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Understanding circular economy transitions: The case of circular textiles

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Abstract

The circular economy has been proposed to transform global textile supply chains which are currently challenged by a complex nexus of sustainability issues related to the dominant fast fashion trend. Research on circular economy in the textile sector often focuses on businesses or consumers as key enablers in *circular transitions*, yet it treats them as independent entities and thereby neglects the study of interactions that can provide insight at the systems level. The proclaimed "circular textile mission" in the Netherlands setting a national target for 100% circularity by 2050 is used as case study to address this research gap. We explore the circular textile transition processes found in the context of the Dutch mission and compare the development and interactions among various technical and non-technological solutions produced by engaged actor constellations for assessing key factors driving and blocking the overall mission fulfilment. To these ends, we derive a theoretical framework based on innovation system theory and conceptualize the Dutch circular textile transition as a *Mission-oriented Innovation System* (*MIS*). Analyzing the structure and functioning of the Dutch mission-oriented innovation system, we show that (1) there is a good match between the formal Dutch circular textile mission and system actor perceptions; (2) system actors have formed structures around three dominant *solution trajectories* in the Dutch system: secondhand, mechanical recycling, and chemical recycling; (3) these trajectories expose distinct key virtuous and vicious cycles, which characterize (4) the entire system as formative. Overall, the secondhand trajectory shows most developed structures and most positive dynamics, chemical recycling carries most technological breakthrough potential, whereas mechanical recycling is a mature technology but lacks market demand and supply. We compare the three solution trajectories, discuss the disruptive nature of the Dutch circular textile transition, and suggest installing Extended Producer Responsibility (EPR) as a potential intervention for accelerating system transformation. The study concludes with reflections on the case learnings and considerations for further research on mission-oriented innovation systems.

KEYWORDS
circular disruption, circular economy mission, circular economy transition, circular fashion, circular textile, circular textile transition, mission-oriented innovation system

1 | INTRODUCTION

The rise of the fast fashion business model four decades ago and the outsourcing of textile production to emerging economies have turned the textile sector into one of the most unsustainable industries in the world (EU, 2019; Niinimäki et al., 2020). In particular, the sector's waste problem is expected to grow, and it has recently become highly exposed. Whereas in the European Union (EU) there has long been an infrastructure for textile re-collection, less than half of all items retain any form of second use or recycling, and only about 1% can be reused in "new" textiles (EU, 2019). Countries like Ghana have become a dumping ground for re-collected clothes from the United States, EU, and Australia — 40% of the 13–15 million garments that arrive each week immediately become discarded in landfills due to their low quality (ABC, 2021; BBC, 2021). In addition, the COVID-19 crisis has led to a temporary break-down in international secondhand textile markets (Politico, 2020; Reuters, 2020) and has demonstrated that the entire sector has entered a state of vulnerability and brittleness (Gunderson & Holling, 2002), in which its mounting sustainability problems have rendered it a case of "disruption overdue."

A shift towards the circular economy (CE)—henceforth referred to as "circular transition"—is widely regarded as a trigger for the necessary disruption in the global textile sector and as a way to mitigate the complex nexus of sustainability issues associated with the sector (Harvard Business Review, 2019; UNEP, 2018; UNEP 2021). Building on principles and properties associated with the CE (see Blomsma & Brennan, 2017; Kirchherr et al., 2017), a circular textile sector has to be based on multiple, consecutive cycling of materials (Lewandowski, 2016), and traceability of material inputs across all lifecycle stages (Chemsec, 2018; Jurgilevich et al., 2016) as a lever for drastically changed design, production, and consumption models with significantly lower negative environmental and social impacts, for example, moving from maximizing the *number of items sold*, to maximizing and retaining the *value per item* (Vinit et al., 2021).

The Netherlands has adopted a particularly active and leading role in establishing a circular textile sector over the past years and has proclaimed CE a "mission," setting a national target for 100% circularity by 2050 (I&W, 2020). Our aim is to explore the circular textile transition processes found in the context of the Dutch mission and to compare the development and interactions among various technical and non-technological solutions produced by the engaged actor constellations in order to assess key factors driving and blocking overall mission fulfilment. For this purpose, we derive a theoretical framework which combines elements of established innovation systems theory with new dimensions from the mission-oriented innovation systems (MIS) framework which is being developed to shed light on the systemic dynamics that are the result of such a mission (Hekkert et al., 2020a).

Comparative actor and solution perspective are to date nearly absent in the textile literature (for exceptions, see Mishra et al., 2021, Fischer & Pascucci, 2017), which has often examined in separate studies how specific business models or strategies are implemented by a single type of business actor (Franco, 2017; Sandvik & Stubbs, 2019; Todeschini et al., 2017) and adopted by consumers (Camacho-Otero, 2019; Elzinga et al., 2020). We suggest that, researchers, practitioners, and policymakers can profit from the comparative insights on circular transitions offered by new types of system-oriented studies that examine development of the structures and interactions actors produce in multiple parallel solution trajectories in the specific context of missions.

Below, we first introduce the theoretical framework (Section 2), and next, we present the qualitative multi-method approach (Section 3). Section 4 then provides a stepwise analysis of the Dutch MIS, giving an overview of the system structure and identifying the main solution trajectories and the related circularity strategies in the Dutch textiles sector. Subsequently, we select and study in-depth the MIS dynamics of three main MIS solution trajectories. We compare their current state of development and thereby also discuss the disruptive nature of the mission which is followed by three key interventions for MIS acceleration (Section 5). Finally, we reflect on case insights and the application of the MIS framework (Section 6).

2 | THEORETICAL FRAMEWORK

Sustainability-led missions such as the circular textile transition are responses to complex and interdependent, multi-level, multi-actor societal problems of decentralized nature and intend to mark a paradigm change in innovation policy to more strongly guide the direction of corporate and societal innovation towards specific sustainability objectives (Diercks et al., 2019; Janssen et al., 2021; Mazzucato, 2018). Thereby, CE missions have arguably started to place the CE concept in a new context away from voluntary corporate sustainability strategy towards a collective societal implementation effort.

Hekkert et al. (2020a) have posed that the transformation processes brought about by missions can be conceptualized as taking place in a spatially and temporally defined MIS. This idea of MIS, takes inspiration from the technological innovation system framework (TIS), one of the key frameworks used to analyze innovation and transformative dynamics in specific sectors and technological fields (Bergek et al., 2015; Hekkert et al., 2007) and often used to defining instruments supportive of accelerating the desired socio-technical transitions (Bettin, 2020; Esmailzadeh, 2020; Kieft, 2021).

Owed to the complex nature of problems addressed by missions, Hekkert et al. (2020a) expect that the existence of multiple, parallel streams of solution trajectories is characteristic in early stages of MIS. MIS analysis is yet under development, yet it seeks to carry the idea of innovation system functioning and interaction of actors beyond describing development and diffusion of single technological solutions (TIS) and towards understanding interactions between solution trajectories characterized by multiple technological and non-technological innovations, including social innovation.

We propose here that when studying circular transitions, circularity strategies such as defined by Reike et al. (2018) can offer a simple and useful heuristic for categorization of solution trajectories in a MIS. They distinguish 10Rs: 0, Refuse; 1, Reduce; 2, Reuse/Resell; 3, Repair; 4, Refurbish; 5, Remanufacture; 6, Repurpose; 7, Recycle; 8, Recover energy; 9, Remine. Lower numbers stand for practices enabling product and material reduction or direct reuse, higher numbers are typically less desirable from a sustainability perspective (see Appendix A, and for a similar heuristic, Potting et al., 2017).

Our tentative MIS framework builds on TIS in understanding the interaction dynamics in the mission-driven innovation systems as emerging from two main elements: the system *structure* and, second, so-called system *functions*. We distinguish actors in the system (e.g., companies, universities, intermediaries, and authorities) from the structural physical and non-physical components they create (Bergek et al., 2008; Wieczorek et al., 2013): (1) institutions (ranging from initiatives, rules, and laws to various forms of institutional innovation), (2) infrastructure, and (3) technology. There are different sets of TIS functions in use; we base the set of system functions on Hekkert et al. (2007), which are (**F1**) entrepreneurial experimentation, (**F2**) knowledge development, (**F3**) knowledge diffusion, (**F4**) guidance of the search, (**F5**) market formation, (**F6**) resources mobilization, and (**F7**) creation of legitimacy. We refer to Hekkert et al. (2007) for an extensive discussion of these system functions.

With a broad portfolio of solutions typically co-existing in missions, we set out a number of changes to this set of system functions. First, following Wanzenböck et al. (2020), convergence needs to take place in the mission problem/solution space regarding the combinations of solutions that may jointly solve the societal problem (Wanzenböck et al., 2020). We therefore propose to change "guidance of the search" (F4) into (a) problem directionality (the extent to which the societal mission is acknowledged and shared) and (b) solution directionality (solutions proposed to the specific problems and the expectations related to these solutions). In this specific study, we employ these notions to analyze directionality for the MIS as a whole, whereas we describe the directionality of solutions found in individual trajectories as "guidance of the search."

Second, we add "coordination" as a function to describe those processes that contribute to the alignment of actors in the innovation system regarding the directionality and prioritization of problems and solutions within and across solution trajectories in a MIS (Hekkert et al., 2020a; Janssen et al., 2021; Wesseling & Meijerhof, 2021). Coordination issues can be heightened in circular transitions as (a) there is formation of value chain links among actors who are traditionally not interlinked and (b) actors are often geographically dispersed, and c) value creation and sharing gets reconfigured in circular value chains (Kanda et al., 2021).

