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RESEARCH AND ANALYSIS

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Barriers to the circular economy: The case of the Dutch technical and interior textiles industries

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Abstract

The academic literature offers some insights about lagging progress on circular economy (CE) transition, including cultural, regulatory, market, and technical barriers. There is also an increasing body of knowledge about barriers to CE adoption that takes a macro-level perspective across industries. However, such studies have largely neglected the industry scale. This study fills that gap by examining barriers to CE transition in the Dutch technical and interior textiles industries. Using data from 27 interviews with manufacturers and retailers, the study finds that high costs for production and marketing, along with lack of consumer interest, are among the most substantial barriers. To provide a system-wide perspective, the study conceptualizes relationships among barriers as a chain reaction: limited knowledge of CE design options raises the difficulty and cost of delivering high-quality circular products at the firm level, while limited availability of circular supply streams combined with the orientation of existing production systems toward linear supply chains constrain CE transition at the industry level. These findings highlight the need for intervention at levels beyond the scale of individual firms, a key implication for public policy.

KEYWORDS
circular economy, industrial ecology, Netherlands, public policy, sustainability, textiles

1 | INTRODUCTION

Despite the growing body of research about circular economy (CE) practices (Kirchherr & van Santen, 2019), there remains an incomplete understanding about factors determining individual firms' ability to adopt CE practices—particularly at the industry-specific level. To fill this gap, this article addresses barriers to CE adoption from the perspective of the Dutch technical and interior textiles industries. Interior textiles are "specialised textiles used [for comfort or aesthetics] in homes, offices, hospitals, hotels, schools, aircraft and automobile interiors" (Krishnakumar & Sureshkumar, 2017). Technical textiles are "materials and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics" (Textile Institute, 1994); examples of the latter are professional apparel (e.g., police armor and uniforms for food preparation), medical materials like bandages and slings, and materials for agricultural production or storage. See Appendix S1, Supporting Information, for a comprehensive list of products typically made by each industry.

The technical and interior textiles industries, which we analyze collectively, have undertaken some efforts to embrace CE but has not been particularly successful; their practices remain primarily linear despite high potential for CE transition. The industry has been found to exploit the natural environment through the use of chemicals, water, and land (De Souza et al., 2010; Fischer & Pascucci, 2017; Franco, 2017; Muthu, 2017; Ozturk et al., 2016; Terinte et al., 2014). High demand for textiles has also led to substantial production of waste that, despite potential for reuse and recycling, ultimately occupies landfills or is processed through incineration (De Souza et al., 2010; Fischer & Pascucci, 2017; Franco, 2017; Muthu, 2017; Ozturk et al., 2016; Terinte et al., 2014).

In seeking to understand the barriers to CE transition in the technical and interior textiles industries, this study builds on a study by Kirchherr et al. (2018) that identified cultural barriers, tepid consumer interest and awareness, hesitant company culture, and incoherent public policies as barriers most commonly cited. The analytical framework used in the referenced study is selected as a starting point for this study for three reasons: the study is among the most cited of its kind, was conducted relatively recently (with timely and emerging policy challenges in mind), and is empirically based on a context (the EU) that is similar to the context in this study (the Netherlands). The limitation of the Kirchherr et al. study, however, is that it took an economy-wide perspective and was not industry-specific; thus, its findings are appreciated primarily at a macro-level. The present study, by contrast, investigates CE barriers at an industry-specific level and is also one of the few medium-N studies of CE barriers (see Kirchherr and van Santen (2019) for a review of related literature). Further, the present study identifies a combination of CE barriers that unfold in a sequence that differs from the Kirchherr et al. study, generating new insights for how one constraint to transition leads to another. These insights are elaborated in the discussion.

This study's research question asks: what barriers are faced by firms in the Dutch technical and interior textiles industries in transitioning to CE? We use the four barrier types proposed by Kirchherr at al. (2018) to interpret findings, across which the aforementioned chain reaction is identified. We conceptualize this chain reaction as the cascading sequence of interconnected factors that create or perpetuate barriers to CE transition. It is this type of systemic perspective that leads us to consider barriers not as independent forces but as interrelated. Our conceptual justification is that effectiveness in the study and practice of CE is contingent on recognizing the concept not as a marginal or perfunctory exercise but as a systemic macro-transition focused on sustainability—as argued by Kirchherr et al. (2017): "CE must be understood as a fundamental systemic change instead of a bit of twisting of the status quo to ensure its impact" (p. 229). This perspective justifies our exploration of barriers as a chain reaction.

This article proceeds with a literature review about CE transition as a system-wide effort, CE barriers within the technical and interior textiles industries, and a description of how our framework has been previously applied. The article continues with background on CE policy in the Netherlands and on the Dutch textiles industry. A description of data and methods follows, including interview sampling and data coding processes. The subsequent section presents and discusses findings—including a description of how a chain reaction of factors leads to high costs of producing and selling circular products and by extension low consumer interest. The conclusion provides a summary, suggests opportunities for further research, and describes actionable policy implications.

2 | LITERATURE REVIEW

The concept of CE is in practice a sustainability transition away from the linear production model and thus invites a system-based view of barriers. The conceptual roots of CE are not new, with early notions going back to the late 1960s (Fischer & Achterberg, 2016; Gregson et al., 2004; Boulding, 1966). According to Kirchherr et al. (2017), CE is "an economic system based on business models that replace the 'end-of-life' concept by closing the loop through reducing, recovering, reusing and recycling materials in production, distribution and consumption processes" (p. 224–225). While the CE concept encompasses many practices that have long been adopted in piecemeal fashion, it has congealed into a collection of related practices across a hierarchy of activities (e.g., the 'R ladder'; Rood & Kishna, 2019; Potting and Hanemaaijer, 2018). More broadly, the concept provides a vision for moving away from linear production paradigms amidst urgency to pursue environmental sustainability. Despite its clear prescriptions, however, the concept has in some instances been co-opted by industry for commercial purposes, reminiscent of a long-running corporate effort colloquially referred to as 'green-washing' (Watson, 2017; Dahl, 2011; Holcomb, 2008). Many firms have embraced the language of circularity for branding purposes without necessarily adopting substantive changes that reflect the concept (Crocker, 2018; Kalmykova et al., 2018; Valenzuela & Böhm, 2017). As such, better understanding is needed about barriers in order to push firms to more substantively embrace CE beyond interpreting it simplistically or using it merely as a branding mechanism.

