



Analysis of barriers to implementing the circular supply chain in the Vietnam textile industry

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Abstract

The circular supply chain model has emerged as a trend in numerous countries, garnering significant interest, including Vietnam, owing to its substantial economic, social, and environmental benefits. Nevertheless, implementing a circular supply chain in the textile industry encounters numerous challenges. This research analyzes barriers to implementing the circular supply chain in Vietnam's textile industry employing the Analytic Hierarchy Process (AHP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) methods. This research identifies key barriers, which are then prioritized for resolution, ultimately facilitating the proposal of a circular model. The result highlights that the barrier of insufficient financial resources has the highest weight, followed by lack of government support and technology transfer, considered top priorities for successfully implementing a circular supply chain in the Vietnamese textile industry.

Keywords: Analytic Hierarchy Process (AHP) method, Decision Making Trial and Evaluation Laboratory (DEMATEL) analysis, financial resource, government support, technology transfer

JEL classification: L67, P23, Q56.

1. Introduction

The textile and garment industry plays a significant role in a country's economic structure. However, it is also a major contributor to environmental pollution and the depletion of natural resources (Saccani et al., 2023). According to the regulations of importing countries with strict requirements such as the EU, concerning product origin and the Extended Producer Responsibility (EPR), textile products must ensure increased circularity (EC, 2023). These requirements mean that if textile products from Vietnam do not meet the market standards, they will not be allowed to be imported. To adapt to the conditions of importing countries, countries like Bangladesh and China have prepared to meet the demands of challenging markets such as the EU and the USA. The operations of a circular supply chain model emphasize the integration and extension of the supply chain from design to end-of-life recovery (Linton et al., 2007), requiring coordination between forward and reverse supply chains through the integration of an extended network of enterprises (Genovese et al., 2017; Batista et al., 2018a). A circular supply chain emphasizes applying circular economy principles, including reuse, recycling, reduction, repair, redesign, and remanufacturing. Specifically, a circular supply chain aims towards the 6R+ concept (Batista et al., 2018b; Caldera et al., 2019; Lahane et al., 2020).

Implementing a circular supply chain in the textile industry and transitioning textile businesses from linear to circular supply chains face numerous significant barriers. Many studies have investigated the barriers textile enterprises face during the transition to a circular supply chain. For instance, Snoek (2017) classified barriers in the textile industry into two categories: internal barriers, including technology, operations, economics, knowledge, and information, and external barriers, such as market, societal factors, supply chain collaboration, infrastructure, policies, and regulations. Rathinamoorthy (2019) identified key barriers textile enterprises face, including cultural, technological, and market regulations in transitioning to circularity in the supply chain. After identifying these barriers, Baltussen (2019) categorized them into major groups such as social, environmental, standards, economic, operational, management, infrastructure, and technology in the Dutch textile industry. Pathak and Endayilalu (2019) grouped the barriers to implementing circularity in the textile sector as economic constraints, lack of supportive projects and government incentives, insufficient information, lack of technical knowledge, and lack of support from the supply and demand network. Araujo Galvão et al. (2018) and Moktadir et al. (2018)

highlighted potential barriers, including technology, customer behavior, financial and economic constraints, policies and regulations, management, performance indicators, and social aspects of the circular economy.

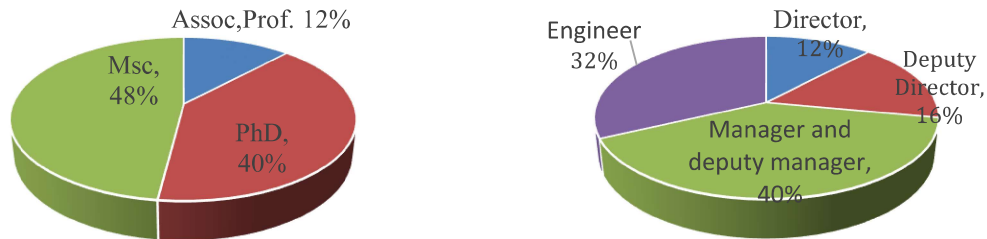
Implementing circular supply chain practices in Vietnam's textile industry still faces many challenges and difficulties. Vietnam has around thirteen thousand textile enterprises with over fifty thousand factories nationwide, but only about ten percent of these factories meet the LEED standards (Le, 2023). Therefore, compared to Bangladesh, Vietnamese enterprises need to make more positive changes to meet the requirements of importing countries. Consequently, promoting the implementation of a circular supply chain model is imperative.

To build a circular supply chain, studying the challenges and barriers businesses face is essential. Analyzing these barriers will provide a critical basis for identifying solutions to develop the future circular supply chain of Vietnam's textile industry. This study analyzes these barriers using the following research questions: What are the prominent barriers related to implementing a circular supply chain for the textile industry in the context of Vietnam? How can the selected barriers be analyzed to understand their priority levels in applying a circular supply chain? What are the main barriers to implementing a circular supply chain for the textile industry? What are the interrelationships among the key barriers?