Third, we first introduce the idea of *regime change* as a new function in this paper for better understanding changes in institutional structures and the behavior of incumbent actors. Typically, the term regime is associated with incumbent system actors profiting from the status quo (Loorbach et al., 2017). We argue that in MIS, regime actors may transform the system alongside other actors (e.g., by means of F1 – entrepreneurial activity, or F2 – producing new knowledge), ally with change-driving entrepreneurs, or strategize and interfere to influence mission problem and solution directionality rather than merely opposing novelty. This view goes beyond transition studies, where regime actors are thought to experience shock-wise reconfiguration and displacement (Loorbach et al., 2017; Smith & Stirling, 2008). We further hold that regime change can but may not necessarily be viewed as final MIS outcome but it can also be conceptualized as a function reflected in the other MIS dynamics including the mission's framing.

The changes to functions that form the basis of our theoretical approach to make it more suitable for circular transition formulated as missions relate to directionality, coordination and regime change (see Table 1). Furthermore, the consideration of circularity strategies for trajectory categorization is suggested which may additionally serve researchers for analyzing coordination among the adopted circularity strategies.

Since we assume the different MIS solution trajectories and actors engaged therein lobby by for legitimacy and resources, it is important to take the stage of development of the different solution trajectories into account; for example, those with a longer history may enjoy higher legitimacy and resource endowments than novel trajectories. To indicate the stage of development, we apply the well-known development stages of technological transitions (S-curve): pre-development (up to prototype development), development (up to market introduction), take-off (up to fast market growth), acceleration (up to inflection point of slower market growth), and stabilization (Bento & Wilson, 2016; Hekkert et al., 2011; Kieft et al., 2021; Markard & Hekkert, 2013; Suwa & Jupesta, 2012).

TABLE 1 Nine functions for MIS analysis

F1	Entrepreneurial activities and experimentation
F2	Knowledge development
F3	Knowledge diffusion
F4	(a) Problem directionality (b) Solution directionality
F5	Market formation
F6	Resources mobilization
F7	Creation of legitimacy
F8	Coordination
F9	Regime change

In line with conventional TIS theory, the overall state of development (phase) and functioning of single MIS trajectories comes forward looking at the interaction of the nine functions above. This is based on the central idea that system forces interact as to result in vicious and virtuous feedback loops holding back or fostering trajectory development — a line of thought widely recognized in the innovation and transition literature (Bergek et al., 2008; De Gooyert et al., 2014; Jacobsson et al., 2004; Negro et al., 2008; Suurs & Hekkert, 2009).

3 | RESEARCH METHODS

We conducted a qualitative multi-method study (Aspers & Corte, 2019), with a focus on the Netherlands as a case study. In the application of the MIS framework, our study represents an early exploratory attempt that derives insights by applying methods of data collection from established practices from the innovation systems literature. More detailed explanations on the case study selection, data collection and analyses can be found in the extended version of this method section.

3.1 | The Netherlands as a case study

We delineate the MIS to the national level as a purely analytical choice guided by the purpose of our study (Markard et al., 2015). The Netherlands was selected as a case for various reasons. Most importantly, the Netherlands is generally regarded as a frontrunner in formulating circular economy ambitions evidenced by government targets for a 100% circular economy by 2050 (Rijksoverheid, 2016a), and its clear mission for circular textiles (I&W, 2020). Other reasons included: Its stable retail market in terms of volume (Maldini et al., 2017), a tradition in textile design and manufacturing (Textielnet.nl, n.d.), and access to a number of larger brands headquartered in the Netherlands. We acknowledge that the United Kingdom, Scandinavian countries, Japan, Taiwan, the United States, and a few others may have served as equally good case studies.

3.2 | Research steps guiding data collection and analysis

Data collection and analysis were iterative processes which we considered completed at the point of theoretical saturation (Bryman, 2016; Strauss & Corbin, 1998). The data collection process was guided by four main questions and research steps (Table 2) that reflect the theoretical ideas presented in Section 2.

We used three main data collection methods: "desk research," one workshop and 20 interviews to gather "system actor knowledge and perceptions" (see interview guide), and "event data" detailed in Table 3. The data were triangulated in such a way as to ensure that each analytical step was covered by more than one data collection method (Figure 1). The mixed method approach allowed us to combine our overview of factual events with a large number of personal assessments of how the innovation system is functioning.

Desk research and descriptive data from the events served for understanding *what* characterizes the MIS (Steps I and II). This was triangulated with workshop and interview results. Triangulation of the events' system function analyses with the workshop and the interviews served to evaluate the dynamics in the circular solution trajectories and *how* they affect the overall MIS (Steps III and IV).

As a key benefit of this iterative mixed method, we were able to detect and minimize potential biases from single sources (such as interviewee memory bias, group think in the workshop). The order in which we collected data enabled intermediary analyses of the entire MIS resulting in a more targeted approach for the subsequent data collected (e.g., outcomes of the workshop were used for more specific interview questions). Approaches to systematically synergize qualitative data on the functioning of trajectories that emerge in MIS-type studies have yet to be further developed. We opted to conclude the analytical process holding a one-day workshop with inputs (summaries) from all the data collected and analyzed.

3.3 | Data analysis

In analyzing the data, we followed the four steps presented above and triangulated results as shown in Figure 1. For the first analytic step (I),

TABLE 2 Research steps and questions

Step I	The mission and system actor problem and solution perceptions	Question I	Do actors share an understanding of the main problems that need to be addressed? Is there a circular textile mission based on clear and shared (convergent) problem and solution directionality?
Step II	Mission structure and trajectories	Question II	Which actors are present in the innovation system and what are the dominant rules that guide actor behavior? What are dominant solution trajectories (in terms of actor engagement and institutions) that have emerged to date?
Step III	Trajectory development and functioning (vicious and virtuous cycles)	Question III	What is the state of development of the dominant individual trajectories and what are the underlying reasons for the dynamics they expose?
Step IV	Trajectory comparisons (including specific attention to new MIS functions)	Question IV	How do the trajectories compare and what is the role of coordination and regime change within and across trajectories (cross-trajectory developments and functioning)?

TABLE 3 Data sources and details on data collection

Method	Step	Type of source	Consulted number and time span	Search/sampling strategy	Extra information on selection/categorization
1: Desk research	I–IV	General data Google (and interviewee recommendations)	73 documents, 2012–2020	Search terms in English and Dutch, e.g., *Dutch circular textile OR clothing, circular textile OR clothing AND the Netherlands, textile OR clothing reuse AND the Netherlands OR Dutch*	Preceded other steps and was non-exhaustive; used to identify relevant organizations (system structure) and for selecting relevant reports and other publications, results were categorized as policy documents and government (research) reports (24), other (research) reports (14), CE initiatives (14), branch organization (4), other data (17)
	II	Actor list Dutch Circular Textile Valley	182 companies (incl. non-profits), 2020	DCTV website found through Google search, original list was updated with actors from "general data" and "event data"	List with all known supply chain actors, classified into different types of actors, the contact details of 182 companies were obtained in addition for analyzing geographic spread (Esri)
2: System actor knowledge and perceptions	I–IV	Workshop	Key stakeholder workshop, 13 subjects, June 2020, 3 hours	Criteria sampling, snowball sampling	Participants: Branch organization, policymaker, investor, clothing collector, entrepreneurs circular textiles, brand/retailers, as discussion input to workshop each participant filled in a survey on system functioning, see Appendix B
		Interviews	Expert interviews, 20 subjects, Aug–Oct 2020, 40–120 minutes each	Criteria sampling, snowball sampling	Same stakeholder groups as above and a standard provider, networking organizations and different branch organization, see Appendix B
3: Event data	I–IV	General data (GD)	88 events, 2012-2020	Selected from documents retrieved in Google search	All policy documents and extensive (research) reports were selected from "general data"
		LexisNexis (LN)	105 events, 2015-2020	*Circular AND textile AND ("the Netherlands" OR Netherlands OR Holland)*	All relevant results were analyzed (newspaper articles, policy documents, other media)
		Textilia, Vakblad Mannenmode and Vakblad Vrouwenmode (TV)	112 events, 2015–2020	Magazines found through Google search, search terms e.g., "*circular*" *and* "*closed-loop*"	Professional Dutch magazine, all relevant results found were analyzed
		Just style magazine (JS)	172 events, Oct 2019–Oct 2020	Search terms, e.g., "*circular*" *and* "*closed-loop*"	Professional international magazine with articles on over 162 companies, a full year of coverage was analyzed

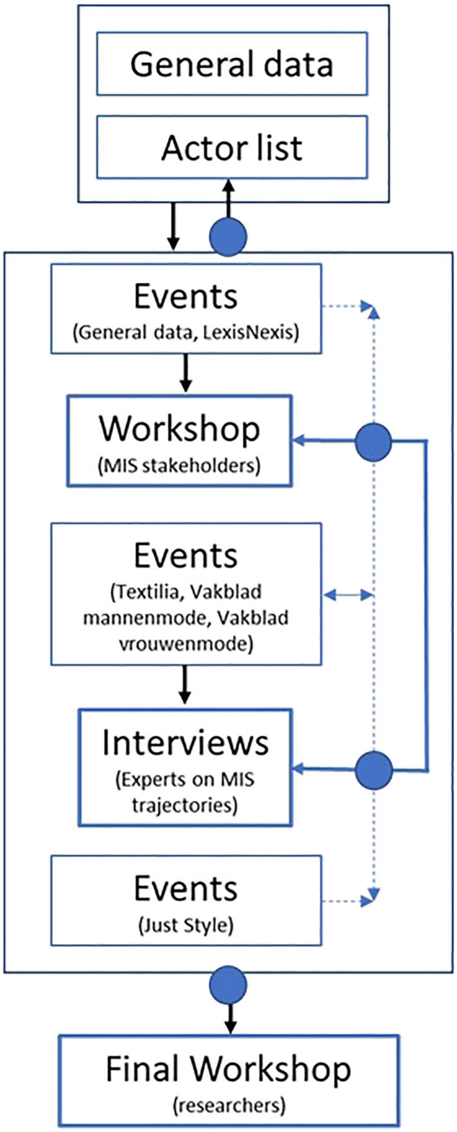

FIGURE 1 Data triangulation

we looked for statements of intent, targets and visions on CE. In comparing the grey literature ("general data") collected to perceptions stated in interviews and the workshop in order to identify if system stakeholders agree on the presence of a mission, its problems, and the main solutions to be developed.

