Hindawi
Mathematical Problems in Engineering
Volume 2022, Article ID 4327074, 13 pages
https://doi.org/10.1155/2022/4327074

Research Article

Analysis of the Driving Factors of the Extended Producer Responsibility System in China's Tire Industry

Hu Houbao,[1] Chen Qiang,[1] and Liu Junjun[2]

[1]*School of Economics & Management, Tongji University, 1239 Siping Rd., Shanghai 200092, China*
[2]*School of Business Administration, Faculty of Business Administration, Southwestern University of Finance and Economics, Chengdu 611130, China*

Correspondence should be addressed to Liu Junjun; liujunj@swufe.edu.cn

Received 18 January 2022; Accepted 8 March 2022; Published 28 March 2022

Academic Editor: Ching Ter Chang

The effective treatment of wrap tires could mitigate black pollution, reduce carbon emission, and supply risks. The Extended Producer Responsibility (EPR) system is an effective way to deal with the problems aroused from wrap tires in some countries. In order to analyze the driving factors for the EPR system in the Chinese tire industry, this study first identifies the key driving factors based on literature analysis, expert interviews, and field research. And then, using the grey decision-making and trial evaluation laboratory (Grey-DEMATEL) method, the interrelationships among these factors were quantified analyzed. We find that the causal factor is to "strengthen the service function of dealers and service providers and improve the satisfaction of sales channels." Finally, sensitivity analysis was performed to ensure the robustness of the results. Conclusions are summarized below. If the implementation of the EPR system for tire companies can promote the sales of new tires, achieving the economic and environmental benefits must be the most critical factor. The effect factor is to fulfill social responsibility and achieve the brand effect. This result is in line with the original intention of tire companies to fulfill social responsibility and realize resource recycling. The key factors are related to policy guidance and regulations at the national level. And managerial implications are suggested for promoting the EPR system in China tire industry.

1. Introduction

The disposal of used and waste tires has become a global challenge. The random disposal of scrap tires creates serious environmental problems ("black pollution") and poses high-risk safety hazards such as fire [1]. This situation is particularly serious in China. The country is the world's largest tire producer and consumer, accounting for about 40% of the global annual tire output and generating more than 300 million scrap tires each year, of which less than 50% are effectively disposed of [2]. At the same time, waste tires have great potential to be recycled and reused through processes such as tire retreading, reclamation of rubber (powder), thermal cracking, and prototype utilization [3]. Of these avenues, the production of reclaimed rubber (powder) can effectively alleviate the Chinese tire industry's dependence on imported natural rubber. The industry accounts for more than 70% of China's natural rubber consumption, 90% of which comes from foreign imports [4]. In addition, as tire production is a highly energy-intensive process, the reuse of scrap tires (retreading, etc.) can effectively reduce the carbon emissions of tire producers. Thus, the effective disposal and recycling of used tires are of strategic importance to China as they not only reduce the environmental hazards but also alleviate to some extent the impact of natural rubber as a "limiting" resource on China's economy [5, 6].

The Chinese government has been committed to the effective disposal of scrap tires. In 2011, the National Development and Reform Commission (NDRC) included waste tires in the catalog of key areas for resource utilization in the 12th Five-Year Plan. In 2015, the Ministry of Finance introduced special tax incentives to encourage the recycling and reuse of waste tires. The NDRC organized a symposium in 2019 to discuss the role of Extended Producer Responsibility (EPR) in the treatment and disposal of waste tires in China based on the experience of other countries. The establishment and practice of EPR aim to address pollution and achieve waste recycling at the same time. Currently, an EPR system for tires has been successfully implemented in some countries. With the state, enterprises, and the public paying increased attention to environmental protection, the atmosphere is also favorable for the implementation of an EPR system for tires in China. In the context of the construction of an ecological civilization, relevant policies, laws, and regulations have been introduced in China to regulate the scrap tire market from various perspectives, which is encouraging the recycling of scrap tires and promoting the sustainable development of the tire industry as a whole. Although an EPR system entails extra costs for tire producers, it also reduces their raw material procurement costs and risks. In addition, it is also an important aspect of the social responsibility of tire producers as it will help build a good social image. However, in practice, companies are still not sufficiently motivated, with only limited actions being taken thus far; i.e., they have not been strongly incentivized.

Against this backdrop, this paper aims to systematically elaborate on the driving factors for the implementation of an EPR system in China's tire industry and uses the Grey-DEMATEL method to study the correlations between individual drivers in order to reveal the most imminent and fundamental driving forces among them and provide the government and enterprises with a basis for the effective formulation and implementation of an EPR system.

2. Materials and Methods

2.1. Literature Review

2.1.1. EPR System. The concept of EPR is first defined by Lindhqvist [7] as a strategy to reduce the total environmental impact of a product by requiring producers to be responsible for the whole life cycle of the product. The basic assumption of the EPR system is that producers could reduce environmental impact in the design stage of a product [8]. The philosophy of EPR has been adopted by the government in its policymaking. These policy instruments derived from the EPR system include disposal tax, reuse and recycle programs, and other related bans or restrictions. Under the EPR system, these producers are encouraged to develop new disposal products by using some measures like sourcing green materials, developing innovative dismantling techniques, and designing modular components [9–11]. The implementation of the EPR system is expected to deal with the waste problems through the joint efforts of various stakeholders [5]. It has been adopted in many countries for dealing with waste from electrical and electronic equipment, vehicles, packaging, battery, and tires [12–14].

Some barriers and challenges for EPR system implementation have been identified [5, 15–17]. These barriers include lacking a mature collection system of waste, weak technical capabilities, and absence of laws and regulations. Fortunately, the positive elements of the system provide lots of win-win opportunities. Thus, reasonable incentive strategies will promote the implementation of the EPR system [18]. Gui et al. [19] recommended several incentive ways to promote EPR implementation, such as enhancing design incentives, and fair cost allocation design for stakeholders. Li et al. [18] pointed out that EPR law was necessary for waste management and closed-loop supply chain management. Hickle [20] suggested the government should build a platform for all products' EPR implantation beyond legislation. The incentive system or drivers for the EPR system involve different stakeholders and cover binary levels (macroscopic and microcosmic levels) [21, 22].

2.1.2. Key Drivers (1) Macrolevel Driving Factors

D_1: Green development is a development concept at the national level.

The path of green development is an important component of Xi Jinping's thought on economic development and socialism with Chinese characteristics for a new era. The construction of an ecological civilization is the backbone of the sustainable development of China's economy [23, 24]. The carbon neutrality and carbon peak goals under the green development plan will inevitably require the tire industry to tackle the problem of "black pollution" and realize the recycling and harmless reuse of scrap tires, which is an important driving factor for the government to promote the implementation of Extended Producer Responsibility.

D_2: The related laws require the implementation of EPR for some products.

Legislation is the optimal avenue and necessary prerequisite to promote EPR [18]. The EU's experience has shown that the EPR system established under the framework of the 1999/31/EC law has promoted the recycling of used tires, achieving a 23% to 100% recycling rate of used tires in major member countries [25]. The Circular Economy Promotion Law and the Solid Waste Prevention Law have already required the implementation of EPR for certain products. Although no mandatory catalog has been established, they have certainly promoted the implementation of EPR by enterprises to some extent.

D_3: Recycled rubber is a strategic alternative to rubber.

