \tilde{d}_{12} & \dots & \tilde{d}_{1n} \\ P_2 & \tilde{d}_{21} & - & \dots & \tilde{d}_{2n} \\ \vdots & \vdots & \vdots & - & \vdots \\ P_n & \tilde{d}_{n1} & \tilde{d}_{n2} & \dots & - \end{bmatrix}$$

Figure 4. Pairwise comparison matrix (Tseng and Chiu, 2013)

Where p_i and d denotes i^{th} practice and Fuzzy triangular number, respectively. In the continue, the integrated matrix is formed as shown in figure 5. It is calculated to a geometrical average of the opinion experts in pairwise comparison matrixes.

$$G = \begin{bmatrix} - & \tilde{g}_{12} & \dots & \tilde{g}_{1n} \\ \tilde{g}_{21} & - & \dots & \dots \\ \vdots & \vdots & - & \dots \\ \tilde{g}_{n1} & \dots & \dots & - \end{bmatrix}$$

Figure 5. Integrated matrix

Thus, the normalized matrix is calculated of division integrated matrix on amount of α that is calculated by equation 1 (Abdullah & Zulkifli, 2015).

$$\gamma = \max_{1 \leq i \leq n} \sum_{j=1}^n u_{ij} \quad (1)$$

Where u_{ij} denotes the upper limit of Fuzzy numbers in an integrated matrix. In continue, the defuzzification matrix is calculated using the best non-fuzzy performance (BNP) method that is obtained by equation 2 (Gumus et al., 2013).

$$BNP_{ij} = \frac{u_{ij} \cdot l_{ij} + m_{ij} \cdot l_{ij}}{3} + l_{ij} \quad (2)$$

In the next step, a threshold limit is calculated by equation 3 (Abdullah & Zulkifli, 2015).

$$C = \frac{\sum_{j=1}^n \sum_{i=1}^n a_{ij}}{n^2} \quad (3)$$

Where a_{ij} and n denote crisp numbers and dimensions of the normalized matrix and c is a threshold limit. Then, the incidence matrix is calculated to compare to compare the defuzzification matrix entries with the threshold limit one by one. If an entry was greater than or equal to the threshold limit, then it is replaced to 1 number and otherwise is replaced to 0 number. In continue, the initial reachability matrix is calculated. This matrix is obtained by adding the incidence matrix to the identity matrix (Xiong et al., 2011). Then, the final reachability matrix is calculated by the intervention of transition. The transactional relationship in interpretive structural modeling is a basic assumption.

Transition means that if element a is effective on element b and the element b is effective on element c , element a is effective on element c . This matrix is calculated, so that equation 4 is obtained:

$$M^* = M^k = M^{k+1} \quad , \quad k > 1 \quad (4)$$

Where M and k denote the initial reachability matrix and a natural number, respectively. The reachable, antecedent, and common sets are obtained from the final reachability matrix in the next step. To this purpose, at first, reachable and antecedent sets are determined. Then, the common settings for each element is determined (Jia et al., 2014). Elements with the same antecedent set and common set are put in the highest hierarchy of interpretative structural model. When the elements of the highest level are determined in the first repetition, they are removed from other elements. This action is repeated until levels of all elements are determined (Muduli et al., 2014). After that, an interpretive structural model is drawn to remove transitions (Azhagan & Haq, 2013).

In the end, MICMAC analysis is done, which categorizes barriers into four clusters. Cluster I included practices which have low driving and dependence power. Cluster II included practices having high dependence and low driving power. Cluster III included practices that are having high driving power and high dependence. Finally, Cluster IV included practices that have high driving power and low dependence (Chander et al, 2013).

Application of the proposed methodology

In this section, firstly, the pairwise comparisons matrix was formed based on the opinions of experts. Table 3 shows the pairwise comparisons matrix for the 1st expert.