For analytic step II, we used the list of 182 companies (entrepreneurs, collectors, support technology providers etc.) as a basis and mapped actors using different software (Miro, Esri, Python). We updated the list with more individual companies and other actors throughout the research, and added details such as each actors' circular textile inputs, circular outputs, infrastructure used/provided, and partnerships. The dominant system trajectories followed from triangulating these factual data on the system structure (e.g., well-represented vs. weakly represented actors) with workshop insights. Applying the 10R framework by Reike et al. (2018), we categorized circular activities and (non)-technological innovations we had found.

The function analysis and identification of the trajectory development stage (S-curve) form the most comprehensive analytic step (III and IV). We compared interview and workshop data to the event analyses. System functions are not be viewed as variables in the traditional sense, but they form (interpretative) categories (Suurs et al., 2009).

a. We first coded the workshop transcript and the interview data (Saldana, 2016) using the seven system functions as coding categories.[1] There are yet no guidelines for the new functions, wherefore these were coded inductively (e.g., sentences like "he [company CEO] finds circular business models tricky" were coded as function 9 – regime change).
b. For all the event data (method 3), we created a database in a spreadsheet which gives insight into the history and order of events, event descriptions, the distribution of events over the different system functions, and factors that influenced the events, for example, previous events or context factors. These analyses are based on Negro et al. (2008) and Poole et al. (2000).

TABLE 4 Abbreviations used for references in the results section

Data source	Abbreviation used in results	Specification
WORKSHOP	W1	Insight comes forward from the workshop conducted and from comments of at least two participants
INTERVIEWS	I1, I2, […], I30	Insight comes forward from interviewee or individual workshop participant, numbered and labeled I (1–30)
EVENTS (EVENT NUMBER IN DATABASE)	GD1, GD2, […], GD88	Insight comes forward from desk research (general data = GD)
	TV1, TV2, […], TV112	Insight comes forward from one of the three Dutch textile magazines (Textilia, Vakblad Mannenmode, Vakblad Vrouwenmode)
	LN1, LN2, […], LN105	Insight comes forward from event in Lexis Nexis magazine
	JS1, JS2, […], JS170	Insight comes forward from event in just style magazine
OTHER DESK RESEARCH	Not applicable	Regular referencing with source

The events were allocated to the system functions using a classification scheme with diagnostic questions on system functions (Hekkert et al., 2011)[2] and adding subcategories iteratively (see Appendix C). Note that in event analysis, one data source typically contains multiple events, for example, an article describing a product launch – F1 mentioning that the product requires new logistics – F6, makes for two events in the database.

c. For each input we used (i.e., workshop transcript, individual interview transcript, single event), we assessed if a system function (F1–F9) shows positive or negative fulfilment using a (+/−) system.

Triangulation among the event data (method 3) and between methods 2 and 3 (see Table 3) allowed us to identify positive and negative patterns of interaction between the nine system functions (vicious and virtuous cycles) emerging from the data. For placing our results into a more global context, we also compared event data from the Dutch MIS to the data from the international magazine Just Style. The trajectory development stage was established triangulating various data from method 1 to method 3, and diagnostic questions from Hekkert et al. (2011) on development stages[3] were used as orientation for defining boundaries between these stages.

3.4 | Data presentation

The data sources used, their abbreviations in the results section, and specifications on the data labelling are found in Table 4. For example, (I2, GD10) is an insight from "Interview 2" and "General Data event 10. Events given as GD1:G10 follow up in sequence. The main reason for presenting references as shown below was to present our case study results in a credible and traceable manner and to allow for other researchers to reproduce and build on the findings in accessing the event database.

4 | RESULTS

4.1 | Presence of a shared mission

In the Netherlands, we see clear signs that attaining a circular textile sector is conceived and framed a mission by different stakeholder groups. The Dutch government had first started "Green Deals"[4] on textile waste, textile recycling, (bio-based) fiber development and inquiring collection and sorting between 2012 and 2014 (GD18: GD23, GD24,GD25). By 2019, "Regional Deals"[5] on circular textile had emerged lending the topic more weight locally (GD26:GD28); at the same time, first policy statements appear urging for national policies and actions (GD30:GD36).

In 2020, the Dutch government made a formalized mission for the Dutch circular textile sector, supported by a policy ("*Beleidsprogramma circulair textiel 2020–2025*") and a first execution plan (GD14:GD17, TV16, TV69) which includes step-wise targets: By 2030, 50% of all textile products sold in the Netherlands shall contain circular and sustainable materials (made from at least 30% recycled materials) and of all inputs and products in the Dutch market at least 50% are to be recycled post-use. For 2050, a 100% Dutch circular textile economy is envisioned (GD15).

However, textile is not among the Dutch five "top sectors"[6] and despite the formal commitments, the attention to the topic in government had long been starkly fluctuating (I7, I29). Not surprisingly, the Dutch government in its legal notice refers to an "existing momentum" for implementing its ambitious 2050 goal (I&W, 2020). This suggests informal MIS structures created by Dutch system actors during the first circular textile "Deals" and the increasingly louder global calls for a circular textile "mission" (LN28, JS62, JS68, JS87, JS96, JS138, JS143, JS146, Rijksoverheid, 2016a) were important in preceding the formalization of the mission.

Evidently, the official mission is widely supported by the Dutch stakeholders' groups (see Box 1) (W1). The branch organizations of the sector (e.g., *Modint*, *INretail*, and Vereniging Herwinning Textiel) and new network organizations representing circular entrepreneurs have supported the government in drawing up roadmaps on subaspects of a Dutch circular textile sector since 2017 (GD51: GD65), and a new version of the leading covenant "Sustainable textiles" is under way (GD85,GD86) to include provisions on circular economy (W1).

Many Dutch retailers and other system actors state that they have an explicit and shared view on the key problems of the sector and the urgency to act (W1, Box 1). The fast fashion business model dominating the sector is critically labelled by many as root cause driving a "race to the bottom" "through the cost-efficient business model" which has real costs "paid by people in production countries" (GD62). This business model is perceived to exacerbate fundamental problems in the system like the general lack of supply chain transparency, environmental impacts from production and consumption (e.g., wastefulness), pricing and fairness issues in the global supply chains, and problematic consumer attitudes from lacking awareness (see interview quotes Appendix).

While there is strong agreement at this point in time on the circularity as a mission that should drive forward all aspects of

BOX 1

"I think what matters is that urgency. We all understand that we have to change something. Look at the amount of raw materials, look at the business models - the urgency was certainly filled with life, both by the national government - very beautiful, and also in the region." (translated from Dutch).

- Networking organization circular textiles.

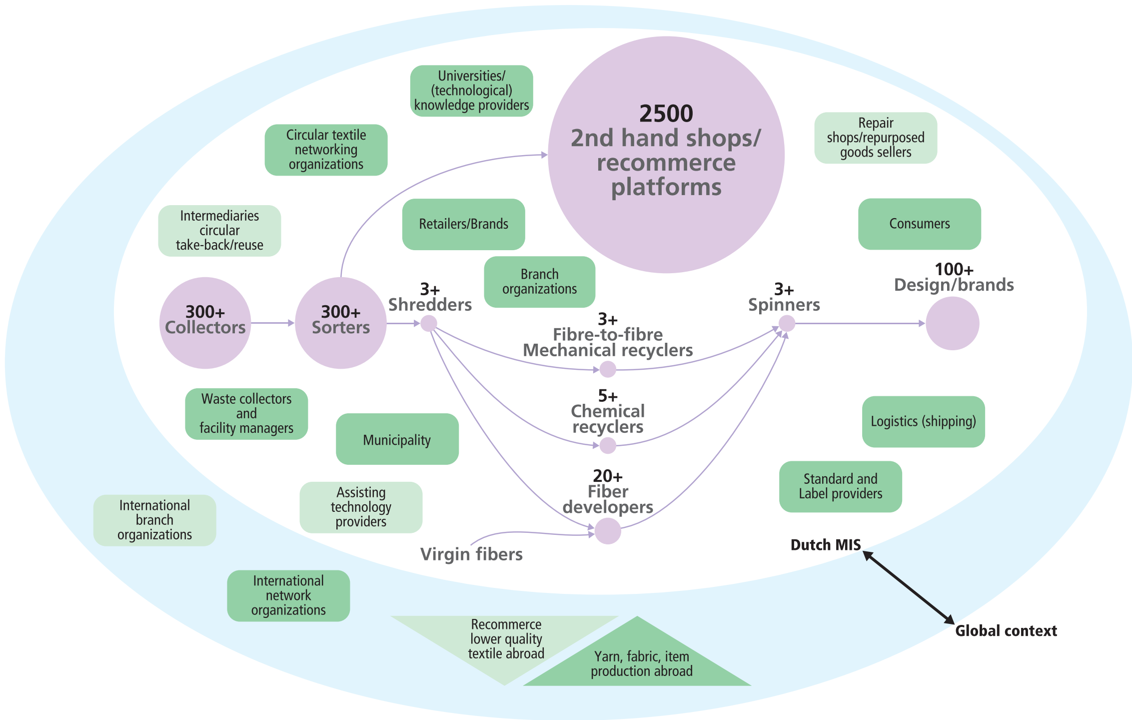

FIGURE 2 Overview of main actors in the Dutch MIS for the circular textile sector. This figure was created grouping similar actors and using Miro and Python software for supply chain mapping. Round shapes indicate key company actors with engagement in circular solutions and arrows show their supply chain connections. The size of the round shapes is proportionate to the size of actors in the Dutch MIS. We show no additional infrastructure and institutions, but found the structural components produced by these key system actors tend to relate to their size, i.e., high number of collectors and sorters makes for an extensive collection and sorting infrastructure. Rectangular shapes represent other main system actors, those with darker colour (darker green) are better represented actors (in numbers) than light green ones, yet we found all of these to actively take part in the mission. For all the rectangular shapes, the shape size is unrelated to the actor numbers. For a detailed discussion of the system actors and their numbers, see Hekkert, Reike, et al. (2020b)