Recycled resources are obtained from waste products through recycling and reuse. Originating from primary resources, they also compete with, replace, and supplement the primary resources. Recycled resources will play an important role in supporting socioeconomic development when social resource accumulation reaches a certain scale [26]. Recycled rubber made from waste tires can replace a certain proportion of fresh rubber, which is widely used in economic activities nationwide [27].

D_4: Scrap tires as a recycled resource to support the sustainable development of the tire industry.

With institutional support, the multiplier effect of recycled resources can significantly enhance the sustainable use of resources, reduce the consumption of primary resources, and support the sustainable development of the industry [26]. A retreaded tire can save more than 70% of the primary resources, including rubber, steel, fiber, and carbon black.

D_5: Strengthened government crackdown on non-compliant companies.

In China's dualistic economic structure, waste products are a low-priced commodity. The process of promoting EPR should take into account both policy protection and the need to strengthen the crackdown on non-compliant enterprises (those that emphasize economic development while polluting the environment). Through a binding system of fines, deposit refunds, prepayment, and credit ratings, the government can regulate companies and punish violators, thus promoting better compliance with the EPR system and contributing to the construction of a national circular economy [13, 28, 29]. More than 70% of waste tires in China were used to produce recycled rubber and rubber powder, causing serious secondary pollution during the production process, so many enterprises have been shut down.

D_6: National ministries and commissions frequently issue policies on the scrap tire industry.

As a typical recycled resource industry, the scrap tire industry has caught the attention of business and government agencies for its ecological significance and green development implications. In 2017, the *Guidance on Accelerating the Development of the Recycled Resources Industry* was promulgated; it called for the establishment of a recycled resources system represented by the scrap tires industry by 2020 and the institution of a functional EPR system. The General Office of the State Council's "*Guidance on Actively Promoting Supply Chain Innovation and Application*" issued in 2017 required the implementation of an EPR system focusing on tires and other products. In January 2019, the NDRC issued a letter to solicit opinions on the *Implementation Plan for Building an Extended Producer Responsibility System in the Tire Sector*.

(2) Microlevel Driving Factors for Companies

D_7: Access to government subsidies and preferential policies.

The government can use incentives such as rewards, subsidies, tax incentives, and differential pricing to promote better implementation of an EPR system by enterprises, which would be conducive to the construction of a national circular economy [10, 30].

D_8: Practicing social responsibility and achieving brand influence.

The EPR system is not limited to environmental responsibility in the production process but extends its green pledge throughout the entire life cycle of the product [20]. The public's sociopsychological attitude toward remanufactured products can impact their purchasing decisions; the government's encouragement of the public's green consumption can have a positive impact on the brand image of enterprises and encourage them to establish an EPR system [31] to achieve a closed-loop cycle of waste and sustainable development [18, 32].

D_9: Reducing the cost of use for end users.

In Italy, recycled products (remanufacturing) have been found to reduce the cost of use for end users (consumers) and promote consumers' use of retreaded tires [33], generating a sustainable downstream market.

D_{10}: Using recycled materials to reduce costs.

The use of recycled materials can effectively supplement the supply of raw materials; thus, it can not only maintain a stable supply chain but also lead to more affordable prices [34], which indirectly increases the profitability of a company [35].

D_{11}: Scrap tire recycling can boost new tire sales.

The sociopsychological attitudes of the general public toward remanufactured products determine customer purchase decisions [31]. Encouraging the public's preference for green consumption can have a positive impact on increasing customer volume and sales for companies, which in turn promote their EPR systems [18].

2.2. Typical Cases of Scrap Tire Recycling in the Chinese Tire Industry. Although China has not yet required the establishment of an EPR system for tires, responsible enterprises have already established or are planning to establish their own recycling units to carry out practical activities for the recycling of waste tires. Hangzhou Zhongce Rubber Co., Ltd., is one of the largest tire enterprises in China and has been among the top ten tire sellers in the world for multiple years in a row. Established in 2009, Zhongce Rubber Recycling Technology Co., Ltd., is a wholly-owned subsidiary of Zhongce Rubber, undertaking the recycling of its own brand of scrap tires.

In October 2014, Zhongce Rubber Recycling Technology Co., Ltd., was approved as a backbone enterprise of the NDRC's "Double Hundred Project" to promote the comprehensive utilization of waste tires. In March 2014, the China Tire Retreading and Recycling Association, Ministry of Commerce, Ministry of Finance, and Ministry of Industry and Information Technology designated Zhongce as the only pilot site in China to carry out recycling work. In June 2014, Zhongce featured among the first batch of enterprises to meet the industry access requirements for comprehensive utilization of scrap tires by the Ministry of Industry and Information Technology. In November 2015, it was shortlisted for the Ministry of Industry and Information Technology's "List of Major Demonstration Projects for National Resource Recycling and Utilization." As Zhongce is one of the largest tire producers in China and the first to implement the demonstration work, the research on the driving factors of tire recycling in Zhongce provided important practical significance for exploring the driving factors of EPR and building an EPR system in China's tire industry. The research obtained the following findings.

The main driving factors of Hangzhou Zhongce's scrap tire recycling initiative stem from the following aspects. (1) Undertaking social responsibility and demonstration effect: the management of Hangzhou Zhongce, as the leader of the domestic tire industry, took the initiative to recycle waste tires as part of efforts to fulfill its social responsibility. At the 2019 China Rubber Annual Conference, the company chairman stated that "Zhongce Rubber has been committed to exploring the recycling of scrap tires since 2011. The project does not generate profits, but the loss is not a lot, and I think it is part of the enterprise's social responsibility philosophy." (2) Reducing environmental pollution and saving resources: the reuse of waste tires will reduce "black pollution," save resources and support the sustainable development of the tire industry. (3) Brand promotion: Zhongce believes that recycling tires can enhance the brand value and improve the image of the company in the eyes of the public and government. (4) Promoting new tire sales: brand enhancement can drive the sales of new tires. (5) Strengthening the service functions of dealers and retailers: the recycling of scrap tires solved dealers' problems of storing and processing scrap tires and enhanced the service functions. (6) Reducing the cost of tire use for end users: retreading and using recycled materials can reduce costs. Therefore, in addition to the driving factors obtained through the literature analysis, a new driving factor emerged in the case of Zhongce.

D_{12}: Strengthening the service functions of dealers and retailers to enhance customer satisfaction.

Tires reach consumers through dealers and retailers. At the same time, the retail sites also assume responsibility for recycling used tires. Strengthening the service functions of dealers and service providers improves consumer satisfaction with sales channels.

3. Research Methodology

3.1. Determination of the Key Driving Factors. In this study, there are 12 main drivers of the Extended Producer Responsibility (EPR) system in the tire industry in China (Table 1), which were identified and refined primarily through the following processes:

The first approach was a literature review. This study reviewed theoretical research on EPR from domestic and international literature and also took into consideration established EPR practices of the tire industries in European countries and the United States and their national development concepts, regulations, and policies.

The second avenue was expert interviews. A three-hour, semistructured thematic meeting was held with the director of the Technical and Economic Committee of the Chinese Rubber Association, as well as the adviser and the secretary-general of the Scrap Rubber Recycling Branch. This was followed by several return visits to the secretary-general of the Scrap Rubber Recycling Branch, as well as communications on related issues with industry experts and enterprise technical managers.

