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DECISION SUPPORT MODEL FOR EVALUATING BARRIERS OF CIRCULAR SUPPLY CHAINS FOR SUSTAINABILITY IN THE TEXTILE INDUSTRY: A CASE STUDY IN VIETNAM

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THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF INTERNATIONAL BUSINESS

FACULTY OF BUSINESS ADMINISTRATION

Ho Chi Minh, Vietnam

November, 2023

ACKNOWLEDGEMENT

With the efforts and collaboration of our team members, this thesis was completed within the term given; thanks for taking part. Foremost, we express our gratitude to our mentor, Nguyen Ngoc Ai Thy, who allowed us to undertake this remarkable study and offered her patient support, inspiration, and expertise throughout the entire research journey. Her assistance enabled us to cultivate new talents and skills, leading to the successful completion of this project.

Additionally, we sincerely thank our FPT University lecturers for imparting the foundational knowledge and essential skills during years of education that enabled us to produce a study.

Last but not least, we express our special thanks to everyone willing to help us during our survey and research process in November 2023.

Ho Chi Minh, November 2023

Authors of the thesis

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ABBREVIATIONS AND ACRONYMS LIST

Abbreviation	Full explanation
CE	*Circular Economy*
CSC	*Circular Supply Chain*
AHP	*Analyst Hierarchy Process*
MCDM	*Multi-Criteria Decision Making*
SC	*Supply Chain*
WCED	*World Commission on Environment and Development*
SSC	*Sustainable Supply Chain*
ECE	*Education for the circular economy*
SMEs	*Small and Medium Enterprises*
MODM	*Multi-objective decision making*
MADM	*Multi-attribute decision making*
GTA	*Graph-theoretic approach*
FTAs	*Free trade agreements*
ELECTRE	*Elimination and Choice Translating Reality*
TOPSIS	*The Technique for Order of Preference by Similarity to Ideal Solution*
PROMETHEE	*Preference Ranking Organization Method for Enrichment Evaluation*
CI	*Consistency index*
CR	*Consistency ratio*
RI	*Random index*
B.Sc	*Bachelor of Science*

MBA	*Master of Business Administration*
M. Sc	*Master of Science*
PhD	*Doctor of Philosophy*
CSR	*Corporate Social Responsibility*
B2B	*Business To Business*
NGOs	*Non-Governmental Organisations*

CHAPTER 1: INTRODUCTION

1.1. Overview of the research topic

1.1.1. Situation of the textile industry

It cannot be denied that the textile industry is worthy of investment and one of the industries significantly contributing to the country's economy in general and Vietnam in particular. The top 5 countries with the most significant exports include China, India, Vietnam, Bangladesh, and Turkey. According to the World Trade Organization's Report in August 2021, Vietnam's textile and garment industry's exports rose to second place in the world in 2020, just behind China (vietnamtimes, 2021).

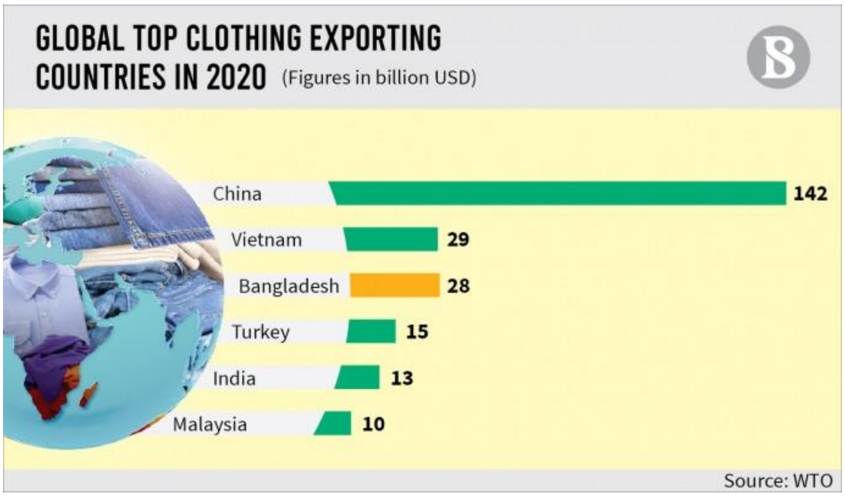

Figure 1.1 Global top clothing exporting countries in 2020

(Source: WTO, 2020)

As per VIRAC, Vietnam's textile and garment industry exhibited positive outcomes in 2022, achieving an export turnover of 44 billion USD, marking a roughly 10% increase from 2021. However, towards the end of the fourth quarter in 2022, the global economic and political landscape faced sudden challenges, including the ongoing tensions in the Russia-Ukraine conflict, a slowdown in economic growth, rising inflation, Etc. The demand for garments is anticipated to decrease in 2023, particularly in Vietnam's key import markets, the US and the EU (virac, 2023). Vietnam's textile and garment industry is also facing difficulties and challenges such as epidemics, global economic recession, and reduced purchasing power in both the domestic market and the markets of major importing countries such as the US, Japan, Korea, China, Etc. At the same time, currencies in some large importing countries have a depreciation trend, affecting the import and export activities of Vietnam's textile and garment industry (bnews, 2022).

The global textile and garment market faces supply chain disruptions, rising protectionism, and changing consumer preferences. Major importers from the US, Europe, and Japan are shifting their sourcing strategies to favor suppliers offering integrated, localized, and transparent production processes from raw materials to finished products. However, Vietnam's textile and garment industry lacks more supply chain linkages, which hinders its competitiveness and sustainability (congly, 2023).

As predicted, the initial months of 2023 witnessed a rather bleak scenario for Vietnam's textile and garment industry, experiencing a significant downturn compared to last year. As indicated by the VIRAC report, during the initial quarter of the current year, the textile and garment production in the country amounted to US$8.701 billion, reflecting an 18.63% decline in comparison to the corresponding period in 2022. In particular, the production of casual clothing by Vietnamese enterprises witnessed a decrease of approximately 10% compared to last year (virac, 2023).

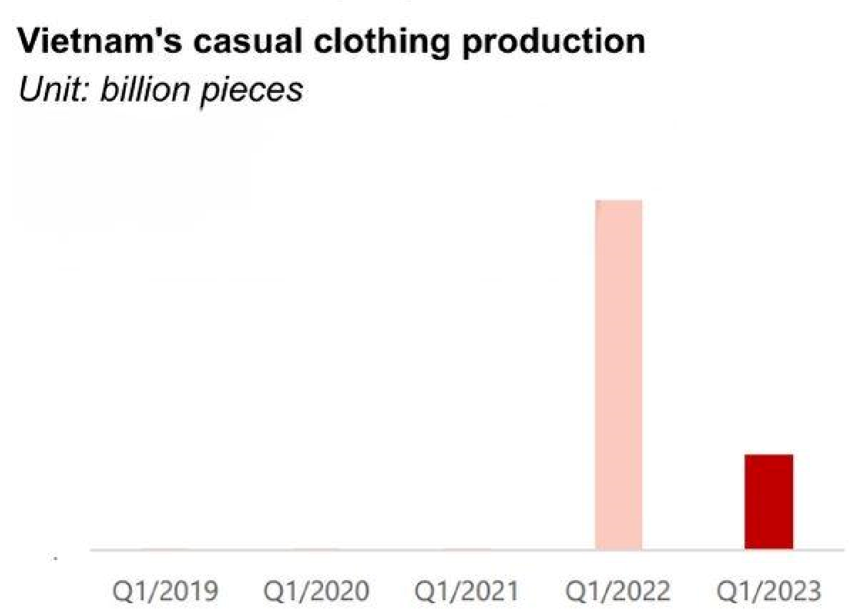

Chart 1.1 Vietnam’s casual clothing production

(Source: Virac)

The industry has actively engaged in various free trade agreements (FTAs), particularly in 2020, opening new avenues for market expansion. However, these FTAs bring about challenges as textile enterprises are required to adhere to novel ecological design criteria and standards. Consequently, there is a pressing need for the industry to undergo a green transformation to embrace an eco-friendly export strategy (Do & Tran, 2021).

Furthermore, the sector is dedicated to reducing its emissions, aligning with the Vietnamese Government's commitment to achieving Net Zero Emissions by 2050, a pledge made at the 2021 United Nations Climate Change Conference (COP26) (vietnamplus, 2022).

In pursuit of sustainability and circularity in the textile value chain, the industry has redefined its development objectives and embraced innovative technologies. This includes adopting clean raw materials and recycled resources alongside implementing green and sustainable production methods that prioritize environmental protection and social responsibility (Vietnam National Textile and Garment Group, 2022).

1.1.2. The Textile Industries Moving towards the Circular Economy

The global shift towards a circular economy has become unavoidable to address the demands of sustainable development amid escalating challenges such as diminishing natural resources, environmental degradation, pollution, and the pressing issues of climate change and biodiversity loss (Arthur et al., 2022). Notably, the significance of the circular economy (CE) has been rising for manufacturing companies in the contemporary world due to the growing emphasis on sustainability and eco-friendly practices. In a circular economy, the circulation of used materials is extended for as long as possible, facilitating the restoration and recreation of products and materials after each production or consumption cycle (Arthur et al., 2022). This framework minimizes waste by reimagining products, refining manufacturing processes, and optimizing supply chains to sustain a continuous flow of resources within a closed loop (Jia et al., 2020).

The prevailing resource-intensive and linear take-make-dispose approach, which has been dominant since the Industrial Revolution, aligns with technological advancements prioritizing off-shoring, low-cost production, and volume-based manufacturing (Lieder & Rashid, 2016). This methodology has led to widespread depletion of natural resources, climate change, and societal imbalances, with particularly severe consequences in developing world contexts.

Consequently, the Circular Economy (CE) has emerged as a transformative model, gaining increased attention from the business, policy, and sustainable development communities (Bocken et al., 2018; Geissdoerfer et al., 2017; Schröder et al., 2020). Vermeulen (2015) affirmed that transitioning from a linear economy to a circular one is unavoidable for manufacturing companies aiming to establish a sustainable and equitable global economy. Pressing concerns like climate change and escalating carbon emissions have compelled companies to transition from a linear to a circular economy (Mazzanti and Montini, 2014; Atlason, Giacalone, and Parajuly, 2017; Coste-Maniere et al., 2019; Zhou, Song, and Cui, 2020).

Various countries and regions have formulated their roadmaps for implementing a circular economy. Recently, the European Union introduced an action plan to promote circular economy practices (European Commission, 2020). Several European countries, including Finland, the Netherlands, and France, have also developed individual circular economy roadmaps. Australia has also established a national roadmap for plastics, tires, glass, and paper (National Science Agency, 2021). In Asia, the People's Republic of China (PRC) has implemented new regulations to enhance the effectiveness of its circular economy models and sustainability initiatives (Kennedy and Johnson, 2015).

The Circular Economy model has received significant emphasis from the Communist Party and the Government of Vietnam. In line with this, the Political Report of the Party Central Committee, Session XII, presented to the Congress, suggests establishing a circular economy as a primary developmental focus for the country from 2021 to 2030. To foster the advancement of the circular economy in Vietnam, Article 142 of the 2020 Environmental Protection Law explicitly outlines the involved stakeholders, including ministries, agencies at the ministerial level, and provincial-level people's committees. These entities must incorporate circular economy considerations into their strategies, plans, programs, and projects, particularly concerning waste management, reuse, and recycling.

The Circular Economy (CE) has found primary application in the textile industry, mainly due to the industry's substantial environmental pollution resulting from its intricate manufacturing procedures. Recognized as the second most environmentally detrimental sector globally (Malik et al., 2014), the textile industry operates linearly, employing a supply chain saturated with toxic substances that extensively contaminate air, water, and soil. The accumulation of textile waste has been a global concern; however, adopting recycling or reusing practices for textile products can mitigate the generation of new waste from virgin materials (Dahlbo et al., 2017).

The fashion textiles industry, known for its linear operations, is one of the most environmentally harmful sectors globally. Its highest environmental impact occurs during the manufacturing stage, characterized by substantial energy, chemical, and water usage (Niinimäki et al., 2020; Shirvanimoghaddam et al., 2020). Moreover, these activities predominantly occur in developing countries, which are more susceptible to the adverse effects of unsustainable business practices. Given its status as the most environmentally polluting manufacturing industry with the potential for environmental impact reduction, the textile industry has been the subject of previous studies on CE and sustainability (Camacho-Otero, Pettersen, & Boks, 2020; Mukherjee, 2015; Todeschini, Cortimiglia, Callegaro-de-Menezes, & Ghezzi, 2017).

In response to the escalating importance of zero waste and the adverse effects of a linear economy within the textile industry, this study delves explicitly into the textile sector. Despite the recommendation for textile companies to transition from a linear to a circular economy, numerous barriers hinder the seamless adoption of CE practices. Consequently, this study focuses on identifying and understanding the barriers that impede companies from embracing Circular Economy implementations.

1.2. Problem Statement

1.2.1. Total domestic and foreign textile and garment demand

All sectors of the social economy are closely linked together, creating the basis for developing other sectors, and the textile and garment industry is no exception. In Vietnam's industrial, construction, agricultural, and service systems, the textile and garment industry play a vital role in promoting the development of other economic sectors (Cosmatechnology, 2021).

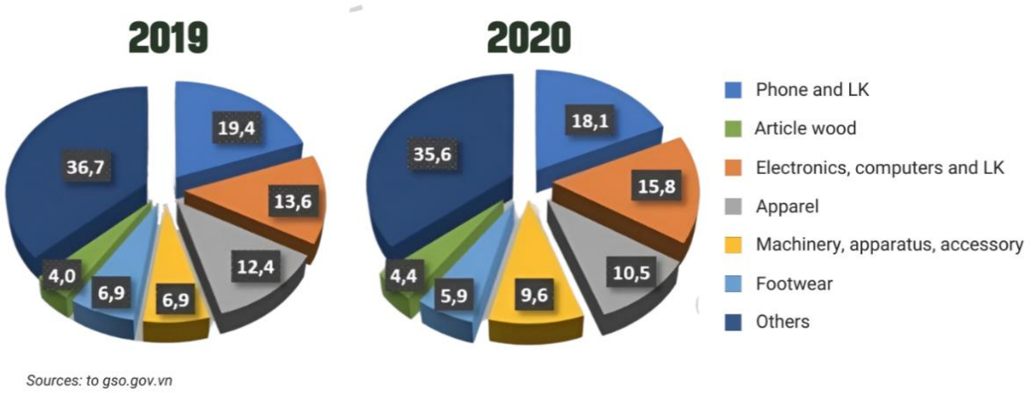

Chart 1.2 Proportion of export turnover of some major products in Vietnam in 2019-2020

(Source: gso.gov.vn)

As the image shows, the textile and garment industry contributes the top 3 proportion of export turnover among all industries. As the textile industry develops, the agricultural industry will naturally develop together with fields such as cotton growing, jute production, or silkworm farming. This continues to impact industries producing raw materials directly. Not only that but if the development of the textile industry is sustainable, other industries, such as machinery manufacturing and technology software design, will also have substantial progress. At the same time, service industries such as transportation and marketing will also have great opportunities to develop. Thus, Vietnam's economy, focusing mainly on agriculture, will gradually transform towards an industry-service model (Cosmatechnology, 2022).

Total world demand for Textiles and Garments in 2023 is expected to decrease by about 8-10%. According to Mr. Truong Van Cam, Secretary of the Vietnam Textile and Apparel Association, Vietnam's textile and garment exports in 2023 could reach around 40 billion USD, down 9-10% compared to 2022 (virac, 2023b).

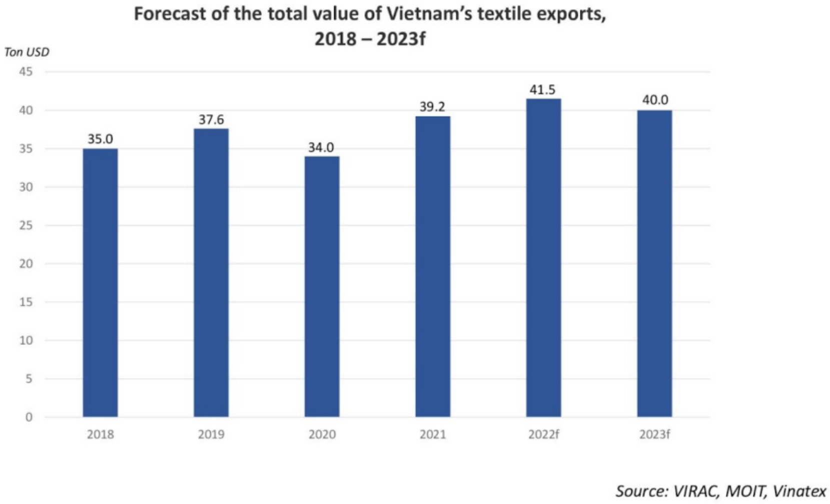

Chart 1.3 Forecast of the total value of Vietnam's textile exports, 2018-2023
(Source: VIRAC, MOIT, Vinatex)

In particular, the European Commission has put forth initiatives for the EU's latest Textile Strategy, integral to the European Green Deal, to solve global problems such as climate change, social imbalance and environmental pollution (Meyer B, 2011).

By 2030, textile products entering the EU market should possess a prolonged lifespan, be recyclable, primarily crafted from recycled fibers, devoid of harmful substances, and be manufactured in adherence to social and environmental rights. With an increasing emphasis on global "green" consciousness, it becomes imperative for the textile industry to change. Vietnamese enterprises must capitalize on this opportunity to invest in technology and devise solutions to diminish waste and environmental pollution (virac, 2023b).

1.2.2. Fast fashion

The fashion apparel industry has undergone significant changes over the past two decades, marked by increased demand, a rise in fashion seasons featuring mass production of short-cycle clothing, and structural shifts in the supply chain (Bhardwaj & Fairhurst, 2010). The concept of 'fast fashion,' developed in France, has played a role in catering to the demand for trendy, relatively inexpensive, and quickly produced clothing, especially among teenage and adolescent women (Doeringer & Crean, 2006). Significant players like Inditex (owner of ZARA) have embraced this concept, prioritizing fast and cost-effective production aligned with the latest trends demanded by consumers. However, this business model could be more sustainable as it focuses on producing low-quality items at the lowest cost, challenging sustainable manufacturing (Fall T, 2016).

Addressing the issue by increasing the price of clothing is a complex solution due to the industry's infrastructure. All stakeholders in the supply chain aim to maximize profits, and raising prices may not necessarily benefit the factory workers; the added costs might be lost along the way (Huntsman, 2016). Despite these challenges, consumers still desire beautiful, comfortable, affordable clothing (Fall T, 2016). The prevailing business models are deeply ingrained, with a mindset of "why change a successful business model" (Huntsman, 2016). Multinationals benefiting from their current business models need more incentives to alter their approach.

The adverse impact of fast fashion manifests in environmental consequences, marked by the overproduction of clothing items and the excessive disposal of garments, contributing to a significant increase in waste. Approximately 32 billion garments are produced annually for the fashion industry, with a staggering 64% of them ultimately finding their way into landfills (Moi truong Hop Nhat, 2022).

1.2.3. Impact of the Textile Industry on the Environment

The global textile sector contributes $2.4 trillion to the manufacturing industry's revenue and employs 300 million people across the value chain. Despite its economic significance, the textile industry presents considerable environmental challenges. It is responsible for approximately 2-8% of the world's greenhouse gas emissions, consuming 215 trillion liters of water annually, leading to a $100 billion loss due to underutilization. Moreover, the industry is a key contributor, responsible for about 9% of the annual microplastic pollution in the ocean, primarily originating from the laundering of synthetic textiles such as polyester (bnews, 2022).

The consequences of these impacts have led to an increasing demand for the implementation of "green" or "sustainable development" practices within the textile and garment industry, advocated at the international, national, and corporate levels (Moorhouse, 2022).

The creation of apparel and household textiles involves the utilization of primary raw materials and water. Specifically, the textile industry holds the second-highest ranking in terms of land use and is fifth in greenhouse gas emissions (EEA, 2019). The production processes for textiles involve significant quantities of various chemicals, and the laundering of textiles introduces additional chemicals and microplastics into household wastewater. Consequently, the textile industry impacts natural ecosystems throughout each stage of its production processes (Stål & Jansson, 2017). Often, textiles are either exported to developing countries, incinerated, or disposed of in landfills, as recycling rates remain notably low (EEA, 2019; Scharff, 2014).

Recognizing the environmental implications, (EU, 2015) has suggested the textile industry as a priority sector in one of its recent documents. The Commission is advocating for a comprehensive EU Strategy for Textiles. (EU, 2020) recommends that manufacturers of textile materials embrace eco-designs and sustainability measures, fostering engagement in closed-loop systems. These systems entail the responsible use and reuse of resources, addressing the use of diverse chemicals, and encouraging businesses and consumers to opt for textile reutilization and repair facilities (EU, 2020; Monea et al., 2020).

1.3. Research Objective

This study is based on expert consistency based on the barriers presented, experts preferred by the top 5 main barriers; from there, we provide recommendations for businesses in the circular economy. Research with the help of experts gets the top barrier, increasing the research result's robustness.

OBJ1**:** Understand and identify the barriers of Circular supply chain for the textile industry in Vietnam

OBJ2: Determine the relative weights of the CSC barriers

OBJ3: Propose the managerial implications of the proposed work and constructive recommendations for Vietnamese textile and garment enterprises to overcome the most important barriers to moving towards a circular economy.

1.4. Research Question

These objectives give rise to the Research Question and understanding of this study:

Q1. How important is the circular economy to Vietnam's textile and garment industry?

Q2. Which is the top 5 barriers affecting the transition to a circular economy for Vietnam's textile and garment industry?

Q3. What are constructive recommendations for Vietnamese textile and garment enterprises to overcome barriers to moving towards a circular economy?

1.5. Research Scope

Title	Number of respondents	Authors
Exploring barriers to smart and sustainable circular economy: The case of an automotive eco-cluster	5	Kayikci, Y. *et al.*, 2021
The transition from linear economy to circular economy for sustainability among SMEs: A study on prospects, impediments, and prerequisites	6	Sharma, N.K. *et al.*, 2020
Managing operations for circular economy in the mining sector: An analysis of barriers intensity	7	Singh, R.K. *et al.*, 2020
Barriers to the adoption of the circular economy in the Brazilian sugarcane ethanol sector	4	Jesus, G.M. *et al.*, 2021
Investigating barriers to circular supply chain in the textile industry from Stakeholders' perspective	11	Kazancoglu, I. *et al.*, 2020
Exploring the decisive barriers to achieve circular economy: Strategies for the textile innovation in Taiwan	9	Huang, Y.-F. *et al.*, 2021

Table 1.1 Literature review scope

As shown in Table 1.1, we have searched and listed a number of studies by authors; these research articles focus on different methods such as AHP, AHP-GTA, Fuzzy Delphi Method, Fuzzy-DEMATEL and the number of experts that these studies collect, the number of respondents from 5 to 10. On the other hand, because research time is limited and the process of working with experts requires a lot of time, we decided to choose seven experts to participate in evaluating the barriers for our research.

In this study, we will stop by providing solution proposals for businesses. Our research method for data collection was face-to-face interviews, focusing on a group of education teachers about supply chains and business experts in domestic textile and garment enterprises in Vietnam.

- Number of respondents expected: 7 experts;
- Criteria for Selecting Survey Assessment Experts;
    - Number of years of experience: over six years experience
    - Field of work: working in departments (eg, production department, quality management department, sustainable development department, etc.) at small, medium-sized, multinational corporation and foreign invested enterprise textile enterprises in Vietnam.
    - Management level: from Middle Management Level and above

1.6. Methodology and Data Review

In this research, multiple methods were applied to collect and analyze data. The primary research was implemented based on qualitative and quantitative research gathered through direct interviews and analyzed by AHP.