sustainability — social, economic and environmental — (W1), there is disagreement on other key aspects. Particularly, entrepreneurs (start-ups) favor a re-shoring of production activities to the Netherlands as part of the mission. There is consensus that Dutch supply could realistically cover only a small proportion of local demand (5–10%) (W1, I3). Robotization and digitalization as important trends render early re-shoring potentially strategic (I3, I8, I11) but cost-intensive, with there still being clear competitive advantages in current production countries (I5).

Related to this is the disagreement on how ethical and economic fairness in textile supply chains is to be included in the mission (I18, I19). The Dutch government supports international (research) projects (LN5, LN29, TV93) but has shown strong interest in keeping technology (IPR) and profits from circular textile innovations inside the Dutch borders (W1, I18). In contrast, start-up entrepreneurs make use of production capacities and product line knowledge abroad and therefore are open to share benefits (I17, I18). Less fundamental disagreement exists on other sub-aspects of the mission, for example if it threatens certain supply chain actors (see Appendix D, I29). There is also debate on the degree to which consumers can be expected to play an active role in driving the mission with stakeholders viewing companies and government mainly responsible (W1; I27, I29), and whether the older or younger generations of consumers need to be a main mission target (see Appendix D).

We conclude that there is strong convergence on problem directionality, as views on the key problems are widely shared among all actors. The Dutch government provides a certain level of directionality through its clear and quantified target for CE and its vested interest in solutions that benefit the local economy, yet government leaves the solution pathways mainly open to the collective efforts of actors in the system.

4.2 | The DUTCH MIS structure and its three dominant trajectories

The Dutch MIS considered for this research can be seen in Figure 2. Some key MIS actors and institutions have emerged over the last 5–10 years (e.g., network organizations, online and stationary shops with circular business models) (TV2), others are long-established actors that have started to integrate more circular activities into their organizations (e.g., collection and sorting companies). The numbers in Figure 2 should be taken with caution, as we make no claims to exhaustiveness. The Dutch MIS is constantly evolving, and numbers merely serve to indicate proportionate size of key actors (filled shapes) in the system to each other nowadays.[7]

In line with theoretical assumptions on MIS (see Section 2), different solution trajectories can be detected. Overall, we identified seven trajectories that mark the main circular innovation activities in the Dutch MIS structure. These cover a variety of circularity strategies (see Reike et al., 2018) and include

1. ***Slow fashion*** **(*R0–R1*)**, including more conscious consumption and use (washing), consumer-to-consumer textile sharing (no transfer of ownership), permanent collections (LN40, TV95);
2. ***New fibers*** **(*Concept and Design lifecycle, R0-R1*)**, as innovation in fibers and technology for material substitution and consecutive recycling (LN20, GD25, TV2), replacing material inputs with high environmental impact (e.g., cotton) by materials with lower impact (e.g., hemp and mycelium), refusing hard-to-recycle fiber blends;
3. ***Secondhand*** **(*R2*)**, referring to re-use of pre-owned clothes (GD59, TV4, TV90, TV103, TV111) through secondhand sales and new product-service systems (PSS) giving access to fashion (rental models); knows many different actor constellations (peer-to-peer, business-to-consumer) and models focused on different textile quality (from luxury to secondhand markets abroad for low quality textile);
4. ***Repair*** **(*R3*)**, offered by retailers, in workshops and repair cafés, or executed as Do-It-Yourself by consumers to attain life-time extension (LN25, LN37, TV91);
5. ***Mechanical recycling of textiles*** (***R7***), as the process of recycling textile fabric back into fibers with grinding, shredding, carding. Aimed at circularity, it is not traditional recycling (R8) but avoids adding virgin and non-sustainable materials for attaining new fibers (R0–R2); typically, it requires additions of different post-consumer materials (e.g., PET plastic). Where necessary, minimal input of sustainable virgin material is used for making new textiles. It needs clean and sorted input materials of similar colors and type (GD35, GD41, GD81, GD87, TV2, TV15, TV18, TV20, TV33, TV74);
6. ***Chemical textile recycling of textiles*** (***R7***), is adopting a series of chemical processes to depolymerize/dissolve the fiber from the fabric into monomer/solvent form to create new fibers. Consequently, it aims at R0-R2, not R, yet most existing approaches use a mix of post-consumer textiles and sustainable virgin materials to make new fibers. A few technologies exist using zero virgin materials but these currently need mono-fibers as inputs (i.e., textile item from 100% cotton) (GD35, GD58, GD73, TV1, TV2, TV43, TV66); and
7. *Open loop recycling* (*R7*), as the use of post-consumer products into products for other industries (e.g., insulation and board materials).

Viewed in terms of the type of actors needed for functioning circular value chains, our system mapping brought forward that Dutch actors together can create a functioning closed-loop supply and value chain. However, some actors are rather overrepresented (collectors, sellers) and others heavily underpopulated (industrial-scale weavers and spinners). The four trajectories marked in bold are currently prioritized and dominate the Dutch MIS; we therefore refer to these as "dominant trajectories." For further analysis, we excluded fiber innovation due to scoping and other reasons. Much of the key technology that promises circular fibers from non-virgin materials (e.g., agricultural residues) and less impactful materials (e.g., mycelium, growing cattle skin cells in-vitro) is in a very early development stage.[8] This left us with three trajectories: secondhand, mechanical recycling, and chemical recycling. The system actors and trajectory dynamics are discussed in the following.

4.2.1 | The secondhand trajectory

The secondhand trajectory has existed for decades and it is the only one which shows a *well-functioning market*[9] (**F5**). As such, this trajectory is in the acceleration phase. Growing by 7% in 2019 alone, it is the dominant and most starkly growing circular textile trajectory in the Netherlands and globally (FD, 2020; McKinsey & Company, 2021). It is comprised of roughly 2,500 businesses in 2020 offering three main subsolutions: (online) recommerce models (retailers and peer-to-peer), rental models (online and clothing libraries) and non-commercial secondhand. The latter, translated to "kringloopwinkel" in Dutch, holds a 60% market share at the moment, but market growth is mainly induced by online platforms where consumers act as sellers and customers (e.g., *The Next Closet*, *Sharedrobes*, *United Wardrobe*, *Poshmark*) (TV4, GD49, GD88). Especially recommerce, but also specific rental models (baby, clothes, luxury items) see high *entrepreneurial activity* and many new entries (**F1**). Clothing libraries have been another new trend but struggle with demand, profitability, (−**F5**), and *resource supply*, particularly of high-quality items (−**F6**) more than the other models (I29, TV102).

All sub-solutions rely on pre- and post-consumer textiles which are collected and sorted through different means — manually by (online) shop owners and "kringloopwinkels" or through collectors, sorters and third-party take-back agencies, the latter three combine manual and automated processes (TV31). Low quality items are directly or indirectly sold on to charities or businesses abroad (GD42, GD75).

Many critical MIS functions in this trajectory are already well-fulfilled (see Figure 3). There is consumer *knowledge* on this trajectory (**F2**) through the traditional "kringloopwinkel" (**F1**) and the *legitimacy* of this trajectory has recently grown further (**F7**). First, through *guidance of the search* using awareness raising campaigns (**F3**) such as citizen collection initiatives (**F4**) (***A***[10]), and secondly, resulting from aggressive marketing strategies used by new large *market entrants* (**F1**) (***B***) (I24, I1, I2). Market *knowledge* (**F2**) is crucial in carving out profitable business models as actors need to compete with different value proposition on price and quality (see Appendix F). Knowledge deficits affect individual smaller actors (like stationary rental shops), yet they have small effects on the development of this trajectory as a whole.