CE transition been explored in a variety of contexts: extended producer responsibility for the electronics industry in South Korea (Manomaivibool & Hong, 2014), bottom-up initiatives for CE transition in the Netherlands (Russell et al., 2020), closed-loop supply chains and CE transition for the automotive industry in India (Bhatia et al., 2020) and Pakistan (Agyemang et al., 2019), business models and stakeholder behaviors as they impact CE transition in the built environment (Hart et al., 2019), technologies and materials access in circular procurement in Netherlands cities (Campbell-Johnston et al., 2019), and innovation in business models, circular design, and collaboration in Netherlands manufacturing (Luttikhuis, 2020). The complexity of CE transition is reflected in numerous barriers to the adoption of related practices across categories of business activities including design and production, consumption, recycling and recovery, and logistics (van Eijk, 2015). A robust literature has materialized around the issue of transition barriers; Sopjani et al. (2020) review 527 publications addressing transitions away from linear production models, and similar reviews are provided by Grafström and Aasma (2020), Jusel and Burinskienė (2019), and Lieder and Rashid (2016). CE barriers can be classified also as 'hard' (technical and economic) or 'soft' (values and attitudes) (de Jesus & Mendonça, 2018). Kirchherr et al. (2018) classify CE barriers into four types: cultural (most pressing), technical (least pressing), market, and regulatory. Ghisellini and Ulgiati (2020) further propose seven classifications of barriers, adding 'economic' (R&D investment), 'financial' (access to capital), and 'networking' (platforms) to the four proposed by Kirchherr et al. Russell et al. (2020) propose five classifications of barriers: finance, institutions, policy, technology and knowledge, and social factors. Dieckmann et al. (2020) identify nine barriers for CE in waste feather processing in the UK, and Vermunt et al. (2019) identify internal and external barriers analyzed across four types of CE business models among 31 firms in the Netherlands. Van Loon and Van Wassenhove (2020) find that the greatest barrier is the absence of economically viable CE transition plans at the firm level. The literature has also examined strategies for overcoming such barriers. For example, Gupta et al. (2020) use a Delphi-based study with input from manufacturing experts in India to identify 37 barriers from which seven response strategies are derived; these strategies are marketing, R&D, upskilling, networking, regulations, technology, and economic incentives. This wide mix of analytical perspectives illustrates how scholarship has variously sought to understand the challenges of CE transition.

Barriers to CE transition specifically within the textiles industry are receiving increased attention in the literature. In a review of 109 academic articles related to such barriers, Jia et al. (2020) derive a conceptual framework in which barriers (e.g., insufficient strategic planning, training and education, performance measurement, and investment) lead to compromised performance that impacts the design of products, practices, and business relationships related to CE transition. In a review and focus group-based study of CE transition in the textiles industry, Kazancoglu et al. (2020) identify 25 barriers sorted into nine categories (as a departure from previous classifications), including management and decision-making. Suarez Visbal (2020) investigates the impact on social and employment-related factors of CE transition strategies originating in the Netherlands and their manifestation in value chains, and Fischer and Pascucci (2017) examine CE transition as a catalyst for new types of institutional arrangements, approaches to ownership and service provision, and interfirm collaborations within the Dutch textiles industry. To this emerging literature focused on the Dutch textiles industry we add an empirically based identification of CE barriers in a chain reaction, illustrating how individual barriers magnify their effects by inter-relating.

This article's analysis is based on the framework introduced by Kirchherr et al. (2018). The framework is an effort to theorize barrier types across cultural, regulatory, market, and technical factors with a cross-industry focus. Cultural factors include, at a high level, the predominance of the linear production system and, within that, company cultures and attitudes that limit CE facilitation efforts like willingness to collaborate and customer awareness about and willingness to purchase circular products. Regulatory barriers include lagging global consensus on matters of material exchange and usage, and the related effects on firms with supply chains across borders. These barriers also include obstructing rules and laws that impact procurement and production. Market barriers include limited funding and capital access for investment in the kinds of infrastructures that enable CE transition, leading to high up-front investment costs. Low prices for virgin (nonreused) materials and standardization of processes and products in a linear frame also contribute to market barriers. Finally, technical barriers emerge from lack of data about the impacts of CE transition, reducing commitment to the types of larger-scale initiatives and infrastructures whose scale would improve the economic feasibility of CE transition; this barrier and the associated lack of commitment diminish firms' willingness to design and deliver circular products. In the study, Kirchherr et al. (2018) identify a causal chain reaction within this framework, beginning with lack of data (fourth barrier) and progressing through lack of finding (third barrier), obstructing laws (second barrier, emerging in the absence of industry pressure), and ending with limited consumer awareness and interest as a cultural factor emerging from the high cost of circular end-products. In similar fashion, this study empirically identifies the presence of a chain reaction in the Dutch technical and interior textiles industries by framing the inquiry and interpretation through the Kirchherr et al. (2018) framework.

3 | BACKGROUND

3.1 | CE policy in the Netherlands

The Netherlands has been described as a country poised for CE transition (Potting et al., 2017; van Buren et al., 2016; Bastein et al., 2013). The Dutch government has exhibited commitment by outlining five priority industries in promoting CE transition: biomass and food, plastics, manufacturing, construction, and consumer goods (Government of the Netherlands, 2016). Given these industry-based initiatives, studies have emerged addressing CE transition (if not barriers specifically) at the industry level in the Netherlands; examples are logistics (van Buren et al., 2016), mobile phone repair (Türkeli et al., 2019), eco-cement (Kemp et al., 2017), e-waste (Golsteijn & Martinez, 2017), water use and treatment (Roest et al., 2016), and plastics (Verrips et al., 2019; Leslie et al., 2016).