AHP methods determine the weights of barriers and ranking. In addition, it also proposes solutions for businesses to overcome those barriers.

Primary data was extracted from experts' opinions through interviews. Secondary data was based on online references (such as news, research articles, and books) and consultation with business experts and lecturers about the supply chain.

1.7. Conclusion

This thesis introduces the textile industry background and an overview of The Textile and Fashion Industries Moving towards the Circular Economy. In investigating this problem, the research subject, research scope, and proposed research questions are identified.

1.8. Thesis Outline

The other part of the thesis (excluding the abstract, appendix, reference, list of tables and figures, abbreviations, and acronyms list) is laid out as follows:

Chapter 1: Introduction

Chapter 1 briefly provides basic information about the background, objective, research question, and methodology.

Chapter 2: Literature Review

Chapter 2 presents relevant theories that are the basis for developing research questions. Use the AHP method to evaluate barriers.

Chapter 3: Methodology

Chapter 3 presents research methods such as qualitative, quantitative, and observational studies. Data collection and analysis methods are clarified in this chapter.

Chapter 4: Emprical case analyst

Chapter 4 analyses and applies the model and methods proposed in Chapter 3 to a Pairwise comparison of main and sub-barrier barriers and calculates the weights of those barriers. From there, there are rankings for it.

Chapter 5: Conclusion and Implication

The final chapter answers the research inquiries by recapitulating the discoveries and proposing approaches for the government, businesses, and involved parties to devise a strategic framework for surmounting obstacles in progressing toward a Circular Economy for sustainable development within Vietnam's textile industry. Limitations and implications of this study are also reminded to guide the utilization of our outcomes in future research.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

For the purpose of clarifying concepts and issues related to the topic of our research we conduct a review of studies regarding circular economy concept, meaning of Sustainable Supply Chain, circular supply chain, multi-criteria decision making (MCDM), the analytic hierarchy process (AHP) and barriers that have two streams of paper: main barriers and sub-barriers in this literature review section. Based on the review, 9 main barriers with 24 sub-barrier have been categorized as follows Table 2.3. We searched databases EBSCO, ScienceDirect (SDOL), and Google Scholar.

2.2. Meaning of CE, SSC, and CSC

2.2.1. Definition of Circular Economy

Circular economy (CE) is a sustainable economic model that aims to reduce the dependence on natural resources and minimize waste generation in the production and consumption processes. CE encourages the reuse, recycling, regeneration, and redesign of products, components, and materials to maintain their value and function at the highest possible level (Ghisellini et al. 2016). CE is considered a solution for the issues of resource security, environmental impact, and economic growth (Geissdoerfer et al. 2017).

Kirchherr et al. (2017) gathered 114 definitions of the circular economy, categorizing them across 17 dimensions to enhance clarity on the concept. Their paper represents the inaugural comprehensive effort to elucidate the circular economy's actual meaning through scientific research. The circular economy concept makes two significant contributions: firstly, it underscores the significance of elevated value and quality material cycles in a novel way, and secondly, it reveals the potential of integrating the sharing economy with sustainable production to foster a more sustainable culture of production and consumption.

Articulate the circular economy (CE) concept according to the sustainable development and sustainability science principles outlined by the World Commission on Environment and Development (WCED). Undertake a thorough examination of the concept, focusing on its environmental sustainability aspect. This paper marks the inaugural and comprehensive endeavor to comprehend the circular economy concept through rigorous scientific research. It illuminates the potential of CE across dimensions: economic, environmental, and social of sustainable development. (Korhonen, J. et al. 2017).

According to Vietnam Environmental Protection Law 2020, circular economy is an economic model in which design, production, consumption and service activities aim to reduce the exploitation of raw materials, extend product life cycles, limit waste generation and reduce waste. minimize negative impact on the environment.

2.2.2. Definition of Sustainable Supply Chain

A supply chain refers to the organized system encompassing all companies, facilities, and processes that produce and deliver a product or service to the final customer. Supply chain management involves the coordination of sourcing, manufacturing, inventory management, and shipping across all participants in the supply chain, aiming to optimize efficiency and enhance customer satisfaction (idms. vn, 2022).

A sustainable supply chain is a fully integrated set of transparent, ethical, and environmentally responsible practices into a competitive and successful model. It necessitates comprehensive visibility throughout the entire supply chain, from sourcing raw materials to product distribution, returns, and recycling processes (idms. vn, 2022). According to Masoumik et al. (2014), a sustainable supply chain closes the loop of both upstream and downstream flows of products and materials through recycling and recovery of used items. It actively participates in sustainability-conscious practices that consider goals from all three dimensions—economic, environmental, and social—of sustainable development, aligning with customer and stakeholder requirements.

2.2.3. Sustainable Supply Chain for the Textile Industry

Creating a sustainable supply chain for the textile industry involves transforming production and business models. This shift encompasses moving beyond selecting sustainable materials to implementing a pollution-free and eco-friendly production process, delivering products and services labeled as environmentally friendly to customers (Vietnam Industry Agency, 2023).

The production process prioritizes the use of safe inputs and outputs for both humans and the environment. This process begins with selecting eco-friendly raw materials, such as organic cotton, hemp, bamboo, or recycled fibers. Additionally, the production process aims to optimize resource usage and minimize waste generation. It involves reducing or eliminating hazardous substances and materials that negatively impact human health and the environment, such as toxic dyes, pesticides, or microplastics. (Bich, 2022).

Doan, T. M. H., & Vu, T. A. (2023) also advocated for an approach beyond mere green labeling. A sustainable supply chain for the textile and garment industry should actively pursue resource efficiency and waste reduction, aligning with the three pillars of sustainable development: environment, society, and economy. Firstly, the sustainable production process requires minimizing or eliminating substances and materials harmful to human health and the environment. Secondly, it involves designing clothes for reuse and recycling, incorporating renewable energy sources. Beyond mitigating environmental impacts, a sustainable supply chain for the textile industry also prioritizes employees' social well-being and improved working conditions.

2.2.4. Circular Supply Chain in the Textile Industry

An overview of the circular textile SC is shown in *Figure 2.1* below.

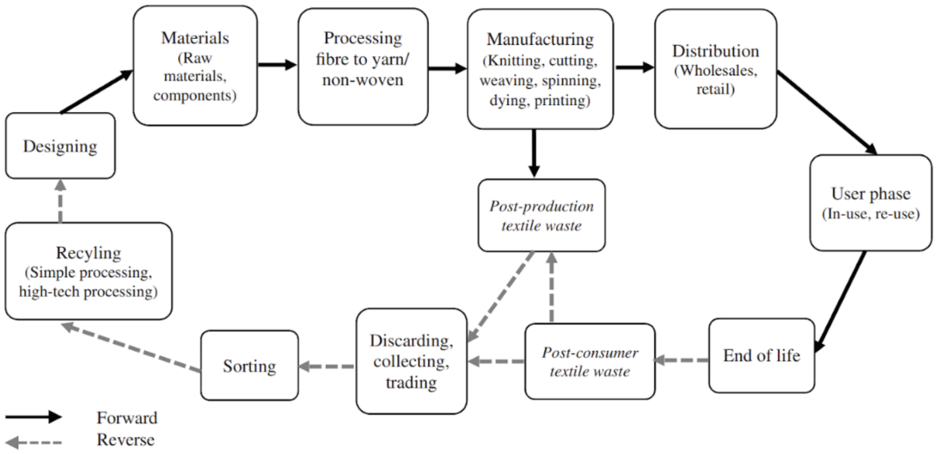

Figure 2.1 Circular textile supply chain

(Source: Kazancoglu, I. et al., 2020)

In a supply chain, the steps follow traditional processes as follows: Designing -> Materials (Raw materials, components) ->Processing fiber to yarn/ non-woven -> Manufacturing (Knitting, cutting, weaving, spinning, dying, printing) -> Distribution (Wholesales, retail) -> User phase (In-use, re-use). CSC primarily addresses material flows within economic systems, emphasizing the enhancement, dematerialization, closure, deceleration, and narrowing of resource loops. In the context of circularity, raw materials are kept within a continuous circular flow which includes End of life -> Post-consumer textile waste -> Post-production textile waste ->Discarding, collecting, trading ->Sorting ->Recycling (Simple processing, high-tech processing) -> (Designing) (Lahane et al., 2020; Geissdoerfer, Morioka, de Carvalho, & Evans, 2018; Kumar & Suganya, 2019).

CSC provides the advantage of diverting used products as waste by recycling value and reuse in the production of secondary products (Genovese et al., 2017).

2.3. Circular supply chain barriers framework

In this section, a total of 9 main barriers and 24 sub-barriers were identified and focused on by the team, as presented in *Table 2.1*. The barriers are described in detail below.

No	Main Barriers	Sub-Barriers
B1	***Management and decision-making***	*B1.1. Lack of performance evaluation system*
		B1.2. Lack of acceptance of new business models
		B1.3. Lack of traceability
B2	***Labour***	*B2.1. Labour intensiveness*
		B2.2. Lack of trained intermediate staff
B3	***Design challenges***	*B3.1. Lack of complementary processes*
		B3.2. Complexity in product architecture
B4	***Materials***	*B4.1. Availability of recyclable materials*
		B4.2 Lack of high-quality
		B4.3 Complexity in material composition
		B4.4 High cost of raw materials
B5	***Rules and regulations***	*B5.1 Lack of sectorial standardization*
		B5.2 Lack of certifications
B6	***Knowledge and awareness***	*B6.1 Lack of CE awareness*
		B6. 2 Lack of theoretical information
		B6.3 Lack of technical know-how
B7	***Integration and collaboration***	*B7.1 Lack of sharing information and communication*
		B7.2 Lack of constant supplier
		B7.3 Lack of shared vision and willingness to collaborate
B8	***Economic***	*B8.1 High investment cost*
		B8.2 Uncertainty in Profitability
		B8.3 Failure to provide the scale of production
B9	***Technical infrastructure***	*B9.1 Inadequate of infrastructure facilities*
		B9.2 Lack of high-tech in reverse logistics

Table 2.1 Circular supply chain barriers framework

2.3.1. Management and decision-making

This topic is about the overall management challenges surrounding operations at the enterprise level. It highlights issues such as “lack of performance evaluation system” (*2.3.1.1*), “lack of acceptance of CE models” (*2.3.1.2*), and “lack of traceability” (*2.3.1.3*).

2.3.1.1. Lack of performance evaluation system

Evaluating business performance is an extremely important task for businesses, especially textile and garment businesses. The business performance of an enterprise reflects the ability to combine input resources, allowing to minimize costs in business activities to achieve the business's profit goals. Evaluating business performance helps businesses know the strengths that need to be promoted and the limitations that need to be overcome in using resources, especially in the context of increasingly fierce global competition today. The lack of a quantitative performance measurement system and performance metrics for CE creates managerial challenges, particularly for yarn, fabric, and garment producers, as well as collectors and recyclers (Su et al., 2013; Mangla et al., 2018; Jia et al., 2020; Govindan et al., 2014; Bianchini et al., 2019). According to the 2018 business results report and the 2019 plan from the Vietnam Textile and Garment Group (Vinatex, 2019), Vietnam's textile and garment export industry achieved a remarkable milestone, reaching 36.2 billion USD, reflecting a notable 16.4% increase compared to 2017. This positions Vietnam among the top three global textile-exporting countries, trailing only China and India (Vinatex, 2019). However, the year 2020 witnessed a downturn for the textile industry due to the prolonged impact of the Covid-19 pandemic, leading to a 0.5% decline in the textile industry's industrial production index (Ministry of Industry and Trade of the socialist republic of Vietnam, 2021). Despite these challenges, the sector remains significant for Vietnam's economic development, driven by increasing foreign direct investment (FDI) inflows attracted by growth potential and various trade agreements. Foreign enterprises in the textile and garment sector leverage modern machinery and automated technologies, resulting in low costs and high productivity. However, the dependence on processing and low labor costs for export growth has posed challenges in meeting the demand from the US and Europe (Government News, 2020). The expanding role of Vietnam's textile and garment industry underscores its importance for the country's socioeconomic development, emphasizing the need for effective management practices and performance evaluation to ensure competitiveness and sustained growth (Wang et al., 2022).

2.3.1.2. Lack of acceptance of CE models

The Circular Economy (CE) represents a shift in business operations from the conventional linear model to a more sustainable system (Elisha, 2020). CE integrates recycling, redesign, reduction, and reuse into existing production and consumption practices, necessitating profound systemic alterations in the production, utilization, and disposal of products and materials (Bressanelli et al., 2020). Adopting CE as a business model may encounter reluctance from companies, impacting yarn, fabric, and apparel manufacturers, designers, brand owners, retailers, and even government policymakers (Govindan et al., 2013; Kirchherr & Piscicelli, 2019). In Asia, the People's Republic of China (PRC) has implemented new regulations to enhance the effectiveness of circular economy models and sustainability initiatives (Kennedy & Johnson, 2016). The Party and Government of Vietnam are keenly interested in the circular economy model. The Political Report of the 12th Party Central Committee, submitted to the Congress, outlines the establishment of a circular economy as the country's key development direction for the period 2021-2030, emphasizing the promotion of circular economy development in the textile and garment industry in Vietnam (Communist Party Of Vietnam, 2021).

2.3.1.3. Lack of traceability

Currently, there are no tools available for manufacturers or recyclers to monitor and assess the lifespan of sold goods, predict the quantity and value of returned items, and determine the frequency of collection. To address this gap, textile traceability tools should be integrated into production and distribution networks. Adopting circular economy (CE) traceability involves using proprietary identifiers assigned to track source components (Jia et al., 2020). The challenge of monitoring the durability of product lines and substances within CE impacts manufacturers of fibers, fabrics, and garments, along with brand owners, retailers, collectors, and prospective recyclers, highlighting tracking and tracing concerns (Govindan & Hasanagic, 2018; Radhakrishnan, 2022). Product traceability is increasingly becoming a mandatory trend in import markets; for instance, the United States enforces anti-forced labor laws effective from June 2022, and EU countries are implementing traceability regulations for textile and garment supply chains under the Supply Chain Inspection Law. This poses a challenge for Vietnam's textile industry, given its substantial reliance on imported raw materials, particularly the annual importation of around 1.6 million tons of cotton (Government News, 2023). The textile and garment sector in Vietnam faces mounting pressure to enhance traceability and ensure product sustainability. Improving traceability not only enhances transparency and accountability but also minimizes environmental and social risks, elevates product quality and safety, and fosters consumer trust and acceptance (Vinatex, 2023).

2.3.2. Labour

The CE needs high labor intensity in the textile industry, especially in the human resources category, such as “labor intensiveness” (*2.3.2.1*) and “lack of trained intermediate staff” (*2.3.2.2*).

2.3.2.1. Labor intensiveness

Sectors or activities within the Circular Economy (CE) often exhibit a higher level of labor intensity, mitigating potential job losses resulting from a paradigm shift (Llorente-González & Vence, 2020). The textile industry, in particular, is limited in its capacity to replace labor with automation. Garment manufacturing automation is relatively modest, mainly focused on pre-assembly tasks like pattern sorting and cutting. Sewing operations remain labor-intensive, with the skill set of line operators significantly influencing productivity (Goto & Endo, 2014). In 2021, the textile, garment, and footwear industry achieved an export turnover exceeding $60 billion, and by 2022, this figure is projected to reach $71 billion, contributing to 18% of the country's total export turnover. This industry provides employment for 4.3 million workers, constituting 30% of industrial and construction workers and 10% of the total working-age population in the country. Textile and garment, ranked as the fifth-largest industry, and leather and footwear as the sixth, share a common characteristic of being labor-intensive. However, this reliance on labor serves as an advantage for these industries' development, given Vietnam's ample labor force, forecasted to reach 105 million people by 2030, with the working-age population accounting for about 60% (Truong, 2023).

2.3.2.2. Lack of trained intermediate staff

The textile and garment industry, being labor-intensive, serves as a crucial avenue for generating new employment opportunities, particularly in absorbing surplus low-skilled labor in developing nations. This assertion is underscored by the experiences of various countries, including Bangladesh, Sri Lanka, Vietnam, and Mauritius, where early-stage development of the textile industry played a pivotal role in propelling them from low-income to middle-income status, signifying significant growth (Radukić et al., 2023). In the current landscape of Vietnam's textile and garment sector, a substantial portion of the workforce comprises unskilled laborers engaged in product processing, with a scarcity of technical qualifications in areas like dyeing, fabric finishing, or product design. Approximately 75% of workers in this industry lack adequate training, with many having received less than three months of training. This poses a challenge for the industry as it endeavors to adopt modern technology, enhance domestic production ratios, and navigate the transition towards higher automation (Ministry of industry and trade of the socialist republic of Vietnam, 2022). Businesses are prioritizing intermediate human resource training to keep pace with technological advancements, addressing the evolving demands for equipment and machinery in highly automated sectors, such as the Fiber-Textile dyeing industry and specific stages of the Garment industry (Vinatex, 2023).

2.3.3. Design challenges

In the textile industry, a product undergoes various additional processes such as cleaning, coating, dyeing, and welding until it assumes its final form. This main barrier emphasizes "lack of complementary processes" (*2.3.3.1*) and "complexity in product architecture" (*2.3.3.2*).

2.3.3.1. Lack of complementary processes

Within the textile industry, the production process encompasses various stages, starting from the processing of raw materials like regenerated cellulose fibers, synthetic fibers, and inorganic fibers. This process extends to knitting, weaving, or non-woven methods to create fabrics, which can be further subjected to finishing steps such as dyeing, printing, cutting, sewing, etc. Ultimately, the outcome is a finished garment ready for the market (Franco, 2017). Each of these stages involves specialized processes, machinery, and knowledge. Efficient coordination among these processes is crucial to ensure the quality, efficiency, and adaptability of textile production (Jia et al., 2020). Notably, the garment industry's supply chain is characterized by numerous links, featuring not only a multitude of production steps but also a high degree of globalization (Rose, 2023).

2.3.3.2. Complexity in product architecture

Product complexity, as defined by Novak and Eppinger (2001), pertains to the number of components in a product design that require specification and manufacturing or procurement. An example of a low-complexity garment is a t-shirt, typically made from yarn, branding, cotton, and dye. In contrast, a high-complexity product, such as a bra, includes various components like hooks, hook tapes, eyelets, cups, elastic bands, foam, rings, straps, sliders, fabric, and wires (Franco, 2017). Vietnam Textile and Garment Day should emphasize the production of complex, high-value products, steering away from basic items or those with self-adhesive materials (Nghi, 2022). The focus should be on developing new products by leveraging existing strengths and incorporating changes, additions, or subtractions in materials, technologies, and techniques across the production process—from spinning methods and fiber materials to weaving effects, dyeing technology, garments, and packaging. An example of innovation in this context is the blending of viscose fiber with cotton during spinning, resulting in vibrant and bold colors when dyed.

The combination of different materials can yield distinct effects, providing a range of options under similar environmental conditions (Ministry of Industry and Trade of the Socialist Republic of Vietnam, 2022).

2.3.4. Materials

Materials constitute essential inputs for production and play a crucial role in circular manufacturing. This complexity introduces barriers such as “the availability of recyclable materials” (*2.3.4.1*), “lack of high quality” (*2.3.4.2*), “complexity in material composition” (*2.3.4.3*), and “high cost of raw materials” (*2.3.4.4*).

2.3.4.1. Availability of recyclable materials

The availability and quality of recycled materials are constrained, as noted by Kol et al. (2013). Presently, recycling often results in a form of downcycling (Andersen, 2006). Simultaneously, the demand for raw materials persists due to production and disposal delays. Additionally, when products have longer lifespans, it delays the point at which the resources within them can be recycled (Andersen, 2006). Currently, only a mere 3% of discarded clothing is repurposed for recycling and upcycling into textiles—a highly intricate and challenging process. The recycling of synthetic fibers involves melting and reprocessing to maintain the same length as virgin fibers without compromising quality. Conversely, recycling and reprocessing wool or cotton garments are even more intricate, necessitating their combination with virgin fibers to achieve marketable quality (Vinatex, 2022).

2.3.4.2. Lack of high quality

Companies aspire to cultivate a sustainable brand image among consumers, but managers are reluctant to compromise the final product's quality by incorporating recycled materials (Jia et al., 2020). The inability to offer high-quality remanufactured products underscores the significance of raw materials in ensuring textiles' comfort, durability, and overall performance (Kirchherr et al., 2018). According to the Vietnam Textile and Apparel Association (VITAS), numerous domestic businesses actively engage in the circular economy, fostering sustainable development to align with export demands. However, challenges persist, particularly for small businesses that struggle to independently source recycled and eco-friendly materials (Cafef, 2023). Despite this shift, the quest for high-quality recycled materials for green development encounters ongoing difficulties (VCCI, 2023).

2.3.4.3. Complexity in material composition

The textile industry's ability to produce high-quality fabrics and textiles hinges significantly on the quality and composition of raw materials (Chen & Burns, 2006). Textile material complexity can take various forms within the industry, such as fiber blends combining fibers like cotton, polyester, or nylon. Complex finishing treatments, including waterproofing, fireproofing, or anti-wrinkle processes, involve intricate management of chemical ingredients. Additionally, the composition of dyes, pigments, and inks used for coloring textiles can be intricate, demanding precise control for desired color fastness and appearance (Claudio, 2007). The Vietnam Textile and Apparel Association (VITAS) actively innovates by modifying materials, technologies, and techniques across the production process, from spinning methods and fiber materials to textile effects, dyeing technology, garment design, and packaging. This innovation extends to the creation of new fibers made from diverse sources like rice husks, coconut shells, corn, catfish slime, crab shells, yogurt, plastic bottles, activated carbon, and carbon (Ministry of Industry and Trade of the Socialist Republic of Vietnam, 2022).

2.3.4.4. High cost of raw materials

Using recycled materials incurs higher costs than raw materials (Kazancoglu et al., 2020). The process involves substantial initial expenses to transform old goods into usable raw materials, necessitating advanced machinery and skilled workers with design and assembly capabilities. Consequently, this approach leads to higher prices than conventional clothing manufacturing methods. Vietnam presently imports approximately 80% of the fabric for exported garments, and despite commendable domestic efforts, there remains a significant reliance on imported raw materials. This dependency encompasses cotton, textile fibers, fabrics of various types, and raw materials crucial to the textile, garment, leather, and shoe industries, with a substantial portion sourced from China (VTV, 2022).

2.3.5. Rules and regulations

Existing governmental rules and regulations primarily align with a linear economy rather than the principles of a circular economy (CE). The identified barriers encompass “lack of sectorial standardization” (*2.3.5.1*), and “lack of certifications” (*2.3.5.2*)

2.3.5.1. Lack of sectorial standardization

Standardization is the act of establishing, with respect to actual or potential problems, terms for common and repeated use, with a view to achieving an optimal level of order in each setting. (ISO 2017). Lack of sectoral standardization that is requirements for waste collection and recycling do not comply with the standards. Lack of sectoral standardization can cause issues in ensuring quality and efficiency, measuring and monitoring the supply chain, and other issues. The recycling procedure involves transforming already recycled materials, such as scraps, residual textiles, and aged fabrics, into raw fabric materials. This conversion process enables the utilization of these materials to produce new products (Hart, J. *et al.* 2019). In the textile industry, especially in the recycling of materials, there needs to be a clear and orderly remanufacturing process. Compliance with the process must be based on specific regulations to avoid causing other harm. However, there are no specific regulations for each recycling route and many businesses do not comply with specific criteria for materials collection and recycling, which can lead to problems with quality assurance and materials recycling efficiency, monitoring, and measurement in the supply chain (Govindan, K. and Hasanagic, M. 2018). In Vietnam, the lack of specific regulations for circular business activities still exists. The relevant legal system needs to integrate the thinking of the THI economy to complete other relevant regulations such as laws on public investment to promote green procurement and environmentally friendly consumption; legislation on standards and regulations to assign clear responsibilities to ministries and branches in developing standards and regulations for raw materials and secondary materials; Law on protecting consumer rights aims to ensure "the right to repair and update products and extend the product life cycle" (The Manager Magazine 2022).