The third approach was a special investigation at the enterprise. At the end of 2017 and in March 2018, a special research meeting was held at Hangzhou Zhongce Recycling Technology Co., Ltd. More than 20 people participated in the event, including the vice general manager of Hangzhou Zhongce Group, the general manager of Zhongce Recycling Technology Co., Ltd., technical and quality management personnel, university researchers, and members of industrial associations.

3.2. DEMATEL Questionnaire Development and Data Collection. Based on expert advice, the questionnaire was divided into three parts. The first part contained the basic information of the respondents, the second part defined the driving factors, and the third part collected the core data. The data collection started in December 2017 with a series of interviews with several industry experts to understand the current situation of waste tire management in China. In March 2018, a team of experts went to Hangzhou Zhongce Recycling Technology Co., Ltd., to organize on-site workshops and production site visits to understand the practical aspects of scrap tire management. These interviews and surveys helped shed light on the drivers and barriers. Prequestionnaire interviews were conducted with the most representative entrepreneurs, technical experts, and experts from industrial organizations from July to September 2018, with 33 valid questionnaires collected out of 37. Based on the results of the prequestionnaire surveys, some factors were removed and the sentences of the questionnaire were reorganized to make it more accurate and academic. Finally, in December 2018, five experts were selected from the abovementioned organizations to complete the comparison of the barriers. All of them had solid experience in the tire industry and a thorough understanding of the recycling industry. The experts were from tire companies, industry organizations, and recycling companies, with two managers from tire companies (one senior and one middle level), two experts from rubber associations (deputy secretary-general and branch secretary-general), and one senior manager from a recycling company. As these experts had participated in face-to-face interviews, discussion symposiums, telephone discussions, and written communications in the early stage, they held consistent views about relevant entries, thus eliminating individual bias. Meanwhile, for the purpose of standardization, the influencing factors were explained for a better understanding of the experts. The research method in this paper was to form a matrix based on the third part. All the evaluation results collected from 5 experts are displayed in Table 2. After the grey number clearing process, a basic matrix was obtained and subject to Grey-DEMATEL analysis.

The following section provides a brief description of the organizations for which the five experts were working. Tire manufacturers and rubber recycling companies are two key players in an integrated supply chain management system,

Table 1: Driving factors for tire companies to implement EPR system.

No.	Driving factors	No.	Driving factors
D_1	Green development is a development concept at the national level	D_7	Access to government subsidies and preferential policies
D_2	The related laws require the implementation of EPR for some products	D_8	Practicing social responsibility and achieving brand influence
D_3	Recycled rubber is a strategic alternative to rubber	D_9	Reducing the cost of use for end users
D_4	Scrap tires as a recycled resource to support the sustainable development of the tire industry	D_{10}	Using recycled materials to reduce costs
D_5	Strengthened government crackdown on noncompliant companies	D_{11}	Scrap tire recycling can boost new tire sales
D_6	National ministries and commissions frequently issue policies on the scrap tire industry	D_{12}	Strengthening the service functions of dealers and retailers to enhance customer satisfaction

while industry associations know the whole picture of the industry. Therefore, the data for this paper came from two tire companies, Bridgestone China and Double Coin Tire; two associations, the China Rubber Industry Association and the Scrap Rubber Resource Comprehensive Utilization Branch of the China Rubber Industry Association; and one recycling company (Hangzhou Zhongce Recycling Technology Co., Ltd.).

Founded in 1931, Bridgestone is a Japanese tire company and is also currently one of the world's largest tire manufacturers. Bridgestone (China) Investment Co., Ltd., is a wholly-owned subsidiary of Bridgestone in China. Its Tire Division consists of four factories located in Shenyang, Tianjin, Wuxi, and Huizhou, which mainly produce commercial vehicle tires and car tires, as well as a retreading factory for aircraft tires in Qingdao. The Tire Division has about 6,000 employees. Bridgestone prioritizes environmental protection in its daily operations and has proposed a vision for everything to be recycled by 2050. Recycled products from tires are used to partially replace rubber in the production process to promote environmentally friendly practices and achieve its goal of being a sustainable company. Bridgestone has designated a special department to manage the supply of recycled rubber.

Double Coin Tire is one of the earliest tire producers in China and was once the largest tire company in the country, making great contributions to the domestic tire industry. Double Coin Tire has four production bases in China and follows a corporate philosophy of producing safe, green, and environmentally friendly products. Double Coin Tire has been actively promoting the recycling of tires.

The China Rubber Industry Association (CRIA) was established in 1985 and is composed of 1,500 members and 15 professional branches. CRIA is a voluntary organization that guides the development of the rubber industry, provides technical and policy services to the industry, and drafts industry group standards. It also serves as a communication channel between the government and enterprises. Promoting a circular economy and reducing carbon emissions is an important mission of CRIA.

The Scrap Rubber Resource Comprehensive Utilization Branch, a branch of CRIA, was also established in 1985. Its purpose is to promote the recycling of scrap rubber in China. The branch is a resource-based organization established by enterprises closely related to recycling. It serves as a communication channel between government agencies and enterprises, pushes technological innovation, publicizes and encourages a circular economy, and promotes the establishment of standards and regulations.

Hangzhou Zhongce Recycling Technology Co., Ltd., is a recycling enterprise established in 2009 as a wholly-owned subsidiary of Zhongce Rubber Group, the largest tire manufacturer in China and one of the top ten enterprises in the global tire industry. The main business of Hangzhou Zhongce Recycling Technology Co., Ltd., is the extension of sales of Zhongce Rubber tires, as well as the recycling and comprehensive utilization of waste tire resources, including through tire retreading, repair, recycling and comprehensive utilization of relevant resources, and sales of downstream products. The enterprise follows the basic principle of reduction, reuse, and recycling of the circular economy. It has established a world-leading industry chain for the comprehensive utilization of waste tires, including scrap tire sorting, retreading, rubber powder production, and reclamation of waste rubber. In addition, Hangzhou Zhongce Recycling has established a national-level demonstration line for the comprehensive utilization of waste tires.

3.3. Data Processing and Analysis. DEMATEL (Decision-making Trial and Evaluation Laboratory) was proposed by the Bastille National Laboratory in the United States in 1971 to identify the fundamental influencing factors from many influencing factors and provide support for decision-making. This method is applied for analyzing the causal relationship among critical factors, e.g., driving or barrier factors, which is identified under a structural theoretical model. Diagraph theory is embedded in the DEMATEL method, helping us reveal the causal relationship by dividing and connecting associated factors behind the issues [36]. In this method, all the relevant factors are classified into two quadrants: causal and affected by analysis of the interdependence relationship levels among factors [37]. The responses from experts for influencing degree between two factors are organized as a visual map to provide directions for solving the problems in the real world [38].