Distinguishing Dutch CE policy from that of other countries—including China, a robust early adopter of CE-related practices—is its focus on resource management ('up-stream' sourcing and natural systems) rather than 'end-of-pipe' or 'end-of-life' factors like waste management and materials recycling and recovery. A study of the Netherlands by the not-for-profit organization Circle Economy (2020) found that the country reached 24.5% economy-wide circularity in 2020. However, this measure is based on the percentage of consumed materials (i.e., "minerals, fossil fuels, metals and biomass") cycled back into the economy and is thus not a complete measure of comprehensive circularity as promoted by the policy visions of the Netherlands government. Beyond this rather narrow recycling-based operationalization of circularity, the Netherlands has still eclipsed many peer countries in focusing on resource management more broadly (Brears, 2018).

In the interest of advancing CE transition, policy ambitions to reduce consumption of abiotic (nonliving natural) resources are achievable through increased use of renewable resources, refinements to energy and production processes, and redesigns in the product chain from resource extraction to waste management. Policy strategies in the Netherlands are focused principally on improvements in resource efficiency across existing and new product chains, and on the use of sustainably sourced materials to substitute for the use of abiotic materials (Potting et al., 2017). According to a policy report published by PBL Netherlands Environmental Assessment Agency (Potting & Hanemaaijer, 2018), "the preliminary government target for 2030 is a 50% decrease in the use of primary abiotic resources (minerals, metals and fossil fuels), while the target for 2050 is a fully circular economy in the Netherlands" (p. 8). Additionally, the Netherlands government's official policy document "A Circular Economy in the Netherlands by 2050" directly addresses the issue of CE transition obstacles, which include regulatory hindrances, high price of circular materials, insufficient knowledge and expertise at the firm level, counterproductive behavior among firms and consumers, vested commercial interests in maintaining the status-quo, and lack of international cooperation (p. 17). It is clear that deeper understandings about barriers to CE transition are needed, and the Netherlands is an instructive case.

3.2 | Textiles industry in the EU and the Netherlands

To understand how CE barriers manifest themselves, the industry-specific perspective has instructive value. In Europe, textiles are considered a core consumer goods industry, accounting for roughly 37% of all industrial activity and employing roughly 1.7 million workers (EURATEX, 2017; Franco, 2017). The industry also holds the problematic reputation of being highly unsustainable due to its prolific use of water, hazardous chemicals, and fossil fuels needed for producing synthetics (Boström & Micheletti, 2016; Franco, 2017; Resta et al., 2016). Due to constraints in recovering materials, the potential for recycling in the industry is somewhat limited (Hawley, 2006). Additionally, the industry's environmental impacts reflect a growing geographic imbalance between production and consumption, with production based in lower-income countries that must absorb the negative externalities of manufacturing, and consumption based in wealthier countries producing large amounts of consumer waste (Safaya et al., 2016; Saxena et al., 2017; Tyler, et al., 2006).

This study focuses on firms engaged in secondary and tertiary activities. Regarding the secondary sector, Dutch textiles manufacturing firms typically import already-processed materials (e.g., fibers, yarns, and fabric). Depending on the product (e.g., interior textiles or technical textiles), secondary manufacturing processes can occur in the Global North or Global South. Despite the prevalent share of textile secondary manufacturing activity worldwide taking place in Global South countries through outsourcing and 'offshore' contracting, many Dutch firms are embracing an emerging industry trend (Kochar, 2018; Sello, 2018) by bringing secondary processes and production steps in-house (within facilities in the Netherlands) to enhance customer responsiveness and quality control. Further, the increasing sophistication of technical processes (e.g., nanotechnology as applied to textiles; Brouwer and Van Der Zwan, n.d.) represents the growing appetite among Dutch firms to repatriate production processes while enhancing precision and value-add. This underscores the relevance of examining barriers faced by Dutch firms not only from the retail perspective but also from the production perspective. Figure 1 provides a schematic overview of the textiles industry supply chain, distinguishing among primary, secondary, and tertiary sectors; percentages for collection and recycling, incineration and landfill, and collection and reuse are based on data from FFact (2014). Table 1 provides an overview of the 'R strategies' adopted by the technical and interior textiles industries.

4 | DATA AND METHODS

4.1 | Interview approach and sampling

The Netherlands is chosen as the country context because it has been active in CE practice and would be expected to have experience facing barriers to CE transition. In exploring the Dutch technical and interior textiles industries, we further narrow the study to small- and medium-sized enterprises (SMEs), focusing on production (secondary sector) and retail delivery (tertiary sector). SMEs are defined as firms employing up to 50 individuals (small) and between 51 and 520 individuals (medium) (European Commission, 2015). This qualitative study uses data from 27 interviews of professionals holding positions in management, leadership, or other influence with their organizations. The sampling strategy aimed to capture the perspectives of interviewees with the greatest degree of influence over the strategic actions of their firms. Baker and Edwards (2012) state that 15 to 20 interviews are sufficient to reach thematic saturation (i.e., no novel findings are generated by conducting additional interviews); multiple other studies have also determined that thematic saturation is obtainable from 20 or fewer interviews (Hennink et al., 2017; Namey et al., 2016; Ando et al., 2014; Francis et al., 2010; Guest et al., 2006). Based on these studies, we determined that a minimum of 20 interviews was enough to reach thematic saturation for the study. The snowball sampling method was used, in which interviewees made referrals to other