2.3.5.2. Lack of certifications

The certificate provides for the management and quality control of recycled materials to avoid any impact on product quality and the environment. The survey took this aspect into account due to its alignment with the European Union's action plan for the circular economy, which underscores the significance of environmental certification as a strategic tool to progress toward circularity. In this way, companies may improve their resource efficiency, develop systematic auditing, and show the transparency of their processes (Ormazabal, M. et al. 2018). To build a policy system to encourage circular economic development, promote recycling and reuse of waste, and develop renewable energy such as tax incentives, land access, and investment incentives for businesses. Enterprises apply the circular economy model in production and business by researching the granting of circular economy certification to businesses and production units to have a basis for implementing priorities, and incentives, and as a tool business marketing tool. (Toan, N.N. 2022).

2.3.6. Knowledge and awareness

The challenges posed by “lack of CE awareness” (*2.3.6.1*), “lack of theoretical information” (*2.3.6.2*), and “lack of technical know-how” (*2.3.6.3*) constitute a major obstacle in transitioning current business models or production technologies to embrace the CE.

2.3.6.1. Lack of CE awareness

Lack of circular economy awareness which is insufficient knowledge of circular economy concepts among supply chain associates business, the dearth of knowledge regarding the advantages of transitioning to the circular economy inside the company and supplier chain. The lack of knowledge of business about the principles and processes in the circular economy and supply chains, technical knowledge and management capacity of companies is a significant barrier that will change existing business models or production technologies and adopt the circular economy.(Rizos, V. *et al.* 2016). Encouragingly, a significant portion of survey participants conveyed their active involvement in recycling and repairing endeavors, particularly when equipped with a better comprehension of the principles underlying the circular economy. This enhanced comprehension included principles such as the recovery and reuse of waste materials. Furthermore, businesses acknowledged the waste management sector as a source of new business opportunities. A similar investigation involving 157 Chinese enterprises revealed that, despite a noticeable "gap" between awareness and actual practices within firms, there exists a reasonable understanding of the circular economy influenced by diverse contextual and cultural factors. (Liu, Y. and Bai, Y. 2014). The effective shift toward a circular economy necessitates collaborative endeavors, demanding the sharing and spread of knowledge and innovation across various stakeholders in the value chain. Given the restricted implementation of novel circular business models, there is a limited track record of successful frameworks that could enhance practical understanding. This lack of extensive experience induces uncertainty when introducing circular practices.(Kok, L., Wurpel, G. and Ten Wolde, A. 2013). Although Vietnam has a number of policies and programs to support and encourage businesses to apply circular economic models, sustainable business, and environmental protection, these policies and programs have not met the needs of the economic needs of businesses, especially small and medium enterprises. The level of understanding of environmental regulations regarding the circular economy model of Vietnamese businesses is still very limited (Nhân Dân,2023).

2.3.6.2. Lack of theoretical information

Lack of theoretical information about the type of materials that should be used in the products and how to produce the textile products by applying the circular economy. When applying the circular economy to the textile industry, businesses lack information about raw materials, especially fabric materials in the textile industry and how to combine and mix chemicals in recycling. Therefore, the quality of the products created cannot be guaranteed and directly affects the process of creating products. (Xue, B. *et al.* 2010; Guerra, B.C. and Leite, F. 2021).

2.3.6.3. Lack of technical know-how

The lack of technical know-how in the circular economy of the textile industry can be understood as a lack or limitation in the technical knowledge, skills, and methods required to execute a weekly business model effectively (Franco, 2017; Pasqualotto, 2015). Limited technical and technological expertise can impede Small and Medium Enterprises from transitioning their conventional business model into a circular one. (Liu, Y. and Bai, Y. 2014). Revamping conventional operations necessitates the integration of new technologies promoting sustainable production and consumption—specifically in areas like eco-design, clean production, and life cycle assessment—into existing linear business models. Accomplishing this shift also requires skilled professionals capable of managing these technologies. However, the demand for environmentally friendly technologies is frequently insufficient, and there is often a lack of technical expertise (Geng, Y. and Doberstein, B. 2008). Vietnam's textile and garment industry has used new technologies such as nanofoam, ozone, or cold annealing coils to make the industry cleaner, greener, and more economical in production. However, the problem of balancing investment costs and profits is a barrier for businesses to apply sustainable development solutions (Tạp chí Tuyên Giáo 2022).

2.3.7. Integration and collaboration

The main barrier to companies transitioning to the CE is the challenge of collaboration, given that many businesses within the supply chain are still rooted in a linear economy. In addition to this, “lack of sharing information and communication” (*2.3.7.1*), “lack of constant supplier” (*2.3.7.2*), and “lack of shared vision and willingness to collaborate” (*2.3.7.3*) pose significant challenges in the textile industry.

2.3.7.1. Lack of sharing information and communication

Sharing information plays a crucial role in facilitating a circular economy. Providing details about processed products and the activities of various stakeholders enables businesses to effectively maintain the circulation of products and materials (Jäger-Roschko, M. and Petersen, M. 2022). Vietnam is continuing to perfect the market, transforming a linear economy into a circular economy. For example, parts of rags are recycled by some businesses into new fabrics, and pants and shirt products made using part of this recycled fabric are labeled CE (which helps circulate products on the Internet, the European market, and the EFTA Free Trade Association). But this is only a small part of the domestic enterprises that are gradually forming an alliance to recycle waste and by-products. Governments and businesses need joint action for big change, mobilizing global action to enable a circular economy (Nhân Dân, 2023).

2.3.7.2. Lack of constant supplier

The challenge of insufficient support from the supply and demand network primarily arises from the dependence on the active engagement of both suppliers and customers in adopting sustainable practices. Achieving successful implementation of a circular economy requires collaboration from all parties throughout the supply chain (van Buren, N. *et al.* 2016). However, suppliers and service partners might hesitate to participate in innovative circular economy processes due to concerns about potential risks to their competitive edge or a mindset that doesn't prioritize circular economy practices (Luthra, S. *et al.* 2011). Embracing a circular business model is poised to heighten intricacies across the supply chain, encompassing logistical, financial, and legal dimensions, thereby influencing the value chain of a product, process, or service. Within this framework, governance-related matters, including ownership, distribution of costs, and benefits along the value chain, must be resolved to enable the effective implementation of circular business models. The process of navigating the transition within circular supply chains can be both time-intensive and costly, often necessitating collaboration with new entrants in the market (Trianni, A. and Cagno, E. 2012).

2.3.7.3. Lack of shared vision and willingness to collaborate

Partners in the collaboration may exhibit reluctance to fully integrate, engage, and participate in the partnership throughout the entire supply chain. This hesitancy might arise from a lack of a shared vision, apprehensions about surrendering control, or various challenges and constraints associated with promoting the sustainable development of the sector. (Calicchio Berardi, P. and Peregrino de Brito, R. 2021). Phil Brown et al. (2018) demonstrated a growing trend in collaboration, characterized by earlier and more profound engagement. This collaborative effort is constructed on relational elements that encompass normative and value-driven motivations. In the context of circular-oriented innovation, these motivations emerge from both individual and organizational levels, encompassing intrinsic and extrinsic factors. These motives find expression through the Circular Economy (CE) vision, collaborative strategies for circular-oriented innovation, and the associated technical and operational challenges (Brown, P., Bocken, N. and Balkenende, R. 2019).

2.3.8. Economic

"High investment cost" (*2.3.8.1*), "uncertainty in profitability" (*2.3.8.2*), and "failure to provide the scale of production" (*2.3.8.3*) as additional barriers in the realm of international economics. During the transition to CE, textile manufacturers face substantial investment costs associated with transforming their infrastructure and adopting new technologies.

2.3.8.1. High investment cost

As companies transition to the Circular Economy, they need to modify their infrastructure, which incurs increased investment costs due to the adoption of new technologies, certification processes, and employee training. Additionally, the expenses associated with recycled fibers used in production and the collection of waste fabrics are notably high (Huang, Y.-F. *et al.* 2021). One of the most prominent obstacles to the implementation of the circular economy has been widely mentioned in the literature: a lack of capital for investment cost. The corporation must invest a significant amount of time and resources in order to carry out tasks like production planning, inventory management, distribution planning, and management of a reverse logistics network in order to transition from a linear to a circular production/business model. (Kok, L., Wurpel, G. and Ten Wolde, A. 2013). Since they are typically more sensitive than large firms to any additional expenses resulting from green business, the amount of upfront costs, the indirect (time and human resources) costs, and the estimated payback period are especially essential. The successful adoption of a circular economy business model requires continuous assessment and improvement of the product's lifecycle. Consequently, the organization must devote a substantial number of resources to maintain the commitment of all stakeholders, including customers and staff (Rizos, V. *et al.* 2016).

2.3.8.2. Uncertainty in profitability

When transitioning to a circular economy, companies are concerned about profits and cause them to be reluctant in making investments. Profit uncertainty in the general context of the textile and garment industry refers to the inability to predict or know for certain the level of profitability that businesses within the sector can achieve. The textile and garment industry can be influenced by various factors such as fluctuations in the supply of raw materials, shifts in market demand, weather variations, transportation costs, and other elements that may impact the profitability of businesses within the sector (Dash, M., & Nalam, S. G., 2009). The uncertainty surrounding profitability and return on investment impacts companies' outlook and leads to their hesitance in making investment decisions. In Vietnam, the uncertainty in profitability within the textile and garment industry is a notable concern. This casts apprehension over businesses as the predictability and assurance of profits are no longer straightforward. Particularly, fierce competition from other countries in the region along with the shift towards circular economy models in many nations further amplifies this uncertainty. Textile and garment enterprises face the potential of a competitive price reduction from rivals with more stable material supplies or those implementing more sustainable production solutions. To minimize risks, companies need to curb new investments and focus on maintaining current operations (CafeF 2023).

2.3.8.3. Failure to provide the scale of production

Failure to provide the scale of production in the textile industry refers to the inability to achieve the desired or necessary level of production capacity or output within this sector. This shortfall can be attributed to various factors, including insufficient demand, limited resources, operational challenges, or market dynamics that hinder attaining targeted production scale goals (Majumdar et al., 2021). Particularly in the context of Vietnam, this notion highlights the formidable challenge of establishing and implementing a suitable and effective production framework within the textile sector. This challenge may stem from a variety of reasons, such as a lack of clear strategic planning, inadequate adoption of modern technologies, deficiencies in infrastructure, or difficulties in aligning production processes with the evolving trends and demands of the industry (An H., 2022, September 7). In essence, the failure to provide the required scale of production in the textile sector not only impacts individual businesses but also affects the overall growth and competitiveness of the industry within the country. On the other hand, more than 70% of enterprises in the industry are small and medium enterprises, difficult to invest in and apply new technologies (Bộ Công thương Việt Nam 2021).

2.3.9. Technical infrastructure

Amid the shift to the CE, challenges in “inadequate of infrastructure facilities” (*2.3.9.1*) and “lack of high-tech in reverse logistics” (*2.3.9.2*) have led to deficiencies in the collection and sorting of textile products and materials.

2.3.9.1. Inadequate of infrastructure facilities

Infrastructure is a crucial component of production and the development of a circular economy. Fluctuations in quality and the lack of proper infrastructure utilized during production can significantly impact an organization's outcomes in terms of product quantity, income, profit, and overall job creation within the economy (Mugo, A. N., Kahuthia, J. & Kinyua, G. 2019). The deficiencies in infrastructure within the textile industry, such as production facilities, storage and warehousing systems, transportation networks, technical facilities, and energy sources, pose challenges to sustaining production scales, fulfilling orders, and ensuring product quality (Deng, T. (2013). The circular economy emphasizes the recycling and regeneration of resources, requires not only the restructuring of current infrastructures but also the establishment of new infrastructures to facilitate these processes. Adjusting hard infrastructures is essential for the cycling of material resources, while intervening in soft infrastructures is equally vital to enable more inclusive decision-making processes that drive these resource flows. In the textile industry in Vietnam, the lack of infrastructure has given rise to notable challenges. Production facilities and workshops do not meet modern standards and lack advanced technology, affecting the potential for increased production and product quality assurance (Người Lao động 2023). The scarcity in storage and warehouse systems complicates the management of materials, products, and inventory, impacting flexibility in meeting orders and maintaining stable supply sources (VN Economy 2023). Furthermore, inadequate transportation and traffic infrastructure impede the flow of materials and products, hindering their movement from suppliers to manufacturing facilities and, subsequently, to consumer markets (The Diplomat., 2021, May 4). The deficiency in technical infrastructure poses significant challenges as well, with limited modern machinery, production equipment, and technology affecting production efficiency and timelines (VN Economy 2023). Furthermore, the shortage of stable and sustainable energy supply significantly impacts production activities and increases operational costs.

2.3.9.2. Lack of high-tech in reverse logistics

The reverse logistics of picking up excess packaging material was found to be a barrier. It took some organization, dedication, forethought, and math because the courier had to be paid in addition to offering financial advantages to the sender and recipient. This "matchmaking" intricacy created an early hurdle that persisted for a considerable amount of time. Only by working together with an online platform for surplus materials and an eager entrepreneur from different industries—both of whom were referred to as the enabler of matching values—was this barrier surmounted. Working with cardboard packaging had the benefit of standardized material, which was an obvious facilitator. Since no specialized knowledge was needed for the initiative, neither an enabler nor a barrier applied (van Keulen, M. and Kirchherr, J. 2021). The lack of robust reverse logistics is posing a significant challenge to the successful implementation of the Circular Economy (CE). This infrastructure deficiency hampers the efficient operation of reverse logistics systems and sustainability within organizations, contributing to environmental issues reduction. Furthermore, this infrastructure deficit not only disrupts the seamless integration of circular principles but also weakens the effectiveness of reverse logistics activities aimed at waste reduction and resource optimization (M., Waqas et al., 2021). Therefore, addressing this infrastructure gap becomes crucial to foster smooth integration between circular principles, sustainability, and reverse logistics operations within the business ecosystem (Vishwakarma et al., 2022c). Managing product returns and reverse logistics can be intricate and costly, especially in the textile industry. Establishing efficient reverse logistics processes, encompassing inspection, refurbishment, recycling, or responsible disposal, can mitigate the impact of returns in the supply chain and minimize waste. Inadequate transportation and storage infrastructure impede material reception and product distribution. Delays and instability in transportation lead to supply chain disruptions, negatively affecting the industry's performance and profitability (Bouzon, M., et al, 2015). For sustainable development, substantial investment in reverse logistics is imperative to ensure streamlined and effective operation (Công Thương 2022). Moreover, in Vietnam, awareness of this issue remains limited, and businesses face distinct challenges, particularly small and medium-sized enterprises. Hence, implementing reverse logistics in the Vietnamese textile industry faces many challenges and difficulties.

2.4. Methodology

The transition from the linear economy to the circular economy faces many challenges and barriers at different levels (micro, meso, and macro). The barriers may relate to the technical, economic, political, legal, social, cultural, attitudinal, and behavioral factors of the stakeholders (Khan et al. 2021). To identify and evaluate these barriers, multi-criteria decision-making (MCDM) methods are needed to consider multiple criteria and standards in a complex and uncertain context (Gonçalves and Campos 2022).

MCDM is a group of mathematical methods used to support the selection or ranking of alternatives based on multiple criteria or attributes that may be conflicting or inconsistent. MCDM can be divided into two types: multi-objective decision making (MODM) and multi-attribute decision making (MADM). MODM is used when the alternatives are continuous and generated by optimizing multiple objectives. MADM is used when the alternatives are discrete and evaluated by comparing multiple attributes (Triantaphyllou 2000).

In the field of CE, MCDM is used to measure the indicators and aspects of CE at different levels, as well as to solve problems related to CE such as product design, technology selection, supply chain management, public policy and business strategy. Gonçalves and Campos (2022) synthesized 22 MCDM techniques applied in CE, in which the analytic hierarchy process (AHP) was the most used method. AHP is a MADM method developed by Saaty (1980) to solve complex decision making problems. AHP is based on building a hierarchical structure of objectives, criteria, sub-criteria and alternatives, then using comparison matrices on a 1-9 scale to calculate the weights and consistency of criteria and alternatives.

Some studies have used AHP to assess the barriers of CE in different industries and contexts. For example, Singh et al. (2020) used AHP and graph-theoretic approach (GTA) to identify the barriers to executing the CE model within the context of the Indian mining industry. They found that the lack of awareness and knowledge, the lack of government support and regulation, and the lack of market demand and incentives were the most critical barriers. They also proposed some strategies to overcome these barriers, such as conducting training and education programs, developing policies and standards, and creating a platform for collaboration and innovation. Santos et al. (2019) identified and classified the main barriers for adopting CE practices using AHP method for prioritization. They conducted a survey with 30 experts from different sectors in Brazil and obtained 12 barriers grouped into three categories: organizational, external, and internal. They found that the lack of government incentives and regulations, the lack of consumer awareness and demand, and the lack of organizational culture and strategy were the most significant barriers. They also recommended some measures to address these barriers, such as creating public policies and incentives, raising consumer awareness and participation, and fostering organizational change and leadership. Wicaksono et al. (2018) used AHP method to identify and analyze barriers to the implementation of CE in the furniture industry and create a strategy to anticipate these barriers. They conducted a case study with a furniture company in Indonesia and identified 11 barriers grouped into four categories: economic, social, technological, and environmental. They found that the high initial investment cost, the low consumer preference for recycled products, and the lack of technology for recycling were the most influential barriers. They also developed a strategy matrix based on SWOT analysis to overcome these barriers, such as diversifying product lines, improving product quality, and adopting green technology. These studies show that AHP is a useful tool to evaluate multiple criteria and alternatives in complex decision-making problems related to CE.

2.5. Literature review summary of evaluation barriers

Our research has a total of 9 primary barriers and 24 sub-barriers that have been identified and selected by the team through research articles by many authors, depending on each research article such as geographical location, scope of study. Depending on the country, time of research, research object and research purpose, they choose different sets of barriers. Furthermore, the barriers that the group identified have been commented on, built and adjusted by experts to suit the research content of the article. Below is a summary of research articles that have studied those barriers:

Authors [Ref]	Management and decision-making (B1)			Labour (B2)		Design challenges (B3)		Materials (B4)				Rules and regulations (B5)		Knowledge and awareness (B6)			Integration and collaboration (B7)			Economic (B8)			Technical infrastructure (B9)	
	Lack of performance evaluation system	Lack of acceptance of CE models	Lack of traceability	Necessity of intensive workforce	Lack of trained intermediate staff	Lack of complementary processes	Complexity in product architecture	Availability of recyclable materials	Lack of high quality	Complexity in material composition	High cost of raw materials	Lack of sectorial standardization	Lack of certifications	Lack of CE awareness	Lack of theoretical information	Lack of technical know-how	Lack of sharing information and communication	Lack of constant supplier	Lack of shared vision and willingness to collaborate	High investment cost	Uncertainty in profitability	Failure to provide the scale of production	Insufficiency of reverse logistics infrastructure	Inadequate of transport infrastructure
Jia et al.	☑	☑		☑	☑							☑	☑							☑				
Hartley, K. et al.			☑		☑				☑		☑	☑				☑				☑		☑		
Koszewska, M.			☑					☑		☑	☑	☑		☑								☑	☑	☑
R. Rathinamoorthy		☑						☑			☑	☑			☑	☑	☑						☑	
Majumdar, A. et al.	☑				☑	☑					☑	☑		☑				☑	☑	☑			☑	☑
Garcés-Ayerbe et al.			☑	☑	☑							☑								☑				
Charef, R. et al.		☑	☑			☑	☑		☑	☑	☑	☑		☑			☑		☑					☑
Fabian Takacs et al.			☑	☑				☑	☑		☑	☑		☑	☑	☑	☑		☑	☑	☑			
Binoy Debnath et al.	☑			☑	☑			☑				☑			☑	☑			☑		☑	☑		☑

Table 2.2 Literature review summary of evaluation barriers

2.6. Research gap

Currently, the trend of environmental protection associated with socio-economic development is increasingly focused. The Textile and Garment industry also has innovations in development goals and technology to meet trends. Sustainable supply chain such as using clean raw materials, recycled materials, green production, sustainable production associated with environmental protection and social responsibility. Research articles utilizing the Analytic Hierarchy Process (AHP) method to explore circular economy applications in the textile industry are emerging globally. In Brazil, where the fashion industry serves as a significant job creator but also faces environmental challenges, a study has investigated factors influencing the adoption of circular economy practices, employing a combination of SWOT analysis and the AHP approach (Oliveira et al., 2023). Similarly, China's textile-printing industry, a vital component of its economy, grapples with environmental concerns. A study utilizing the AHP method has assessed the establishment of a cleaner production system to conserve water and minimize waste in this industry (Tong et al., 2012). Meanwhile, India focuses on recycled materials for textile and garment products, addressing challenges through a multi-criteria decision-making (MCDM) approach, providing insights into the obstacles and opportunities of circular economy practices in the Indian textile industry (Thinakaran et al., 2023).

Furthermore, several studies delve into the challenges and barriers associated with implementing circular economy practices in the textile industry across diverse countries. This complements the insights derived from the previously mentioned Indian research paper. In the Taiwanese textile industry, both government authorities and industry leaders express concerns regarding CE barriers (Huang et al., 2021). In the Netherlands, a comprehensive analysis examines the global transition to a circular economy, particularly within the textile sector. The study scrutinizes the research landscape and outlines barriers to achieving circularity (Snoek, 2017). Likewise, the textile industry in the Czech Republic, an EU member state, is the subject of a research paper identifying barriers to circularity. The study provides an overview and suggests potential policy responses for the local textile sector (Zoupalova et al., 2023).

Concluding from research articles from countries around the world, they mentioned the barriers and challenges in the circular economy of the textile industry, and moreover mentioned the AHP or MCDM research method. In fact, in Vietnam, there is no shortage of research articles on the textile and garment industry, but no one has mentioned the circular economy or the AHP - MCDM method, especially no research articles have been found talking about these. Barriers to CE or circular SC in the textile industry. Therefore, the group's research paper is a premise for the circular economy barriers of the textile and garment industry in Vietnam.

Author(s)	Title	Country	Research method
Oliveira et al., 2023	*Combining SWOT with AHP for analyzing the adoption of a circular economy in the apparel industry in Brazil*	Brazil	AHP method
Tong et al., 2012	*An AHP-based water-conservation and waste-reduction indicator system for cleaner production of textile-printing industry in China and technique integration*	China	AHP method
Thinakaran et al., 2023	*Analyzing the challenges to circular economy in Indian Fashion Industry*	India	MCDM method
Huang et al., 2021	*Exploring the decisive barriers to achieve circular economy: Strategies for the Textile Innovation in Taiwan*	Taiwan	FDM method
Snoek, 2017	*Circular Economy in the Textile Industry - Transition theory in start-ups in the textile industry*	Netherlands	Semi-structured interviews
Zoupalova et al., 2023	*Barriers to the circular economy in textile industry: a case study of the Czech Republic*	Czech Republic	Purposive sampling method

Table 2.3 GAP in Literature review

CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter provides a better understanding of the methodology in this study, plus the rationale for why it was chosen.

3.1.1. Research philosophy

The research philosophy refers to the origin, nature, and development of knowledge (Clementz et al., 2011). Philosophy involves the assumptions that guide how a phenomenon is collected, analyzed, and used. There are four main research philosophies in business and management, as follows:

Realism is the perspective that things that are known or perceived have an existence or reality that is independent of whether anyone is thinking about or perceiving them based on a personal viewpoint.

Interpretivism is the approach that considers the level of interest one has in the research. The basis of this approach is to acknowledge the differences between people.