2. Research methodology

This study employs a mixed-method approach, combining qualitative and quantitative methods for assessment to measure the barriers to a circular supply chain. The concept of the circular economy and its implementation remains relatively new to most businesses. Therefore, the evaluation model is synthesized from various studies and adjusted through qualitative research with experts. Based on expert evaluations in the textile industry, this study developed a preliminary survey to refine the questions in the questionnaire before conducting the official survey. The main target group for the official survey includes officials, experts teaching, researching, and working in environments related to the textile industry. To increase independence and consistency and to avoid response duplication, the research team selected two groups of experts for interviews and analysis: (1) a group of academic experts who teach and research textiles at universities and colleges; and (2) a group of experts from textile enterprises, who have practical experience in managing textile supply chains. The positions and titles of the respondents are described in Figure 1.

FIGURE 1: Proportion of experts participating in the survey from academic and textile enterprise sectors



Source: Authors' survey.

Implementing a circular supply chain presents many challenges and barriers hindering progress toward a more circular and sustainable economy. The barriers are categorized and described into main groups, as shown in Table 1.

TABLE 1: Model of barriers to circular supply chain implementation

Barriers		Criteria
Management	QL1	Lack of Effective Performance Measurement System
	QL2	Lack of Senior Management Support
	QL3	Difficulty in Designing Circular Textile Products
Material	NL1	Availability of recyclable materials
	NL2	Difficulty in maintaining circular product quality
	NL3	Complexity in manufacturing components
Infrastructure	CS1	Lack of infrastructure for reverse logistics
	CS2	Lack of facilities for recycling, reprocessing, collecting, sorting
	CS3	Difficulties in collecting and sorting
Regulations and Standards	TC1	Lack of textile circularity assessment standards
	TC2	Lack of certification and environmental management systems
	TC3	Lack of policies and regulations for textile circularity

Knowledge and awareness	NT1	Lack of full awareness of circular economy
	NT2	Lack of technical know-how
	NT3	Lack of theory on applying circular economy to the textile industry
Supply chain cooperation	HT1	Lack of information sharing among supply chain members
	HT2	Lack of consistent suppliers in the supply chain
	HT3	Lack of a common vision and willingness to collaborate
Budget	KT1	Lack of financial resources
	KT2	Low profit margins for circular products
	KT3	Small scale of circular textile production
Technology	CN1	Lack of traceability systems
	CN2	Lack of technology transfer
	CN3	Lack of circular and sustainable technologies

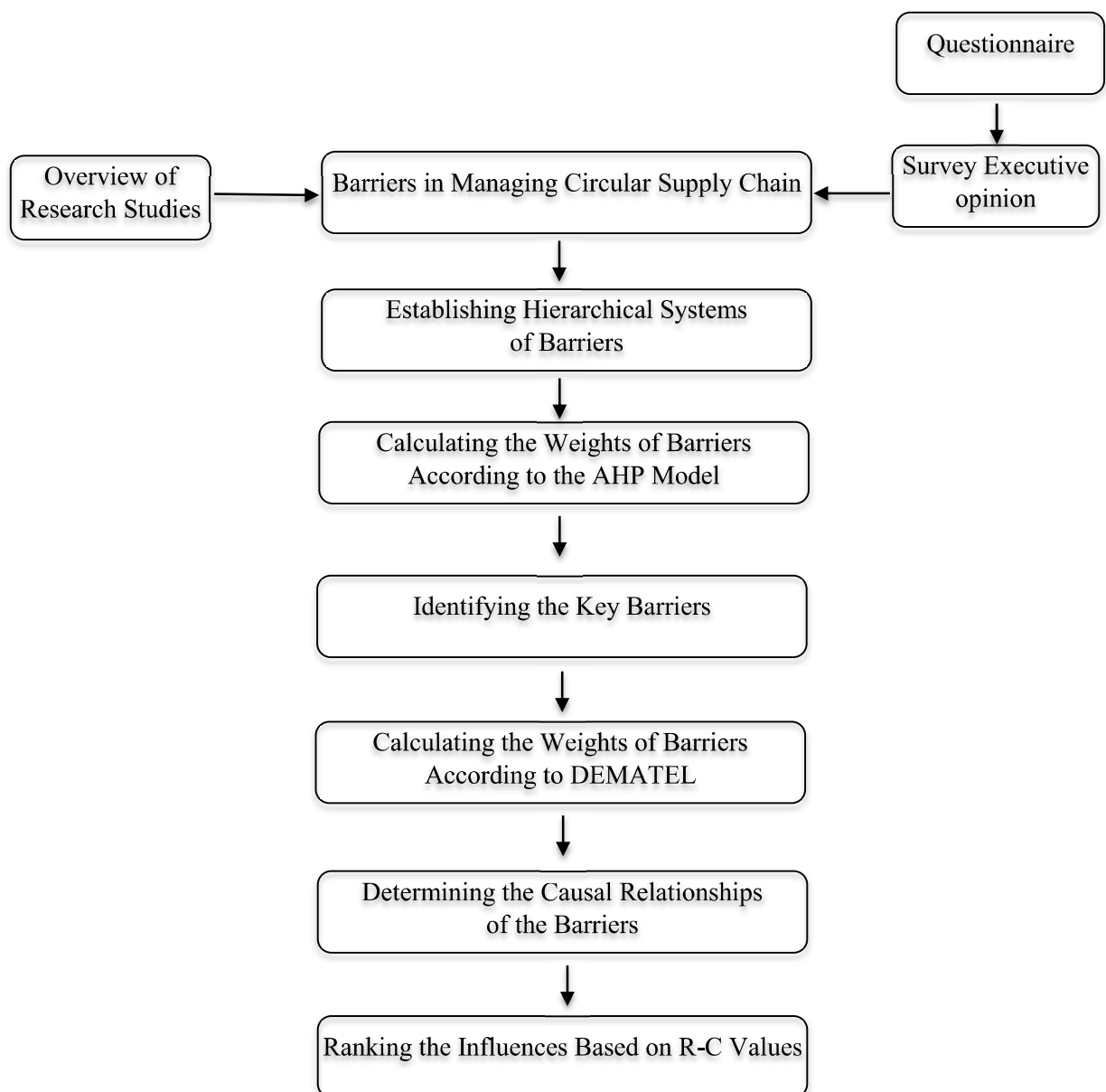
Source: Authors' compilation.