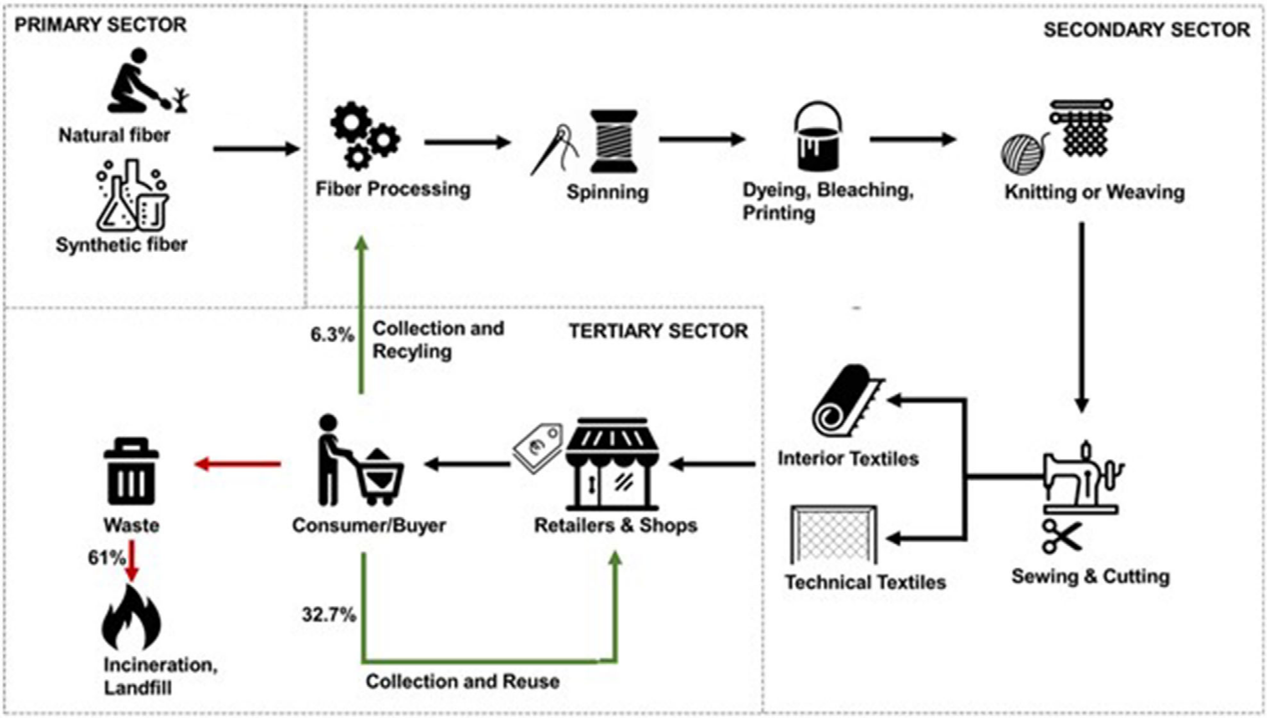

FIGURE 1 Schematic overview of the textiles industry (*Source*: authors; source for numerical data: FFact, 2014)

TABLE 1 'R strategies' of the technical and interior textiles industries

Strategy	Details
Reuse	• A common method at the firm level is through product-as-a-service models (PaaS). An example is the leasing or renting of carpet tiles. After a certain number of years, the party leasing carpet tiles can choose a new model or design and 'old' tiles are cleaned and resold (reused) for a cheaper price to another interested party. Products are reused through second-hand resale (on- or offline). • Manufacturers most often do not possess insight into the consumer behavior regarding this issue because the transaction occurs outside the scope of their business. Hence, it is not within their power to adopt or manage the process unless they promote this consumer behavior indirectly through marketing and or communication effort.
Refurbish	• Refurbishing or repairing (e.g., repairing service offered by a company) is a strategy observed in some of the surveyed interior textiles firms. For example, a carpet can be refurbished to improved condition in order to extend its lifetime. In the case of technical textiles, refurbishment is rare due to high quality requirements to maintain the functionality of the technical textile (e.g., a rope or net that needs to endure certain pressures or strengths). • A barrier in refurbishment is that products can rarely be restored to original functional quality. For that reason, the aim is to extend the functional lifetime with at least minimum quality requirements to fulfil the product's function, often at the cost of the product's aesthetics.
Recycle	• Mechanical or chemical recycling, with a majority of efforts done mechanically due to the often low technological sophistication of chemical recycling initiatives. • Chemical recycling is done often when the product has high levels of pollution (e.g., an end-of-life filter from the technical textiles subsector). • Mechanical recycling typically involves shredding fabric material back to fibers and reprocessing the fibers to make new textiles.

potential interviewees in their networks (Kirchherr and Charles, 2018; Handcock & Gile, 2011). The interview selection sampling technique sought to generate a random sample across the two sub-industries (technical and interior textiles).

To encourage interviewees to respond openly and freely, the names of interviewees and their firms were pledged to be anonymized during the coding process. All interviews were conducted by telephone, as represented by the first element of the code (T) used in Table 2. The second coding element represents the industry in which the firm is active (S for secondary or T for tertiary). The third coding element represents the size of the firm

TABLE 2 Interview codes and details ($N = 27$)

Technical textiles		Interior textiles	
Code	**Role**	**Code**	**Role**
TSS1	Company co-owner	TSS2	Marketing manager
TSS3	Business developer	TSS7	N/A
TSS4	Manager	TSM1	Director of sustainability
TSS5	Business owner	TSM2	Leading developer
TSS6	N/A	TSM4	Quality manager
TSM3	R&D manager	TSM9	Factory manager
TSM5	Company director and owner	TSM10	Sustainability manager
TSM6	Company owner	TSM11	N/A
TSM7	Maintenance and engineering manager	TTS1	Managing director
TSM8	CEO	TTS2	Company director
TTS4	N/A	TTS3	N/A
TTM1	Company manager	TTM3	Sales manager
TTM2	Sales and marketing manager	TTM4	Innovation manager
TTM5	Sourcing coordinator		

(S for small and M for medium). The number at the end of the coding line (i.e., 1,2,3…10) indicates the chronological order in which interviews were conducted. Table 2 displays information about interviewee positions and the industries they represent (12 for interior textiles and 14 for technical textiles).