Positivism is the paradigm that relies on statistical analysis based on quantifiable observations.

Pragmatism is the method that deals with practical problems and solutions. This is a research approach that aims to understand why issues occur and try to resolve them. In pragmatism, different types of research can be conducted at the same time.

3.1.2. Research approaches

The three main types of research approaches are inductive, deductive, and abductive.

Inductive research involves collecting data and developing a theory based on the data analysis. It uses specific observations to make general conclusions. The data collection process aims to explore a phenomenon, identify themes and patterns, and create a conceptual framework. The theory development process is theory generation and building (Saunder et al., 2010).

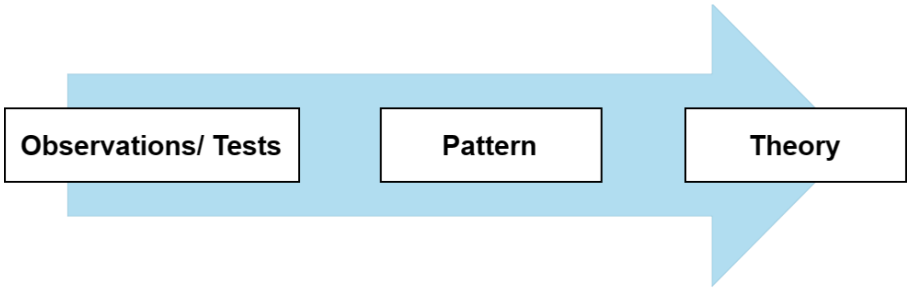

Figure 3.1 Inductive process in research approach

Deductive research involves generalizing from the general to the specific. It starts with a theory and leads to a new hypothesis. It then tests the hypothesis with data and narrows down the results. It uses facts, laws, descriptions, or objects to draw logical conclusions. In deductive reasoning, if the premises are true, the conclusion must also be true. The data collection process aims to evaluate propositions or hypotheses related to an existing theory (Saunder et al., 2010).

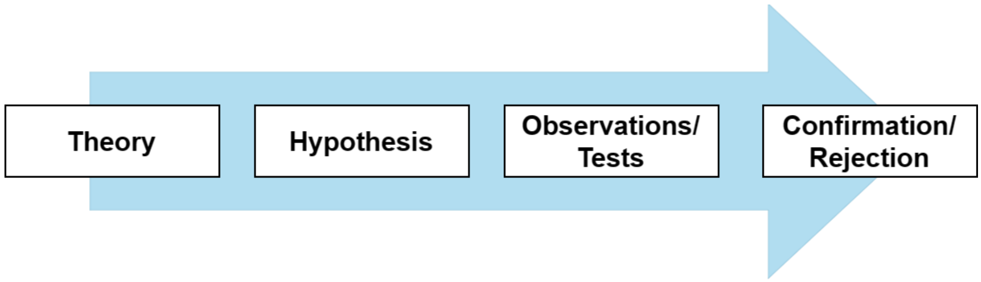

Figure 3.2 Deductive process in research approach

Abductive research involves combining inductive and deductive reasoning. It uses known premises to generate testable conclusions that are influenced by both specific and general interactions. The data collection process aims to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework, and test this through data collection. The theory development process is theory generation or modification, incorporating existing theory where appropriate to build a new theory or modify the existing theory (Saunder et al., 2010).

3.1.3. Research methods

Data collection can be divided into two main types: qualitative and quantitative. The difference between these types of data depends on whether they are numerical (numbers) or non-numerical (words).

Quantitative research is characterized by the results presented in the form of numbers. This kind of study involves comparing and evaluating general criteria.

Qualitative research is expressed in the form of words, such as expert opinions. It is used to understand and interpret phenomena. This type of research allows for gathering deep insights on topics that are not well known.

This research used both quantitative and qualitative data to enhance the strengths and overcome the limitations of each type of data.

3.2. Proposed Method

3.2.1. Methods related to multi-criteria decision-making problem

Supplier selection in supply chain management is basically a multi-criteria decision-making (MCDM) problem. There are two main types of MCDM research: multi-objective decision-making (MODM) and multi-attribute decision-making (MADM). MODM deals with problems that have continuous decision spaces, with many possible alternatives. MADM is suitable for problems that have discrete decision spaces, with predefined options; and is often used to choose the best set of decision options from a limited list of available options (*Table 3.1*).

Method	Describe	Advantages	Disadvantages
AHP	Pairwise comparisons between alternatives with different criteria and estimate the weights of the criteria.	• It is easy to use and scale up. • It is flexible, intuitive and consistent. • The problem is structured into a hierarchy, the importance of each factor is clear, and it can be adjusted to fit different problem sizes.	There are no rules for ranking, which can lead to conflicts between judgments and criteria arrangements.
ELECTRE	It is used to choose the best solution that has the most benefits and the least conflict with the functionality of other criteria.	It uses a ranking order of preference.	It is time-consuming.
TOPSIS	It is used to find an alternative that is the closest to the ideal solution and the farthest from the negative	• It has a simple process. • It is easy to use and	• It does not consider the correlation between attributes when using a distance

	solution in a multidimensional mathematical space.	program. • It has the same number of steps regardless of the number of attributes.	matrix. • It is difficult to measure and maintain the consistency of the plan.
PROMETHEE		• It is easy to use; it does not require the criteria to be compatible with each other.	• It does not have a clear method for assigning weights.
Grey Theory	• It can deal with all situations of incomplete data and overcome the limitations of other methods.	• It has a unique solution when the information is perfect.	• It does not provide the best solutions.

Table 3.1 Summary of methods used in the MADM problem

Table 3.1 shows the advantages and disadvantages of different decision-making methods. The AHP method is one of the techniques that can help solve problems with conflicting and diverse criteria. Many studies have used AHP to solve problems in various aspects, such as: supplier selection for a Polyamide fiber factory, a pharmaceutical factory in Ghana, a steel factory and for small-scale, medium-scale and large-scale industries. Therefore, AHP was chosen to support decision-making in assessing the barriers to circular supply chain sustainability in the textile and garment industry in Vietnam.

3.2.2. AHP method

Triantaphyllou and Mann stated that the AHP method has attractive mathematical properties that have drawn the attention of many researchers and that the input data for AHP are easy to obtain. The Analytical Hierarchy Process (AHP) is a method that was developed within the Multi-Criteria Decision Making (MCDM) framework, which includes primary and secondary barrier criteria. The AHP method was proposed by Saaty in the 1980s. It is a ranking process that is used for decision-making and that has been widely applied in various fields, such as business, economics, government, industry, education, health, and others. The method focuses on prioritizing the selection criteria and distinguishing the more important criteria from the less important ones. Moreover, the AHP method uses judgment to analyze the data. This paper discusses four main steps of AHP that can be used in decision-making problems, which are: problem modeling, weight valuation, weight aggregation, and sensitivity analysis. The steps begin with hierarchy construction, where the objective is highlighted and the criteria and alternatives are identified. Then, the criteria and alternatives are compared and their relative rankings are calculated.

To determine the priorities on each level of the hierarchy, a pairwise comparison matrix is used, which compares the relative importance of each pair of elements using the scale shown in *Table 3.2*.

Intensity of importance	**Definition**
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate values

Table 3.2 Scale of Relative Importance

The following steps describe how to apply AHP to a decision problem.

Step 1: Identify the main goal, criteria, and alternatives of the decision, and construct a hierarchical tree as shown in Figure 2 below. This step involves the following tasks:

• Define the main goal of the decision, which is the desired outcome or objective that you want to achieve. For example, the main goal could be to select the best supplier, the best investment option, or the best location for a new branch.

• Identify the criteria that are relevant and important for evaluating the alternatives and achieving the goal. The criteria should reflect the different aspects or dimensions of the decision problem, such as cost, quality, risk, or sustainability.

• Construct a hierarchical tree that represents the structure of the decision problem. The hierarchical tree consists of three levels: the goal at the top, the criteria and sub-criteria at the middle, and the alternatives at the bottom.

Step 2: Create pairwise comparison matrices. In these matrices, the criteria and sub-criteria are rated by experts according to their importance. The matrix has (k) rows and (k) columns, where (k) is the number of criteria or sub-criteria. The element (a_{ij}) represents the relative importance of the index (i) in the row compared to the index j in the column.

$$A = (a_{ij})_{k\times k} \begin{bmatrix} 1 & a_{12} & \dots & a_{1k} \\ a_{21} & 1 & \dots & a_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ a_{k1} & a_{k2} & \dots & 1 \end{bmatrix} \quad (1)$$

Step 3: Develop normalized matrices.

Divide each of the numbers in a column of the comparison matrix by its column sum. This will result in a normalized matrix, where the numbers in each column add up to one.

$$C_{ij} = \frac{A_{ij}}{\sum_{i=1}^{n} A_{ij}} \begin{bmatrix} C_{11} & C_{12} & \dots & C_{1n} \\ C_{21} & C_{22} & \dots & C_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ C_{n1} & C_{n2} & \dots & C_{nn} \end{bmatrix} \quad (2)$$

For all j = 1, 2, …, n.

Step 4: Develop a priority vector. The priority vector (f) is determined by averaging the row entries in the normalized matrix.

$$W_{ij} = \frac{\sum_{j=1}^{n} C_{ij}}{n} \begin{bmatrix} W_{11} \\ W_{21} \\ \vdots \\ W_{n1} \end{bmatrix} \quad (3)$$

For all i = 1, 2, …,

Step 5: Calculate consistency ratio. In this step, the relevant priorities are provided by the priority vector (f) matching to the largest eigenvector (λ_{max}).

$$A \times f = \lambda_{max} \times f \quad (4)$$

λ_{max} is the largest eigenvalue of the comparison matrix in the AHP method. It is used to calculate the consistency index and the consistency ratio, which measure how consistent the pairwise comparisons are.

λ_{max} can be obtained by finding the eigenvector that satisfies the equation

$$A \times W = \lambda_{max} \times W \quad (5)$$

where *A* is the comparison matrix and *W* is the priority vector.

The consistency index (CI) is determined by the ratio of the largest eigenvector (λ_{max}) and the number of criteria (n).

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (6)$$

The consistency ratio is a metric that indicates the consistency between pairwise comparisons. The consistency ratio (CR) is obtained by dividing the consistency index (CI) and the random index (RI), i.e., as shown in *Table 3.2*.

$$CR = \frac{CI}{RI} \quad (7)$$

Matrix size	Random Consistency Index (RI)
1	0.00

2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Table 3.3 The Values of Random Index (RI)

If *CR* is less than or equal to 0.1, the results are acceptable. Otherwise, the pairwise comparison matrix needs to be revised.

Step 6: Calculate the overall weight of the objective function is the weighted sum of the weights of the alternatives with respect to each criterion. It represents the final score or ranking of each alternative for the decision problem.

$$Function\ 1 = F_{11} \times W_1 + F_{12} \times W_2 + \cdots + F_{1u} \times W_u \quad (8)$$

$$Function\ v = F_{v1} \times W_1 + F_{v2} \times W_2 + \cdots + F_{vu} \times W_u$$

where W_u is the overall weight of the *v-th* alternative, W_u is the weight of the *u-th* criterion, and F_{vu} is the weight of the *v-th* alternative with respect to the *u-th* criterion.

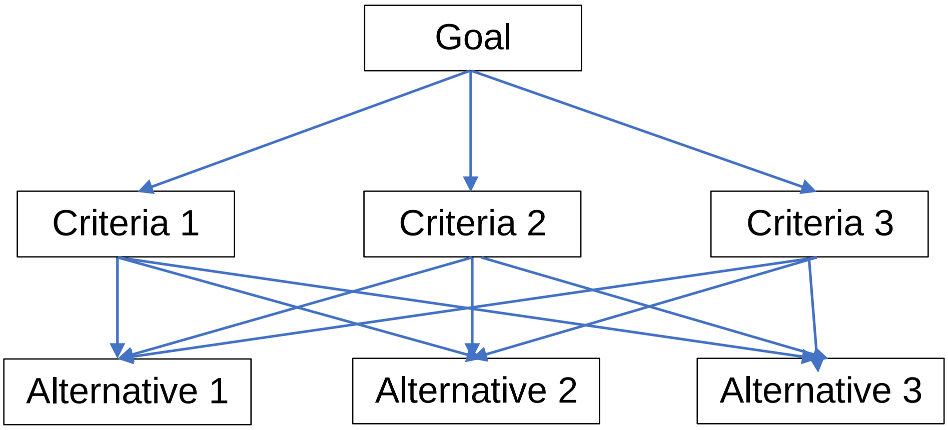

Figure 3.3 A structure of the hierarchical tree

CHAPTER 4: EMPIRICAL CASE ANALYST

4.1. Case study

AHP, which Satty first introduced, is utilized to do the comparison within barriers and find their importance weights (*Figure 4.2*). The reason for selecting AHP is that AHP helps to do the weight-wise comparison of criteria and rank them accordingly (Jain et al., 2015; Yadav & Desai, 2017). That increases the strength of the methodology against the uncertainties. Therefore, the AHP model is deployed to the CSC barriers for textile companies to implement the CE, such as Management and Decision-making, Labour, Design challenges, Material, Rules and regulations, Knowledge and awareness, Integration and collaboration, Economic, Technical infrastructure are proposed, thereby offering some solutions to overcome the most critical barriers to transit into the circular economy in the textile industry.

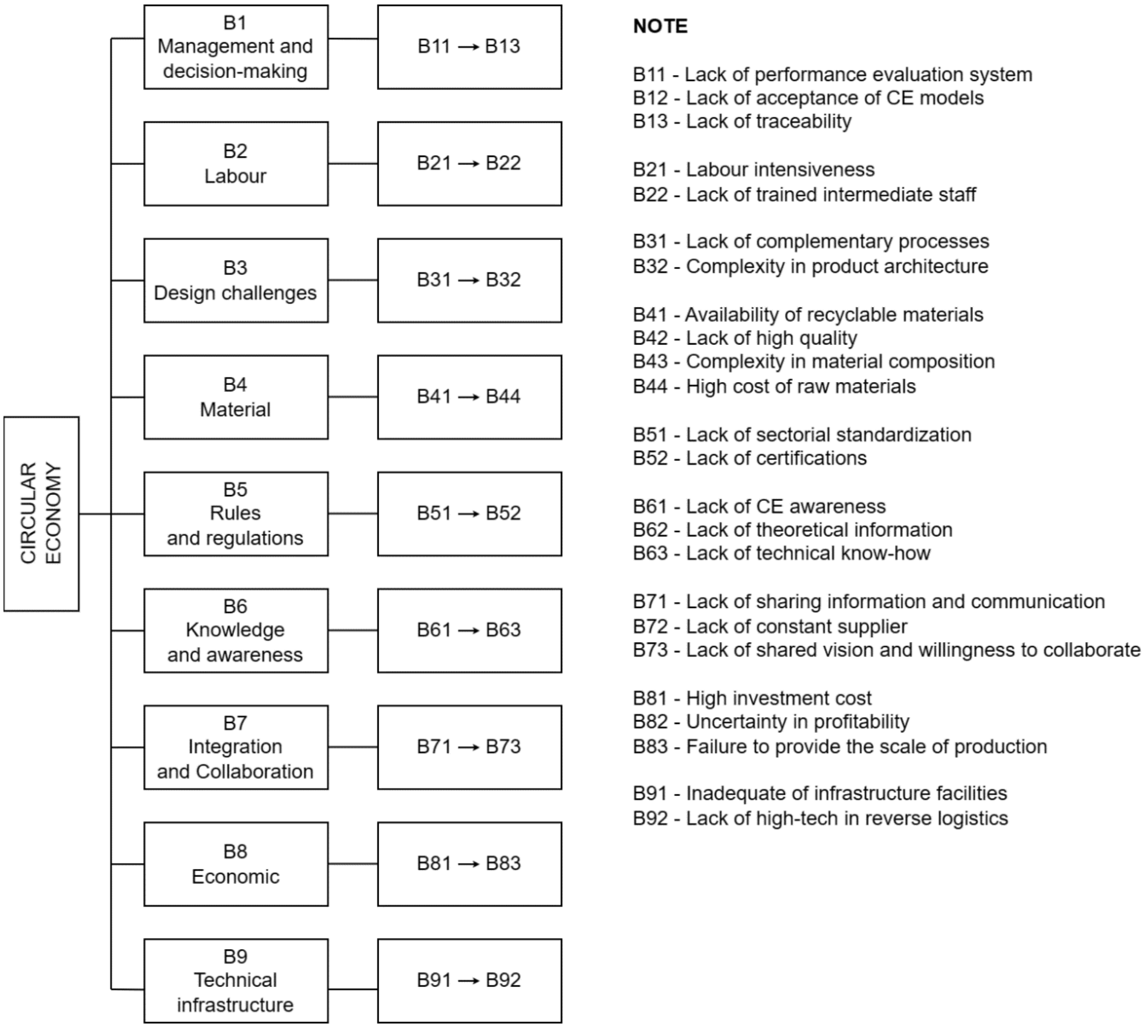

Figure 4.1 The hierarchical structure of the CSC barriers set

In this study, the interview technique was employed to collect data. Experts in the textile sector in Vietnam were interviewed. The reason for using this data collection method is because CSC in the textile industry is a new research field that requires interviewees to have in-depth knowledge of the circular economy and long-term experience in the textile industry. Furthermore, CSC has only just begun to be implemented in Vietnam's textile sector. For detailed analysis, we have considered seven experts to decide relative weights to different barriers. These industry experts have more than six years of experience. We had various meetings with experts to decide with consensus. In case of any difference of opinion, the majority decision was accepted. Results are analyzed below. Six experts have been working in the companies directly in the supply chain, such as retailers, yarn and fabric manufacturers, raw material suppliers, and garment manufacturers. They have worked in different sustainability-related positions, such as sustainable development manager, production and quality manager, and general director. Another expert has been working in the governmental and policymaker agencies. They were included in the research to understand the perspectives of governmental and non-profit organizations regarding sustainability and circularity in the textile industry.

Among the seven experts, most of them graduated from the Faculty of Business and Faculty of Engineering, and a few of them also earned PhD and MBA degrees. The details can be seen in Table 4.1. These experts have been included in the research because of their experiences and long working years in the field, that is, between 8 and 20 years. After collecting data, the steps of the AHP method explained above were applied to data analysis.

Expert	Highest educational qualification obtained	Position in the supply chain	Expert's position	Number of years of work experience	Gender
E1	B.Sc	Garment manufacturer	Quality & sustainable development manager	10	Female
E2	MBA	Garment manufacturer	Garment Technology - Account Manager	10	Female
E3	M. Sc	Garment manufacturer	Procurement manager	8	Male
E4	B.Sc	Yarn, Fabric, Garment Manufacturer	Production & quality manager	9	Female
E5	MBA	Retailer Yarn, Fabric Manufacturer	General Director	15	Male
E6	PhD	Governmental and Policy Maker	Researcher on corporate governance and policy consultant in Vietnam.	20	Male
E7	B.Sc	Raw Material Supplier	Sustainable Development Manager	10	Male

Table 4.1 Information about industrial experts

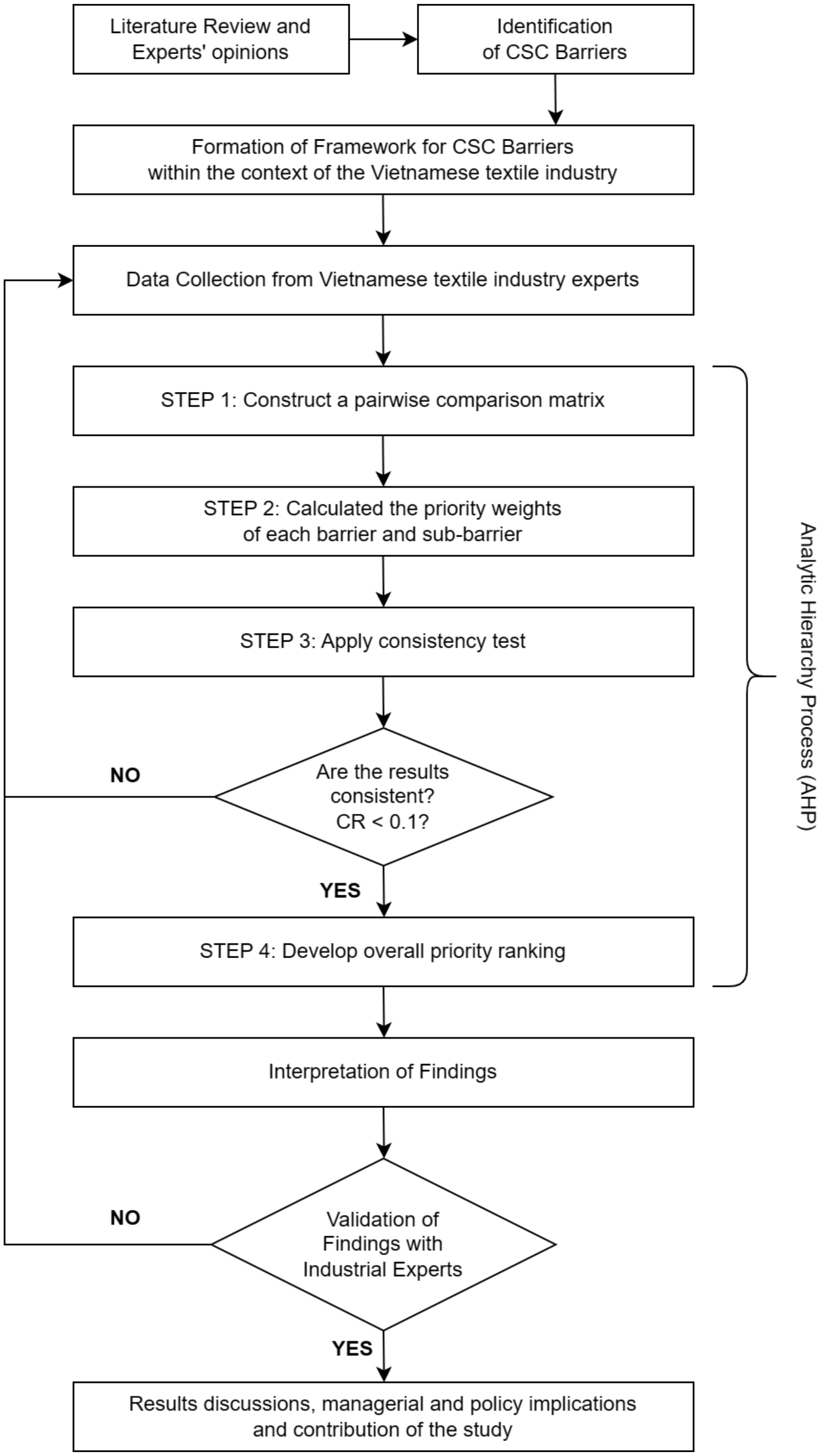

Figure 4.2 Flowchart of proposed AHP method

4.3. Results AHP

4.2.1. Main Barriers

A step-by-step standard approach of AHP (Saaty, 1987) is applied in this section to prioritize sub-barriers in each category. In the Analytical Hierarchy Process (AHP) method, the questionnaire is used for the survey, and the expert's judgment will influence the decision-making process. The survey asked respondents to assess the impact of predetermined attributes based on their judgment and experience. Invite them to add new attributes if necessary. Therefore, designing a questionnaire suitable for the research problem is very important. The questionnaire is sent to ten experts with deep textile industry experience as a first step. Regarding the purpose of the study, the significance of the barriers, sub-barriers, and the survey structure is explained in depth, and the information of the experts (gender, age, working experience, positions in the company, and education level).