Table 3. pairwise comparisons matrix for 1st expert

Barriers	B ₁	B ₂	B ₃	B ₄	B ₅	B ₆	B ₇	B ₈	B ₉	B ₁₀	B ₁₁	B ₁₂	B ₁₃	B ₁₄	
Lack of circular economy culture	B ₁	-	l	m	vh	v	m	vh	l	v	l	vh	l	v	m
Lack of collaboration among supply chain partners	B ₂	l	-	l	m	l	no	v	l	l	no	m	vh	l	vh
Lack of guidelines for re-manufacturing products	B ₃	no	no	-	v	v	m	v	m	vh	l	m	l	no	l
Lack of financial assistance from government	B ₄	m	vh	l	-	no	v	m	vh	v	vh	v	v	m	l
Obstructing laws and regulations challenges in the safe return of waste to the biosphere	B ₅	m	l	no	v	-	m	vh	l	m	l	m	vh	l	vh
Lack of reverse logistics facilities	B ₆	v	v	m	m	l	-	v	v	m	l	v	m	vh	l
High upfront investment cost	B ₇	m	vh	l	v	vh	l	-	l	v	v	m	vh	l	l
Lack of technologies and technical skills	B ₈	m	vh	l	vh	l	l	vh	-	l	v	m	m	l	no
Cheap virgin material	B ₉	m	l	no	l	vh	vh	l	m	-	vh	l	v	v	m
stakeholders with short-term agendas	B ₁₀	no	l	l	m	no	l	l	l	l	-	no	m	l	no
Uncertainty of consumer demand	B ₁₁	l	vh	m	vh	l	vh	l	vh	m	m	-	no	l	vh
Lack of market mechanisms for waste recovery	B ₁₂	no	l	m	l	no	l	no	l	l	v	l	-	no	l
Lack of social awareness	B ₁₃	l	vh	v	v	m	l	l	vh	l	v	m	vh	-	vh
	B ₁₄	no	l	l	m	l	vh	no	l	l	m	l	vh	vh	-

To continue, we obtained integrated, normalized, and defuzzification normal matrixes. After that, we calculated the threshold limit and obtained a value of 0.021 for it. In the next step, initial reachability matrices were calculated, as shown in table 4. The final reachability matrix has been calculated to equation 4 as shown in table 5.

Table 4. Initial reachability matrix

	B ₁	B ₂	B ₃	B ₄	B ₅	B ₆	B ₇	B ₈	B ₉	B ₁₀	B ₁₁	B ₁₂	B ₁₃	B ₁₄
B ₁	1	0	0	1	0	0	0	0	0	1	0	0	1	0
B ₂	0	1	0	0	0	0	0	0	0	0	0	0	0	0
B ₃	1	1	1	1	0	0	0	0	0	0	0	0	1	0
B ₄	0	0	0	1	0	0	1	0	0	0	0	0	0	0
B ₅	1	0	0	0	1	0	0	1	0	0	0	0	1	0
B ₆	1	0	0	1	0	1	1	0	0	1	0	0	0	0
B ₇	0	1	0	0	0	0	1	0	0	0	0	0	0	0
B ₈	1	1	0	1	0	0	0	1	0	0	0	0	0	1
B ₉	0	0	0	0	0	1	1	0	1	0	1	0	0	1
B ₁₀	0	1	0	0	0	0	0	0	0	1	0	0	1	0
B ₁₁	1	0	0	0	0	1	1	0	0	0	1	0	1	0
B ₁₂	0	1	1	0	0	0	0	0	1	0	0	1	0	1
B ₁₃	1	1	0	0	0	0	1	0	0	0	0	0	1	0
B ₁₄	1	0	1	1	0	1	1	0	0	0	1	0	1	1

Table 5. final reachability matrix

	B ₁	B ₂	B ₃	B ₄	B ₅	B ₆	B ₇	B ₈	B ₉	B ₁₀	B ₁₁	B ₁₂	B ₁₃	B ₁₄	Influence
B ₁	1	1	0	1	0	0	1	0	0	1	0	0	1	0	6
B ₂	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
B ₃	1	1	1	1	0	0	1	0	0	1	0	0	1	0	7
B ₄	0	1	0	1	0	0	1	0	0	0	0	0	0	0	3
B ₅	1	1	1	1	1	1	1	1	0	1	1	0	1	1	12
B ₆	1	1	0	1	0	1	1	0	0	1	0	0	1	0	7
B ₇	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2
B ₈	1	1	1	1	0	1	1	1	0	1	1	0	1	1	11
B ₉	1	1	1	1	0	1	1	0	1	1	1	0	1	1	11
B ₁₀	1	1	0	1	0	0	1	0	0	1	0	0	1	0	6
B ₁₁	1	1	1	1	0	1	1	0	0	1	1	0	1	0	9
B ₁₂	1	1	1	1	0	1	1	0	1	1	1	1	1	1	12
B ₁₃	1	1	0	1	0	0	1	0	0	1	0	0	1	0	6
B ₁₄	1	1	1	1	0	1	1	0	0	1	1	0	1	1	10
Dependence	11	14	7	12	1	7	13	2	2	11	6	1	11	5	