Businesses and experts widely apply the multi-criteria decision-making (MCDM) method because it organizes critical factors into a hierarchical structure and analyzes their interrelationships (Borouhaki and Malczewski, 2010). Among MCDM methods, the Analytic Hierarchy Process (AHP) is the most common MCDM approach that facilitates adequate qualitative, quantitative, or combined decisions. This process organizes elements into a hierarchical framework (Saaty, 1980). According to Lahane and Kant (2021), the most significant barrier to adopting circular supply chain practices is the “lack of support from senior management and commitment.” Additionally, Luthra et al. (2016) highlighted that “the government support policy” is a key barrier significantly hindering the transformation towards sustainable development in the automotive industry supply chain.

Building on these insights, this study analyzes the barriers to implementing a circular supply chain for the textile industry in Vietnam through a barrier ranking model. It seeks to identify the relationships among these barriers to determine the critical issues requiring immediate attention in Vietnam's current context.

The Analytic Hierarchy Process (AHP) helps establish the hierarchy of barriers. However, since these barriers influence one another, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method must be used to identify the interrelationships among the barriers. Therefore, this study combines the AHP and DEMATEL methods to identify the critical barriers that need to be prioritized for resolution, as illustrated in the research model in Figure 2.

FIGURE 2: **Research model for identifying barriers**



The main barriers are first evaluated in the research model combining AHP and DEMATEL, and their priority levels are compared using the AHP method. Then, each barrier is assigned a weight using the DEMATEL method to identify the interrelationships among them, providing a basis for ranking the barriers. This process can be detailed into five steps:

Step 1: Determine the comparison matrix for the values between criteria pairs. The levels of importance between criteria are assessed according to a scale, with the paired comparison values a_{ji} for the criteria taking values from 1 to 9 and their inverse a_{ji} (Saaty, 1987).

Step 2: Calculate the weights for each criterion. After establishing the matrix, calculate the weights for the factors by summing the values in each matrix column, then dividing each matrix value by the corresponding column sum. The weights of the criteria are calculated using the following equations:

$$w_i = \left[(a_{i1}) \times (a_{i2}) \times \dots \times (a_{im}) \right]^{\frac{1}{m}}, \forall i \tag{1}$$

$$nw_i = \frac{w_i}{\sum_{i=1}^m w_i}, \forall i \tag{2}$$

The consistency of the weight values is checked against the experts' evaluations. According to Saaty (1987), a consistency ratio (CR) of ten percent or less is acceptable. If the CR is greater than ten percent, it indicates an inconsistency in the evaluations, and adjustments are required.

$$CR = \frac{CI}{RI} \tag{3}$$

Where CI is the Consistency Index and RI is the Random Index. CI is calculated using the following formula:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

λ_{max} is principal eigenvalue of the pairwise comparison matrix (n x n), it is calculated:

$$\lambda_{max} = \sum_{i=1}^n w_i * \sum_{j=1}^n a_{ij}$$

RI is determined from a predefined table (Table 2 - this table provides RI values for up to 15 criteria)

TABLE 2: Random Index (RI) corresponding to the number of selected factors considered

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.52	0.89	1.12	1.24	1.36	1.41	1.45	1.49	1.51	1.54	1.56	1.57	1.59

Source: Saaty (1987).

Step 3: Calculate the priority of the options according to each criterion. Calculations in this step are performed similarly to steps 1 and 2 with used data being the results of priority comparisons. In other words, the evaluation is conducted through n matrices with n different criteria, resulting in n matrices with 1 column and m rows (m is the option). The CR is double-checked to ensure reliability.

Step 4: Calculate the score for each option. The matrix from Step 3 showing the weight of each option according to the criteria will be multiplied by the weight matrix of criteria obtained in Step 2. The resulting matrix will have m and 1 column. The option with the highest weight value is considered the most remarkable one.