Data was collected via the questionnaire based on a nine-point scale (Saaty, 1987). If the rating is assigned 1, it signifies equal importance of both factors; if assigned 9, it indicates absolute importance over the other factor. This calculation is a relative scaling, i.e., the factors are ranked or rated relatively or based on relative importance. After this, a pairwise comparison of different categories of barriers was done. Table 4.2 shows Pairwise judgment matrices of main barriers by Expert 1 – Expert 7. Table 4.3 shows the Initial Comparison Matrices' main barriers. Table 4.4 shows the final pairwise judgment matrix of main barriers based on averaging the judgments of 7 experts. After that, the pairwise comparison matrix (Table 4.4) is normalized by formula (2), in which each element in the matrix is divided by its column total to generate a normalized pairwise matrix, as shown in Table 4.5. The weights are computed by equation (3), in which the sum of the normalized row of the matrix is divided by the number of barriers used (n=9) to generate a weighted matrix in Table 4.6. The consistency ratio (CR) of the matrix of all matrices was also checked. It is acceptable if the CR value is lower than or equal to 0.1. On the contrary, if CR value is greater than 0.1 we need to request the expert's revised judgment.

Pair-wise comparison matrix by Expert #1									
Main Barriers	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**
B1	**1**	1	6	1/2	1/2	1/3	4	1/4	3
B2	1	**1**	5	1/2	1/3	1/3	4	1/5	1
B3	1/6	1/5	**1**	1/5	1/6	1/7	1/3	1/8	1/3
B4	2	2	5	**1**	1/2	1/3	2	1/4	3
B5	2	3	6	2	**1**	1	3	1/2	4
B6	3	3	7	3	1	**1**	3	1/2	3
B7	1/4	1/4	3	1/2	1/3	1/3	**1**	1/6	1/2
B8	4	5	8	4	2	2	6	**1**	4
B9	1/3	1	3	1/3	1/4	1/3	2	1/4	**1**
Total	**13.750**	**16.450**	**44.000**	**12.033**	**6.083**	**5.810**	**25.333**	**3.242**	**19.833**

Pair-wise comparison matrix by Expert #2									
Main Barriers	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**
B1	**1**	2	7	1	1/3	1/4	4	1/5	2
B2	1/2	**1**	5	1/3	1/2	1/4	3	1/6	2
B3	1/7	1/5	**1**	1/6	1/6	1/5	1/4	1/7	1/3
B4	1	3	6	**1**	1/2	1/4	3	1/4	4
B5	3	2	6	2	**1**	1	5	1	5
B6	4	4	5	4	1	**1**	5	1/2	4
B7	1/4	1/3	4	1/3	1/5	1/5	**1**	1/6	2
B8	5	6	7	4	1	2	6	**1**	5
B9	1/2	1/2	3	1/4	1/5	1/4	1/2	1/5	**1**
Total	**15.393**	**19.033**	**44.000**	**13.083**	**4.900**	**5.400**	**27.750**	**3.626**	**25.333**

Pair-wise comparison matrix by Expert #3									
Main Barriers	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**
B1	**1**	1/2	8	1/3	1/4	1/3	3	1/4	1
B2	2	**1**	4	1	1/3	1/5	3	1/4	1/2
B3	1/8	1/4	**1**	1/5	1/6	1/8	1/3	1/9	1/4
B4	3	1	5	**1**	1/3	1/4	3	1/3	2
B5	4	3	6	3	**1**	1	5	1/3	3
B6	3	5	8	4	1	**1**	5	1	2
B7	1/3	1/3	3	1/3	1/5	1/5	**1**	1/7	2
B8	4	4	9	3	3	1	7	**1**	5
B9	1	2	4	1/2	1/3	1/2	1/2	1/5	**1**
Total	**18.458**	**17.083**	**48.000**	**13.367**	**6.617**	**4.608**	**27.833**	**3.621**	**16.750**

Pair-wise comparison matrix by Expert #4									
Main Barriers	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**
B1	**1**	2	7	1	1/2	1/5	4	1/4	2

B2	1/2	**1**	5	1/2	1/5	1/4	3	1/5	3
B3	1/7	1/5	**1**	1/3	1/5	1/7	1/2	1/8	1/3
B4	1	2	3	**1**	1/4	1/2	3	1/5	4
B5	2	5	5	4	**1**	1/2	4	1	5
B6	5	4	7	2	2	**1**	4	1/3	4
B7	1/4	1/3	2	1/3	1/4	1/4	**1**	1/6	1/2
B8	4	5	8	5	1	3	6	**1**	5
B9	1/2	1/3	3	1/4	1/5	1/4	2	1/5	**1**
Total	**14.393**	**19.867**	**41.000**	**14.417**	**5.600**	**6.093**	**27.500**	**3.475**	**24.833**

Pair-wise comparison matrix by Expert #5

Main Barriers	B1	B2	B3	B4	B5	B6	B7	B8	B9
B1	**1**	1	6	1	1	1/3	4	1/4	1
B2	1	**1**	5	1/3	1/3	1/3	3	1/6	2
B3	1/6	1/5	**1**	1/5	1/6	1/8	1/2	1/8	1/4
B4	1	3	5	**1**	1/2	1/2	3	1/4	4
B5	1	3	6	2	**1**	1	6	1	5
B6	3	3	8	2	1	**1**	5	1/3	4
B7	1/4	1/3	2	1/3	1/6	1/5	**1**	1/7	2
B8	4	6	8	4	1	3	7	**1**	5
B9	1	1/2	4	1/4	1/5	1/4	1/2	1/5	**1**
Total	**12.417**	**18.033**	**45.000**	**11.117**	**5.367**	**6.742**	**30.000**	**3.468**	**24.250**

Pair-wise comparison matrix by Expert #6

Main Barriers	B1	B2	B3	B4	B5	B6	B7	B8	B9
B1	**1**	1/2	5	2	1/2	1/3	4	1/4	2
B2	2	**1**	5	1/2	1/2	1/3	3	1/5	1
B3	1/5	1/5	**1**	1/6	1/7	1/7	1/3	1/6	1/3
B4	1/2	2	6	**1**	1	1/3	3	1/5	2
B5	2	2	7	1	**1**	1	5	1/2	3
B6	3	3	7	3	1	**1**	6	1/2	2
B7	1/4	1/3	3	1/3	1/5	1/6	**1**	1/6	1/2
B8	4	5	6	5	2	2	6	**1**	5
B9	1/2	1	3	1/2	1/3	1/2	2	1/5	**1**
Total	**13.450**	**15.033**	**43.000**	**13.500**	**6.676**	**5.810**	**30.333**	**3.183**	**16.833**

Pair-wise comparison matrix by Expert #7

Main Barriers	B1	B2	B3	B4	B5	B6	B7	B8	B9
B1	**1**	2	7	1/2	1/4	1/2	4	1/4	2
B2	1/2	**1**	5	1/2	1/3	1/2	3	1/4	3
B3	1/7	1/5	**1**	1/4	1/6	1/7	1/5	1/8	1/3
B4	2	2	4	**1**	1/2	1/3	3	1/4	3

B5	4	3	6	2	**1**	1	4	1/2	4
B6	2	2	7	3	1	**1**	5	1	4
B7	1/4	1/3	5	1/3	1/4	1/5	**1**	1/5	1
B8	4	4	8	4	2	1	5	**1**	4
B9	1/2	1/3	3	1/3	1/4	1/4	1	1/4	**1**
Total	**14.393**	**14.867**	**46.000**	**11.917**	**5.750**	**4.926**	**26.200**	**3.825**	**22.333**

Table 4.2 Pairwise judgment matrices of main barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									**Right Barrier Is Greater**									**Number of Experts**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	Extremely important		***Very strong important***		***Strongly important***		***Slightly important***		***Equal***		***Slightly important***		***Strongly important***		***Very strong important***		***Extremely important***		
B1								**3**	**2**	**2**								**B2**	**7**
B1		**1**	**3**	**2**	**1**													**B3**	**7**
B1								**1**	**3**	**2**	**1**							**B4**	**7**
B1									**1**	**3**	**1**	**2**						**B5**	**7**
B1										**1**	**4**	**1**	**1**					**B6**	**7**
B1						**6**	**1**											**B7**	**7**
B1												**6**	**1**					**B8**	**7**
B1							**1**	**4**	**2**									**B9**	**7**
B2					**6**	**1**												**B3**	**7**
B2									**1**	**4**	**2**							**B4**	**7**
B2										**2**	**5**		**1**					**B5**	**7**
B2										**1**	**3**	**2**	**1**					**B6**	**7**
B2						**1**	**6**											**B7**	**7**
B2												**2**	**3**	**2**				**B8**	**7**
B2							**2**	**2**	**2**	**1**								**B9**	**7**
B3											**1**	**1**	**3**	**2**				**B4**	**7**
B3													**1**	**5**	**1**			**B5**	**7**
B3													**1**		**4**	**2**		**B6**	**7**
B3										**2**	**3**	**1**	**1**					**B7**	**7**
B3														**1**	**1**	**4**	**1**	**B8**	**7**
B3											**5**	**2**						**B9**	**7**
B4									**1**	**4**	**1**	**1**						**B5**	**7**
B4										**2**	**3**	**2**						**B6**	**7**
B4							**6**	**1**										**B7**	**7**
B4											**1**	**4**	**2**					**B8**	**7**
B4						**3**	**2**	**2**										**B9**	**7**
B5									**6**	**1**								**B6**	**7**
B5				**1**	**3**	**2**	**1**											**B7**	**7**
B5									**3**	**3**	**1**							**B8**	**7**
B5					**3**	**2**	**2**											**B9**	**7**
B6					**6**	**1**	**1**											**B7**	**7**
B6									**2**	**3**	**2**							**B8**	**7**
B6						**4**	**1**	**2**										**B9**	**7**
B7													**1**	**4**	**2**			**B8**	**7**
B7								**3**	**1**	**3**								**B9**	**7**
B8					**5**	**2**												**B9**	**7**

Table 4.3 Initial Comparison Matrices of Main barriers

Main Barriers	B1	B2	B3	B4	B5	B6	B7	B8	B9
B1	**1**	1.286	6.571	0.905	0.476	0.326	3.857	0.243	1.857
B2	0.778	**1**	4.857	0.524	0.362	0.314	3.143	0.205	1.786
B3	0.152	0.206	**1**	0.217	0.168	0.146	0.350	0.132	0.310
B4	1.105	1.909	4.615	**1**	0.512	0.357	2.857	0.248	3.143
B5	2.100	2.763	5.951	1.953	**1**	0.929	4.571	0.690	4.143
B6	3.066	3.182	6.853	2.800	1.077	**1**	4.714	0.595	3.286
B7	0.259	0.318	2.857	0.350	0.219	0.212	**1**	0.165	1.214
B8	4.118	4.884	7.603	4.038	1.448	1.680	6.074	**1**	4.714
B9	0.538	0.560	3.231	0.318	0.241	0.304	0.824	0.212	**1**
Total	**13.116**	**16.108**	**43.540**	**12.105**	**5.503**	**5.269**	**27.391**	**3.489**	**21.452**

Table 4.4 Pairwise judgment matrix of Main barriers

Normalized	B1	B2	B3	B4	B5	B6	B7	B8	B9
B1	0.076	0.080	0.151	0.075	0.087	0.062	0.141	0.070	0.087
B2	0.059	0.062	0.112	0.043	0.066	0.060	0.115	0.059	0.083
B3	0.012	0.013	0.023	0.018	0.031	0.028	0.013	0.038	0.014
B4	0.084	0.119	0.106	0.083	0.093	0.068	0.104	0.071	0.147
B5	0.160	0.172	0.137	0.161	0.182	0.176	0.167	0.198	0.193
B6	0.234	0.198	0.157	0.231	0.196	0.190	0.172	0.171	0.153
B7	0.020	0.020	0.066	0.029	0.040	0.040	0.037	0.047	0.057
B8	0.314	0.303	0.175	0.334	0.263	0.319	0.222	0.287	0.220
B9	0.041	0.035	0.074	0.026	0.044	0.058	0.030	0.061	0.047
Total	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Table 4.5 Normalized Pair-wise matrix of Main barriers

	Weights	Ranking
B1. Management and decision-making	0.0919	**5**
B2. Labour	0.0731	**6**
B3. Design challenges	0.0209	**9**
B4. Material	0.0971	**4**
B5. Rules and Regulations	0.1717	**3**
B6. Knowledge and awareness	0.1890	**2**
B7. Integration and Collaboration	0.0394	**8**
B8. Economic	0.2706	**1**
B9. Technical infrastructure	0.0462	**7**
Consistency Ratio (CR) = 0.0283		

Table 4.6 Pairwise comparisons of main barriers

The weight vector can be derived from the information presented in *Table 4.2* and *Table 4.4* above:

$$\begin{bmatrix} 1 & 1.286 & 6.571 & 0.905 & 0.476 & 0.326 & 3.857 & 0.243 & 1.857 \\ 0.778 & 1 & 4.857 & 0.524 & 0.362 & 0.314 & 3.143 & 0.205 & 1.786 \\ 0.152 & 0.206 & 1 & 0.217 & 0.168 & 0.146 & 0.350 & 0.132 & 0.310 \\ 1.105 & 1.909 & 4.615 & 1 & 0.512 & 0.357 & 2.857 & 0.248 & 3.143 \\ 2.100 & 2.763 & 5.951 & 1.953 & 1 & 0.929 & 4.571 & 0.690 & 4.143 \\ 3.066 & 3.182 & 6.853 & 2.800 & 1.077 & 1 & 4.714 & 0.595 & 3.286 \\ 0.259 & 0.318 & 2.857 & 0.350 & 0.219 & 0.212 & 1 & 0.165 & 1.214 \\ 4.118 & 4.884 & 7.603 & 4.038 & 1.448 & 1.680 & 6.074 & 1 & 4.714 \\ 0.538 & 0.560 & 3.231 & 0.318 & 0.241 & 0.304 & 0.824 & 0.212 & 1 \end{bmatrix} \text{x} \begin{bmatrix} 0.092 \\ 0.073 \\ 0.021 \\ 0.097 \\ 0.172 \\ 0.189 \\ 0.039 \\ 0.271 \\ 0.046 \end{bmatrix} = \begin{bmatrix} 0.858 \\ 0.680 \\ 0.191 \\ 0.915 \\ 1.615 \\ 1.802 \\ 0.359 \\ 2.581 \\ 0.424 \end{bmatrix}$$

$$\begin{bmatrix} 0.858 \\ 0.680 \\ 0.191 \\ 0.915 \\ 1.615 \\ 1.802 \\ 0.359 \\ 2.581 \\ 0.424 \end{bmatrix} / \begin{bmatrix} 0.092 \\ 0.073 \\ 0.021 \\ 0.097 \\ 0.172 \\ 0.189 \\ 0.039 \\ 0.271 \\ 0.046 \end{bmatrix} = \begin{bmatrix} 9.337 \\ 9.301 \\ 9.131 \\ 9.422 \\ 9.403 \\ 9.533 \\ 9.106 \\ 9.536 \\ 9.185 \end{bmatrix}$$

As the number of barriers is 9, we take n = 9, λ_{max}, and the *CI* value is calculated as follows:

$$\lambda_{max} = \frac{9.337+9.301+9.131+9.422+9.403+9.533+9.106+9.536+9.185}{9} = 9.3281$$

$$CI = \frac{\lambda_{max} - n}{n-1} = \frac{9.3281-9}{9-1} = 0.0410$$

Based on Table 3.3 , with $n = 9$ we have an $RI = 1.45$

$CR = CI/RI = 0.0410/1.45 = 0.0283 < 0.1$

With a consistency ratio (*CR*) of 0.0283, which is less than or equal to 0.1, the data comparing the primary pairs of barriers is appropriate and guarantees consistency. Therefore, this data remains valid for calculations and does not require re-evaluation.

4.2.2. Sub criteria

Similar steps are followed for the evaluation of sub-barriers

- **Management and decision-making (B1)** sub-barriers

Pair-wise comparison matrix by Expert #1			
	B11	**B12**	**B13**
B11. Lack of performance evaluation system	**1**	1/2	3
B12. Lack of acceptance of CE models	2	**1**	4
B13. Lack of traceability	1/3	1/4	**1**
Total	**3.333**	**1.750**	**8.000**

Pair-wise comparison matrix by Expert #2			
	B11	**B12**	**B13**
B11. Lack of performance evaluation system	**1**	1/4	2
B12. Lack of acceptance of CE models	4	**1**	3
B13. Lack of traceability	1/2	1/3	**1**
Total	**5.500**	**1.583**	**6.000**

Pair-wise comparison matrix by Expert #3			
	B11	**B12**	**B13**
B11. Lack of performance evaluation system	**1**	1	3
B12. Lack of acceptance of CE models	1	**1**	5
B13. Lack of traceability	1/3	1/5	**1**
Total	**2.333**	**2.200**	**9.000**

Pair-wise comparison matrix by Expert #4			
	B11	**B12**	**B13**
B11. Lack of performance evaluation system	**1**	1/2	4
B12. Lack of acceptance of CE models	2	**1**	5
B13. Lack of traceability	1/4	1/5	**1**

Total	**3.250**	**1.700**	**10.000**

Pair-wise comparison matrix by Expert #5			
	B11	**B12**	**B13**
B11. Lack of performance evaluation system	**1**	1/2	2
B12. Lack of acceptance of CE models	2	**1**	4
B13. Lack of traceability	1/2	1/4	**1**
Total	**3.500**	**1.750**	**7.000**

Pair-wise comparison matrix by Expert #6			
	B11	**B12**	**B13**
B11. Lack of performance evaluation system	**1**	1/3	3
B12. Lack of acceptance of CE models	3	**1**	5
B13. Lack of traceability	1/3	1/5	**1**
Total	**4.333**	**1.533**	**9.000**

Pair-wise comparison matrix by Expert #7			
	B11	**B12**	**B13**
B11. Lack of performance evaluation system	**1**	1/2	2
B12. Lack of acceptance of CE models	2	**1**	4
B13. Lack of traceability	1/2	1/4	**1**
Total	**3.500**	**1.750**	**7.000**

Table 4.7 Pairwise judgment matrices of B1 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									**Right Barrier Is Greater**									**Number of Experts**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	Extremely important		***Very strong important***		***Strongly important***		***Slightly important***		***Equal***		***Slightly important***		***Strongly important***		***Very strong important***		***Extremely important***		
B11									**1**	**4**	**1**	**1**						**B12**	**7**
B11						**1**	**3**	**3**										**B13**	**7**
B12					**3**	**3**	**1**											**B13**	**7**

Table 4.8 Initial Comparison Matrices of B1 sub-barriers

Management and decision-making	B11	B12	B13
B11. Lack of performance evaluation system	**1**	0.512	2.714
B12. Lack of acceptance of CE models	1.953	**1**	4.286
B13. Lack of traceability	0.368	0.233	**1**
Total	**3.322**	**1.745**	**8.000**

Table 4.9 Pairwise judgment matrix of B1 sub-barriers

Normalized	B11	B12	B13
B11. Lack of performance evaluation system	0.301	0.293	0.339
B12. Lack of acceptance of CE models	0.588	0.573	0.536
B13. Lack of traceability	0.111	0.134	0.125
Total	**1**	**1**	**1**

Table 4.10 Normalized Pair-wise matrix of B1 sub-barriers

	Weights	Ranking
B11. Lack of performance evaluation system	0.311	**2**
B12. Lack of acceptance of CE models	0.566	**1**
B13. Lack of traceability	0.123	**3**
CR = 0.0043		

Table 4.11 Pairwise comparisons of B1 sub-barriers

- **Labour (B2)** sub-barriers

Pair-wise comparison matrix by Expert #1		
	B21	**B22**
B21. Labour intensiveness	**1**	3
B22. Lack of trained intermediate staff	1/3	**1**
Total	**1.333**	**4.000**

Pair-wise comparison matrix by Expert #2		
	B21	**B22**
B21. Labour intensiveness	**1**	1/2
B22. Lack of trained intermediate staff	2	**1**
Total	**3.000**	**1.500**

Pair-wise comparison matrix by Expert #3		
	B21	**B22**
B21. Labour intensiveness	**1**	1
B22. Lack of trained intermediate staff	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #4		
	B21	**B22**
B21. Labour intensiveness	**1**	3
B22. Lack of trained intermediate staff	1/3	**1**
Total	1.333	4.000

Pair-wise comparison matrix by Expert #5		
	B21	**B22**
B21. Labour intensiveness	**1**	3
B22. Lack of trained intermediate staff	1/3	**1**
Total	**1.333**	**4.000**

Pair-wise comparison matrix by Expert #6		
	B21	**B22**
B21. Labour intensiveness	**1**	4
B22. Lack of trained intermediate staff	1/4	**1**
Total	**1.250**	**5.000**

Pair-wise comparison matrix by Expert #7		
	B21	**B22**
B21. Labour intensiveness	**1**	2
B22. Lack of trained intermediate staff	1/2	**1**
Total	**1.500**	**3.000**

Table 4.12 Pairwise judgment matrices of B2 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									**Right Barrier Is Greater**									**Number of Experts**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	Extremely important		***Very strong important***		***Strongly important***		***Slightly important***		***Equal***		***Slightly important***		***Strongly important***		***Very strong important***		***Extremely important***		
B21						**1**	**3**	**1**	**1**	**1**								**B22**	**7**

Table 4.13 Initial Comparison Matrices of B2 sub-barriers

Labour	**B21**	**B22**
B21. Labour intensiveness	**1**	2.357
B22. Lack of trained intermediate staff	0.424	**1**
Total	**1.424**	**3.357**

Table 4.14 Pairwise judgment matrix of B2 sub-barriers

Normalized	B21	B22
B21. Labour intensiveness	0.702	0.702
B22. Lack of trained intermediate staff	0.298	0.298
Total	**1**	**1**

Table 4.15 Normalized Pair-wise matrix of B2 sub-barriers

	Weights	Ranking
B21. Labour intensiveness	0.702	**1**
B22. Lack of trained intermediate staff	0.298	**2**
CR = 0		

Table 4.16 Pairwise comparisons of B2 sub-barriers

- **Design challenges (B3)** sub-barriers

Pair-wise comparison matrix by Expert #1		
	B31	**B32**
B31. Lack of complementary processes	**1**	2
B32. Complexity in product architecture	1/2	**1**
Total	**1.500**	**3.000**

Pair-wise comparison matrix by Expert #2		
	B31	**B32**
B31. Lack of complementary processes	**1**	3
B32. Complexity in product architecture	1/3	**1**
Total	**1.333**	**4.000**

Pair-wise comparison matrix by Expert #3		
	B31	**B32**
B31. Lack of complementary processes	**1**	3
B32. Complexity in product architecture	1/3	**1**

Total	**1.333**	**4.000**

Pair-wise comparison matrix by Expert #4		
	B31	**B32**
B31. Lack of complementary processes	**1**	1
B32. Complexity in product architecture	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #5		
	B31	**B32**
B31. Lack of complementary processes	**1**	1
B32. Complexity in product architecture	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #6		
	B31	**B32**
B31. Lack of complementary processes	**1**	2
B32. Complexity in product architecture	1/2	**1**
Total	**1.500**	**3.000**

Pair-wise comparison matrix by Expert #7		
	B31	**B32**
B31. Lack of complementary processes	**1**	3
B32. Complexity in product architecture	1/3	**1**
Total	**1.333**	**4.000**

Table 4.17 Pairwise judgment matrices of B3 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									Right Barrier Is Greater									Number of Experts
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
	Extremely important		*Very strong important*		*Strongly important*		*Slightly important*		*Equal*		*Slightly important*		*Strongly important*		*Very strong important*		*Extremely important*		
B31							3	2	2									**B32**	7

Table 4.18 Initial Comparison Matrices of B3 sub-barriers

Design challenges	B31	B32
B31. Lack of complementary processes	**1**	2.143
B32. Complexity in product architecture	0.467	**1**
Total	**1.467**	**3.143**