Some factors like the bias of experts and ambiguous information could lead to inconsistent decision-making. And the DEMATEL method is not suitable in an unclear or undefined environment [37]. To mitigate these

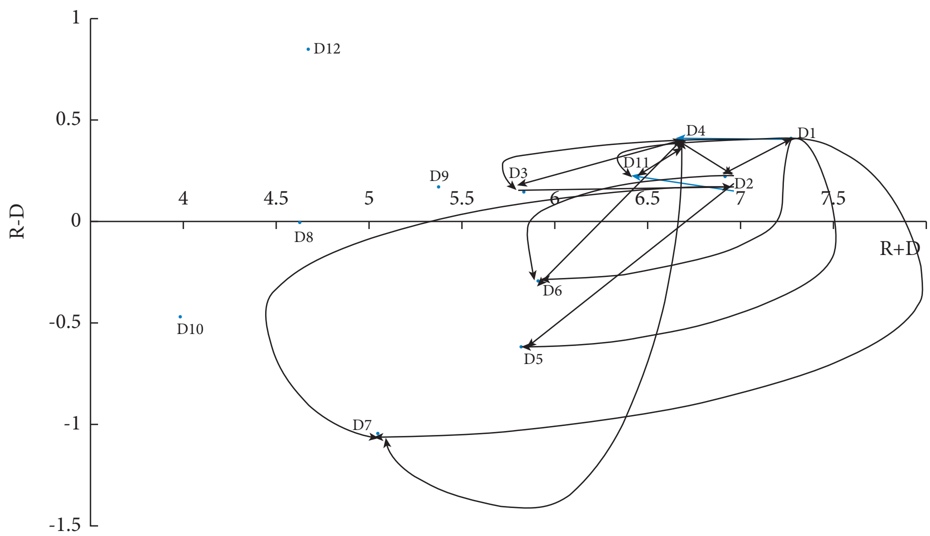

Figure 1: Cause-effect diagram of driving factors.

shortcomings, grey set theory is more effective than fuzzy concepts in applying the DEMATEL method [39]. As the fuzzy-based DEMATEL method could not map the membership function, this combination of grey and the DEMATEL method makes more confident decisions under human involvement [40]. In reality, experts' analysis of the relationship between various factors tends to be ambiguous and their recognition of the importance of the factors that drive the implementation of ERP by Chinese tire companies varies. Hence, this paper used the Grey-DEMATEL method to quantify the drivers with the specific analysis process listed hereinafter.

Using the principles of graph theory and matrix theory, DEMATEL can effectively identify the fundamental influences from many complex influencing factors to provide support for decision-makers [41]. This approach has been widely used in previous research work, including in the fields of waste collection and remanufacturing [37, 42] and integrated green supply chains [43]. In this paper, the DEMATEL approach was used to reveal the most urgent and most critical drivers that need to be addressed in the long term according to their importance. In addition, the combination of DEMATEL with the grey method was able to reduce the uncertainty caused by the subjective evaluation of experts [37, 44].

Taking into account the available studies, the specific analysis process was as follows:

Step 1: According to the literature [45], the semantic variables of the experts were derived as shown in Table 3.

Step 2: The basic grey number influence matrix was obtained.

Step 3: According to the literature [46, 47], the grey number clarification directly affected the matrix.

Step 4: According to the literature [45], the grey semantic variables with the expert weights were derived; see Table 4. The experts' weights were assigned differently according to their positions, knowledge, and working experiences on waste tires. Initially, experts 1–5 were assigned weights of 0.25, 0.25, 0.2, 0.15, and 0.15, respectively. Based on the expert weights (see Table 4), the direct influence matrices of the individual experts were combined into a direct influence matrix, with the combined direct influence matrix.

Step 5: The direct influence matrix was standardized and the combined influence matrix was calculated.

Step 6: The causality and centrality of each driver were calculated; see Table 5.

Step 7: A Cartesian coordinate system was established based on the centrality and causality of each driver, the position of each driver in the coordinate system was marked, and the cause-effect diagram of the distribution of driving factors was plotted. At the same time, the initial value of $\theta = 0.3062$ was set based on the mean and standard deviation of the combined influence matrix T, while curved arrows were plotted, as shown in Figure 1.

The equation associated with DEMATEL is shown below.

Set$A$ as the original relationship matrix, in the form of $i \times i$ matrix, where a_{mn} indicates the degree of influence of the factor m on n, and C denotes the direct relationship matrix after standardization. The total relationship matrix $S$was calculated according to equation (3), where I denotes the unit matrix. D and R were calculated based on equations (4) and (5).

$$K = \frac{1}{\max 1 \leq m \leq i \sum_{n=1}^{i} a_{mn}}, \quad (1)$$

$$C = K \times A, \quad (2)$$

$$S = C(I - C)^{-1}, \quad (3)$$

Table 2: Data collected from five experts.

Expert 5	1	2	3	4	5	6	7	8	9	10	11	12
1	0	3	3	3	3	2	4	1	2	2	3	3
2	4	0	2	3	0	0	3	1	3	2	3	0
3	1	2	0	3	1	1	1	0	0	0	0	0
4	3	3	2	0	3	2	3	1	2	2	3	1
5	3	2	1	2	0	3	3	1	1	0	3	0
6	3	2	1	2	2	0	2	1	2	2	3	2
7	2	1	1	1	1	2	0	0	0	0	2	1
8	0	0	2	2	2	1	3	0	2	1	1	1
9	3	2	3	1	3	3	1	2	0	1	2	0
10	2	2	1	2	1	2	1	2	1	0	1	0
11	3	3	3	3	2	2	3	1	1	1	0	1
12	2	2	1	3	2	3	3	1	2	1	0	0
Expert 2	1	2	3	4	5	6	7	8	9	10	11	12
1	0	4	3	3	4	3	3	3	2	3	4	2
2	4	0	4	4	4	4	4	4	4	4	4	4
3	4	4	0	3	4	4	4	3	3	3	4	4
4	4	4	4	0	4	4	4	3	3	3	4	4
5	4	4	3	3	0	3	3	3	3	3	3	3
6	4	4	3	3	3	0	3	3	3	3	3	3
7	4	4	2	2	2	3	0	2	2	2	2	2
8	4	4	4	3	3	3	3	0	3	3	3	4
9	4	4	4	4	4	4	3	3	0	2	3	2
10	2	2	2	2	2	2	2	2	2	0	2	2
11	4	4	4	4	4	4	4	4	4	4	0	4
12	4	4	3	3	3	4	3	3	3	3	4	0
Expert 3	1	2	3	4	5	6	7	8	9	10	11	12
1	0	3	2	2	4	3	2	2	3	2	3	2
2	3	0	2	3	2	3	1	2	3	2	2	1
3	2	3	0	2	3	2	2	1	1	2	3	2
4	3	2	3	0	2	1	2	3	3	2	2	3
5	3	2	3	2	0	2	2	1	1	2	3	2
6	2	3	2	2	1	0	2	3	2	2	4	2
7	2	3	1	2	3	2	0	2	2	2	2	1
8	3	2	3	1	2	1	2	0	3	3	1	2
9	3	2	2	2	1	2	3	2	0	2	2	2
10	1	2	2	3	4	2	2	1	2	0	1	1
11	2	3	1	2	2	3	3	2	2	3	0	1
12	3	2	3	2	3	3	2	2	1	2	2	0
Expert 4	1	2	3	4	5	6	7	8	9	10	11	12
1	0	4	3	3	2	3	2	3	3	1	3	2
2	3	0	4	4	3	4	3	1	1	1	4	2
3	4	3	0	4	3	4	1	3	3	1	3	1
4	4	4	4	0	3	3	1	1	1	1	2	1
5	0	1	1	1	0	1	0	1	1	1	1	1
6	1	1	1	1	3	0	0	1	1	1	1	1
7	0	0	0	0	0	0	0	2	1	1	1	0
8	0	0	0	0	0	0	0	0	1	1	0	0
9	1	1	2	2	1	1	1	2	0	1	2	1
10	0	0	0	0	0	0	0	2	0	0	0	0
11	3	3	3	3	3	3	1	2	1	1	0	0
12	1	1	1	1	1	1	0	2	2	1	1	0
Expert 5	1	2	3	4	5	6	7	8	9	10	11	12
1	0	4	0	2	4	1	4	1	1	0	4	0
2	2	0	1	0	2	1	3	0	0	0	1	0
3	0	1	0	3	0	1	0	3	3	0	0	0
4	0	0	0	0	0	3	0	2	4	0	0	0
5	1	2	0	1	0	1	1	1	2	0	1	0
6	1	1	2	3	0	0	1	0	0	0	1	0
7	1	1	0	1	2	2	0	1	1	0	2	0

Table 2: Continued.