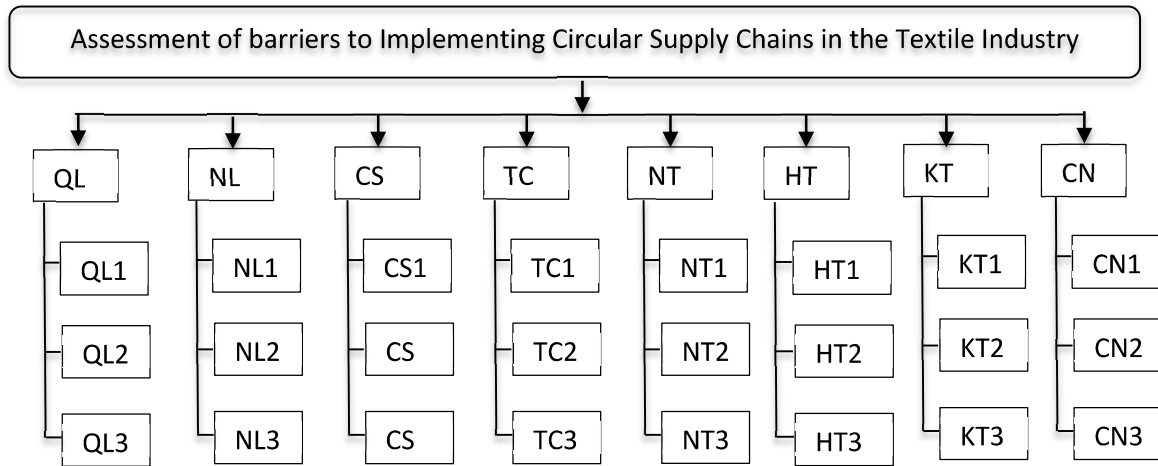
Step 5: Calculate the weights for the key barriers using the DEMATEL method (Si et al., 2018). The DEMATEL method uses quadrant graphs to illustrate the causal relationship between factors (barriers).

3. Research results

3.1. Barriers ranking analysis with AHP

Figure 3 shows the research model illustrating the structure of barriers to implementing CSC in Vietnam's textile industry.

FIGURE 3: Hierarchy of barriers to implementing a CSC in the textile sector



Source: Authors' compilation

The results were obtained through expert interviews to assess the degree of correlation between pairs of barriers. Table 3 below presents the data collected from the experts' opinions for the inverse matrix concerning the correlation results between the pairs of barriers. Calculations will be performed using the AHP method based on this evaluation.

TABLE 3: Pairwise comparison of key barriers

	QL	NL	CS	TC	NT	HT	KT	CN
QL	1	7/5	8/5	9/5	2	8/5	5/7	3/2
NL	5/7	1	8/5	2	5/4	1	1	8/9
CS	5/8	5/8	1	5/4	3/2	8/5	1	6/5
TC	5/9	1/2	4/5	1	1	5/4	8/9	7/5
NT	1/2	4/5	2/3	1	1	7/6	1	7/5
HT	5/8	1	5/8	4/5	6/7	1	6/7	3/2
KT	7/5	1	1	9/8	1	7/6	1	1
CN	2/3	9/8	5/6	5/7	5/7	2/3	1	1

Source: Survey results.

TABLE 4: AHP analysis results for main barrier groups

	QL	NL	CS	TC	NT	HT	KT	CN	Weight of Key Barriers	Ranking	CR
QL	0.166	0.194	0.177	0.185	0.211	0.168	0.097	0.157	0.1695	1	1,9% < 10% satisfy the requirement
NL	0.116	0.136	0.203	0.205	0.135	0.115	0.142	0.088	0.1428	2	
CS	0.102	0.084	0.125	0.127	0.160	0.169	0.131	0.120	0.1273	4	
TC	0.093	0.069	0.102	0.104	0.107	0.129	0.119	0.140	0.1078	6	
NT	0.085	0.108	0.084	0.105	0.108	0.122	0.133	0.140	0.1108	5	
HT	0.103	0.124	0.077	0.084	0.092	0.105	0.113	0.154	0.1067	7	
KT	0.228	0.128	0.127	0.116	0.108	0.123	0.133	0.101	0.1332	3	
CN	0.105	0.154	0.104	0.074	0.077	0.068	0.131	0.099	0.1018	8	

Source: Calculation using the AHP method by the authors.

TABLE 5: Comparison of component barrier pairs and AHP analysis results for each component barrier group

Criteria	QL1	QL2	QL3	Weight Value of Each Barrier			Weight
QL1	1	1	5/3	0.389	0.372	0.415	QL1 = 0.392
QL2	1	1	4/3	0.377	0.360	0.335	QL2 = 0.357
QL3	3/5	3/4	1	0.234	0.268	0.250	QL3 = 0.251
Total	2.600	2.750	4.000	RI	λ_{max}	CI	CR
				0.58	3.000	0.002	0.4% < 5%
Criteria NL	NL1	NL2	NL3	Weight Value of Each Barrier			Weight
NL1	1	4/3	6/5	0.392	0.441	0.341	NL1 = 0.391
NL2	3/4	1	4/3	0.287	0.322	0.380	NL2 = 0.330
NL3	5/6	3/4	1	0.321	0.236	0.279	NL3 = 0.279
Total	2.583	3.083	3.533	RI	λ_{max}	CI	CR
				0.58	3.020	0.01	1.7% < 5%
Criteria CS	CS1	CS2	CS3	Weight Value of Each Barrier			Weight
CS1	1	7/5	4/3	0.408	0.425	0.390	CS1 = 0.408
CS2	5/7	1	1	0.288	0.300	0.319	CS2 = 0.302
CS3	3/4	1	1	0.304	0.274	0.291	CS3 = 0.290
Total	2.464	3.400	3.333	RI	λ_{max}	CI	CR
				0.58	3.002	0.0012	0.2% < 5%
Criteria TC	TC1	TC2	TC3	Weight Value of Each Barrier			Weight
TC1	1	3/2	7/5	0.418	0.459	0.373	TC1 = 0.416
TC2	2/3	1	7/5	0.286	0.313	0.364	TC2 = 0.321