4.2 | Transcribing and coding

Interview questions were designed to help identify firm-level barriers to adoption of CE practices (see Appendix S2, Supporting Information, for a full list of interview questions). This design approach and the subsequent data analysis reflect the following principal themes: (i) barriers to CE adoption, (ii) the chain reaction these barriers generate, and (ii) strategies and challenges to overcome these barriers. We also used interviews to help identify the chain reaction, as described in the literature review and in Kirchherr et al. (2018). To this end, we probed interviewees to discuss linkages between barriers and possible chain reactions, and to reflect on opportunities for public policy to address issues related to chain reactions. The coding framework was adapted from that used by Kirchherr et al. (2018), which adopted four classifications of barriers (cultural, market, regulatory, and technical). These four classifications are defined as follows; a 'cultural barrier' is a mix of beliefs about CE that cohere into established patterns or habits deeply engrained in organizations (Kirchherr et al., 2018); a 'regulatory barrier' is a public policy that limits the legal freedom of firms to adopt or experiment with alternative practices that would facilitate CE transition; a 'technical barrier' is an impediment or bottleneck that limits the operational or technological capacity of a firm to alter existing approaches to production; a 'market barrier' limits the competitive exchange of goods that may make CE transition more economically viable. In remaining consistent with the coding procedures of the Kirchherr et al. study, we also adopt that study's approach of identifying chain reactions. As mentioned in the introduction, we conceptualize this chain reaction as the cascading sequence of interconnected factors that create or perpetuate barriers to CE transition.

During the coding process, analytical dimensions were established that enabled the categorization of trends through word frequencies and key phrases. All transcriptions were coded and analyzed using NVivo 11. Reflecting the structure of the questionnaire, the analysis focused on (i) barriers to CE adoption and (ii) strategies and challenges to overcome these barriers. Interviewees were asked to list the five most significant barriers to CE transition and responses were quantified by their total number of mentions. Responses were mapped and categorized according to the most commonly referenced barriers, and classification of barrier types reflected the same approach used by Kirchherr et al. (2018); barriers not classifiable under predetermined categories were labeled and coded accordingly. Findings are interpreted through a conceptual chain reaction, as described in the literature review and by Kirchherr et al. (2018) as a sequence of factors that together reflect the embeddedness of barriers within the overall CE ecology.

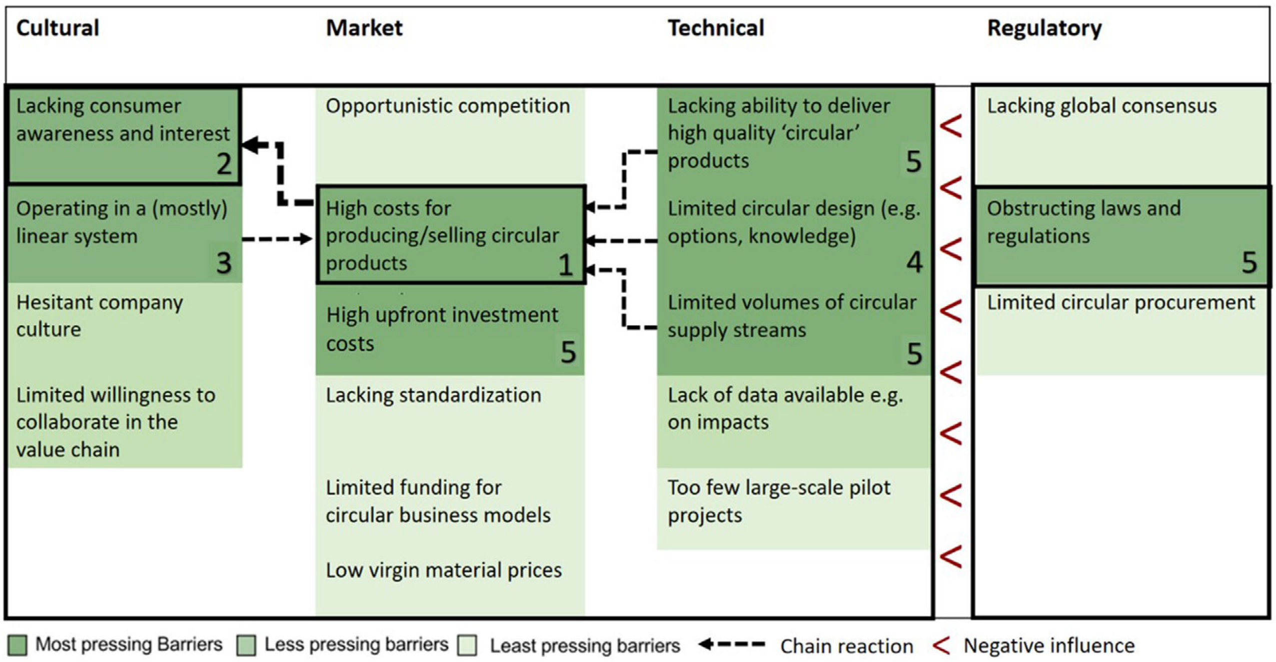

FIGURE 2 CE barriers across four categories (numbers represent rank of barrier severity) (*Source*: authors, adapted from Kirchherr et al., 2018)