Expert 5	1	2	3	4	5	6	7	8	9	10	11	12
8	0	0	0	2	1	0	0	0	2	1	0	1
9	0	0	1	2	1	1	0	1	0	1	0	0
10	0	0	0	1	1	1	0	1	0	0	1	0
11	1	1	0	1	4	1	2	1	1	0	0	1
12	1	1	0	1	1	0	1	0	1	4	0	0

Table 3: Semantic variables with expert weight.

Semantic variables	Grey number
Not important (N)	[0, 0]
Relatively unimportant (VL)	[0, 0.25]
Normal (L)	[0.25, 0.5]
Relatively important (H)	[0.5, 0.75]
Very important (VH)	[0.75, 1]

Table 4: Expert background and initial weights.

Expert no.	Organization	Age	Position	Number of years in the industry	Initial weights
1	Hangzhou Zhongce Recycling Technology Co.	39	General manager	16	0.25
2	China Rubber Industry Association	58	Vice-secretary	36	0.25
3	Double Coin Tire	38	Head of information and intelligence department	14	0.2
4	Scrap Rubber Resource Comprehensive Utilization Branch	42	Secretary-general	4	0.15
5	Bridgestone (China) Investment Co.	38	Supplier management manager	16	0.1

$$D = \left[\sum_{n=1}^{i} S_{mn}\right] i \times 1, \tag{4}$$

$$R = \left[\sum_{m=1}^{i} S_{mn}\right] i \times 1'. \tag{5}$$

4. Results and Discussion

4.1. Research Findings. Based on the centrality and causality of each driving factor of an EPR system in tire companies (Table 6) and the cause-effect diagram (Figure 1) between the factors, the following conclusions were drawn.

(1) First, to analyze the factors that promote the implementation of EPR in tire enterprises, it is necessary to analyze the underlying causes that facilitate implementation, i.e., the causal and consequential factors. The causal factors are not prone to change but the consequential factors can be readily changed. According to Figure 2, the driving factors affecting the implementation of an EPR system in tire enterprises were ranked based on the magnitude of the causal factors ($R_i - C_i > 0$, readily influence other factors) in the following order: D_{12}, D_1, D_4, D_{11}, D_2, D_9, and D_3. Of these factors, D_{12} (strengthen the service functions of dealers and service providers to improve satisfaction with sales channels), D_1 (green and circular development is a national-level development concept), and D_4 (scrap rubber as a recycled resource to support the sustainable development of the tire industry) were the top three contributing factors. The reasons are obvious in that if the implementation of an EPR system for tire companies can promote the sales of new tires, the most important causal factor must be the achievement of both economic and environmental benefits. At the same time, it makes sense that the requirements at the national level, which are mandatory, are crucial for the survival and development of an enterprise. Therefore, it was listed in the second place. The factor D_4 indicates that the implementation of the EPR system may accelerate the recycling of scrap tires.

At present, tire companies have a broad consensus on the importance of resource recycling. The leading companies in the industry have devoted more resources to recycling scrap tires such as building an integrated supply chain connecting forward and reverse supply chains, buying or building recycling companies. Therefore, it is recommended that the government first actively promote and provide guidance on recycling of scrap tires in the mainstream media, encourage the green consumption behavior of the general public, and help enterprises promote their brand image, thereby increasing the number of customers, expanding sales, and exerting

Table 5: The comprehensive influence matrix of driving factors.

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}
D_1	0.2943	0.3993	0.3205	0.3505	0.3903	0.3451	0.3567	0.2525	0.2916	0.2418	0.3743	0.2245
D_2	0.3812	0.2670	0.3055	0.3493	0.3234	0.3241	0.3282	0.2308	0.2869	0.2336	0.3398	0.1927
D_3	0.2974	0.3073	0.1904	0.3009	0.2864	0.2751	0.2508	0.2102	0.2309	0.1865	0.2790	0.1734
D_4	0.3708	0.3537	0.3141	0.2479	0.3370	0.3197	0.3100	0.2430	0.2869	0.2272	0.3236	0.2094
D_5	0.2798	0.2620	0.2173	0.2370	0.1873	0.2465	0.2424	0.1642	0.1882	0.1673	0.2604	0.1496
D_6	0.2855	0.2804	0.2280	0.2649	0.2571	0.1937	0.2442	0.1972	0.2157	0.1921	0.2792	0.1724
D_7	0.2116	0.2079	0.1479	0.1757	0.1941	0.1978	0.1365	0.1445	0.1503	0.1316	0.1979	0.1061
D_8	0.2302	0.2147	0.2140	0.2083	0.2171	0.1864	0.2179	0.1182	0.2062	0.1672	0.1866	0.1447
D_9	0.2921	0.2660	0.2537	0.2561	0.2588	0.2616	0.2409	0.2040	0.1606	0.1741	0.2535	0.1513
D_{10}	0.1679	0.1761	0.1450	0.1771	0.1766	0.1683	0.1520	0.1352	0.1358	0.0862	0.1448	0.0925
D_{11}	0.3392	0.3439	0.2824	0.3171	0.3278	0.3140	0.3151	0.2259	0.2418	0.2228	0.2333	0.1780
D_{12}	0.2804	0.2645	0.2263	0.2578	0.2628	0.2707	0.2507	0.1895	0.2087	0.1959	0.2372	0.1171

a positive impact. Second, the government should continue to promote the concept of green development with the recycling of waste tires. Finally, they should establish a special fund and related supporting policies to provide financial subsidies, tax concessions, credit rating bonus points, etc. to enterprises that implement EPR, and simplify the workload of enterprises in the implementation of the policies.

(2) The driving factors that were susceptible to the influence of other factors ($R_i - C_i < 0$) were ranked in the order of magnitude: D_8, D_6, D_{10}, $D_{5,}$ and D_7. These factors were impacted by other factors and subsequently indirectly influenced EPR. They were relatively easy to be changed, for example, D_8 (practicing social responsibility and achieving brand influence), D_6 (frequent issuance of policies on the scrap tire industry by state ministries and commissions), and D_{10} (using recycled materials to reduce costs). D_8 and D_{10} focused on the social image of a company and how technology enhanced the competitiveness of a company, respectively. The social image of a company affects the public's perception and opinion of the company, which ultimately impacts their purchasing decisions. In the long run, enterprises should pay more attention to social responsibility and build brand influence. The use of recycled materials is in line with the intention of enterprises to fulfill their social responsibility and achieve resource recycling. D_6 (frequent issuance of policies by state ministries and commissions) indicates that enterprises can utilize industry policies to actively participate in the EPR of waste tires to gain advantages. These challenges provide directions for the green transformation of tire companies and implementation of an EPR system could orientate the companies' green behaviors. Currently, they should pay more attention on soft aspects, e.g., fulfilling social responsibility, disclosing related information, and building green brand image.