In the next step, after determining the reachable and antecedent sets, the unity of these sets for each practice was determined. The practices with identical antecedent and common sets were put in the highest level of the interpretive structural model. After the first repetition, the highest practices were removed.

The same procedure repeated until the level of all practices was determined, as shown in table 6.

Table 6. 9 repetitions

Repetition	Antecedent set	Reachable set	Common set	Level
1	2	1,2,3,4, 5, 6,7, 8,9, 10,11,12,13,14	2	1
2	7	1, 3, 4, 5, 6, 7, 8, 9,10,11,12,13,14	7	2
3	4	1, 3, 4, 5, 6, 8, 9,10,11,12,13,14	4	3
4	1,10,13	1, 3, 5, 6, 8, 9,10,11,12,13,14	1,10,13	4
5	3	3, 5, 8, 9,11,12,14	3	5
6	6	5, 6, 8, 9,11,12,14	6	6
7	11	5, 8, 9,11,12,14	11	6
8	14	5, 8, 9,12,14	6	7
9	9	5, 9,12	9	8
8	8	5, 8,12	8	8
9	5	5	5	9
9	12	12	12	9

In the next step, an Interpretive structural model was formed to remove the transitions, as shown in figure 6.

After that, MICMAC analysis was done for barriers of circular economy in the downstream petroleum industry as shown in figure 7.