Table 4.19 Pairwise judgment matrix of B3 sub-barriers

Normalized	B31	B32
B31. Lack of complementary processes	0.682	0.682
B32. Complexity in product architecture	0.318	0.318
Total	**1**	**1**

Table 4.20 Normalized Pair-wise matrix of B3 sub-barriers

	Weights	Ranking
B31. Lack of complementary processes	0.682	**1**
B32. Complexity in product architecture	0.318	**2**
CR = 0		

Table 4.21 Pairwise comparisons of B3 sub-barriers

- **Material (B4)** sub-barriers

Pair-wise comparison matrix by Expert #1				
	B41	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	**1**	4	2	1/2
B42 Lack of high quality	1/4	**1**	1/3	1/5

B43 Complexity in material composition	1/2	3	**1**	1/3
B44 High cost of raw materials	2	5	3	**1**
Total	**3.750**	**13.000**	**6.333**	**2.033**
Pair-wise comparison matrix by Expert #2				
	B41	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	**1**	5	2	1/2
B42 Lack of high quality	1/5	**1**	1/3	1/4
B43 Complexity in material composition	1/2	3	**1**	1/2
B44 High cost of raw materials	2	4	2	**1**
Total	**3.700**	**13.000**	**5.333**	**2.250**
Pair-wise comparison matrix by Expert #3				
	B41	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	**1**	3	1/2	1/3
B42 Lack of high quality	1/3	**1**	1/3	1/6
B43 Complexity in material composition	2	3	**1**	1/2
B44 High cost of raw materials	3	6	2	**1**
Total	**6.333**	**13.000**	**3.833**	**2.000**
Pair-wise comparison matrix by Expert #4				
	B41	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	**1**	3	2	1/3
B42 Lack of high quality	1/3	**1**	1/2	1/6
B43 Complexity in material composition	1/2	2	**1**	1/4
B44 High cost of raw materials	3	6	4	**1**
Total	**4.833**	**12.000**	**7.500**	**1.750**
Pair-wise comparison matrix by Expert #5				

	B41	B42	B43	B44
B41. Availability of recyclable materials	**1**	4	1	1/2
B42 Lack of high quality	1/4	**1**	1/3	1/5
B43 Complexity in material composition	1	3	**1**	1/3
B44 High cost of raw materials	2	5	3	**1**
Total	**4.250**	**13.000**	**5.333**	**2.033**
Pair-wise comparison matrix by Expert #6				
	B41	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	**1**	3	2	1/2
B42 Lack of high quality	1/3	**1**	1	1/4
B43 Complexity in material composition	1/2	1	**1**	1/3
B44 High cost of raw materials	2	4	3	**1**
Total	**3.833**	**9.000**	**7.000**	**2.083**
Pair-wise comparison matrix by Expert #7				
	B41	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	**1**	5	3	1/2
B42 Lack of high quality	1/5	**1**	1/2	1/5
B43 Complexity in material composition	1/3	2	**1**	1/4
B44 High cost of raw materials	2	5	4	**1**
Total	**3.533**	**13.000**	**8.500**	**1.950**

Table 4.22 Pairwise judgment matrices of B4 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									Right Barrier Is Greater									Number of Experts
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
	Extremely important		*Very strong important*		*Strongly important*		*Slightly important*		*Equal*		*Slightly important*		*Strongly important*		*Very strong important*		*Extremely important*		
B41					**2**	**2**	**3**											**B42**	**7**
B41							**1**	**4**	**1**	**1**								**B43**	**7**
B41										**5**	**2**							**B44**	**7**
B42									**1**	**2**	**4**							**B43**	**7**
B42												**2**	**3**	**2**				**B44**	**7**
B43										**2**	**3**	**2**						**B44**	**7**

Table 4.23 Initial Comparison Matrices of B4 sub-barriers

Material	**B41**	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	**1**	3.857	1.786	0.452
B42 Lack of high quality	0.259	**1**	0.476	0.205
B43 Complexity in material composition	0.560	2.100	**1**	0.357
B44 High cost of raw materials	2.211	4.884	2.800	**1**
Total	**4.030**	**11.841**	**6.062**	**2.014**

Table 4.24 Pairwise judgment matrix of B4 sub-barriers

Normalized	**B41**	**B42**	**B43**	**B44**
B41. Availability of recyclable materials	0.248	0.326	0.295	0.225
B42 Lack of high quality	0.064	0.084	0.079	0.102
B43 Complexity in material composition	0.139	0.177	0.165	0.177
B44 High cost of raw materials	0.549	0.412	0.462	0.496
Total	**1**	**1**	**1**	**1**

Table 4.25 Normalized Pair-wise matrix of B4 sub-barriers

	Weights	Ranking
B41. Availability of recyclable materials	0.273	**2**
B42. Lack of high quality	0.082	**4**
B43. Complexity in material composition	0.165	**3**
B44. High cost of raw materials	0.480	**1**
CR = 0.0108		

Table 4.26 Pairwise comparisons of B4 sub-barriers

- **Rules and Regulations (B5)** sub-barriers

Pair-wise comparison matrix by Expert #1		
	B51	**B52**
B51. Lack of sectorial standardization	**1**	3
B52. Lack of certifications	1/3	**1**
Total	**1.333**	**4.000**

Pair-wise comparison matrix by Expert #2		
	B51	**B52**
B51. Lack of sectorial standardization	**1**	3
B52. Lack of certifications	1/3	**1**
Total	**1.333**	**4.000**

Pair-wise comparison matrix by Expert #3		
	B51	**B52**
B51. Lack of sectorial standardization	**1**	2
B52. Lack of certifications	1/2	**1**
Total	**1.500**	**3.000**

Pair-wise comparison matrix by Expert #4		
	B51	**B52**

B51. Lack of sectorial standardization	**1**	1
B52. Lack of certifications	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #5		
	B51	**B52**
B51. Lack of sectorial standardization	**1**	1
B52. Lack of certifications	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #6		
	B51	**B52**
B51. Lack of sectorial standardization	**1**	2
B52. Lack of certifications	1/2	**1**
Total	**1.500**	**3.000**

Pair-wise comparison matrix by Expert #7		
	B51	**B52**
B51. Lack of sectorial standardization	**1**	3
B52. Lack of certifications	1/3	**1**
Total	**1.333**	**4.000**

Table 4.27 Pairwise judgment matrices of B5 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									**Right Barrier Is Greater**									**Number of Experts**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	Extremely important		***Very strong important***		***Strongly important***		***Slightly important***		***Equal***		***Slightly important***		***Strongly important***		***Very strong important***		***Extremely important***		
B51							**3**	**2**	**2**									**B52**	**7**

Table 4.28 Initial Comparison Matrices of B5 sub-barriers

Rules and regulations	B51	B52
B51. Lack of sectorial standardization	**1**	2.143
B52. Lack of certifications	0.467	**1**
Total	**1.467**	**3.143**

Table 4.29 Pairwise judgment matrix of B5 sub-barriers

Normalized	B51	B52
B51. Lack of sectorial standardization	0.682	0.682
B52. Lack of certifications	0.318	0.318
Total	**1**	**1**

Table 4.30 Normalized Pair-wise matrix of B5 sub-barriers

	Weights	Ranking
B51. Lack of sectorial standardization	0.682	**1**
B52. Lack of certifications	0.318	**2**
CR = 0		

Table 4.31 Pairwise comparisons of B5 sub-barriers

- **Knowledge and awareness (B6)** sub-barriers

Pair-wise comparison matrix by Expert #1			
	B61	**B62**	**B63**
B61. Lack of CE awareness	**1**	3	2
B62. Lack of theoretical information	1/3	**1**	1/2
B63. Lack of technical know-how	1/2	2	**1**
Total	**1.833**	**6.000**	**3.500**

Pair-wise comparison matrix by Expert #2			
	B61	**B62**	**B63**

B61. Lack of CE awareness	**1**	5	1
B62. Lack of theoretical information	1/5	**1**	1/4
B63. Lack of technical know-how	1	4	**1**
Total	**2.200**	**10.000**	**2.250**

Pair-wise comparison matrix by Expert #3			
	B61	**B62**	**B63**
B61. Lack of CE awareness	**1**	4	3
B62. Lack of theoretical information	1/4	**1**	1
B63. Lack of technical know-how	1/3	1	**1**
Total	**1.583**	**6.000**	**5.000**

Pair-wise comparison matrix by Expert #4			
	B61	**B62**	**B63**
B61. Lack of CE awareness	**1**	5	1
B62. Lack of theoretical information	1/5	**1**	1/3
B63. Lack of technical know-how	1	3	**1**
Total	**2.200**	**9.000**	**2.333**

Pair-wise comparison matrix by Expert #5			
	B61	**B62**	**B63**
B61. Lack of CE awareness	**1**	4	2
B62. Lack of theoretical information	1/4	**1**	1/2
B63. Lack of technical know-how	1/2	2	**1**
Total	**1.750**	**7.000**	**3.500**

Pair-wise comparison matrix by Expert #6			
	B61	**B62**	**B63**
B61. Lack of CE awareness	**1**	5	2

B62. Lack of theoretical information	1/5	**1**	1/4
B63. Lack of technical know-how	1/2	4	**1**
Total	**1.700**	**10.000**	**3.250**

Pair-wise comparison matrix by Expert #7			
	B61	**B62**	**B63**
B61. Lack of CE awareness	**1**	3	2
B62. Lack of theoretical information	1/3	**1**	1/2
B63. Lack of technical know-how	1/2	2	**1**
Total	**1.833**	**6.000**	**3.500**

Table 4.32 Pairwise judgment matrices of B6 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									**Right Barrier Is Greater**									**Number of Experts**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	Extremely important		***Very strong important***		***Strongly important***		***Slightly important***		***Equal***		***Slightly important***		***Strongly important***		***Very strong important***		***Extremely important***		
B61					**3**	**2**	**2**											**B62**	**7**
B61							**1**	**4**	**2**									**B63**	**7**
B62									**1**	**3**	**1**	**2**						**B63**	**7**

Table 4.33 Initial Comparison Matrices of B6 sub-barriers

Knowledge & awareness	**B61**	**B62**	**B63**
B61. Lack of CE awareness	**1**	4.143	1.857
B62. Lack of theoretical information	0.241	**1**	0.476
B63. Lack of technical know-how	0.538	2.100	**1**
Total	**1.780**	**7.243**	**3.333**

Table 4.34 Pairwise judgment matrix of B6 sub-barriers

Normalized	B61	B62	B63
B61. Lack of CE awareness	0.562	0.572	0.557
B62. Lack of theoretical information	0.136	0.138	0.143
B63. Lack of technical know-how	0.303	0.290	0.300
Total	**1**	**1**	**1**

Table 4.35 Normalized Pair-wise matrix of B6 sub-barriers

	Weights	Ranking
B61. Lack of CE awareness	0.564	**1**
B62. Lack of theoretical information	0.139	**3**
B63. Lack of technical know-how	0.297	**2**
CR = 0.0003		

Table 4.36 Pairwise comparisons of B6 sub-barriers

- **Integration and Collaboration (B7)** sub-barriers

Pair-wise comparison matrix by Expert #1			
	B71	**B72**	**B73**
B71. Lack of sharing information and communication	**1**	1/4	1/2
B72. Lack of constant supplier	4	**1**	3
B73. Lack of shared vision and willingness to collaborate	2	1/3	**1**
Total	**7.000**	**1.583**	**4.500**

Pair-wise comparison matrix by Expert #2			
	B71	**B72**	**B73**
B71. Lack of sharing information and communication	**1**	1/6	1/3
B72. Lack of constant supplier	6	**1**	4
B73. Lack of shared vision and willingness to collaborate	3	1/4	**1**
Total	**10.000**	**1.417**	**5.333**

Pair-wise comparison matrix by Expert #3			
	B71	**B72**	**B73**
B71. Lack of sharing information and communication	**1**	1/5	1
B72. Lack of constant supplier	5	**1**	5
B73. Lack of shared vision and willingness to collaborate	1	1/5	**1**
Total	**7.000**	**1.400**	**7.000**

Pair-wise comparison matrix by Expert #4			
	B71	**B72**	**B73**
B71. Lack of sharing information and communication	**1**	1/4	1/2
B72. Lack of constant supplier	4	**1**	3
B73. Lack of shared vision and willingness to collaborate	2	1/3	**1**
Total	**7.000**	**1.583**	**4.500**

Pair-wise comparison matrix by Expert #5			
	B71	**B72**	**B73**
B71. Lack of sharing information and communication	**1**	1/5	1/3
B72. Lack of constant supplier	5	**1**	3
B73. Lack of shared vision and willingness to collaborate	3	1/3	**1**
Total	**9.000**	**1.533**	**4.333**

Pair-wise comparison matrix by Expert #6			
	B71	**B72**	**B73**
B71. Lack of sharing information and communication	**1**	1/4	1/3
B72. Lack of constant supplier	4	**1**	3
B73. Lack of shared vision and willingness to collaborate	3	1/3	**1**
Total	**8.000**	**1.583**	**4.333**

Pair-wise comparison matrix by Expert #7

	B71	B72	B73
B71. Lack of sharing information and communication	**1**	1/6	1/2
B72. Lack of constant supplier	6	**1**	3
B73. Lack of shared vision and willingness to collaborate	2	1/3	**1**
Total	**9.000**	**1.500**	**4.500**

Table 4.37 Pairwise judgment matrices of B7 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									**Right Barrier Is Greater**									**Number of Experts**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	Extremely important		***Very strong important***		***Strongly important***		***Slightly important***		***Equal***		***Slightly important***		***Strongly important***		***Very strong important***		***Extremely important***		
B71												**3**	**2**	**2**				**B72**	**7**
B71									**1**	**3**	**3**							**B73**	**7**
B72					**1**	**1**	**5**											**B73**	**7**

Table 4.38 Initial Comparison Matrices of B7 sub-barriers

Integration & Collabaration	**B71**	**B72**	**B73**
B71. Lack of sharing information and communication	**1**	0.212	0.500
B72. Lack of constant supplier	4.719	**1**	3.429
B73. Lack of shared vision and willingness to collaborate	2.000	0.292	**1**
Total	**7.719**	**1.504**	**4.929**

Table 4.39 Pairwise judgment matrix of B7 sub-barriers

Normalized	**B71**	**B72**	**B73**
B71. Lack of sharing information and communication	0.130	0.141	0.101
B72. Lack of constant supplier	0.611	0.665	0.696
B73. Lack of shared vision and willingness to collaborate	0.259	0.194	0.203
Total	**1**	**1**	**1**

Table 4.40 Normalized Pair-wise matrix of B7 sub-barriers

	Weights	Ranking
B71. Lack of sharing information and communication	0.124	**3**
B72. Lack of constant supplier	0.657	**1**
B73. Lack of shared vision and willingness to collaborate	0.219	**2**
CR = 0.0134		

Table 4.41 Pairwise comparisons of B7 sub-barriers

- **Economic (B8)** sub-barriers

Pair-wise comparison matrix by Expert #1			
	B81	**B82**	**B83**
B81. High investment cost	**1**	3	4
B82. Uncertainty in profitability	1/3	**1**	2
B83. Failure to provide the scale of production	1/4	1/2	**1**
Total	**1.583**	**4.500**	**7.000**

Pair-wise comparison matrix by Expert #2			
	B81	**B82**	**B83**
B81. High investment cost	**1**	4	5
B82. Uncertainty in profitability	1/4	**1**	3
B83. Failure to provide the scale of production	1/5	1/3	**1**
Total	**1.450**	**5.333**	**9.000**

Pair-wise comparison matrix by Expert #3			
	B81	**B82**	**B83**
B81. High investment cost	**1**	2	4
B82. Uncertainty in profitability	1/2	**1**	1
B83. Failure to provide the scale of production	1/4	1	**1**
Total	**1.750**	**4.000**	**6.000**

Pair-wise comparison matrix by Expert #4

	B81	B82	B83
B81. High investment cost	**1**	1	3
B82. Uncertainty in profitability	1	**1**	2
B83. Failure to provide the scale of production	1/3	1/2	**1**
Total	**2.333**	**2.500**	**6.000**

Pair-wise comparison matrix by Expert #5			
	B81	**B82**	**B83**
B81. High investment cost	**1**	2	4
B82. Uncertainty in profitability	1/2	**1**	2
B83. Failure to provide the scale of production	1/4	1/2	**1**
Total	**1.750**	**3.500**	**7.000**

Pair-wise comparison matrix by Expert #6			
	B81	**B82**	**B83**
B81. High investment cost	**1**	4	5
B82. Uncertainty in profitability	1/4	**1**	2
B83. Failure to provide the scale of production	1/5	1/2	**1**
Total	**1.450**	**5.500**	**8.000**

Pair-wise comparison matrix by Expert #7			
	B81	**B82**	**B83**
B81. High investment cost	**1**	2	5
B82. Uncertainty in profitability	1/2	**1**	3
B83. Failure to provide the scale of production	1/5	1/3	**1**
Total	**1.700**	**3.333**	**9.000**

Table 4.42 Pairwise judgment matrices of B8 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									Right Barrier Is Greater									Number of Experts
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
	Extremely important		*Very strong important*		*Strongly important*		*Slightly important*		*Equal*		*Slightly important*		*Strongly important*		*Very strong important*		*Extremely important*		
B81						**2**	**1**	**3**	**1**									**B82**	**7**
B81					**3**	**3**	**1**											**B83**	**7**
B82							**2**	**4**	**1**									**B83**	**7**

Table 4.43 Initial Comparison Matrices of B8 sub-barriers

Economic	B81	B82	B83
B81. High investment cost	**1**	2.571	4.286
B82. Uncertainty in profitability	0.389	**1**	2.143
B83. Failure to provide the scale of production	0.233	0.467	**1**
Total	**1.622**	**4.038**	**7.429**

Table 4.44 Pairwise judgment matrix of B8 sub-barriers

Normalized	B81	B82	B83
B81. High investment cost	0.616	0.637	0.577
B82. Uncertainty in profitability	0.240	0.248	0.288
B83. Failure to provide the scale of production	0.144	0.116	0.135
Total	**1**	**1**	**1**

Table 4.45 Normalized Pair-wise matrix of B8 sub-barriers

	Weights	Ranking
B81. High investment cost	0.610	**1**
B82. Uncertainty in profitability	0.259	**2**
B83. Failure to provide the scale of production	0.131	**3**
CR = 0.0061		

Table 4.46 Pairwise comparisons of B8 sub-barriers

- **Technical infrastructure (B9)** sub-barriers

Pair-wise comparison matrix by Expert #1		
	B91	**B92**
B9.1 Inadequate of infrastructure facilities	**1**	2
B92 Lack of high-tech in reverse logistics	1/2	**1**
Total	**1.500**	**3.000**

Pair-wise comparison matrix by Expert #2		
	B91	**B92**
B9.1 Inadequate of infrastructure facilities	**1**	1
B92 Lack of high-tech in reverse logistics	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #3		
	B91	**B92**
B9.1 Inadequate of infrastructure facilities	**1**	1
B92 Lack of high-tech in reverse logistics	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #4		
	B91	**B92**
B9.1 Inadequate of infrastructure facilities	**1**	2
B92 Lack of high-tech in reverse logistics	1/2	**1**
Total	**1.500**	**3.000**

Pair-wise comparison matrix by Expert #5		
	B91	**B92**
B9.1 Inadequate of infrastructure facilities	**1**	2
B92 Lack of high-tech in reverse logistics	1/2	**1**
Total	**1.500**	**3.000**

Pair-wise comparison matrix by Expert #6		
	B91	**B92**
B9.1 Inadequate of infrastructure facilities	**1**	1
B92 Lack of high-tech in reverse logistics	1	**1**
Total	**2.000**	**2.000**

Pair-wise comparison matrix by Expert #7		
	B91	**B92**
B9.1 Inadequate of infrastructure facilities	**1**	3
B92 Lack of high-tech in reverse logistics	1/3	**1**
Total	**1.333**	**4.000**

Table 4.47 Pairwise judgment matrices of B9 sub-barriers by Expert 1 – Expert 7

	Left Barrier Is Greater									Right Barrier Is Greater									Number of Experts
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
	Extremely important		*Very strong important*		*Strongly important*		*Slightly important*		*Equal*		*Slightly important*		*Strongly important*		*Very strong important*		*Extremely important*		
B91							**1**	**3**	**3**									**B92**	**7**

Table 4.48 Initial Comparison Matrices of B9 sub-barriers

Technical infrastructure	B91	B92
B9.1 Inadequate of infrastructure facilities	**1**	1.714
B92 Lack of high-tech in reverse logistics	0.583	**1**
Total	**1.583**	**2.714**

Table 4.49 Pairwise judgment matrix of B9 sub-barriers

Normalized	**B91**	**B92**
B9.1 Inadequate of infrastructure facilities	0.632	0.632
B92 Lack of high-tech in reverse logistics	0.368	0.368
Total	**1**	**1**

Table 4.50 Normalized Pair-wise matrix of B9 sub-barriers

	Weights	**Ranking**
B9.1 Inadequate of infrastructure facilities	0.632	**1**
B92 Lack of high-tech in reverse logistics	0.368	**2**
CR = 0		

Table 4.51 Pairwise comparisons of B9 sub-barriers

Barriers	Weights Concept	Rank Concept	Sub-barriers	Weights Local	Rank Local	Weights Global	Rank Global
B1	0.092	5	B11	0.311	2	0.029	12
			B12	0.566	1	0.052	7
			B13	0.123	3	0.011	20
B2	0.073	6	B21	0.702	1	0.051	8
			B22	0.298	2	0.022	16
B3	0.021	9	B31	0.682	1	0.014	19
			B32	0.318	2	0.007	23
B4	0.097	4	B41	0.273	2	0.027	13
			B42	0.082	4	0.008	22
			B43	0.165	3	0.016	18
			B44	0.480	1	0.047	9
B5	0.172	3	**B51**	0.682	1	**0.117**	**2**
			B52	0.318	2	0.055	6
B6	0.189	2	**B61**	0.564	1	**0.107**	**3**
			B62	0.139	3	0.026	14
			B63	0.297	2	**0.056**	**5**
B7	0.039	8	B71	0.124	3	0.005	24
			B72	0.657	1	0.026	15
			B73	0.219	2	0.009	21
B8	0.271	1	**B81**	0.610	1	**0.165**	**1**
			B82	0.259	2	**0.070**	**4**
			B83	0.131	3	0.036	10
B9	0.046	7	B91	0.632	1	0.029	11
			B92	0.368	2	0.017	17

Table 4.52 Weighting and Ranking Results of AHP

The barriers' and sub-barriers' local and global weights were calculated. These weights would be calculated with the help of the rating provided in the AHP framework. To calculate the global weights, the sub-barriers' local weights and the primary barriers' local weights were multiplied. Due to this, the ranking of all categories of barriers includes Management and decision-making (B1), Labour (B2), Design challenges (B3), Material (B4), Rules and Regulations (B5), Knowledge and awareness (B6), Integration and Collaboration (B7), Economic (B8), Technical infrastructure (B9) and their sub-barriers were demonstrated in Table 4.52 based on their weights. According to this table, the following results are obtained:

- Sub-barriers

- Management and decision-making (B1)

The proposed mathematical model is solved results are obtained. After solving the model, the results are B11=0.311; B12=0.566; B13=0.123.

The optimal ranking order of the 3 sub-barriers of management and decision-making is B12 > B11 > B13. Based on Table 4.52, lack of acceptance of new business models (B12) is the essential sub-barrier of management and decision-making. That means it has the most substantial influence on the management and decision-making.

- Labour (B2)

Labour intensiveness (B21), which has 0.702 weight, is essential for Labour (B2) in circular economy in textile industry. Additionally, one barrier determined as lack of trained intermediate staff 0.298, respectively.

- Design challenges (B3)

Table 4.52 displays the rankings that indicate the B31 (Lack of complementary processes) as the best one and B32 (Complexity in product architecture) as the second one in ranking. B31 (0.682) > B32 (0.318).