TC3	5/7	5/7	1	0.296	0.228	0.264	TC3 = 0.262
Total	2.3381	3.214	3.800	RI	λ_{\max}	CI	CR
				0.58	3.014	0.0071	1.2% < 5%
Criteria NT	NT1	NT2	NT3	Weight Value of Each Barrier			Weight
NT1	1	7/5	7/5	0.411	0.452	0.363	NT1 = 0.409
NT2	5/7	1	3/2	0.298	0.327	0.379	NT2 = 0.334
NT3	5/7	2/3	1	0.291	0.221	0.257	NT3 = 0.256
Total	2.428	3.067	3.900	RI	λ_{\max}	CI	CR
				0.58	3.015	0.0075	1.3% < 5%
Criteria HT	HT1	HT2	HT3	Weight Value of Each Barrier			Weight
HT1	1	4/3	6/5	0.392	0.436	0.346	HT1 = 0.392
HT2	3/4	1	4/3	0.287	0.319	0.370	HT2 = 0.325
HT3	5/6	3/4	1	0.321	0.244	0.283	HT3 = 0.283
Total	2.583	3.083	3.533	RI	λ_{\max}	CI	CR
				0.58	3.016	0.008	1.4% < 5%
Criteria KT	KT1	KT2	KT3	Weight Value of Each Barrier			Weight
KT1	1	6/5	3/2	0.401	0.404	0.397	KT1 = 0.401
KT2	5/6	1	4/3	0.335	0.338	0.342	KT2 = 0.338
KT3	2/3	3/4	1	0.264	0.258	0.261	KT3 = 0.261
Total	2.500	2.950	3.832	RI	λ_{\max}	CI	CR
				0.58	3.000	0.0001	0.01% < 5%
Criteria CN	CN1	CN2	CN3	Weight Value of Each Barrier			Weight
CN1	1	1	1	0.336	0.362	0.308	CN1 = 0.335
CN2	1	1	5/4	0.328	0.354	0.384	CN2 = 0.355
CN3	1	4/5	1	0.336	0.284	0.308	CN3 = 0.309
Total	3.000	2.800	3.250	RI	λ_{\max}	CI	CR
				0.58	3.007	0.0033	0.6% < 5%

Source: Authors' calculations.

Table 5 shows the main barrier groups by calculating and comparing the consistency ratio. We evaluate that the CR index is less than 10%, which meets the requirements for the main barrier group and allows for further categorization of the subordinate barrier groups. Similarly, the component barrier groups in Table 5 demonstrate that all comparisons ensure a consistent CR result within the acceptable range, all below five percent. Thus, the barriers in the model are not conflicting, and the expert scores assigned to the criteria are appropriate. Based on these results, Table 6 summarizes the weighted rankings of the barriers for classification.

TABLE 6: Summary of the overall weight rankings of each barrier

Main barrier	Weight Value of main barrier (1)	Sub-barriers	Component Weight (2)	Total Weight (3 = 1 x 2)	Ranking	
Management	0.1695	QL1	Lack of Effective Performance Measurement System	0.3921	0.0591	4
		QL2	Lack of Government Support	0.3571	0.0611	2
		QL3	Difficulty in Designing Circular Textile Products	0.2508	0.0283	19
Material	0.1428	NL1	Availability of recyclable materials	0.3913	0.0549	7
		NL2	Difficulty in maintaining circular product quality	0.3298	0.0492	9
		NL3	Complexity in Recovered Textile Waste Components	0.2789	0.0288	18
Infrastructure	0.1273	CS1	Lack of infrastructure for reverse logistics	0.4077	0.0588	5
		CS2	Lack of facilities for recycling, reprocessing, collecting, and sorting	0.3024	0.0323	17
Regulation and Standard	0.1078	CS3	Difficulties in collecting and sorting	0.2899	0.0325	16
		TC1	Lack of textile circularity assessment standards	0.4166	0.0487	10
		TC2	Lack of certification and environmental management systems	0.3209	0.0377	13
Knowledge and Awareness	0.1108	TC3	Lack of policies and regulations for textile circularity	0.2625	0.0196	23
		NT1	Lack of full awareness of circular economy	0.4088	0.0387	12
		NT2	Lack of technical know-how	0.3346	0.0249	20
Supply chain Collaboration	0.1067	NT3	Lack of theory on applying circular economy to the textile industry	0.2566	0.0153	24
		HT1	Lack of information sharing among supply chain members	0.3917	0.0516	8
		HT2	Lack of consistent suppliers in the supply chain	0.3254	0.0347	14
Budget	0.1332	HT3	Lack of a common vision and willingness to collaborate	0.2829	0.0235	22
		KT1	Lack of financial resources	0.4006	0.0814	1
		KT2	Challenges in Commercializing Circular Textile Products	0.3386	0.0584	6
Technology	0.1018	KT3	Small scale of circular textile production	0.2608	0.0330	15
		CN1	Lack of traceability systems	0.3352	0.0426	11
		CN2	Lack of technology transfer	0.3554	0.0601	3
		CN3	Lack of circular and sustainable technologies	0.3094	0.0247	21