In general, growing *entrepreneurial activity* (**F1**) and *market formation* (**F5**) (***C***) can be related to low *infrastructure requirements* (**F6**) and

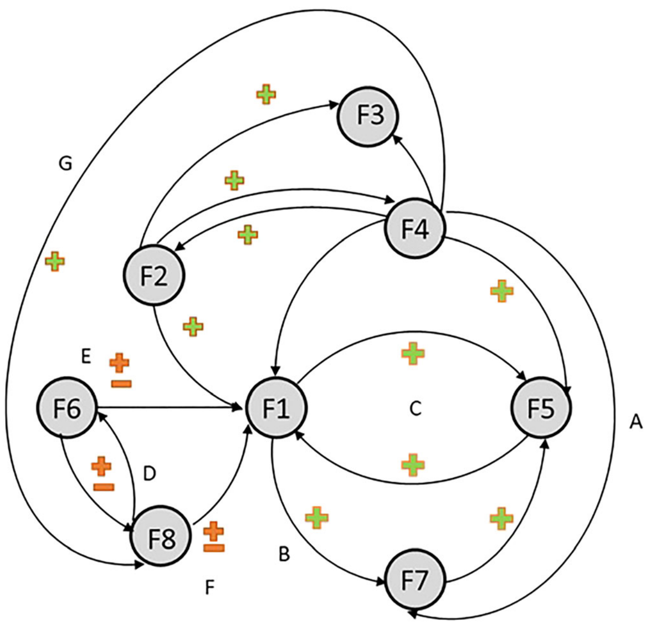

FIGURE 3 Function dynamics in the secondhand trajectory

low technical *knowledge requirements* (**F2**) which keeps risks of exploration low for retailers (**F1 — brands**) and start-ups (**F1**). Demand has risen steeply, *United Wardrobe* alone counted 600,000 customers; in 10 years second hand stores altogether grew by more than 30% (AD, 2017; CBS, 2017). (**F5**). The most weakly fulfilled function in this trajectory affecting all players is *resource* mobilization (−**F6**), primarily concerning the access to high quality clothes. "Kringloopwinkel" and collectors have the steadiest access to such clothes, yet only a small percentage of this (10–15%) can be resold in stores. As well, commercial recommerce and rental schemes rely on consumer incentive schemes and contract clauses (including fines) to warrant take-back. There is hence competition over *resource access* and quality between actors (***D***). Some of the new online platforms have access to venture capital for financing, while stationary secondhand shops lack financiers and are increasingly under pressure from low profit margins (coming from low quality and more competition). The latter therefore increasingly unite for *competitiveness* (**F5**) through scale advantages. Finally, collectors and non-commercial actors are also negatively affected in their resource allocation (−**F6**) and entrepreneurship (−**F1**) through government which still asks royalties tied to the amount of collected textiles (***E***). With the sharp decrease in textile quality, actors are lobbying for change of this outdated provision towards royalties on amounts that can actually be re-processed (I24).

Coordination (−**F8**) among the three different sub-solutions is currently non-existent and shows some negative effects on *entrepreneurship* (−**F1**) and *market* (−**F5**) (***F***). This has already been recognized, and many initiatives by networking organizations and government have *provided guidance* (**F4**) for coordination of collection (**F8, F6**) as one core objective. Additionally, a new law requires separation of household and textile waste from 2025 (**F4**) but using coercive legal instruments for coordinating the businesses operating the sub-solutions in the trajectory seems unlikely and therefore competition is likely to persist as well as lacking *coordination* (−**F8**) (**G**).

The overall dynamics, showing a stark growth in online secondhand are likely to strongly reinforce *legitimacy* (**F7**) and *market* growth (**F5**) in this Dutch trajectory (I1, I2). A successful Dutch start-up (*Wardrobe United*) has been taken over by Vinted, one of the largest growing international platforms (Trouw, 2020). Other large players like *Zalando*, *H&M*, *C&A*, *VF Group*, *The North Face* offer secondhand clothes in addition to regular sales (TV4, TV47, TV79, JS128) and particularly, the more exclusive brands add rental services (JS163). Clear growth forecasts for next decade (McKinsey & Company, 2021) make this a prioritized trajectory in the Dutch MIS and at global scale.

4.2.2 | The mechanical recycling trajectory

At first glance, mechanical recycling would appear to be a lower-ranking circularity strategy (R8). In the textile sector, however, fiber-to-fiber recycling forms a nexus between value recovery and circular design models (EU, 2019).

The Dutch MIS structure shows that different regional clusters have formed around innovative SMEs and in partnership with large collectors and sorters with circularity ambition (e.g., *Wieland Textiles*, *Boer Groep*) due to the Dutch Green Deal (GD18, LN96, GD23). While activities are diverse (design, production, services, sorting, different recycling actors), only three actors with commercial operations were identified, with (small scale) industrial spinning and weaving facilities that allow for fiber-to-fiber recycling (e.g., *Textielstad*, *Wolkat*, *Frankenhuis*). This makes for a fragmented MIS supply chain (GD35, GD44, GD55, GD68).

A number of SMEs (e.g., *Blue Loop Originals*, *Loop A Life*, *MUD Jeans*, *Schijvens*) (I8, I15, I18, LN5, LN8, TV18) focus on marketing mechanically recycled products and first retailers have piloted collections (e.g., We Fashion) (TV7, TV74). We position this trajectory in the take off stage. Over the last years, this MIS trajectory has seen sufficient *guidance of the search* (**F4**) (see Figure 4, ***A***). Private-public partnership programs like "Circular Textile Twente" (2019–2023) (GD28, GD35) have stimulated *entrepreneurial activity* of SMEs and traditional recyclers (**F1 – recyclers**), and across the diverse network organizations organizing this trajectory into a functioning Dutch supply chain receives much attention (I7, W1). It has lower scale, technology, and knowledge requirements than chemical recycling and in its basic form exists for decades which lends the trajectory general *legitimacy* (**F7**). Yet it shows a very complex vicious cycle related to *resource mobilization* (**F6**) which stems from the low quality of input materials, limited technical *knowledge* of mechanical recycling (**F2**), and unprofitable business models from lacking *market demand and supply* (**F5**). This also further affects other functions negatively (see Box 2) means *entrepreneurial activities* by large brands are basically absent **(**−**F1)**.

The core vicious cycle results from lacking *demand* from large brands (−**F5)** to use new fabrics based on recycled fibers which is

BOX 2

"Our biggest problem is growth dynamics - there is a group in Europe, but the willingness to pay is very low. Why? People have been confronted with a fashion chain, which was mainly import. If you compare [prices], fashion is an import good. As long as there is no "sense of urgency" from the government and requirements, for the brands to contribute a part, and invest, I think that [mechanical recycling] is never going to break through. Then you'll have nice initiatives, and nice niche brands taking the lead, but the mainstream is not following (…)." (I3).

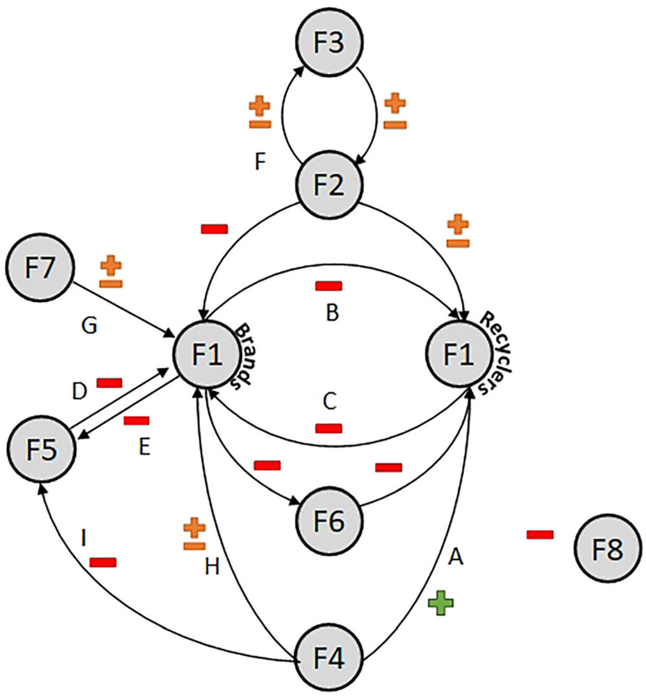

FIGURE 4 Function dynamics in the mechanical recycling trajectory

related to the absence of fibers suitable for covering the broad range of textile items. This low demand leads to a poor business case for investors in this sector (−**F1 – brands**) (***B***). It is considered too risky to invest (−**F6**) in large scale mechanical recycling facilities without a clearly articulated demand. This leads to a "catch-22" situation where mechanical recyclers cannot produce in large quantities (−**F5**) which is in turn a reason why large brands are not eager to shift to recycled textiles. They require fabrics with predictable quality (to avoid *reputational risk*) and availability in large quantities (−**F7**). This lacking *market demand* (−**F5**), resulting in lack of scale, also lowers *learning effects* (−**F2**). Overall, this means prices cannot compete with virgin materials, further driving down *demand* (−**F5**). Finally, the negative cycle is strengthened as consumers lack awareness of the trajectory (−**F5**) and this further, increases the perception by large brands that a shift to recycled fibers is risky (−**F7**). Consequently, production at industrial scale stays limited (a first commercial mill is planned for 2021), and leaves business models unprofitable which further affects *entrepreneurial activities* (−**F1**), *demand* (−**F5**) and *resource mobilization* (−**F6**) negatively (***C&D&E***). On the whole, interest by retailers is rising but they tend not to invest heavily in recycling facilities and other than smaller players under-invest in knowledge development (**F2**), since they frequently outsource item recollection, recycling and production to third parties (I14, GD27).

Knowledge and quality requirements especially affect this vicious cycle (**F**). Most textiles are multi-layered, contain fiber mixes and have low quality making only a very small percentage of recollected post-consumer textiles apt for fiber-to-fiber recycling (I9, I12, GD31). In collaboration with foreign partners, innovation of key automated sorting technology was enabled called *Fibersort*. Knowledge development (**F2**) is crucial for retrieving sufficiently even, long and strong fibers, but blending with other materials in production remains necessary which equals extra (virgin) material inputs and ultimately means a finite number of circular cycles (I3, I7, I9).[11]

Critically, *Fibersort* uncovered that labels on clothes are often inaccurate (GD41). Correct identification of the types of recycled content is hence not only complicated for consumers but practically impossible without advanced technology and further impaired through absence of a common label or certification *guiding consumer choice* for circular textiles (−**F4**). The vast majority of sorters and recyclers rely on manual pre-sorting and processing, meaning that inefficiencies in this trajectory from unknown recyclate composition cannot be tackled. Altogether this drives down *legitimacy* (−**F7**) of the trajectory **(G)**. Tracking and tracing technology can be potentially revolutionary for recollection and sorting management, bringing transparency and engaging consumers (I7, I29).