- Material (B4)

Determine the essential sub-barriers of Material (B4) main barrier that affect the transition to CE for the Vietnamese textile industry. The results show that the weight of the high cost of raw materials in Material has the most significant importance. Thus, the ranking order of four sub-barriers is obtained as follows: B44 > B41 > B43 > B42, 0.480 > 0.273 > 0.165 > 0.082, respectively.

- Rules and Regulations (B5)

Table 4.52 displays the rankings that indicate the B51 (Lack of sectorial standardization) as the best one and B52 (Lack of certifications) as the second one in ranking. B51 (0.682) > B32 (0.318).

- Knowledge and awareness (B6)

By using comparative analysis, we use the same data and have solved this problem by weights and get results: B61 > B63 > B62 (0.564 > 0.297 > 0.139). We defined that sub-barrier B61 (Lack of CE awareness) is the best one and B62 (Lack of theoretical information) is the worst one in terms of the knowledge and awareness (B6) factor.

- Integration and Collaboration (B7)

Integration and Collaboration (B7) sub-barriers are evaluated based on the barrier weights. These sub-barriers, their B71, B72, and B73 values, and ranking orders are indicated in Table 4.52. According to B71, B72, and B73 values are ranked as B72 > B73 > B71. In Vietnam, the lack of constant suppliers is considered the most significant barrier preventing Vietnamese businesses from moving towards a circular economy.

- Economic (B8)

As a result of the application, the weights of sub-barriers in Economic (B8) are calculated as follows: B81=0.610, B82=0.259, B83=0.131. The ranking is given as B81 > B82 > B83. High investment cost is selected as the most affect barrier.

- Technical infrastructure (B9)

Table 4.52 lists the weights and ranks for the barriers. The results indicate that B91 (Inadequate of infrastructure facilities) is the most important, with a weight of '0.632', higher than the remaining barrier, B92 (Lack of high-tech in reverse logistics) respectively, 0.368.

➢ Main barriers

The weights of these barriers were calculated by the AHP method. According to the evaluation results, as expected, Economic (B8) is found to be the most essential main barrier. It is good to see that the weight of Knowledge and awareness (B6) and Rules and Regulations (B5) are very close to Economic (B8). In addition, Material (B4), Management and decision-making (B1), and Labor (B2) are 3 important barriers affecting the transition to a circular economy for the sustainable development of the Vietnamese textile industry. Furthermore, the factor that has the most dismissive influence on the circular economy transition of the textile industry is Technical infrastructure (B9), Integration and Collaboration (B7) Design challenges (B3). Based on Table 4.52, the rank of the main barriers is B8 > B6 > B5 > B4 > B1 > B2 > B9 > B7 > B3, with weights are 0.271, 0.189, 0.172, 0.097, 0.092, 0.073 0.046, 0.039, 0.021 respectively.

➢ 24 sub-barriers

Global weights of the sub-barriers are determined to indicate the importance of one sub-barrier relative to other sub-barriers. The final weighting and ranking results of the main barriers and sub-barriers are shown in Table 4.52. This research finds that high investment cost (B81), Lack of sectorial standardization (B51), and Lack of CE awareness (B61) are the most pressing barriers among all sub-barriers with global weights are 0.165, 0.117, 0.107, respectively.

To validate the results, interviews were conducted with experts engaged in sustainable supply chain operations to ascertain the alignment of the findings with their current challenges. This study's outcomes were consistent with industry experts' expectations, leading to the development of specific implications.

4.4. Discussion

Developing a circular economy is considered a pivotal strategy to enable Vietnam's textile industry to deeply integrate into the global value chain and establish brands that meet international standards. Confronting sustainable development challenges, Vietnam's textile and garment sector must actively endorse circular business approaches, particularly in light of the government's steadfast commitment to lowering net emissions. The industry's significant export market has also outlined a roadmap and specific goals for using recycled products. However, the movement toward a more circular textile industry still faces numerous challenges (Koszewska, 2018). The hierarchy of the AHP model reveals the priority weight of each circular supply chain barrier in the textile industry. The study points out that the five barriers with the highest importance values are listed respectively as: 'High investment cost' (B81), 'Lack of sectorial standardization' (B51), 'Lack of CE awareness' (B61), 'Uncertainty in profitability' (B82), and 'Lack of technical know-how' (B63). These are responsible for non-implementation of CE practices in the Vietnamese textile industry.

High investment cost

Firstly, these findings align with the results of (Hart et al., 2019; Masi et al., 2018; Kumar et al., 2019), who stated that one of the most pressing hurdles to implementing the Circular Economy process is high investment costs. In the majority of CE practices, the high investment cost is a considerable barrier (Liu & Bai, 2014). Similarly, Govindan & Hasanagic (2018) indicated that implementing a circular economy in the supply chain necessitates the redesign of the shop floor and production unit, which includes skilled personnel, construction, technology, and so on. This initial process appears to be difficult for SMEs and micro industries. Pathak and Endayilalu (2019) also pointed out in the study titled "Circular Economy: A Perspective of Ethiopian Textile Sector" that firms must make a significant initial expenditure to adopt and manage CE, as well as to produce and market circular products, make essential technology investments and educate human resources for circular operations.

Furthermore, the interviewee said that the barrier of "High investment costs" may be a symptom of the obstacle of "Lack of acceptance of CE models." Business executives tend to be skeptical about CE and possibly use the logical-sounding argument that "CE is too expensive" to abandon a CE initiative.

Lack of sectorial standardization

Kirchherr et al. (2018) highlighted the absence of standardization as a critical barrier in the transition to CE in research on barriers to the Circular Economy based on a survey in the European Union (EU). Besides, according to expert 2, via interview, CE regulations and laws are not firm and uniform, and some do not suit the CE idea, stifling the actions of yarn, fabric, garment manufacturers, and the government. Vermunt et al. (2019) also implied that the lack of refurbishing and recycling norms and standards leads to uneven product quality. Similarly, Jia et al. (2020) emphasized that harmonized standards must be agreed upon to guarantee that items are developed and manufactured with an eye on the later end-of-life phases. Moreover, the requirement for measurements and standards for recycled goods, as well as industrial uniformity, constitutes a significant hurdle in terms of material efficiency (Hart et al., 2019).

Lack of CE awareness

Lack of CE awareness is the third most crucial barrier. Similarly, the research of (Saha et al., 2021) found that the degree of comprehension, equally vital in CE implementation in the textile and garment industries, must be addressed. More knowledge among industry practitioners is needed to reduce the negative environmental effect of the sector's supply side. Besides, ecological sustainability must improve owing to the requirement for increased staff understanding and abilities to ensure an environmentally friendly manufacturing process. Laari et al. (2016) also implied that manufacturers must raise knowledge of how after-sales service, repair, reuse, carbon offsetting, and B2B CSR investment may positively contribute to sustainability performance. Masi et al. (2018) also asserted that even while environmental awareness and a sense of urgency to become more sustainable have risen worldwide, a need for more understanding and a sense of urgency remain significant impediments to adopting sustainable practices.

Furthermore, according to research by Govindan & Hasanagic (2018), many people must be made aware of the circular economy. Consumers' awareness of refurbishing items is limited nowadays. Many people believe that new things are superior to reconditioned products. This study could conclude that a lack of CE awareness is a critical CSC barrier in the Vietnamese textile industry.

Uncertainty in profitability

Uncertainty in profitability is similar to Kazancoglu et al. (2020) uncertainty in profitability and return on investment, which means that the return on investment is unknown since it is difficult to define and quantify the long-term effects of CE advantages by manufacturers, collectors, and recyclers. Furthermore, because enterprises must understand the new business model's cash flow, income, and cost development, this factor has been identified as a barrier to the CSC's short-term adoption. Besides, Brink (2018) indicated that because the costs of virgin materials are cheaper than those of sustainable goods, brands and retailers want to make and sell huge quantities. Thus, uncertainty about whether they can generate a sufficient number of circular products increases uncertainty in their profitability.

However, Kumar et al. (2019) also found that CE assists businesses in saving money and increasing profitability. It lowers input prices and reduces environmental fines and waste creation by enabling costs through a sustainable supply chain and end-of-life management. Companies may create additional revenues by selling their garbage rather than disposing of it using the closed-loop concept of supply chains.

Lack of technical know-how

In this research, a lack of technological know-how is one of the most significant impediments to the textile industry's transformation to a circular economy. These are consistent with the opinion of (Rizos et al., 2016), who stated that a lack of technical and technological know-how might prevent SMEs from transitioning from a linear to a circular business model. Besides, the study of Tura et al. (2018) introduced a framework of drivers and barriers of the circular economy, and findings also indicate that more technical expertise is needed to change old business models or industrial technology and implement CE. According to Snoek (2017), Muradin and Foltynowicz (2019), one of the barriers to CE is a need for more scholarly and realistic knowledge regarding CE principles. The lack of information about implementing CE, particularly on the benefits of CE for businesses, is the most significant obstacle to enterprises investing in and implementing CE (Rodríguez, 2017). There is still a lack of technical understanding, particularly on replacing existing virgin materials with recyclable materials (Roosendaal, 2018). Furthermore, a lack of Circular Economy awareness makes it difficult to provide quality circular items to the market.

CHAPTER 5: CONCLUSION AND IMPLICATIONS

5.1. Conclusion

Vietnam's textile and garment industry is currently undergoing a gradual shift in focus towards efficient and sustainable development based on the circular economy model. Adopting circular economy practices, particularly in the textile sector, aids resource optimization and substantial environmental impact reduction. This proactive approach mitigates the traditional linear model's challenges, fostering economic growth. Nevertheless, the industry encounters obstacles in implementing circular economy measures.

This study mainly proposes a conceptual framework for barriers of CSC in the transition to the circular economy in the Vietnamese textile industry. The first phase entailed an extensive literature review and consultation with industry experts to identify 24 barriers spanning relevant supply chain stages under nine main categories. This thesis requires an objective approach using the Analytic Hierarchy Process (AHP) method to prioritize these barriers based on their relative importance. According to the research findings, the most significant barriers to Vietnam's textile industry's transition to a circular economy include high investment costs (B81), lack of sectorial standards (B51), lack of CE awareness (B61), uncertainty in profitability (B82), and lack of technical know-how (B63).

Based on these findings, the study not only contributes valuable insights into the barriers hindering CE implementation, but the policy and management implications, along with recommendations, are provided to the government, industry, and stakeholders so that they can make a strategic plan to overcome the barriers in the transition to Circular Economy towards sustainable development in Vietnam's textile industry.

5.2. Contribution

5.2.1. Theoretical Contribution

This research is at a halt at the initial stage of identifying barriers in the circular economy of Vietnam's textile and garment industry, thereby providing constructive recommendations to solve the above barriers. The research article will become an academic research document in the future. Future research articles can rely on this research article as a foundation to research solutions to these barriers.

5.2.2. Practical Contribution

The research's insights promote the circular economy model to be applied more commonly in the garment industry in Vietnam to help reduce the dependence on natural resources and minimize waste generation in the production and consumption processes.

Valuable practical contributions for textile and garment businesses transitioning to a circular economy in Vietnam, knowing which barriers need to be prioritized to be resolved first, which barriers should be resolved later. Furthermore, it helps businesses come up with strategies to anticipate those obstacles.

The study also provides constructive recommendations to present the policy and management implications, along with recommendations provided to the government, industry, and stakeholders so that they can make a strategic plan to overcome the barriers in the transition to Circular Economy toward sustainable development in Vietnam's textile industry.

5.3. Limitation and Future Research

This research was based on an extensive review of previous empirical research on circular economy and CSC barriers. The study has several limitations, which may lead to future research directions.

Firstly, the literature review has some other barriers, such as organizational, cultural, and customer interest·. It is advised to conduct future research regarding these barriers in the textile industry.

Second, this study is based on inputs from a limited number of experts attributed to resources and time constraints, necessitating careful consideration when interpreting the study's results. In the future, the data can be collected from more industrial experts who work in different links in the textile supply chain to generalize the study results.

Third, AHP approaches have been used in this study, but in the future, other MCDM tools may also be used to compare findings.

Fourth, it is generally challenging for decision-makers to quantify their evaluations because the study has a lot of barriers.

Despite the stated limitations, this research provides valuable knowledge for the industry, stakeholders, and government regarding circular supply chain barriers for the sustainability of the Vietnamese textile industry. Based on literature review and direct interviews with experts, the study also proposes managerial implications and constructive suggestions to overcome the most inadequate barriers.

5.4. Implication

In response to the growing recognition of the need for a circular transition in the Vietnamese textile industry, we investigate the priority of CE barriers based on the AHP method to recommend to the industry that the priority weight of each barrier needs to be considered for developing the strategic plan to overcome these barriers with optimum use of resources. Results imply High investment cost (B81), Lack of sectorial standardization (B51), Lack of CE awareness (B61), Uncertainty in profitability (B82), and Lack of technical know-how (B63) are the most pressing barriers that hinder the transition to a circular economy of Vietnam's textile and garment industry in the current context. The findings should assist the industry in understanding the impact of all the barriers accordingly, and the industry will prepare their strategic action plan to overcome these barriers. This current study also has offered many implications for concerns, managers, and stakeholders in the textile industry related to the most pressing barriers.

High investment cost and Uncertainty in profitability

The barrier with the highest effect value is ‘High investment cost (B81)’. CE is an expensive process requiring considerable upfront investment (Liu & Bai, 2014). However, it does not pay back instantly; it has a long-term economic return. Companies avoid implementing CE because of the lack of financial support mechanisms and tax incentives established in budgeting systems by banks and governments, even when they are prepared to do so. (Geng & Doberstein, 2008; Liu & Bai, 2014). It is an expensive process, except for large companies; it is impossible to cope financially. That's why the barrier of 'Uncertainty in profitability' (B82) appeared in the top 5. Therefore, there is a need for adjustment and support from the government so that businesses can feel more secure in applying the circular economy. According to the experts, Vietnamese textile and garment enterprises need to carefully prepare step by step to transition to a circular economy model. Businesses should proactively share information, be ready to cooperate with each other and call for investment from other businesses. The majority of textile and apparel companies in Vietnam are small and medium-sized businesses. Therefore, government support is necessary to convert the existing linear economy model into the closed loop model, and it is the government's responsibility to create a convenient environment for implementing CE. Government intervention can reduce the high investment costs of a circular business model by providing financial support (Kirchherr et al., 2018). Ensuring the continuity of consumer demand for circular economy products is vital for companies to take advantage of economies of scale and escape ambiguity regarding the feasibility of their operations cyclic. This helps brands and retailers reduce ambiguity about sales and profit margins of circular textile products. Policymakers can regulate, support and enforce the use of circular components, materials and machinery through laws, regulations and incentives.

Lack of sectorial standardization

The barrier with the second-highest significant value is 'Lack of sectorial standardization'. Standardization is the act of establishing, with respect to actual or potential problems, terms for common and repeated use, with a view to achieving an optimal level of order in a given setting. (ISO 2017). For textile operations that are circular, this is a crucial component. Standardization is essential, particularly during the design phase when raw materials and components must be the same. Both production and SC operations will benefit from this. Additionally, the idea of standardization will improve the caliber of circular goods. (Luthra et al., 2019). Most important is the rapid development and implementation of national standards for the Circular Economy. This is both an orientation for standardization activities and an important basis for developing more complete and detailed standards to deploy Circular Economy models in each field and at textile and garment enterprises in Viet Nam. Proposing policies to deploy standardization groups to promote CE in Vietnam, it is necessary to have policies from the State, Ministries and branches to develop and deploy standards such as production and standard groups. sustainable use, group of standards on reuse, recycling, remanufacturing in industry and agriculture, group of environmental standards,...(Phuong. N.K.L., 2022). According to the experts that our group interviewed, governments and policy makers need to be proactive in establishing and maintaining the most common and necessary standards, for example related to issues of product longevity, reuse of components from products, reusability and recovery, extraction of components for further details, reuse, repair, recycling, disposal and identification of components with their environmental impact. From there, to create frameworks, guidelines, support tools and requirements for the implementation of activities of related organizations, contributing to the development of the circular economy and implementing sustainable development goals in Vietnam in the coming period.

Technical Know-how and Lack of CE awareness

The study states the importance of technical know-how. Recycling textile products requires significant knowledge and know-how due to the variety of components and materials within the process. Necessary requirements for businesses to clearly understand the circular economy process and the necessity of switching to a circular economy model. To do so requires timely support and commitment from the company's senior leaders to allocate the necessary financial resources for investing in technical know-how. (Recommend from Experts). Furthermore, the company's human resources need in-depth training and know-how when applying technology to all circular economy activities. It requires business stakeholders to improve their knowledge and technology into the circular economy process such as yarns, fibers, fabrics, garment manufacturers in the production process, designers design in circular product design, collectors and recyclers to deploy the technologies. In addition, policymakers and Vietnam's Ministry of Industry and Trade need to have a reasonable development strategy. Government support is needed to transform the textile industry from linear to CE and maintain circular implementation by technology transfer to eliminate the lack of technical information to implement CE . For example, know-how transfer subsidies, incentives and tax exemptions must also be clearly stated. Such findings may motivate government and local authorities to reconsider its public campaigns, seminars, or conferences in cooperation with academia, enhance the trust of the stakeholders towards circular transition, and increase the awareness of textile companies on the benefits of CE and its contributions to sustainability. In that stage, it is vital to exhibit and share the sustainable benefits of this transition. In fact, exhibitions to raise awareness about CE are still taking place in Vietnam, such as Texfuture Vietnam in the Spring and Summer of 2023. Textfuture Vietnam is The 21st Vietnam International Textile & Garment Industry Exhibition taking place from 25/10/2023-28/10/2023 at Saigon Exhibition & Convention Center (SECC) in that the textile industry is facing an economic recession that may occur after the COVID-19 pandemic. The exhibition aims to develop the Textile and Apparel industry associated with the Circular Economy - Green Economy and Digital Transformation.

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Appendix

Questionnaires

No.	Questions	Answer
1	**Name**	**Nguyen Ba Le**
2	**Gender**	**Male**
3	**Highest educational qualification obtained** ** B. Sc, M. Sc, Ph. D, etc*	**M. Sc**
4	**Areas of expertise** **Please explain specifically the position and area of expertise, e.g., Senior manager of the Quality management Department of Garment company A*	**Procurement manager | MOTIVES INTERNATIONAL | Global Company| Garment manufacturer**
5	**Do you have experience in the textile industry?** **yes/ no*	**Yes**
6	**Years of work experience in the textile and garment industry** ** < 5 years, between 5 years and 10 years, > 10 years*	**8 years**

SURVEY ON BARRIERS OF CIRCULAR SUPPLY CHAIN IN VIETNAM'S TEXTILE INDUSTRY

Background

This study aims to identify and rank circular economy barriers for Vietnam's textile industry in the current context. Barriers were identified from existing literature and expert recommendations. Using the AHP approach, this study ranks each of the factors' pairwise comparisons. From there, deep insights are provided for Vietnamese textile and garment enterprises that transform into a circular economy for sustainable development.

🖎 You serve as an expert in this study. Your contribution is an indispensable part of completing this research.

Instructions

If you think the barrier on the left is more Strongly Important than the barrier on the right, you can tick (✔) in column Strongly Important (5) on the left side. However, if you think that the factor on the right is more Strongly Important than the factor on the left, you can tick (✔) in column number Strongly Important (5) on the right side.

However, suppose you think that both barriers are of equal importance. In that case, you tick (✔) the middle option, i.e. column Equal (1).

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate values

PAIRWISE COMPARISONS (MAIN BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
☐	☐	☐	☐	☐	☐	☐	☐	*Management and decision-making*	☑	*Labour*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☑	☐	☐	☐	☐		☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Labour*	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Design challenges*	☐	*Materials*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Integration and collaboration*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☐	☐	☑	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Materials*	☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Rules and regulations*	☑	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	*Knowledge and awareness*	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Integration and collaboration*	☐	*Economic*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Economic*	☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

PAIRWISE COMPARISONS (SUB-BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
B1. Management and decision-making																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of performance evaluation system*	☐	*Lack of acceptance CE models*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	*Lack of performance evaluation system*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Lack of acceptance CE models*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
B2. Labour																		
☐	☐	☐	☐	☐	☐	☑	☐	*Labour intensiveness*	☐	*Lack of trained intermediate staff*	☐	☐	☐	☐	☐	☐	☐	☐
B3. Design challenges																		
☐	☐	☐	☐	☐	☐	☐	☑	*Lack of complementary processes*	☐	*Complexity in product architecture*	☐	☐	☐	☐	☐	☐	☐	☐
B4. Materials																		
☐	☐	☐	☐	☐	☑	☐	☐	*Availability of recyclable materials*	☐	*Lack of high quality*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	*Availability of recyclable materials*	☐	*Complexity in material composition*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*High cost of raw materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*Complexity in material composition*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*High cost of raw materials*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Complexity in material composition*	☐	*High cost of raw materials*	☐	☑	☐	☐	☐	☐	☐	☐
B5. Rules and regulations																		
☐	☐	☐	☐	☐	☐	☑	☐	Lack of sectorial standardization	☐	Lack of certifications	☐	☐	☐	☐	☐	☐	☐	☐
B6. Knowledge and awareness																		
☐	☐	☐	☐	☐	☐	☑	☐	Lack of CE awareness	☐	Lack of theoretical information	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Lack of CE awareness	☐	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of theoretical information	☐	Lack of technical know-how	☑	☐	☐	☐	☐	☐	☐	☐
B7. Integration and collaboration																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of constant supplier	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of shared vision and willingness to collaborate	☑	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☑	☐	Lack of constant supplier	☐	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐
B8. Cost																		
☐	☐	☐	☐	☐	☐	☑	☐	High investment cost	☐	Uncertainty in profitability	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	High investment cost	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Uncertainty in profitability	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
B9. Technical infrastructure																		
☐	☐	☐	☐	☐	☐	☐	☑	Inadequate of infrastructure facilities	☐	Lack of high-tech in reverse logistics	☐	☐	☐	☐	☐	☐	☐	☐

EXPERT PROFILE

No.	Questions	Answer
1	**Name**	**Luu Nhat Vy**
2	**Gender**	**Female**
3	**Highest educational qualification obtained** ** B. Sc, M. Sc, Ph. D, etc*	**B. Sc**
4	**Areas of expertise** **Please explain specifically the position and area of expertise, e.g., Senior manager of the Quality management Department of Garment company A*	**Quality & sustainable development manager | Decathlon Co. LTD | Garment manufacturer**
5	**Do you have experience in the textile industry?** **yes/ no*	**Yes**
6	**Years of work experience in the textile and garment industry** ** < 5 years, between 5 years and 10 years, > 10 years*	**10 years**

SURVEY ON BARRIERS OF CIRCULAR SUPPLY CHAIN IN VIETNAM'S TEXTILE INDUSTRY

Background

This study aims to identify and rank circular economy barriers for Vietnam's textile industry in the current context. Barriers were identified from existing literature and expert recommendations. Using the AHP approach, this study ranks each of the factors' pairwise comparisons. From there, deep insights are provided for Vietnamese textile and garment enterprises that transform into a circular economy for sustainable development.

🖎 You serve as an expert in this study. Your contribution is an indispensable part of completing this research.

Instructions

If you think the barrier on the left is more Strongly Important than the barrier on the right, you can tick (✔) in column Strongly Important (5) on the left side. However, if you think that the factor on the right is more Strongly Important than the factor on the left, you can tick (✔) in column number Strongly Important (5) on the right side.

However, suppose you think that both barriers are of equal importance. In that case, you tick (✔) the middle option, i.e. column Equal (1).