Source: Authors' calculations.

TABLE 7: Arranged importance levels of barriers

Barrier		Weight	Rank
KT1	Lack of financial resources	0.0814	1
QL2	Lack of Government Support	0.0611	2
CN2	Lack of technology transfer	0.0601	3
QL1	Lack of Effective Performance Measurement System	0.0591	4
CS1	Lack of infrastructure for reverse logistics	0.0588	5
KT2	Challenges in Commercializing Circular Textile Products	0.0584	6
NL1	Availability of recyclable materials	0.0549	7
HT1	Lack of information sharing among supply chain members	0.0516	8
NL2	Difficulty in maintaining circular product quality	0.0492	9
TC1	Lack of textile circularity assessment standards	0.0487	10
CN1	Lack of traceability systems	0.0426	11
NT1	Lack of full awareness of circular economy	0.0387	12
TC2	Lack of certification and environmental management systems	0.0377	13
HT2	Lack of consistent suppliers in the supply chain	0.0347	14
KT3	Small scale of circular textile production	0.0330	15
CS3	Difficulties in collecting and sorting	0.0325	16
CS2	Lack of facilities for recycling, reprocessing, collecting, and sorting	0.0323	17
NL3	Complexity in Recovered Textile Waste Components	0.0288	18
QL3	Difficulty in Designing Circular Textile Products	0.0283	19
NT2	Lack of technical know-how	0.0249	20
CN3	Lack of circular and sustainable technologies	0.0247	21
HT3	Lack of a common vision and willingness to collaborate	0.0235	22
TC3	Lack of policies and regulations for textile circularity	0.0196	23
NT3	Lack of theory on applying circular economy to the textile industry	0.0153	24

Source: Authors' data processing results.

Table 7 presents the overall weights of all barriers evaluated by textile experts with the ranking of each barrier. These values are determined by the AHP method along with the global weights which are calculated by multiplying the weight of each secondary barrier by the weight of the corresponding main barrier group. The research results indicate that “Lack of Financial Resources - KT1” is the most significant barrier that needs to be addressed first, with a local weight of 0.0814, which aligns with the opinions of industry experts. Following this, the barriers identified are “Lack of Government Support - QL2” and “Lack of Technology Transfer - CN2.” The experts surveyed in this study identified technology transfer as a barrier that should be prioritized for resolution in third place, weighing 0.0601. Approximately 70% of textile enterprises operate under the Cut-Make-Trim (CMT) model and outsource production. Therefore, the issue of insufficient technology transfer and the commitment to technology transfer in contracts with foreign companies poses challenges for Vietnamese businesses wanting to implement circular technologies. According to a Ministry of Science and Technology report, the textile industry experienced an average technology renewal rate of 12.47% from 2016 to 2020, falling short of the set target of 15-20%. Additionally, the level of modernization in fiber machinery reached only 3.01 on a 5-point scale, while the weaving sector scored below average (Vu, 2022). These levels indicate that companies are slow in adopting technological advancements and green supply chain initiatives to support circularity.

Furthermore, to achieve a more thorough evaluation and to recognize the various interrelationships among the barriers to implementing a circular supply chain, this study has compiled and selected the eight most significant barriers from each main barrier group based on the results of the AHP analysis. This selection will continue with the DEMATEL analysis, as shown in Table 8.

TABLE 8: Selected important barriers

STT	Barriers	
1	KT1	Lack of financial resources
2	QL2	Lack of Government Support
3	NL1	Availability of recyclable materials
4	HT1	Lack of information sharing among supply chain members
5	CS1	Lack of infrastructure for reverse logistics
6	CN2	Lack of technology transfer
7	TC1	Lack of textile circularity assessment standards
8	NT1	Lack of full awareness of circular economy

Source: Authors' data processing results.

3.2. Results of the DEMATEL Analysis

DEMATEL helps assess the causal relationships among barriers (Si et al., 2018). Through this method, it is possible to evaluate the correlations between barriers and develop a matrix to reflect their relative relationships. This approach identifies dependency relationships, classifies barriers into cause and effect groups, and discovers critical factors through a relationship impact diagram. Based on the previous AHP analysis results, the eight critical barriers were further investigated using the DEMATEL method by interviewing experts regarding the degree of mutual influence on a scale from 0 to 3, wherewith the meanings being: “0: no influence,” “1: low influence,” “2: medium influence,” and “3: high influence.” The steps for calculations using the DEMATEL method are described in the following steps:

- Calculate the average matrix of expert assessments on the degree of influence.
- Compute the normalized matrix of direct influence levels among barriers.
- Determine the total influence matrix among barriers.
- Establish a threshold value as the average of the total influence matrix among barriers for decision-making.