A clear virtuous cycle is formed due to close *knowledge exchange* (**F3**), *guidance* (**F4**) and *coordination* (**F8**) between players forming one supply chain (from re-collection to recycled item). Nevertheless, a vicious core cycle dominates as mechanical recyclers hold back detailed "soft" knowledge on production line efficiencies and fabric treatment — such knowledge acts as potential competitive edge. Since private (and public) investment has been decisive for actor survival, these fuel protectionist attitudes. Despite intense activities from networking organizations directing the system forward, the trajectory lacks sufficient *(policy) instruments* (−**F4**) (***H***) that would push *coordination* of the different Dutch regional clusters forward (−**F8**), increase knowledge exchange among all parties (−**F3**), and demand by consumers and retailers (−**F5**). Looking towards international developments, it is striking that experimentation by retailers, producers and knowledge developing consortia is typically not exclusively focused on mechanical recycling (JS93). Several Dutch retailers and SMEs buy from mechanical facilities in Italy and Spain (e.g., *Recovertex*) and have commercialized products indicating a basic market and supply exists.

4.2.3 | The chemical recycling trajectory

In this solution trajectory, a small number of highly innovative start-ups and spin-offs (e.g., *SaXcell*, *Worn Again*) focuses exclusively on textile-to-textile recycling. These have just started setting up pilot plants and have yet to commercialize products (TV66). Therefore, the trajectory is in the development phase. Particularly *SaXcell* (TV1), stands out with a highly innovative technology that can turn cellulose fibers from high cotton percentage type post-consumer clothes into new cotton fibers.[12] Next to textile-to textile recycling, companies use pre- and/or post-consumer textiles for open and closed-loop polymer (re)cycling (e.g., *CuRe, Ioniqua, Chemport cluster Emmen*) which nowadays still frequently results in re-purposing into granulates or packaging material using additional inputs (e.g., PET). A number of companies focus on advancing green chemistry (*Chemport Emmen*, *DSM*) and complementary innovation, for example, dyeing technology (*Dyecoo*, *Ten Cate*) (GD58, JS71), the latter is ultimately important to design clothes more suitable for closed-loop chemical recycling. Most chemical recyclers work closely with universities, start-ups and other partners for technology development.

Altogether, we found highly positive *entrepreneurial* dynamics (**F1 – recyclers**) (I3, I17) in the system impacted positively by *knowledge development* (**F2**) (Figure 5, ***A***). Yet overall, knowledge on break-through textile-to-textile technologies is still scarce, and these technologies are extremely energy-intensive at small scale (GD53, I17). Knowledge exchange is naturally limited in the sector due to high need for IPR protection, yet players know enough of each other to assess their activities as complementary at this point in time (I17). With premature technology (−**F2**) and few infrastructure (−**F6**), a functioning *market* (−**F5**) is so far absent (***B***). Consumers lack awareness of this trajectory (−**F5**) (***C***); retailers are not themselves engaged in *entrepreneurial activities* (**−F1 – brands**) but start showing interest (**F7**), yet they desire exclusive contracts with recyclers to avoid others reap technological benefits without investing (***D***). The lack of demand increases the *risks of investing into recycling facilities* (−**F5**), leading to a *lack of resources* (−**F6**) (***E***) which further hampers the chemical recyclers who are dependent on economies of scale for attaining profitability and positive environmental impact (I17, I28). To secure a minimum investment for survival, entrepreneurs have invested high sums of own capital (I17).

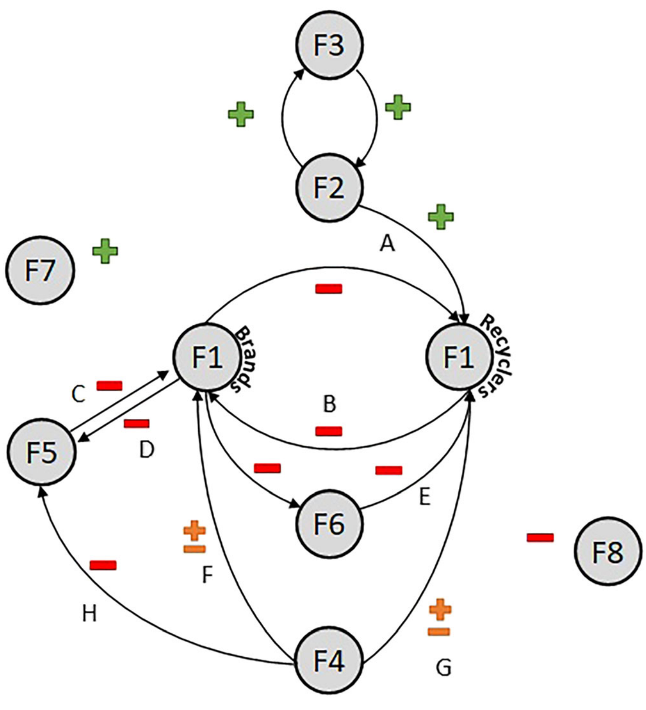

FIGURE 5 Function dynamics in the chemical recycling trajectory

Generally, most of the innovation is supported by investor collaborations containing multiple retailers (often seed funding and prizes), large chemical companies or foreign supply chain partners (**F6**). For example, *Worn Again*, a UK start-up has been repeatedly received support from *H&M* and *Sulzer*, and has just built a pilot-plant in the Netherlands securing another 8 million funding (JS78). As such the trajectory receives more interest of investors than the mechanical recycling trajectory although it suffers from the same negative cycles.

This is because, despite strong vicious cycles, the *legitimacy* **(F7)** of the trajectory is very high. All stakeholder groups in the MIS consider this the only trajectory, which can potentially close the textile loop on its own (JS36). However, there are potential legitimacy issues as retailers deliberately distort consumer knowledge (**F2**) with marketing campaigns, e.g., promoting "biological, certified or recycled cotton" as equally sustainable (NRC, 2021) and selling both products made from recyclates (e.g., 40% PET + 60% cotton) and textile-to-textile recyclable products (recyclable polyester) as 100% circular[13] (ibid). This likely results from lacking political pressure to invest in non-virgin materials and validate product claims (W1). Recently, there is more guidance of the search (***F***), the Fashion for Good consortium launched the "Full Circle Textiles Project: Scaling Innovations in Cellulosic Recycling", including large international retailers like *Laudes Foundation, Birla Cellulose, Kering, PVH Corp* (JS20).

Still, from the perspective of entrepreneurs, there has been extremely little *guidance* (I17, I28) (***G***) and financial support leading to a competition with the mechanical recycling trajectory for attention by government and "system support actors" (***H***). Generally, *coordination* and complementarity of the two trajectories is not well developed (−**F8**) which can eventually lead to diverging interest groups and lobbies (e.g., over capital, input materials) (Hekkert, Reike, et al., 2020b). From a CE perspective, the trajectory is "third in line" nowadays and chemical recyclers have even higher demands on products inputs (percentage of purified material, color compositions) than mechanical recyclers. This renders the development of tracking and tracing technology[14] particularly important for furthering development of this trajectory.

Comparing these dynamics to the international developments, it is obvious that **F1**, **F2** and **F3** show positive fulfilment (Ljungkvist, 2016; JS1, JS11, JS35, JS93, JS111, JS159, JS164, JS168). Chemical companies and spin-off companies are experimenting and exchange knowledge, yet large-scale commercialization is inexistent (I17). A few retailers like *Levi's* and *Bestseller* have single products from patented *Circulose* (JS11) or Tencel fibers but these require other (virgin) inputs. This could point to wider global knowledge deficits, resource mobilization, and coordination issues, although assessing this further is beyond our scope.

5 | CROSS-TRAJECTORY ANALYSIS: CIRCULAR DISRUPTION — UNDER WAY OR DECAY?

In the introduction, we posed that the textile sector can be considered a case of disruption *overdue*. In the Dutch case, we see that Dutch actors share perceptions on problems underlying the mission (see Section 4.1) and the diverse actor constellations are creating new structures aimed at a circular system. This includes incumbents who engage in experimentation and redeploy resources to the MIS. Following a process-oriented perspective on disruptions (Bauwens et al., forthcoming), the emergence of the three solution trajectories and actors starting to reconfigure resources, is indicative of disruption being *underway* in the Netherlands.

At this point, the system structures and dynamics overall point to the system being dominantly in the formative phase. The structures and the positive dynamics are still highly vulnerable (Bento & Wilson, 2016) and negative dynamics can more easily lead to MIS stagnation. The *secondhand trajectory* is the furthest developed and currently shows a stable growth trend along the S-curve (see Figure 6). However, we noted different challenges (such as quality, actor tensions over collection, non-existent seller coordination, etc.) which could potentially jeopardize this trend.

The mechanical recycling trajectory was determined to be in the take-off stage: sufficient networks and basic knowledge exist, and products are marketed. Its challenges relate to quality, demand, and locally lacking infrastructure (for re-shoring), legal barriers (for producing abroad) and lacking consumer awareness. These inhibit the trajectory and could lead to regression in the absence of interventions.