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate values

PAIRWISE COMPARISONS (MAIN BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
☐	☐	☐	☐	☐	☐	☐	☑	*Management and decision-making*	☐	*Labour*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☑	☐	☐	☐	☐	☐		☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Materials*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☑	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Labour*	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Design challenges*	☐	*Materials*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Integration and collaboration*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Materials*	☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Rules and regulations*	☑	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Economic*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Knowledge and awareness*	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Integration and collaboration*	☐	*Economic*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Economic*	☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

PAIRWISE COMPARISONS (SUB-BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
B1. Management and decision-making																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of performance evaluation system*	☐	*Lack of acceptance CE models*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	*Lack of performance evaluation system*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	*Lack of acceptance CE models*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
B2. Labour																		
☐	☐	☐	☐	☐	☐	☐	☐	*Labour intensiveness*	☐	*Lack of trained intermediate staff*	☑	☐	☐	☐	☐	☐	☐	☐
B3. Design challenges																		
☐	☐	☐	☐	☐	☐	☑	☐	*Lack of complementary processes*	☐	*Complexity in product architecture*	☐	☐	☐	☐	☐	☐	☐	☐
B4. Materials																		
☐	☐	☐	☐	☑	☐	☐	☐	*Availability of recyclable materials*	☐	*Lack of high quality*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	*Availability of recyclable materials*	☐	*Complexity in material composition*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*High cost of raw materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*Complexity in material composition*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*High cost of raw materials*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Complexity in material composition*	☐	*High cost of raw materials*	☐	☑	☐	☐	☐	☐	☐	☐
B5. Rules and regulations																		
☐	☐	☐	☐	☐	☐	☑	☐	Lack of sectorial standardization	☐	Lack of certifications	☐	☐	☐	☐	☐	☐	☐	☐
B6. Knowledge and awareness																		
☐	☐	☐	☐	☑	☐	☐	☐	Lack of CE awareness	☐	Lack of theoretical information	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of CE awareness	☑	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of theoretical information	☐	Lack of technical know-how	☐	☐	☑	☐	☐	☐	☐	☐
B7. Integration and collaboration																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of constant supplier	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of shared vision and willingness to collaborate	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	Lack of constant supplier	☐	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐

B8. Cost																		
☐	☐	☐	☐	☐	☑	☐	☐	High investment cost	☐	Uncertainty in profitability	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	High investment cost	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	Uncertainty in profitability	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
B9. Technical infrastructure																		
☐	☐	☐	☐	☐	☐	☐	☐	Inadequate of infrastructure facilities	☑	Lack of high-tech in reverse logistics	☐	☐	☐	☐	☐	☐	☐	☐

EXPERT PROFILE

No.	Questions	Answer
1	**Name**	**Nguyen Thi Dieu Thao**
2	**Gender**	**Female**
3	**Highest educational qualification obtained** ** B. Sc, M. Sc, Ph. D, etc*	**MBA**
4	**Areas of expertise** **Please explain specifically the position and area of expertise, e.g., Senior manager of the Quality management Department of Garment company A*	**Garment Technology - Account Manager | Intertek Vietnam Co. Ltd | Garment manufacturer**
5	**Do you have experience in the textile industry?** **yes/ no*	**Yes**
6	**Years of work experience in the textile and garment industry** ** < 5 years, between 5 years and 10 years, > 10 years*	**10 years**

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Instructions

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However, suppose you think that both barriers are of equal importance. In that case, you tick (✔) the middle option, i.e. column Equal (1).

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate values

PAIRWISE COMPARISONS (MAIN BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
☐	☐	☐	☐	☐	☐	☐	☐	*Management and decision-making*	☐	*Labour*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☑	☐	☐	☐	☐	☐	☐		☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☐		☑	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Labour*	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Materials*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Design challenges*	☐	*Materials*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☑	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Integration and collaboration*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☐	☐	☐	☑
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Materials*	☐	*Rules and regulations*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Rules and regulations*	☑	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Knowledge and awareness*	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Economic*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Integration and collaboration*	☐	*Economic*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Economic*	☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

PAIRWISE COMPARISONS (SUB-BARRIERS)

Extremely important (9)	(8)	Very strong important (7	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7	(8)	Extremely important (9)
B1. Management and decision-making																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of performance evaluation system*	☑	*Lack of acceptance CE models*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	*Lack of performance evaluation system*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Lack of acceptance CE models*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
B2. Labour																		
☐	☐	☐	☐	☐	☐	☐	☐	*Labour intensiveness*	☑	*Lack of trained intermediate staff*	☐	☐	☐	☐	☐	☐	☐	☐
B3. Design challenges																		
☐	☐	☐	☐	☐	☐	☑	☐	*Lack of complementary processes*	☐	*Complexity in product architecture*	☐	☐	☐	☐	☐	☐	☐	☐
B4. Materials																		
☐	☐	☐	☐	☐	☐	☑	☐	*Availability of recyclable materials*	☐	*Lack of high quality*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*Complexity in material composition*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*High cost of raw materials*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*Complexity in material composition*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*High cost of raw materials*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Complexity in material composition*	☐	*High cost of raw materials*	☑	☐	☐	☐	☐	☐	☐	☐
B5. Rules and regulations																		
☐	☐	☐	☐	☐	☐	☐	☑	Lack of sectorial standardization	☐	Lack of certifications	☐	☐	☐	☐	☐	☐	☐	☐
B6. Knowledge and awareness																		
☐	☐	☐	☐	☐	☑	☐	☐	Lack of CE awareness	☐	Lack of theoretical information	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	Lack of CE awareness	☐	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of theoretical information	☑	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
B7. Integration and collaboration																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of constant supplier	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☑	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	Lack of constant supplier	☐	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐
B8. Cost																		
☐	☐	☐	☐	☐	☐	☐	☑	High investment cost	☐	Uncertainty in profitability	☐	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☑	☐	☐	High investment cost	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Uncertainty in profitability	☑	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
B9. Technical infrastructure																		
☐	☐	☐	☐	☐	☐	☐	☐	Inadequate of infrastructure facilities	☑	Lack of high-tech in reverse logistics	☐	☐	☐	☐	☐	☐	☐	☐

EXPERT PROFILE

No.	Questions	Answer
1	**Name**	**Xuan Nhi**
2	**Gender**	**Female**
3	**Highest educational qualification obtained** ** B. Sc, M. Sc, Ph. D, etc*	**B.Sc**
4	**Areas of expertise** **Please explain specifically the position and area of expertise, e.g., Senior manager of the Quality management Department of Garment company A*	**Production & quality manager | Phong Phu Joint Stock Corporation | Yarn, Fabric, Garment Manufacturer**
5	**Do you have experience in the textile industry?** **yes/ no*	**Yes**
6	**Years of work experience in the textile and garment industry** ** < 5 years, between 5 years and 10 years, > 10 years*	**9 years**

SURVEY ON BARRIERS OF CIRCULAR SUPPLY CHAIN IN VIETNAM'S TEXTILE INDUSTRY

Background

This study aims to identify and rank circular economy barriers for Vietnam's textile industry in the current context. Barriers were identified from existing literature and expert recommendations. Using the AHP approach, this study ranks each of the factors' pairwise comparisons. From there, deep insights are provided for Vietnamese textile and garment enterprises that transform into a circular economy for sustainable development.

💌 You serve as an expert in this study. Your contribution is an indispensable part of completing this research.

Instructions

If you think the barrier on the left is more Strongly Important than the barrier on the right, you can tick (✔) in column Strongly Important (5) on the left side. However, if you think that the factor on the right is more Strongly Important than the factor on the left, you can tick (✔) in column number Strongly Important (5) on the right side.

However, suppose you think that both barriers are of equal importance. In that case, you tick (✔) the middle option, i.e. column Equal (1).

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate values

PAIRWISE COMPARISONS (MAIN BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
☐	☐	☐	☐	☐	☐	☐	☑	Management and decision-making	☐	*Labour*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☑	☐	☐	☐	☐	☐	Management and decision-making	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Management and decision-making	☑	*Materials*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Management and decision-making	☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Management and decision-making	☐	*Knowledge and awareness*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	Management and decision-making	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Labour*	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Design challenges*	☐	*Materials*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Integration and collaboration*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☐	☐	☑	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Materials*	☐	*Rules and regulations*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Rules and regulations*	☐	*Knowledge and awareness*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Economic*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Knowledge and awareness*	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Integration and collaboration*	☐	*Economic*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Economic*	☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

PAIRWISE COMPARISONS (SUB-BARRIERS)

Extremely important (9)	(8)	Very strong important (7	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7	(8)	Extremely important (9)
B1. Management and decision-making																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of performance evaluation system*	☐	*Lack of acceptance CE models*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Lack of performance evaluation system*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Lack of acceptance CE models*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
B2. Labour																		
☐	☐	☐	☐	☐	☐	☑	☐	*Labour intensiveness*	☐	*Lack of trained intermediate staff*	☐	☐	☐	☐	☐	☐	☐	☐
B3. Design challenges																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of complementary processes*	☑	*Complexity in product architecture*	☐	☐	☐	☐	☐	☐	☐	☐
B4. Materials																		
☐	☐	☐	☐	☐	☐	☑	☐	*Availability of recyclable materials*	☐	*Lack of high quality*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	*Availability of recyclable materials*	☐	*Complexity in material composition*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*High cost of raw materials*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*Complexity in material composition*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*High cost of raw materials*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Complexity in material composition*	☐	*High cost of raw materials*	☐	☐	☑	☐	☐	☐	☐	☐
B5. Rules and regulations																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sectorial standardization	☑	Lack of certifications	☐	☐	☐	☐	☐	☐	☐	☐
B6. Knowledge and awareness																		
☐	☐	☐	☐	☑	☐	☐	☐	Lack of CE awareness	☐	Lack of theoretical information	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of CE awareness	☑	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of theoretical information	☐	Lack of technical know-how	☐	☑	☐	☐	☐	☐	☐	☐
B7. Integration and collaboration																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of constant supplier	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of shared vision and willingness to collaborate	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	Lack of constant supplier	☐	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐
B8. Cost																		
☐	☐	☐	☐	☐	☐	☐	☐	High investment cost	☑	Uncertainty in profitability	☐	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☑	☐	High investment cost	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Uncertainty in profitability	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
B9. Technical infrastructure																				
☐	☐	☐	☐	☐	☐	☐	☑	Inadequate of infrastructure facilities	☐	Lack of high-tech in reverse logistics	☐	☐	☐	☐	☐	☐	☐	☐

EXPERT PROFILE

No.	*Questions*	*Answer*
1	**Name**	**Ho Van Nghia**
2	**Gender**	**Male**
3	**Highest educational qualification obtained** ** B. Sc, M. Sc, Ph. D, etc*	**MBA**
4	**Areas of expertise** **Please explain specifically the position and area of expertise, e.g., Senior manager of the Quality management Department of Garment company A*	**General Director | Minh Son Trading and Services Garment Co., Ltd | Retailer** **Yarn, Fabric Manufacturer**
5	**Do you have experience in the textile industry?** **yes/ no*	**Yes**

SURVEY ON BARRIERS OF CIRCULAR SUPPLY CHAIN IN VIETNAM'S TEXTILE INDUSTRY

Background

This study aims to identify and rank circular economy barriers for Vietnam's textile industry in the current context. Barriers were identified from existing literature and expert recommendations. Using the AHP approach, this study ranks each of the factors' pairwise comparisons. From there, deep insights are provided for Vietnamese textile and garment enterprises that transform into a circular economy for sustainable development.

💌 You serve as an expert in this study. Your contribution is an indispensable part of completing this research.

Instructions

If you think the barrier on the left is more Strongly Important than the barrier on the right, you can tick (✔) in column Strongly Important (5) on the left side. However, if you think that the factor on the right is more Strongly Important than the factor on the left, you can tick (✔) in column number Strongly Important (5) on the right side.

However, suppose you think that both barriers are of equal importance. In that case, you tick (✔) the middle option, i.e. column Equal (1).

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate values

PAIRWISE COMPARISONS (MAIN BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
☐	☐	☐	☐	☐	☐	☐	☐	*Management and decision-making*	☑	*Labour*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☑	☐	☐	☐	☐		☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Materials*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Rules and regulations*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Labour*	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Design challenges*	☐	*Materials*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☑	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Integration and collaboration*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☐	☐	☑	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Materials*	☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Rules and regulations*	☑	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☑	☐	☐	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Economic*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Knowledge and awareness*	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Integration and collaboration*	☐	*Economic*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☑	☐	☐	☐	*Economic*	☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
PAIRWISE COMPARISONS (SUB-BARRIERS)																		
Extremely important (9)	**(8)**	**Very strong important (7)**	**(6)**	**Strongly important (5)**	**(4)**	**Slightly important (3)**	**(2)**	**BARRIER**	**Equal (1)**	**BARRIER**	**(2)**	**Slightly important (3)**	**(4)**	**Strongly important (5)**	**(6)**	**Very strong important (7)**	**(8)**	**Extremely important (9)**
B1. Management and decision-making																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of performance evaluation system*	☐	*Lack of acceptance CE models*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	*Lack of performance evaluation system*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Lack of acceptance CE models*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
B2. Labour																		
☐	☐	☐	☐	☐	☐	☑	☐	*Labour intensiveness*	☐	*Lack of trained intermediate staff*	☐	☐	☐	☐	☐	☐	☐	☐
B3. Design challenges																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of complementary processes*	☑	*Complexity in product architecture*	☐	☐	☐	☐	☐	☐	☐	☐
B4. Materials																		
☐	☐	☐	☐	☐	☑	☐	☐	*Availability of recyclable materials*	☐	*Lack of high quality*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☑	*Complexity in material composition*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*High cost of raw materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*Complexity in material composition*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*High cost of raw materials*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Complexity in material composition*	☐	*High cost of raw materials*	☐	☑	☐	☐	☐	☐	☐	☐
B5. Rules and regulations																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sectorial standardization	☑	Lack of certifications	☐	☐	☐	☐	☐	☐	☐	☐
B6. Knowledge and awareness																		
☐	☐	☐	☐	☐	☑	☐	☐	Lack of CE awareness	☐	Lack of theoretical information	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Lack of CE awareness	☐	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of theoretical information	☐	Lack of technical know-how	☑	☐	☐	☐	☐	☐	☐	☐
B7. Integration and collaboration																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of constant supplier	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of shared vision and willingness to collaborate	☐	☑	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☑	☐	Lack of constant supplier	☐	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐
B8. Cost																		
☐	☐	☐	☐	☐	☐	☐	☑	High investment cost	☐	Uncertainty in profitability	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	High investment cost	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Uncertainty in profitability	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
B9. Technical infrastructure																		
☐	☐	☐	☐	☐	☐	☐	☑	Inadequate of infrastructure facilities	☐	Lack of high-tech in reverse logistics	☐	☐	☐	☐	☐	☐	☐	☐

EXPERT PROFILE		
No.	***Questions***	***Answer***
1	**Name**	**Huynh Thanh Dien**
2	**Gender**	**Male**
3	**Highest educational qualification obtained** ** B. Sc, M. Sc, Ph. D, etc*	**PhD**
4	**Areas of expertise** **Please explain specifically the position and area of expertise, e.g., Senior manager of the Quality management Department of Garment company A*	**Researcher on corporate governance, entrepreneurship, corporate restructuring, and policy consultant to create a business development environment in Vietnam | Lecturer at HCM University of Economics**
5	**Do you have experience in the textile industry?** **yes/ no*	**Yes**
6	**Years of work experience in the textile and garment industry** ** < 5 years, between 5 years and 10 years, > 10 years*	**20 years in research**

SURVEY ON BARRIERS OF CIRCULAR SUPPLY CHAIN IN VIETNAM'S TEXTILE INDUSTRY

Background

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Intensity of Importance	Definition
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2, 4, 6, 8	Intermediate values

PAIRWISE COMPARISONS (MAIN BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
☐	☐	☐	☐	☐	☐	☐	☐	*Management and decision-making*	☐	*Labour*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐		☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Materials*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Labour*	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Design challenges*	☐	*Materials*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Integration and collaboration*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Materials*	☑	*Rules and regulations*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Rules and regulations*	☑	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☑	☐	☐	☐	☐	*Knowledge and awareness*	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Integration and*	☐	*Economic*	☐	☐	☐	☐	☑	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☐	*collaboration*	☐	*Technical infrastructure*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Economic*	☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

PAIRWISE COMPARISONS (SUB-BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
B1. Management and decision-making																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of performance evaluation system*	☐	*Lack of acceptance CE models*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	*Lack of performance evaluation system*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Lack of acceptance CE models*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
B2. Labour																		
☐	☐	☐	☐	☐	☑	☐	☐	*Labour intensiveness*	☐	*Lack of trained intermediate staff*	☐	☐	☐	☐	☐	☐	☐	☐
B3. Design challenges																		
☐	☐	☐	☐	☐	☐	☐	☑	*Lack of complementary processes*	☐	*Complexity in product architecture*	☐	☐	☐	☐	☐	☐	☐	☐
B4. Materials																		
☐	☐	☐	☐	☐	☐	☑	☐	*Availability of recyclable materials*	☐	*Lack of high quality*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	*Availability of recyclable materials*	☐	*Complexity in material composition*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*High cost of raw materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☑	*Complexity in material composition*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*High cost of raw materials*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Complexity in material composition*	☐	*High cost of raw materials*	☐	☑	☐	☐	☐	☐	☐	☐
B5. Rules and regulations																		
☐	☐	☐	☐	☐	☐	☐	☑	Lack of sectorial standardization	☐	Lack of certifications	☐	☐	☐	☐	☐	☐	☐	☐
B6. Knowledge and awareness																		
☐	☐	☐	☐	☑	☐	☐	☐	Lack of CE awareness	☐	Lack of theoretical information	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Lack of CE awareness	☐	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of theoretical information	☐	Lack of technical know-how	☐	☐	☑	☐	☐	☐	☐	☐
B7. Integration and collaboration																		
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of constant supplier	☐	☐	☑	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of shared vision and willingness to collaborate	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	Lack of constant supplier	☐	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐
B8. Cost																		
☐	☐	☐	☐	☐	☑	☐	☐	High investment cost	☐	Uncertainty in profitability	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	High investment cost	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Uncertainty in profitability	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
B9. Technical infrastructure																		
☐	☐	☐	☐	☐	☐	☐	☐	Inadequate of infrastructure facilities	☑	Lack of high-tech in reverse logistics	☐	☐	☐	☐	☐	☐	☐	☐

EXPERT PROFILE

No.	Questions	Answer
1	**Name**	**Nguyen Lan**
2	**Gender**	**Male**
3	**Highest educational qualification obtained** ** B. Sc, M. Sc, Ph. D, etc*	**B. Sc**
4	**Areas of expertise** **Please explain specifically the position and area of expertise, e.g., Senior manager of the Quality management Department of Garment company A*	**Sustainable Development Manager | Dong Quang Textile Joint Stock Company | Raw material supplier**
5	**Do you have experience in the textile industry?** **yes/ no*	**Yes**
6	**Years of work experience in the textile and garment industry** ** < 5 years, between 5 years and 10 years, > 10 years*	**12 years**

SURVEY ON BARRIERS OF CIRCULAR SUPPLY CHAIN IN VIETNAM'S TEXTILE INDUSTRY

Background

This study aims to identify and rank circular economy barriers for Vietnam's textile industry in the current context. Barriers were identified from existing literature and expert recommendations. Using the AHP approach, this study ranks each of the factors' pairwise comparisons. From there, deep insights are provided for Vietnamese textile and garment enterprises that transform into a circular economy for sustainable development.

🖅 You serve as an expert in this study. Your contribution is an indispensable part of completing this research.

Instructions

If you think the barrier on the left is more Strongly Important than the barrier on the right, you can tick (✔) in column Strongly Important (5) on the left side. However, if you think that the factor on the right is more Strongly Important than the factor on the left, you can tick (✔) in column number Strongly Important (5) on the right side.

However, suppose you think that both barriers are of equal importance. In that case, you tick (✔) the middle option, i.e. column Equal (1).

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate values

PAIRWISE COMPARISONS (MAIN BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
☐	☐	☐	☐	☐	☐	☐	☑	*Management and decision-making*	☐	*Labour*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☑	☐	☐	☐	☐	☐		☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☑	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Labour*	☐	*Design challenges*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Design challenges*	☐	*Materials*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Rules and regulations*	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☐	☐	☐	☐	☑	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☐	☐	☐	☐	☑	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Technical infrastructure*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Materials*	☐	*Rules and regulations*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Knowledge and awareness*	☐	☑	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☐	☐	☑	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Rules and regulations*	☑	*Knowledge and awareness*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☐	*Economic*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	*Knowledge and awareness*	☐	*Integration and collaboration*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐		☑	*Economic*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐		☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

☐	☐	☐	☐	☐	☐	☐	☐	*Integration and collaboration*	☐	*Economic*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Integration and collaboration*	☑	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Economic*	☐	*Technical infrastructure*	☐	☐	☐	☐	☐	☐	☐	☐

PAIRWISE COMPARISONS (SUB-BARRIERS)

Extremely important (9)	(8)	Very strong important (7)	(6)	Strongly important (5)	(4)	Slightly important (3)	(2)	BARRIER	Equal (1)	BARRIER	(2)	Slightly important (3)	(4)	Strongly important (5)	(6)	Very strong important (7)	(8)	Extremely important (9)
B1. Management and decision-making																		
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of performance evaluation system*	☐	*Lack of acceptance CE models*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	*Lack of performance evaluation system*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☑	☐	☐	*Lack of acceptance CE models*	☐	*Lack of traceability*	☐	☐	☐	☐	☐	☐	☐	☐
B2. Labour																		
☐	☐	☐	☐	☐	☐	☐	☑	*Labour intensiveness*	☐	*Lack of trained intermediate staff*	☐	☐	☐	☐	☐	☐	☐	☐
B3. Design challenges																		
☐	☐	☐	☐	☐	☐	☑	☐	*Lack of complementary processes*	☐	*Complexity in product architecture*	☐	☐	☐	☐	☐	☐	☐	☐
B4. Materials																		
☐	☐	☐	☐	☑	☐	☐	☐	*Availability of recyclable materials*	☐	*Lack of high quality*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	*Availability of recyclable materials*	☐	*Complexity in material composition*	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Availability of recyclable materials*	☐	*High cost of raw materials*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*Complexity in material composition*	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Lack of high quality*	☐	*High cost of raw materials*	☐	☐	☐	☑	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	*Complexity in material composition*	☐	*High cost of raw materials*	☐	☐	☑	☐	☐	☐	☐	☐
B5. Rules and regulations																		
☐	☐	☐	☐	☐	☐	☑	☐	Lack of sectorial standardization	☐	Lack of certifications	☐	☐	☐	☐	☐	☐	☐	☐
B6. Knowledge and awareness																		
☐	☐	☐	☐	☐	☐	☑	☐	Lack of CE awareness	☐	Lack of theoretical information	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☑	Lack of CE awareness	☐	Lack of technical know-how	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of theoretical information	☐	Lack of technical know-how	☑	☐	☐	☐	☐	☐	☐	☐
B7. Integration and collaboration																		

☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of constant supplier	☐	☐	☐	☐	☑	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐	Lack of sharing information and communication	☐	Lack of shared vision and willingness to collaborate	☑	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	Lack of constant supplier	☐	Lack of shared vision and willingness to collaborate	☐	☐	☐	☐	☐	☐	☐	☐
B8. Cost																		
☐	☐	☐	☐	☐	☐	☐	☑	High investment cost	☐	Uncertainty in profitability	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☑	☐	☐	☐	High investment cost	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☑	☐	Uncertainty in profitability	☐	Failure to provide the scale of production	☐	☐	☐	☐	☐	☐	☐	☐
B9. Technical infrastructure																		
☐	☐	☐	☐	☐	☐	☑	☐	Inadequate of infrastructure facilities	☐	Lack of high-tech in reverse logistics	☐	☐	☐	☐	☐	☐	☐	☐