(3) Table 6 shows that the centrality of each driving factor is ranked according to the magnitude of the consequential factors ($R_i + C_i$), with D_1, D_2, D_4, D_{11}, and D_9 listed as the top 5 factors. D_1 (green and circular development is a national-level development concept) and D_2 (the related laws require the implementation of EPR for some products) had the greatest influence among the driving factors, implying that they were the most important factors in promoting the implementation of an EPR system. First, it is suggested that the government continue to publicize the concept of green and ecological development and exert influence on the entire industry chain. For instance, the recycling of scrap tires as a matter of social responsibility should be promoted diligently to enhance the brand image of enterprises, increase brand value, and serve as a prerequisite for brand evaluation and promotion. Furthermore, the implementation of relevant regulations should be further strengthened, especially the intensity of law enforcement. Circular economy law and solid waste law require the implementation of an EPR system although not explicitly referring to tire enterprises. And now, there exists a mature atmosphere to deeply implement these laws and tire companies need to develop measures to deal with these problems aroused by scrap tires.

4.2. Sensitivity Analysis. This study carried out a sensitivity analysis of the results through the Grey-DEMATEL method, which determined the effect of a particular expert's potential bias on the results. This study further analyzed the changes in the results based on the changes in the weights of the experts. To facilitate the analysis, the experts with the highest weights (evaluators 1 and 3) were selected and their weights were changed for sensitivity analysis, while the weight of evaluator 2 (0.2) was maintained at the same level. For example, Figure 2(a) shows the causal diagram, where a weight of 0.30 was assigned to evaluators 1 and 3 and 0.1 to evaluators 4 and 5. For case B (see Figure 2(b)), case C (see Figure 2(c)), and case *D* (see Figure 2(d)), three weights (0.275, 0.225, and 0.20, respectively) were assigned to evaluation procedures 1 and 3. The study then used the Euclidean distance to assess the degree of difference between the salient and baseline values. The results for the procedures with the three adjusted weights are shown in Figure 3, with

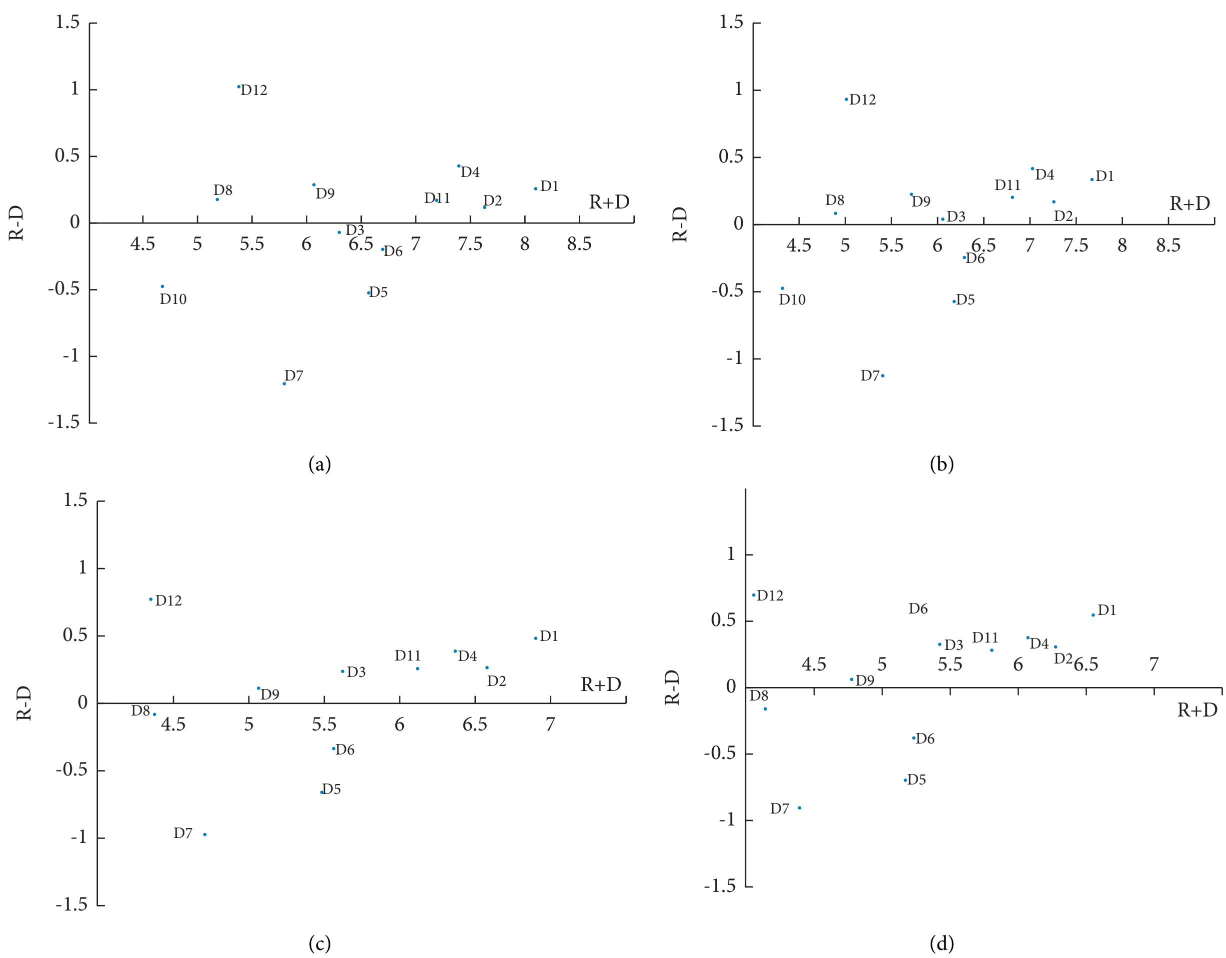

Figure 2: Sensitivity analysis for factors' cause-effect diagram.

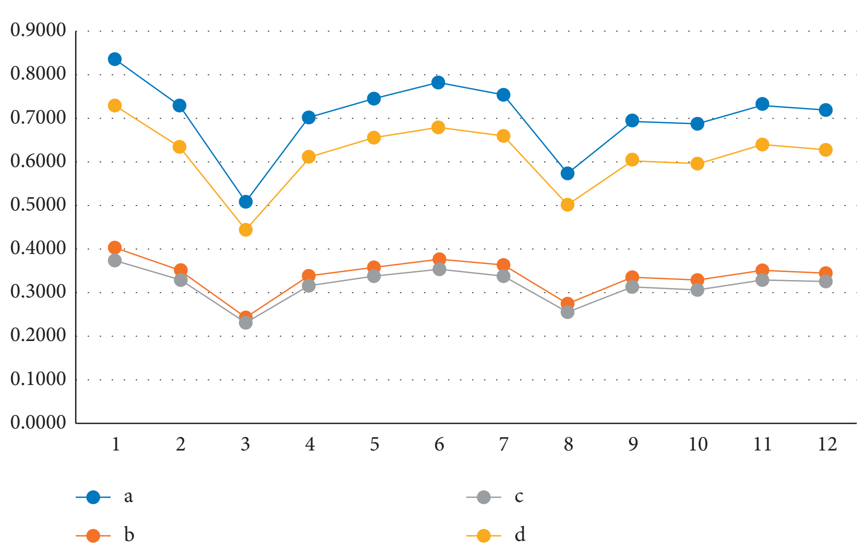

Figure 3: Sensitivity analysis of Euclidean distance.