The chemical recycling trajectory is in the take-off stage concerning products which "downcycle materials" (e.g., shoe to granulates) but when it comes to its key objective (i.e., shoe-to-shoe) it is in the development phase. Knowledge, financial resources and infrastructure are crucial for further development. Quantitatively speaking, this trajectory shows fewer negative functions, but deficits are more substantial than in mechanical recycling. Table 5 shows the functions that we established to require specific attention in each of the trajectories.

Comparing the trajectories, we see basic fulfilment of the function "entrepreneurial experimentation"(**F1**) knowledge development (**F2**), and knowledge diffusion (**F3**) — to a lower extent. Weaknesses in textile quality and collection systems affect all trajectories and currently inhibit their potential. In both, the mechanical and chemical recycling trajectories this triggered a persisting "waiting game" or "catch-22" situation. Lacking consumer awareness (−**F4**) causes an absence of pressure for change (−**F7**) and this keeps demand for recycled fibers by incumbent firms low (−**F5**) which inhibits supply of recycled material from mechanical and chemical recycling operations and commercialization of recycled textile items. Cautious resource investments into the solutions are made by incumbent players (−**F6**). New entrants, in the absence of extensive government support or strategic coalitions (−**F4**) struggle to secure the continuous resource streams (−**F6**) needed for further development of structures, innovation and technology. Financial institutions remain hesitant due to the high-risk profile of industrial plants given the poorly articulated demand of large brands.

These vicious dynamics in the "catch 22" situations that characterize two out of three trajectories seem to hinder overall system development in such ways as to prevent the MIS from moving

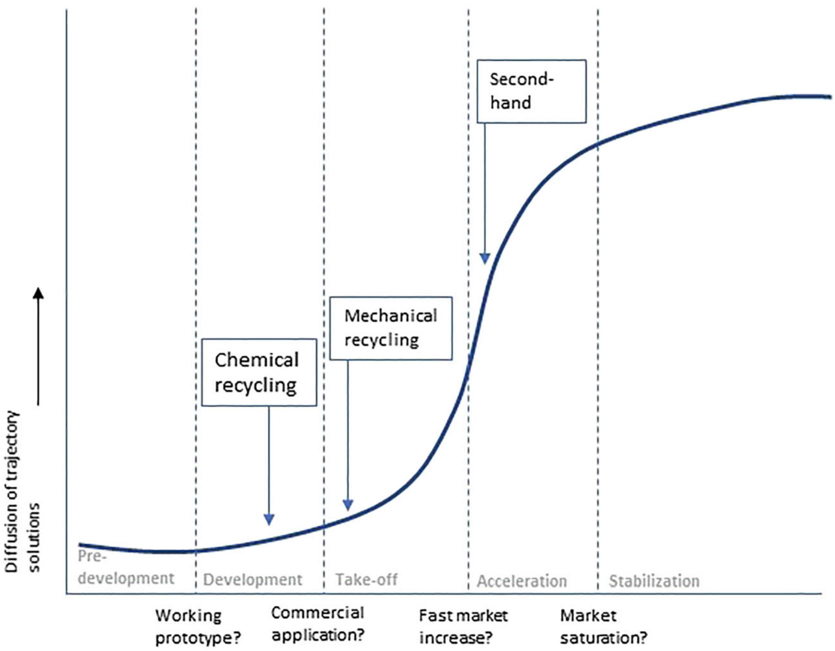

FIGURE 6 Development stage of the solution trajectories

TABLE 5 Functions requiring specific attention in each of the three solution trajectories

System function name	#	Secondhand	Mechanical recycling	Chemical recycling
Entrepreneurial activity	F1			
Knowledge development	F2			(x)
Knowledge exchange	F3			
Guidance of the search	F4		x	
Market formation	F5		x	x
Resource mobilization	F6	(x)	x	x
Legitimacy creation	F7		x	
Coordination	F8	x	x	x
Regime change	F9		x	

towards acceleration. Below we present and discuss our results on how the system dynamics captured through the new system functions introduced in Section 2 affect development of the Dutch MIS.

First, comparative analysis of the three Dutch trajectories reveals the importance of regime actors in shaping MIS directionality and outcomes. On the one hand, large retailers offering secondhand or (mechanically) recycled products often outsource production and logistics to third parties (I14, I22, I29). Many mainly engage in reconfiguring physical resources and continue to under-invest into equipping human resources with a CE mindset, thus rendering CE an add-on rather than new core business. When it comes to support for breakthrough innovation (chemical recycling), these companies also apply traditional strategies. They are eager to invest, under conditions of exclusivity that would grant them a first-mover advantage and so far show reluctance to cooperatively induce Dutch chemical recycling technologies take-off (I17, I5).

On the other hand, incumbent system actors act very differently than posed in the literature on "classic disruptions." In that literature incumbents resist adoption of innovation as they are ill-equipped to adapt and to integrate for a number of reasons (including organizational inertia, lack of foresight, and underinvestment). As a consequence, they lose out against niche actors who eventually attain system overturn (Christensen & Bower, 1996; Gilbert, 2005; Hill & Rothaermel, 2003; Tesfaye & Nguyen, 2012). In the Dutch case, large incumbents like retailers engaged in experimentation with the secondhand trajectory early on (we showed that as F1 – brands), and have been decisive in pushing this trajectory on a stable growth path. Focusing on this "low hanging fruit" solution that requires little knowledge, resources and infrastructure, incumbents demonstrate very strategic responses and rather than resisting MIS development, have shown to use their powers to actively drive forward specific solutions and remain inactive on others. Moreover, they promote secondhand and similar alternatives as circular and "feel-better" choices, thereby stimulating traditional buying behavior over more conscious consumer choice.

These strategic responses make a "classic disruption" unlikely as a mechanism of MIS acceleration and suggest that there is a broader role for studying how such behavior affects trajectory and system development in MIS. If incumbents tend to prioritize "lower ambition" trajectories, this can act to keep radical innovation on a short leash (Smink et al., 2015), and can ultimately hold back system development, slow down the speed of the transition, and shape the mission in ways that leads to the "hijacking" and *decay* of the original missions' intent.

Another key dynamic we detect to affect the entire Dutch MIS development is coordination. Currently we observe that different network organizations and corporate intermediaries kickstart small initiatives play an important role in creating small markets and helping to coordinate the development of local supply chains. This makes cross-trajectory coordination successful within regional clusters (GD26:G28). In Twente, stakeholders from the three trajectories work to form one closed loop supply chain that follows circularity principles organized as to make one partner's outputs another's inputs. Obviously, this can build high interdependence into this local MIS system among players that were not traditionally linked, yet it can also warrant strong coordination among the partners and leads to new forms of value creation and sharing (I28, I29; Kanda et al., 2021).

In contrast, national coordination is insufficient especially across the solution trajectories. Internal trajectory coordination and interregional coordination are at best limited to knowledge exchange (W1). The *Dutch Circular Textile Valley* is charged by the government with MIS coordination at national level on paper (GD17, GD43:GD47; I28, I29) but lacks mandate, resources and mechanisms to coordinate these regional clusters and the three trajectories nation-wide. This poses a severe risk to attaining sustainable outcomes at system level. As Kanda et al. (2021) outline, a central locus of coordination may be important for functioning circular value chains.

We also observed guidance of the search and provision of directionality through governments to affect MIS development. Guidance has been evidenced above all by the ambitious national targets and provision of resources for experimentation, network formation and knowledge development. In this way the Dutch national government contributed significantly to system formation. Mazzucato (2018) suggests complementary instruments and policies are important in missions, but the formation of the Dutch trajectories was not followed up timely with stronger complementary legal instruments. The Dutch government recognizes that infusing resources into underequipped trajectories or acting as launching customer can be a motor of system change (Rijksoverheid, n.d.), but it has effectively not used this power in the past to steer market development. This was found to be a main factor influencing temporary decline and lasting instabilities in the two more radical trajectories (W1) (−F4).

Recently, the Dutch government has started negotiations on an Extended Producer Responsibility (EPR) scheme where the producer pays a fee on each item sold. This binding instrument can offer remedies for past inconsistencies in providing directionality jointly for the trajectories. An EPR can influence investors' and incumbent resource allocation (F6) and sets clear incentives to engage in the two more radical trajectories (F1, F5). Fees from such a scheme can be used to accelerate infrastructure and market development for mechanical and chemical recycling and stationary local resale (F5, F6).

As a strong instrument of guidance and directionality (F4), an EPR can simultaneously address other key system dynamics showing deficits including coordination. With an EPR, the Dutch Circular Textile Valley could be transformed into a "circular value chain management organization" (Vermeulen et al., 2021) which represents both, trajectories and regions, and is lend power and mandate to delegate fees obtained from the EPR towards developing and coordinating the most critical components in the system. This can be accompanied by a comprehensive roadmap which couples targets to resource provisions thereby providing much needed financial certainties for the change driving system actors.

A final consideration regards international guidance (F4) and coordination (F8). The textile sector is void of potent institutions driving sector change, and the Dutch mission is partly dependent on powerful global (corporate) players and global supply chains that are only influenced to a limited extend by national aspirations. Taking initiative towards stronger inter-regional, European and global "coalitions of the willing" for scaling circular activities, infrastructure and complementary innovation such as "advanced textile tracking and tracing technology" could significantly benefit the Dutch mission and the wider global transition towards a more circular sector.

6 | CONCLUSIONS AND REFLECTION

In this study we applied a tentative mission-oriented innovation systems framework (MIS) combined with established elements from innovation systems theory in order to provide a first empirical study on circular transition dynamics that result from mission formulation.