Through these calculation steps, the study obtains results for the relationships through DEMATEL as follows:

TABLE 9: Overall system matrix

	QL2	NL1	CS1	CN2	NT1	KT1	HT1	TC1	R _i
QL2	1.033	1.091	1.123	1.162	1.077	1.170	1.012	1.063	8.730
NL1	1.086	0.935	1.058	1.110	1.006	1.071	0.941	1.017	8.223
CS1	1.002	0.950	0.863	0.988	0.902	1.018	0.869	0.939	7.531
CN2	1.041	1.003	0.997	0.930	0.947	1.034	0.896	0.949	7.798
NT1	1.107	1.060	1.056	1.119	0.903	1.093	0.941	1.017	8.295
KT1	1.172	1.123	1.130	1.182	1.075	1.042	1.025	1.079	8.828
HT1	1.212	1.171	1.173	1.224	1.126	1.192	0.938	1.146	9.181
TC1	1.045	1.035	1.026	1.059	0.971	1.059	0.897	0.875	7.966
C _i	8.697	8.368	8.428	8.773	8.008	8.678	7.518	8.083	

With the threshold value $\alpha = 1,040$.

Source: Authors’ data processing results.

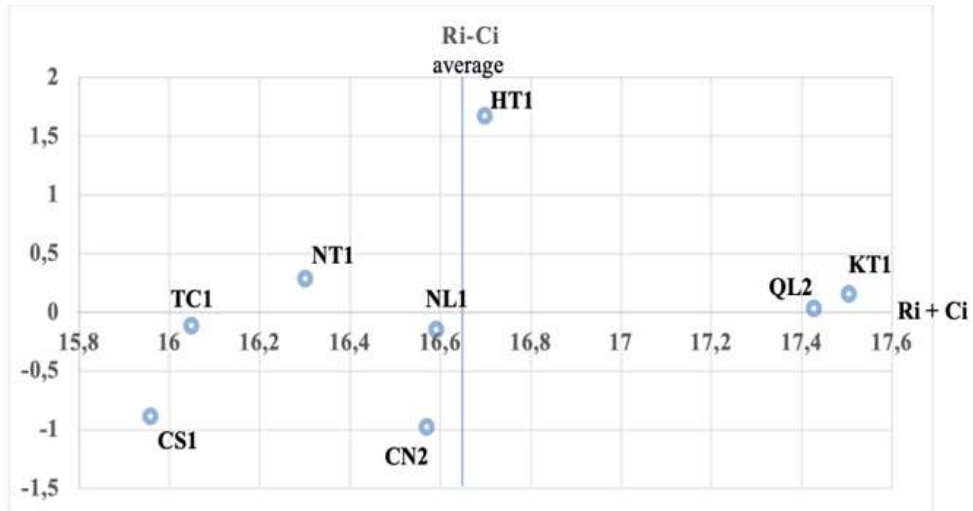
TABLE 10: R-C coefficient analysis table using the DEMATEL method

	Ri	Ci	Ri+Ci	Ri-Ci	Classify	Ranking
QL2	8.730	8.697	17.427	0.032	Cause	2
NL1	8.223	8.368	16.591	-0.145	Effect	4
CS1	7.531	8.428	15.959	-0.896	Effect	8
CN2	7.798	8.773	16.571	-0.976	Effect	5
NT1	8.295	8.008	16.303	0.288	Cause	6
KT1	8.828	8.678	17.506	0.150	Cause	1
HT1	9.181	7.518	16.700	1.663	Cause	3
TC1	7.966	8.083	16.049	-0.117	Effect	7
Average			16,638	0		

Source: Authors' data processing results.

Barriers with an R-C value less than 0 are identified as effects or results, while those with an R-C value greater than 0 are classified as causes. Additionally, the R+C value indicates the barrier's level of impact - strong or weak. The analysis results from Table 10 show that the barrier "Lack of Financial Resources - KT1" is of greatest concern, followed by issues such as "Lack of Government Support - QL2," "Lack of Information Sharing Among Chain Members - HT1," and "Lack of Awareness of Circular Economy in the Textile Industry - NT1." These represent a crucial group of causal barriers to implementing a circular supply chain in the textile sector. Any changes or improvements within this group will significantly affect the other barriers, including a lack of materials for recycling, insufficient technology transfer, absence of evaluation standards, and inadequate infrastructure for reverse logistics. Therefore, this is something that businesses need to assess and address when implementing a circular supply chain model in their textile enterprises.