Table 6: Centrality and causality between various factors (R, C, $R+C$, $R-C$).

Driving factors	R	C	$R+C$	$R-C$
D_1	3.8414	3.4303	**7.2717**	**0.4111**
D_2	3.5627	3.3430	**6.9057**	0.2197
D_3	2.9882	2.8450	5.8332	0.1432
D_4	3.5434	3.1426	**6.6860**	**0.4008**
D_5	2.6019	3.2187	5.8207	−0.6168
D_6	2.8103	3.1032	5.9135	−0.2928
D_7	2.0019	3.0454	5.0473	−1.0436
D_8	2.3117	2.3153	4.6270	−0.0036
D_9	2.7727	2.6036	5.3763	0.1691
D_{10}	1.7573	2.2263	3.9837	−0.4690
D_{11}	3.3415	3.1096	6.4511	0.2319
D_{12}	2.7618	1.9117	4.6735	**0.8500**

most of the Euclidean distance values below 0.80. Thus, bias in weight assignment was not a major issue and the causality evaluation results were robust and reliable.

5. Conclusions

This paper identified the main driving factors of EPR implementation in the Chinese tire industry based on literature analysis, expert interviews, and field research. Furthermore, the Grey-DEMATEL method was applied to quantitatively analyze these drivers to identify the causal and consequential factors of the implementation of an EPR system in the tire industry, as well as the centrality of each factor. It offers timely insight into the origins of the factors influencing the implementation of EPR in the tire industry and provides a reference for the upcoming implementation of policies on the EPR system in the industry. At the same time, to avoid subjective bias in experts' assessment, the results were also subject to sensitivity analysis, which showed that the Grey-DEMATEL method was effective for studying the implementation of EPR in the Chinese tire industry.

The results of the study indicated that the main driving factors for the implementation of an EPR system in China's tire industry were D_{12}, D_1, D_4, D_{11}, D_2, D_9, and D_3. Among them, D_{12} (strengthening the service functions of dealers and service providers to enhance satisfaction with sales channels), D_1 (green and circular development is a national-level development concept), and D_4 (scrap rubber as a recycled resource to support the sustainable development of the tire industry) were the top three causal factors. D_8 (practicing social responsibility and achieving brand influence), D_6 (frequent issuance of policies on the scrap tire industry by state ministries and commissions), and D_{10} (using recycled materials to reduce costs) were the top three consequential factors. Since the causal factors cannot be easily changed, the government and enterprises should develop long-term measures. For instance, D_{12} (improve channel satisfaction) was the most important factor influencing EPR implementation. Thus, it requires active promotion by the government, while enterprises should strengthen channel construction through the joint participation of players along the entire industry chain. Since the consequential factors can be easily changed, the government and enterprises should develop short-term measures. For instance, consequential factor D_{10} (using recycled materials to reduce costs) was the most direct and effective factor. It encouraged enterprises to develop recycled rubber with stable quality and low cost, reduced costs through the use of recycled materials, and enhanced the competitiveness of enterprises.

Factors with high centrality were characterized by a high degree of correlation with other factors and therefore need to be properly addressed. For example, D_1 (green and circular development is a national-level development concept to practice social responsibility and achieve brand influence) and D_2 (the related laws require the implementation of EPR for some products) were the most important factors, showing the most correlation with other items. To effectively realize the conversion of "waste tires into treasure," the state has given clear support at the macrolevel. This development is key to the establishment of an ecological civilization, sustainable development, and carbon emission reduction. The introduction of supporting legislation not only regulates the behavior of enterprises but also points out the future direction for the development of many enterprises. Thus, it is very important to strengthen the guiding role of legislative policies to effectively promote the reuse of waste tires in China. The implementation of an EPR system in China's tire industry is imminent. This study quantified the driving factors for the implementation of an EPR system in China's tire industry through DEMATEL analysis, providing a basis for decision-making by the government and industry.

Data Availability

The data used in this study can be accessed by Table 2.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This work was supported by the Major Project of the National Social Science Foundation (grant number 21ZDA018).

References

[1] J. Fiksel, B. R. Bakshi, A. Baral, E. Guerra, and B. DeQuervain, "Comparative life cycle assessment of beneficial applications for scrap tires," *Clean Technologies and Environmental Policy*, vol. 13, no. 1, pp. 19–35, 2011.

[2] X Ni, *Comprehensive Utilization of Waste Rubber Industry in 2018 and prospect of Development Trend in 2019 [R]*, China Rubber Industry Association, 2019.

[3] Q. Wu, S. Leng, Q. Zhang, and J. Xiao, "Resource and environmental assessment of pyrolysis-based high-value utilization of waste passenger tires," *Waste Management*, vol. 126, pp. 201–208, 2021.

[4] H. Q. Liu, J. Fang, H. J. Zhang, and G. H. Li, "Research on present situation of natural rubber in China," *Guangdong Agricultural Sciences*, no. 9, pp. 240–243, 2009.

[5] H. B Hu, J. J Liu, Q. H Zhu, and Q. Chen, "An integrated supply chain management system for end-of-life tires in China and its promotion barriers: a stakeholder perspective," *Resources, Conservation and Recycling*, vol. 164, 2021.

[6] C. T. R Association, "China tire recycling industry "13th Five-Year" development plan," *China Tire Resources Recycling*, vol. 6, no. 8, pp. 11–20, 2016.

[7] T Lindhqvist, *Extended Producer Responsibility in Cleaner Production [D]*, University of Lund, Lund, 2000.

[8] B. Milanez and T. Bührs, "Extended producer responsibility in Brazil: the case of tyre waste," *Journal of Cleaner Production*, vol. 17, no. 6, pp. 608–615, 2009.

[9] OECD, *Extended Producer Responsibility: A Guidance Manual for Governments [M]*, OECD Publishing, Paris, 2001.

[10] G. T. Hickle, "An examination of governance within extended producer responsibility policy regimes in North America," *Resources, Conservation and Recycling*, vol. 92, pp. 55–65, 2014.

[11] M Dubois, "Extended producer responsibility for consumer waste: the gap between economic theory and implementation [J]," *Waste Management & Research*, vol. 30, no. 9, pp. 36–42, 2012.

[12] C. K Mayers, "Strategic, financial, and design implications of extended producer responsibility in Europe - a producer case study [J]," *Journal of Industrial Ecology*, vol. 11, no. 3, pp. 113–131, 2007.

[13] W Xiang and C Ming, "Implementing extended producer responsibility: vehicle remanufacturing in China [J]," *Journal of Cleaner Production*, vol. 19, no. 6-7, pp. 680–686, 2011.

[14] J. M. Turner and L. M. Nugent, "Charging up battery recycling policies: extended producer responsibility for single-use batteries in the European union, Canada, and the United States," *Journal of Industrial Ecology*, vol. 20, no. 5, pp. 1148–1158, 2016.

[15] J. Park, N. Díaz-Posada, and S. Mejía-Dugand, "Challenges in implementing the extended producer responsibility in an emerging economy: the end-of-life tire management in Colombia," *Journal of Cleaner Production*, vol. 189, pp. 754–762, 2018.