5 | FINDINGS AND DISCUSSION

5.1 | Chain reaction of CE barriers

The concept of a chain reaction of CE barriers reflects the fact that certain barriers generate conditions in which other barriers emerge. The practical implication is that breaking or unraveling this chain reaction requires attention not exclusively on any single factor but concurrently on multiple factors that exist across policy domains, with improvements having a synergistic effect. In the case of CE barriers in the Dutch technical and interior textiles industries, as specified by the arrows in Figure 2, this reaction unfolds as follows: regulatory barriers (i.e., restrictions on new or experimental practices) shape an environment in which technical barriers emerge (i.e., lack of ability to deliver high-quality circular products, limited options and knowledge among firms to embrace circular design, and limited supply streams of circular products). The finding about limited knowledge confirms that of Jia et al. (2020), whose conceptual framework regarding CE barriers includes factors like insufficient training and education. The type of causal relationship present in our identified chain reaction is reflected in findings by Hancher and Moran (1989) that cultural barriers shape regulatory barriers, by Marshall (2012) that regulatory barriers shape market barriers, and by Ahn (2016) that market barriers shape technical barriers. The finding about the role of regulatory barriers, while not a principal barrier for CE transition, confirms findings of de Jesus and Mendonça (2018), Govindan and Hasanagic (2018), and Zhu et al. (2015). This finding about the role of technical barriers confirms similar findings by de Jesus and Mendonça (2018), Shahbazi et al. (2016), and Preston (2012). At the same time, these findings are inconsistent with the relative insignificance of technical barriers found in Kirchherr et al. (2018).

Technical barriers lead to market barriers via high costs for producing and selling circular products and thus limit CE product offerings. The finding about the role of market barriers confirms those of Ranta et al. (2018), Mont et al. (2017), Pheifer (2017), and Rizos et al. (2015). Limited market barriers in turn exacerbate cultural barriers, as high input costs are 'passed on' to end-consumers through high prices for CE products. The finding about cultural barriers confirms those by Kazancoglu et al. (2020), Ranta et al. (2018), Mont et al. (2017), Pheifer (2017), and van Eijk (2015) within firms and similar findings by Repo and Anttonen (2017) across society more broadly. Negative perceptions among end-consumers about high prices, in the absence of awareness about the broader benefits of CE transition, generate a feedback loop that further crystalizes a culture obstructing CE transition. Peripherally, Figure 2 also illustrates that the embeddedness of the linear production system, as a supply-side cultural barrier (i.e., within firms and the industry more generally), leads to high costs for deviating from the dominant system—that is, producing CE products in the absence of a mature market for CE-related inputs and skills. Without CE business partners, firms undertaking CE must do so alone and at relatively high cost, as the general culture remains stagnant and existing investments, systems, and knowledge remain oriented toward linearity. Consequently, CE products become a 'niche' field with relatively thin and uncompetitive markets for inputs and final products.

TABLE 3 CE barriers categorized and scored

Barrier		Scale	Percentage	Ranking
Cultural	Lacking consumer awareness and interest	Industry	46%	**2**
	Operating within a mostly linear system	Industry	42%	**3**
	Limited willingness to collaborate in the value chain	Industry	12%	7
	Hesitant company culture	Firm	8%	8
Regulatory	Obstructing laws and regulations	Industry	23%	**5**
Market	High cost of producing/selling circular products	Industry	73%	**1**
	High upfront investment costs	Firm	35%	**5**
	Low virgin material prices	Industry	8%	8
	Limited funding for circular business models	Firm	8%	8
	Opportunistic competition	Industry	4%	9
	Lacking standardization	Industry	4%	9
Technical	Limited circular designs (e.g., knowledge, options)	Firm	38%	**4**
	Limited volumes of circular supply streams	Industry	35%	**5**
	Lacking ability to deliver high quality circular products	Firm	35%	**5**
	Lack of data, for example, on impacts	Firm	8%	8
	Too few large-scale pilot projects	Industry	4%	9
Scoring ratios				
X:Y	Score of industry-level barriers:Score of firm-level barriers (number)			2.03:1
%:%	Score of industry-level barriers:Score of firm-level barriers (percentage)			67:33

The chain reaction has been identified based on interview data that link one barrier classification with another. For example, an interviewee offers evidence of the culture-market chain reaction, stating "currently, setting up a circular system to return your end-products is quite difficult and not financially attractive for the customer. It could be improved by offering a discount when they buy a new (recycled) product, but it has to be economically viable, otherwise it is just a disadvantage to make it even work" (TSM3). Consumer preference is also cited as a cultural factor limiting market opportunities; according to an interviewee, "even though we offer more sustainable circular products, the consumer will still choose the cheaper option…despite knowing that the product cannot be made that cheap without some negative socio-environmental impacts" (TTM3). The implication is that the production system has been structured over time in a path-dependent way that maximizes its own efficiency and reverts by default to linearity—a phenomenon that has been described as 'linear lock-in' (Sopjani et al., 2020).

5.2 | CE barriers categorized according to salience

To further understand the mechanics of the chain reaction, it is necessary to examine individual barriers and their inter-relationships. Table 3 presents a 'scoring' of individual barriers by percentage of responses mentioning a given barrier, according to the following criteria: highest percentages receive a rank of 1, second highest 2, and so forth. Scores that are equal in percentage share a position in the ranking. Barriers scoring below five percent are excluded from the table. Ratio calculations indicate that industry-level barriers are more substantial than firm-level barriers. It is prudent to note that these data are not representative in a strict statistical sense due to the number of interviews (27).

The most pressing barrier is the high cost of producing and selling circular textile products and offering related services (73% of interviewees' answers). This finding departs from the Kirchherr et al. (2018) study in that a market barrier is seen to be the most pressing among all barrier types, whereas market barriers are found in the Kirchherr et al. study to be the second most pressing (behind cultural). According to an interviewee emphasizing the need to make CE products cost-competitive, "we need to adjust the product to the most competitive price possible for recycling options. We need to internalize and streamline the recycling scheme to be just as efficient as with the normal linear industry process" (TSM1). Another interviewee states, "the first and most pressing barrier of them all has to simply be the costs for us. The trade-off between remanufacturing and recycling linear end-of-life materials into a useful circular product is in many cases too high compared to disposing the materials" (TSM9). These quotes illustrate the mechanics of how market barriers and high costs of production make CE transition difficult for firms. Further, the convenience and efficiency of maintaining existing linear supply chains, as the flip-side of the CE cost barrier, are implied by an interviewee: "our clients expect us to deliver large quantities. Since we cannot do mass production with our circular products, it is not practical to pursue this from either a production or a financial perspective" (TTS2). These issues also highlight the prospect that firm size is associated with severity of CE barriers; smaller firms may lack the size threshold to achieve economies of scale that would make production of circular products profitable.