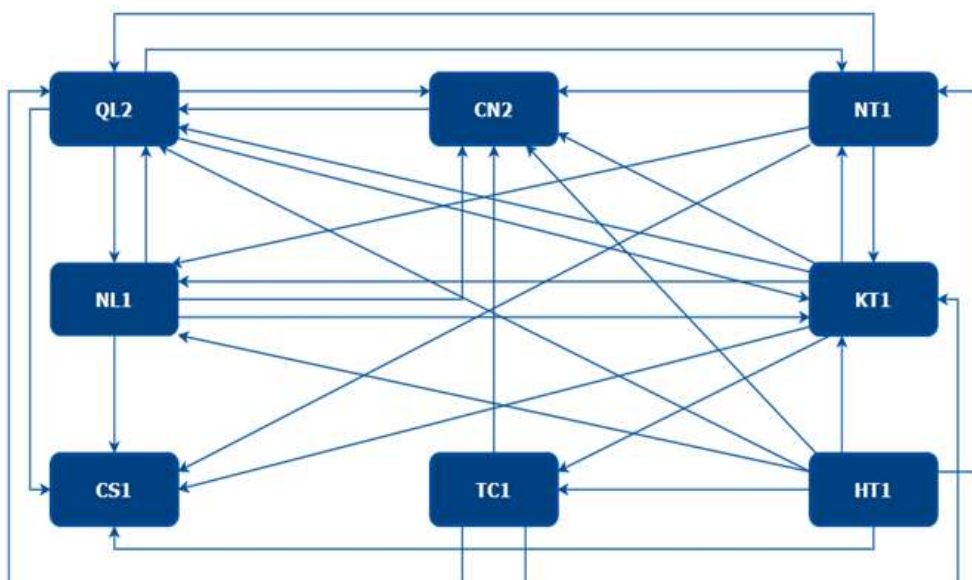
FIGURE 4: The degree of relationship between barriers



Source: Authors' data processing results.

The authors examined the analysis results regarding the degree of influence among barriers through Table 9. With a threshold value of 1.040, any relationships with values lower than this threshold will be eliminated as they are deemed insignificant.

FIGURE 5: Diagram of the relationships among the barriers



Source: Authors' compilation.

To illustrate the relationship between each group of barriers more clearly, the authors use a diagram to visualize the interactions among the barriers through arrows in Figure 5. By combining the processed data from Table 10 with graph theory, conclusions can be drawn about the levels of relationships among these barriers categorized into groups. Each quadrant in Figure 5 represents a level of relationship among these barriers. It is evident that the eight barriers to implementing a circular supply chain in the textile industry focus on three levels, including:

Strong relationship, high prominence (first quadrant): “Lack of financial resources - KT1,” “Lack of government support - QL1,” and “Lack of sharing among chain members - HT1.” These three barriers are core obstacles that significantly impact other barriers. Therefore, these barriers affect the implementation of a circular supply chain model in Vietnam’s textile sector.

Weak relationship, low prominence (third quadrant): This group has four barriers: “Lack of infrastructure for reverse logistics - CS1,” “Lack of circular assessment standards in the textile industry - TC1,” “Unavailability of recyclable materials - NL1,” and “Lack of technology transfer - CN2.” This group of barriers is less affected by other barriers. They are relatively independent obstacles.

Weak relationship, high prominence (second quadrant): “Lack of awareness of the circular economy in the textile industry - NT1.” Other barriers less influence this group of barriers but have a significant impact. The analytical model in this study indicates that this is an independent barrier; the lack of awareness of the circular economy in the textile industry has a considerable effect on the other barriers, and it belongs to the causal group.

The analysis results show that the barriers in the causal group can improve the barriers in the impact group if senior management and the government implement policies supporting green financing or establish information related to reuse/recycling measures for supply chain members. This should be done before designing reusable and recoverable products. These steps will enhance the connectivity within the infrastructure, and collaboration between enterprises will make it easier to source raw materials for recycling.

5. Conclusion

Adopting sustainable development in supply chain activities to foster economic and social progress is essential in the current context that ministries and enterprises need to implement (Decision 889/QĐ-TTg of the Prime Minister approving the National Action Program on Sustainable Production and Consumption for the period 2021-2030). The National Program for Sustainable Production and Consumption is considered one of the important pillars that the Ministry of Industry and Trade is implementing to contribute to achieving the Net Zero target by 2050, as committed by the Vietnamese Government at COP26. Therefore, implementing a circular supply chain in specific sectors, especially the textile industry, is important. However, the transition to a circular supply chain in the textile industry faces numerous challenges; thus, analyzing these barriers to find solutions is both necessary and scientifically meaningful.

The AHP method was used to rank the important barriers and the DEMATEL method to analyze the relationships between these barriers. This approach facilitates the identification of barriers that should be prioritized for resolution, providing a basis for implementing circular supply chain solutions. Consequently, this research contributes to theoretical and practical advancements in the textile industry by identifying eight critical barriers from a total of 24 barriers that impede the adoption of a circular supply chain in the textile sector. Additionally, it classifies the main barriers into groups, determining the priority levels of the barriers based on the weights calculated using the AHP method. Analyzing the relationships between the barriers through the DEMATEL method will help textile companies better understand and control these barriers to implement circular policies in their supply chains effectively. This, in turn, supports waste reduction and fosters the development of a sustainable business environment.

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Article history

Received on April 16, 2024

Revised on April 28, 2024

Accepted on April 28, 2024