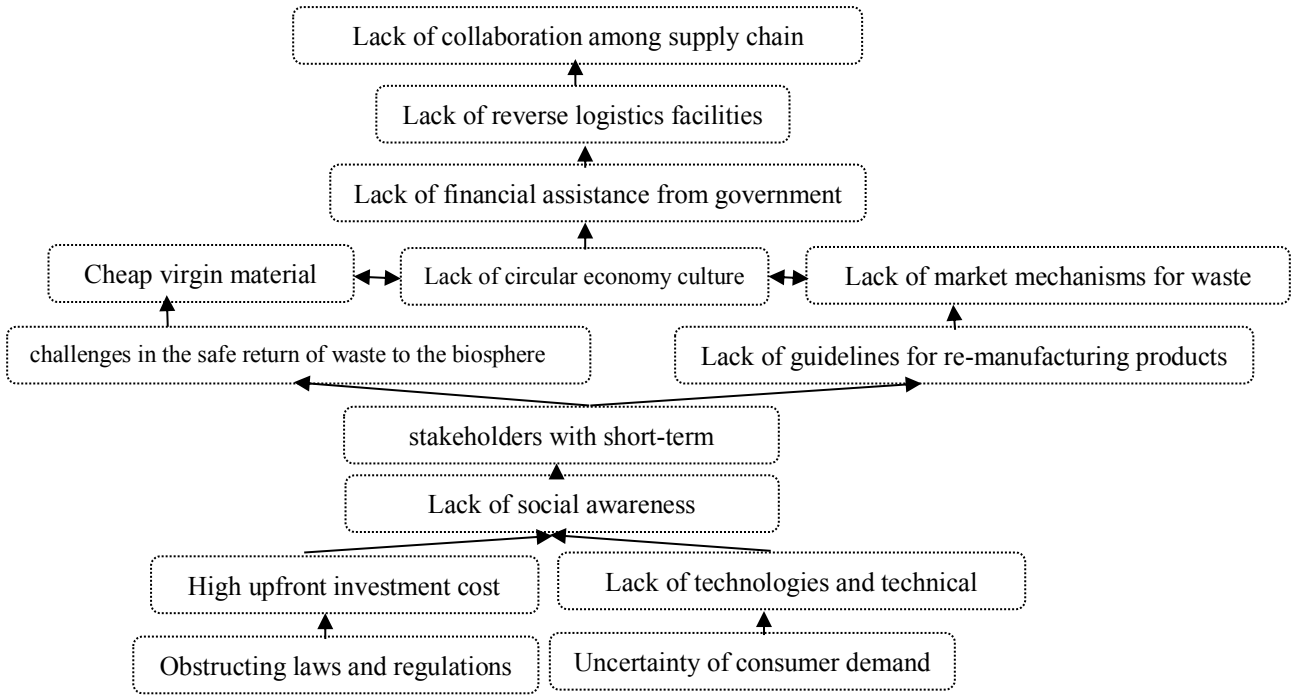


Figure 6. Interpretive Structural Model of the Circular Economy barriers

Driving power	14													
	13													
	12	B5, B12												
	11		B8, B9											
	10				B14									
	9			Cluster IV		B11				Cluster III				
	8													
	7						B3, B6							
	6										B1, B10, B13			
	5									B13				
	4													
	3											B4		
	2			Cluster I						Cluster II			B7	
	1													B2
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
	Dependence Power													

Figure 7. Driving power and dependence barriers of circular economy

The upper matrix shows the classification of barriers of circular economy based on driving power and dependence. In those, the barriers in cluster IV such as stakeholders with challenges in the safe return of waste to the biosphere, Lack of guidelines for re-manufacturing products, short-term agendas, and so on are very important. they have the most influence on other barriers.

Conclusion

Global warming, industrialization of societies, increasing capacity and demand, depletion of non-renewable resources, and over-consumption have posed great challenges for industries. Circular economics as an efficient tool can improve environmental impacts, reduce consumption, and environmental impacts, reduce consumption and prevent increased costs and negative other consequences. This paper offered multi-level modeling of circular economy barriers in downstream petroleum industries. To this purpose, at first, several 14 circular economy barriers were identified using exhaustive literature. The multi-level model of circular economy barriers in the downstream petroleum industry was designed according to the stages of the fuzzy interpretive structural modeling approach. The study results showed that from the viewpoint of experts, due to the placement of “Obstructing laws and regulations” and “Uncertainty of consumer demand” barriers at the root of the model were the most important barriers of circular economy in downstream petroleum industries.

In the next step, barriers of the circular economy were put into four clusters using the MICMAC analysis. The results of the study showed barriers such as “Obstructing laws and regulations”, “Uncertainty of consumer demand”, “High upfront investment cost”, “Lack of technologies and technical skills” and “Lack of social awareness” are the very important in implementation of the circular economy. They have a higher penetration power than others. Because these barriers are at the root of the interpretive structural model. In order to implement a circular economy in the rubber and plastics industry, more attention must be paid to these Barriers. Because removing these barriers can improve the performance of the industry. In addressing those, the role of government is crucial. It is the responsibility of the government to promote the benefits of using products developed through CE practices and, by extension, to stress the need for conserving the environment. Similarly, downstream petroleum industries, emphasizing the rubber and plastics industry must strive to develop their image around social consciousness. Then, in creating social awareness, the knowledge of CE practices must be fostered among the industries and, more importantly, in society. For this, awareness programs must be created for society, and stringent environmental laws must be enforced. Research on circular economics is still in its infancy, and there is no knowledge of how to implement it in industry, and the barriers to implementing this concept in the industry have not been fully identified. Therefore, it is suggested that comprehensive research identify the barriers facing industries.

In this study, a model of circular economy barriers is designed for downstream petrochemical industries. Hence, it is difficult to generalize the results of this study. It is suggested that a similar study be conducted in other industries and the results compared. Also, it is recommended to use the structural equation modeling (SEM) approach for further examination of the validation of the designed model. Also, it may exist in some other a circular economy not identified in this research. Of course, this study has its limitations. Because the required data were obtained by completing a questionnaire from a statistical sample and reporting them, the results may be biased.

This study encompasses these ideas and explores the barriers of the circular economy transition for the downstream petrochemical industries. In this paper, authors review several circular economy initiatives taken by downstream petrochemical industries. The paper aims to demonstrate some common themes across three big mining companies with the help of content analysis; and evaluates the identified barriers of these circular economy initiatives. The authors argue that the downstream petrochemical industries might capitalize on the learning of other industries in relation to CE, enabling timely advancement of circular economy initiatives.

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