The high expense of circular inputs is found to be further exacerbated by the limited volume of circular supply streams and limited technical knowledge about CE (the fourth and fifth highest barriers, respectively). This finding differs from that of Kirchherr et al. (2018), in which technical barriers are found to be the least pressing. An interviewee reflects on the limitations of technical barriers and their influence on market activities through constrained supply: "new circular products cannot be created in [a] volume which already existing products do have, meaning we cannot scale up easily" (TSS3). Similar sentiments are reflected by other interviewees: "scaled-up volumes [are] definitely not existing yet, therefore it is really pricey…in the end the cost-price is always a sensitive issue for the consumer. We are currently working on this" (TSS4); and "it is essential to have a lot of waste streams [used textiles] to create an economically viable process for circularity, which we do not have" (TSM11). Another interviewee reflects on the additional effort involved in overcoming the limited availability of CE inputs and the impacts on meeting demand: "for us, the foremost barrier is quantities. We need a lot of end-of-life flows to create a profitable circular process. In our company, that is not happening yet" (TSM3).

In addition to lack of capacity to fill orders for CE-based inputs or to offer CE-based end-products at prices competitive with their linear counterparts, a cultural barrier (the second highest) is apparent through low consumer awareness and low interest in CE products. Greater value is not placed on CE products by consumers to account for positive externalities or mitigation of negative externalities associated with CE transition; consumers may see only a difference in price and opt for price-competitive linear products. An interviewee states, "despite the fact that we have all these durable circular materials, this is at the expense of price, because it is often high. The consumer does not want to choose above our normal [linear] products" (TSM4). Not only are customer preferences a limitation but also customer behavior as a product of low awareness and interest. Awareness could play a more facilitative role in the sequence of chain reactions leading to wider CE adoption, but behavioral change is slow to materialize. According to an interviewee, "we tried to engage with our customers to have them send their products back at end of life using our return system. Only about 10% showed interest and actually returned their products. That is by far not sufficient to compensate [for] the work and efforts invested in the circular process, [so] we stopped the project" (TTM3). By contrast, regulatory barriers were found to be the least pressing among the top-five. One interviewee identified a regulatory pathway through which consumer interest could be elevated through the market mechanism: "some tax law that puts less tax on CE products…helps battling the consumer's resistance to recycled products" (TSM1).

5.3 | Firm barriers versus industry barriers

Barriers were categorized according to whether they were influenced by firms individually or whether they occur outside the firm-level sphere of influence and thus at the industry level. Scale-based findings (Table 3) about regulatory and market barriers accord with initial expectations, namely that regulatory barriers occur at the industry level and market barriers at both the industry and firm levels. However, technical barriers were expected to occur only at the firm level but are found to occur also at the industry level, implying policy interventions should be tailored according to varying scales. Examples of industry-level technical dynamics are firm-to-firm interdependencies (Fischer & Pascucci, 2017), economies of scale and scope, and shared infrastructures (reminiscent of agglomeration effects; Viladecans-Marsal, 2004; Smith & Florida, 1994). The relative score of firm barriers versus industry barriers suggests that CE transition is not dependent solely on the aggregated choices of individual firms but on a facilitative operating context whose development is beyond the control of a single firm. This implies a role for public policy, as elaborated in the following subsection.

5.4 | Policy strategies identified by respondents

Tables 4 and 5 present the results of interview questions about strategies to overcome CE barriers and associated challenges. The most frequently cited among the seven identified strategies (41% of answers) were extra marketing efforts and raising awareness (mostly regarding firms' individual initiatives to increase sales). Building internal research and development capacities and working with universities and scholars, as related strategies, combined for 31%, followed by 17% for engaging in interfirm collaboration across the supply chain. It is clear that themes identified in the analysis of barriers and policy implications were present in interviewees' identification of strategies. A majority of strategies cited were internally focused rather than industry-focused; this finding is notable given that barriers classified as industry-focused received more frequent mention. Four policy strategies are identified through the analysis of the chain reaction and individual barriers, and relate to the strategies and challenges presented in Table 4: (i) facilitation of markets for circular materials, including subsidization of trading platforms and information-sharing; (ii) promotion of education and awareness among consumers about circular products and the logic for embracing them; (iii) introduction of programs for training and upskilling related to designing, managing, and operating firm-level circular processes; and (iv) high-level promotion of systemic transformation away from linearity.

TABLE 4 Strategies to overcome CE barriers

Barrier (from Table 3)	Strategies to overcome CE barriers*
Cultural	
Lacking consumer awareness and interest	Extra marketing and raising awareness(41%; 26/63)
Operating within a mostly linear system	Internal research and development (21%; 13/63) Working with universities and scholars(10%; 6/63)
Limited willingness to collaborate in the value chain	Looking for collaboration within the supply chain (17%; 11/63)
Hesitant company culture	Pursuing a circular company culture (5%; 3/63)
Regulatory	
Lacking global consensus	Extra marketing and raising awareness (41%; 26/63)
Market	
High costs for producing/selling circular products	Compensating with extra sales from circular initiatives (3%; 2/63)
Technical	
Lacking ability to deliver high quality circular products	Internal research and development (21%; 13/63) Working with universities and scholars(10%; 6/63)
Limited circular designs (i.e., knowledge, options)	
Lack of data available (e.g., on impacts)	
Limited circular supply streams available	Looking for collaboration within the supply chain (17%; 11/63)
Too few large-scale pilot projects	Conducting pilots (2%;1/63)

Barriers not linked with strategies: limited circular procurement, obstructing laws and regulations, opportunistic competition, low virgin material prices, lacking standardization, high up-front investment costs, limited funding for circular business models.
*Number of answers classified / total number of answers.