[16] M. Kojima, A. Yoshida, and S. Sasaki, "Difficulties in applying extended producer responsibility policies in developing countries: case studies in e-waste recycling in China and Thailand," *Journal of Material Cycles and Waste Management*, vol. 11, no. 3, pp. 263–269, 2009.

[17] M. Rahmani, L. Gui, and A. Atasu, "The implications of recycling technology choice on extended producer responsibility," *Production and Operations Management*, vol. 30, no. 2, pp. 522–542, 2021.

[18] X. Li, Y. Li, and K. Govindan, "An incentive model for closed-loop supply chain under the EPR law," *Journal of the Operational Research Society*, vol. 65, no. 1, pp. 88–96, 2014.

[19] L. Gui, A. Atasu, Ö. Ergun, and L. B. Toktay, "Implementing extended producer responsibility legislation," *Journal of Industrial Ecology*, vol. 17, no. 2, pp. 262–276, 2013.

[20] G. T. Hickle, "Moving beyond the "patchwork:" a review of strategies to promote consistency for extended producer responsibility policy in the U.S," *Journal of Cleaner Production*, vol. 64, pp. 266–276, 2014.

[21] N. Kunz, K. Mayers, and L. N. Van Wassenhove, "Stakeholder views on extended producer responsibility and the circular economy," *California Management Review*, vol. 60, no. 3, pp. 45–70, 2018.

[22] K Campbell-Johnston, M Munck, W. J. V Vermeulen, and C. Backes, "Future perspectives on the role of extended producer responsibility within a circular economy: a Delphi study using the case of The Netherlands," *Business Strategy and the Environment*, vol. 30, no. 8, pp. 4054–4067, 2021.

[23] M Wu, M Zhao, and Z Wu, "An evaluation and variation analysis of sustainable development capacity in different regions of China [J]," *International Journal of Environmental Technology and Management*, vol. 23, no. 5-6, pp. 397–413, 2020.

[24] Y Wang, Y Lu, G He, and C. Wang, "Spatial Variability of Sustainable Development Goals in China: A Provincial Level Evaluation," *Environmental Development*, vol. 35, 2020.

[25] E. T. A. R. M Association, *End-of-life Tyre Report-A Valuable Resource with Growing Potential [R]*, ETRMA, Brussels, 2011.

[26] C. Clauzade, P. Osset, C. Hugrel, A. Chappert, M. Durande, and M. Palluau, "Life cycle assessment of nine recovery methods for end-of-life tyres," *International Journal of Life Cycle Assessment*, vol. 15, no. 9, pp. 883–892, 2010.

[27] S. Y Lee, J Hu, and M. K Lim, "Maximising the circular economy and sustainability outcomes: an end-of-life tyre recycling outlets selection model," *International Journal of Production Economics*, vol. 232, 2021.

[28] X. Tong, D. Tao, and R. Lifset, "Varieties of business models for post-consumer recycling in China," *Journal of Cleaner Production*, vol. 170, pp. 665–673, 2018.

[29] J. Yu, P. Hills, and R. Welford, "Extended producer responsibility and eco-design changes: perspectives from China," *Corporate Social Responsibility and Environmental Management*, vol. 15, no. 2, pp. 111–124, 2008.

[30] R. Lifset, A. Atasu, and N. Tojo, "Extended producer responsibility," *Journal of Industrial Ecology*, vol. 17, no. 2, pp. 162–166, 2013.

[31] B. Lebreton and A. Tuma, "A quantitative approach to assessing the profitability of car and truck tire remanufacturing," *International Journal of Production Economics*, vol. 104, no. 2, pp. 639–652, 2006.

[32] A. Atasu, "Operational perspectives on extended producer responsibility," *Journal of Industrial Ecology*, vol. 23, no. 4, pp. 744–750, 2019.

[33] V. Torretta, E. C. Rada, M. Ragazzi, E. Trulli, I. A. Istrate, and L. I. Cioca, "Treatment and disposal of tyres: two EU approaches. A review," *Waste Management*, vol. 45, pp. 152–160, 2015.

[34] N. A. T Center, *Increasing the Recycled Content in New Tires [R]*, NATC, Nevada, 2004.

[35] L. Wang and M. Chen, "Policies and perspective on end-of-life vehicles in China," *Journal of Cleaner Production*, vol. 44, pp. 168–176, 2013.

[36] Y.-C Lee, W.-H Chu, Q Chen, and S. B. Tsai, "Integrating decision-making trial and evaluation laboratory model and failure mode and effect analysis to determine the priority in solving production problems," *Advances in Mechanical Engineering*, vol. 8, no. 4, 2016.
[37] X. Xia, K. Govindan, and Q. Zhu, "Analyzing internal barriers for automotive parts remanufacturers in China using grey-DEMATEL approach," *Journal of Cleaner Production*, vol. 87, pp. 811–825, 2015.
[38] J Kaur, R Sidhu, A Awasthi et al., "A DEMATEL based approach for investigating barriers in green supply chain management in Canadian manufacturing firms," *International Journal of Production Research*, vol. 56, no. 1-2, pp. 312–332, 2018.
[39] S. Luthra, A. Kumar, E. K. Zavadskas, S. K. Mangla, and J. A. Garza-Reyes, "Industry 4.0 as an enabler of sustainability diffusion in supply chain: an analysis of influential strength of drivers in an emerging economy," *International Journal of Production Research*, vol. 58, no. 5, pp. 1505–1521, 2020.
[40] M. Bouzon, K. Govindan, and C. M. T. Rodriguez, "Evaluating barriers for reverse logistics implementation under a multiple stakeholders' perspective analysis using grey decision making approach," *Resources, Conservation and Recycling*, vol. 128, pp. 315–335, 2018.
[41] R. Singh and N. Bhanot, "An integrated DEMATEL-MMDE-ISM based approach for analysing the barriers of IoT implementation in the manufacturing industry," *International Journal of Production Research*, vol. 58, no. 8, pp. 2454–2476, 2020.
[42] M. S. Bhatia and R. K. Srivastava, "Analysis of external barriers to remanufacturing using grey-DEMATEL approach: an Indian perspective," *Resources, Conservation and Recycling*, vol. 136, pp. 79–87, 2018.
[43] M. Agyemang, Q. Zhu, M. Adzanyo, E. Antarciuc, and S. Zhao, "Evaluating barriers to green supply chain redesign and implementation of related practices in the West Africa cashew industry," *Resources, Conservation and Recycling*, vol. 136, pp. 209–222, 2018.
[44] J. Shi, J. Zhou, and Q. Zhu, "Barriers of a closed-loop cartridge remanufacturing supply chain for urban waste recovery governance in China," *Journal of Cleaner Production*, vol. 212, pp. 1544–1553, 2019.
[45] R.-J. Li, "Fuzzy method in group decision making," *Computers & Mathematics with Applications*, vol. 38, no. 1, pp. 91–101, 1999.
[46] X. Fu, Q. Zhu, and J. Sarkis, "Evaluating green supplier development programs at a telecommunications systems provider," *International Journal of Production Economics*, vol. 140, no. 1, pp. 357–367, 2012.
[47] Q. Zhu, J. Sarkis, and Y. Geng, "Barriers to environmentally-friendly clothing production among Chinese apparel companies," *Asian Business & Management*, vol. 10, no. 3, pp. 425–452, 2011.