TABLE 5 Challenges faced in adopting strategies to overcome CE barriers

Challenge	Percentage of respondents identifying*
Strategy shows too few results	45% (14/31)
Strategy works effectively	23% (9/31)
No measurable progress	19% (6/31)
Limited circular budget	10% (3/31)
No challenges with given strategies	10% (3/31)
Strategy is too time-consuming next to core activity	10% (3/31)

*Number of answers classified/total number of answers

6 | CONCLUSION

This study has identified the most pressing barriers to CE transition in the Dutch technical and interior textiles industries: high costs of producing and selling circular products, lack of consumer awareness and interest, broader cultural challenges associated with the continuing primacy of a linear system, limited CE design options and related knowledge, limited circular input supply streams, lacking ability to deliver high-quality CE products, high up-front investment costs, and obstructing laws and regulations. Based on data from 27 interviews, these findings provide insights for policy efforts to accelerate CE transition and are an extension of research on CE barriers by Kirchherr et al. (2018) and on CE policy initiatives by Hartley et al. (2020). To deepen the applicability of these findings, this study not only identified barriers but also pinpointed relationships among barriers as conceptually illustrated through a chain reaction; this analytical exercise highlighted mechanisms by which individual barriers combine to hinder CE transition.

Consideration of barriers beyond firm control necessitates a multi-scaled analysis, and future research has an opportunity to extend the lessons of this industry-level study to other industry and economy-wide studies of CE transition. First, differences in CE barrier dynamics may be observable across industries like technical and interior textiles. This study aimed for thematic saturation in interviews, allowing findings to be representative of the challenges faced across the technical and interior textiles industries (we observed no meaningful difference in findings between the technical and interior textiles industries individually). However, future studies may conduct deeper analysis of either industry to confirm or build on the results found in this study. Second, the study suggests opportunities for theoretical development about the cultural and technical dimensions of paradigm shifts in production systems. While the technical and interior textiles industries are characterized by a particular set of circumstances and challenges, this study offers generalizability for studies of other industries not only in methods (i.e., the survey instrument used and the effort to identify chain reactions) but also in findings (i.e., that CE transition is hampered by barriers classifiable as cultural, regulatory, market, and technical). In particular, the identification of a chain reaction is reflective of the type of complex, interlinked, and embedded barriers characterizing numerous industries that, like textiles, operate through extended supply chains and perpetuate legacies of linear thinking—even amidst pressure to reorient toward emergent practices in sustainability.

This study's examination of barriers through the lens of scale also reveals the presence of industry-level factors in addition to firm-level factors. Given this finding, further research is needed to assess the scalar granularity of existing public policies that promote CE (i.e., whether they target the system-level, industry-level, or firm-level) and associated gaps in policy design, implementation, and scholarly understandings. Empirical insights into how these patterns differ between manufacturers and retailers, along with those between business-to-business as against business-to-consumer activities, would also help specify which policies have the potential for more targeted impacts. The identification of industry-specific barriers has broader applicability first in demonstrating how studies focusing on other industries might proceed and in identifying issues needing further research. As evolving economic and political circumstances build urgency and pressure for CE transition, and as this transition makes measurable if halting progress in the coming years and decades, the scalar perspective concerning barriers will deserve additional research, and this article exhibits how such research can proceed.

In closing, it is prudent to reflect on policy implications as a pathway to foster a commercial environment where CE transition can materialize. As presented, the three strategies for overcoming CE barriers receiving the highest percentage of mentions were extra marketing and raising awareness (41%), internal research and development (21%), and looking for collaboration within the supply chain (17%). Through public policy, governments have a role to play in helping firms realize each of these strategies. The policy options proposed in Subsection 5.3 provide related guidance: facilitation of markets for circular materials, promotion of education and awareness, training and upskilling, and promotion of systemic transformation away from linearity. In designing and implementing these strategies, governments should remain attentive to three factors. First, a fluid discourse between firms and policymakers should be maintained, so that policies are responsive to the commercial needs of firms while remaining effective tools for advancing public policy goals (including sustainability). Second, provisions must be made to monitor evolution in outcomes associated with the introduction of individual policies; this entails systems and agreements to collect and analyze data and communicate insights to policymakers and firms. Finally, for a complex issue such as CE transition—which encompasses an array of factors from technical to commercial and cultural—policymakers must be realistic about what can be measured and managed, and what cannot. CE transition is not achievable solely through a technocratic approach or coercive governance; sustainability is not contingent only on the proper design and calibration of policy instruments. A durable and meaningful CE transition would be a reflection of deeper tectonic shifts in social and cultural priorities, matters that are often slow to evolve. Governments must understand the limited but still consequential scope of their role in fostering such an endogenous evolution in culture, including the integration of ideas about CE into educational curricula, deeper awareness among the public about matters related to sustainability, and a narrative concerning the urgency of acting at both the policy and individual behavioral levels to achieve more sustainable and environmentally responsible production systems.

This supporting information section includes information about sources of data for interviews and figures. It also contains two appendices that provide information about, respectively, products made by the technical and interior textiles industries and interview questions.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA SUMMARY AND AVAILABILITY STATEMENT

The data that support the findings of this study come from interviews conducted first-hand by the researchers. The data are available upon reasonable request submitted to the corresponding author. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of study participants.

Data for Figure 1 come from the following source: FFact. (2014). Massabalans van in Nederland ingezameld en geïmporteerd textile. (November 29). https://www.textielrecycling.nl/uploads/Bestanden/FFact%20Textiel%20rapport%2007.pdf

Data for Figure 2 come from the following source: Kirchherr, J., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., and Hekkert, M. (2018). Barriers to the circular economy: Evidence from the European Union (EU). *Ecological Economics*, 150, 264–272.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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