The case study of the Dutch circular textile transition reveals that there is a good match between the formal Dutch mission (100% circularity by 2050) and stakeholder perceptions, and the actors have formed structures around three dominant CE solution trajectories in the Dutch system: secondhand, mechanical recycling and chemical recycling. We observe that mission formalization acted as signpost that provides guidance for the innovation system actors. Comparing the transition dynamics across MIS solution trajectories, our study found that the government provided strong directionality and system guidance, but in abstaining from implementing strong legal instruments, a "waiting game" or "catch-22" situation currently characterizes each of the two recycling trajectories and these dynamics interact as to inhibit overall MIS development in its formative phase.

Reflecting more critically on the dynamics exhibited in the Dutch MIS and juxtaposing these against the notion of a circular textile sector posed in the introduction, we conclude that despite the existence of radical solutions across all three trajectories, a clear system disruption towards circular design, production and consumption models is thus far not evident in the Dutch circular textile transition. Our study suggests that trajectory and system coordination which were strongly under-developed may additionally be of significant importance in augmenting the negative feedback loops we detected in the Dutch MIS. Most notably, in the absence of coordination there is an eminent risk that positive sustainability impacts attained within one solution trajectory or at one system level fail to generate sustainability impacts at the overall system level (Corvellec et al., 2020; Korhonen et al., 2018). Therefore, the role of coordination should be further studied, especially in the context of circular transitions.

Inquiring the Dutch circular textile transition from the perspective of multiple interrelated actor constellations and solution trajectories we add to transitions studies more generally. In particular, our study puts forward that solution trajectories when viewed in isolation can appear successful, but only taking into account the parallel development of multiple such solution trajectories can reveal the key driving and blocking mechanisms hampering acceleration of a transition. Additionally, such a view adds to practice in nourishing the understanding of practitioners and policy-makers for the collective dimension of their activities—in relating their success and failure to the combined interplay of system structure and dynamics. Our research also implies that instruments and interventions designed for system acceleration need to take into account dynamics within as well as across solution trajectories. One such instrument we suggest for the Dutch case is the installation of an Extended-Producer Responsibility (EPR) — as it can address deficits found across a number of different system dynamics.

Reflecting on the application of the MIS framework we note that through the newly proposed MIS functions (coordination, directionality, regime change) we gained rich additional insights into MIS development but other case studies need to show if this holds more generally. We cannot provide in-depth considerations on the further conceptualization and application of each of these functions. We note that it may be critical for understanding mission development to place a higher focus on power and strategic behavior of actors. This has also been proposed by Wittmann et al. (2021). In the Dutch case, government exerted influence on the direction of search and solutions among the different MIS actor constellations through prioritizing solutions that lead to appropriation of benefits within national borders.

These findings indicate that there remain more conceptual challenges for defining and measuring regime actors and regime change in MIS. As another key limitation our study exclusively examined problem and solution directionality for the Dutch MIS as a whole, yet we suggested that such processes can also be conceived as a MIS function within solution trajectories, since one trajectory typically comprises multiple technological and non-technological solutions. Moreover, similar to our conceptualization of regime change in this paper, MIS directionality arguably involves processes that regard all other functions. Therefore, the function of directionality and its relation to other functions needs to be further conceptualized. For example, our reflections on the role of power in MIS also suggest a nexus between these two functions wherefore exploring "regime change directionality" could provide an interesting avenue of study for a more mature MIS, that is, how exactly regime players strategically engage in the transition to shape problems and mission outcomes.

Nevertheless, further splitting up or analyzing these functions can pose new challenges for conducting feasible MIS studies when multiple trajectories are studied. In the present study, we focused only on three trajectories. Evidently there remain unresolved theoretical and methodological challenges how a higher number of co-evolving solution trajectories can be studied and integrated to give a valid account of the MIS as a whole.

We also saw that scoping challenges arise for mission research. Missions get formulated at various levels, yet ultimately such missions address complex issues that play out at global scale—in the circular textile transition developing countries are still waste havens for lower quality donated clothes from developed countries. In our approach, we delineated the MIS to national level, but we included global events and used this as a means to better verify our results and place the Dutch national mission into its larger context. We propose that future mission oriented studies put focus on and critically investigate how national missions and their objectives relate to the global character of mission problems, and how missions defined at one level contribute to sustainability at other system levels.

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ENDNOTES

[1] The TIS literature knows several ways for identifying system functions (indicators, diagnostic questions). These guidelines were applied more freely in coding text fragments, for the event analysis, we followed these concepts and indicators and added some new categories.

[2] Diagnostic questions cover four main areas: Who is involved in [function name]; What types of circular activities do actors engage in related to [function name]; How do these activities on [function name] benefit system development; Do the activities on [function name] (or the lack thereof) form a barrier for the system to move to the next development stage. Detailed diagnostic questions and the indicators related to these questions vary with the function investigated. As an example: F6 - human resources, physical resources, financial resources; see Appendix B.

[3] Diagnostic questions on development stages are: 1. (End of the) Pre-development phase: is there a working product or service prototype / a working (proto-)institution, 2. (End of the) Development phase: Is there commercial application, 3. (End of the) Take-off phase: Is there fast market growth, 4. (End of the) Acceleration phase: Is there market saturation.

[4] The Dutch Green Deals exist already for a decade and are not directly related to the recent "European Green Deal," except both focus on sustainability. They are covenants under private law between coalitions of companies, civil society organizations and local and regional government. Deals often focused on fostering entrepreneurship, knowledge development and exchange. 2 to 3 years is a regular runtime, they are completed when its goals are attained. To date the Netherlands implemented 235 Green Deals.

[5] Regional Deals aim to stimulate regional welfare (total budget first round: 200 million euros) yet they often focus on other sustainability dimensions as well. Under the concept, multi-stakeholder initiatives provide the same amount as the government to co-finance the "Regio Deal" objectives.

[6] The Dutch policy-making takes specific focus on five top sectors in which it is globally leading with science and technology https://www.rvo.nl/onderwerpen/innovatief-ondernemen/topsectoren#:~:text=Topsectoren%20zijn%20gebieden%20waar%20het,positie%20nog%20sterker%20te%20maken.

[7] We recommend Appendix E for further details of the Dutch system actors and institutions.

[8] The few successfully commercialized fibers require additions of virgin inputs (e.g., Tencel – pulp, Econyl – pre-consumer clothes) and cannot yet cover the full spectrum of textile items. Most importantly, we see a strong link between the fiber innovation trajectory and the two recycling trajectories and expect the former will increasingly gain importance over the mission runtime.

[9] For more clarity, in the analysis, signaling functions related to the nine system functions are provided in italics. Reference will be made to the functions (F1, F2 …) in bold. A minus sign indicates a negatively fulfilled functions, the absence thereof means positive fulfilment of the function.

[10] Single letters (A, B, C …) represent the positive or negative feedback loops in the respective figures.

[11] For example, DutchSpirit have developed a suit which can be recycled 7 times. Then too much blending makes further recycling into the same item impossible.

[12] There are a number of other companies globally which also work on 100% cotton recycling (Re:newcell Sweden) but to our knowledge all of these need other virgin materials (extra cellulose from pulp, organic cotton) or recycled materials (such as PET, other recycled fibers for mixing).

[13] Both of these product scan indeed be 100% circular, however, in the first case this circularity is likely only attained with open-loop recycling and downcycling of the material, only in the latter case there is potential for closed-loop textile-to-textile recycling that enables multiple loops of use.

[14] For an overview of tracking and tracing technology in the apparel sector see UNECE (2020). According to our interviewee (I29) three key technologies are included: 1. Unique identification technology for items (e.g., RFID), 2. Data storage technology and device (e.g., button/label which can capture and store various types of production and use data), 3. Data exchange technology (establishing digital link for reading and exchanging data).

REFERENCES

ABC (Australian Broadcasting Corporation). (2021). Dead White man's clothes. https://www.abc.net.au/foreign/dead-white-mans-clothes/13495096

BBC. (2021). How 'fast fashion' is turning Ghana into a waste dumping ground. https://www.bbc.co.uk/programmes/p09y41dw

Bento, N., & Wilson, C. (2016). Measuring the duration of formative phases for energy technologies. *Environmental Innovation and Societal Transitions*, *21*, 95–112. https://doi.org/10.1016/j.eist.2016.04.004

Bergek, A., Hekkert, M. P., Jacobsson, S., Markard, J., Sandén, B., & Truffer, B. (2015). Technological innovation systems in contexts: Conceptualizing contextual structures and interaction dynamics. *Environmental Innovation and Societal Transitions*, *16*, 51–64. https://doi.org/10.1016/j.eist.2015.07.003

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy*, *37*(3), 407–429. https://doi.org/10.1016/j.respol.2007.12.003

Bettin, S. S. (2020). Electricity infrastructure and innovation in the next phase of energy transition—Amendments to the technology innovation system framework. *Review of Evolutionary Political Economy*, *1*(3), 371–395. https://doi.org/10.1007/s43253-020-00021-4

Binz, C., Harris-Lovett, S., Kiparsky, D., Sedlak, D. L., & Truffer, B. (2016). The thorny road to technology legitimation—Institutional work for potable water reuse. *Technological Forecasting and Social Change*, *103*, 249–263. https://doi.org/10.1016/j.techfore.2015.10.005

Blomsma, F., & Brennan, G. (2017). The emergence of circular economy: A new framing around prolonging resource productivity: The emergence of circular economy. *Journal of Industrial Ecology*, *21*(3), 603–614. https://doi.org/10.1111/jiec.12603

Bryman, A. (2016). *Social research methods* (5th ed.). Oxford University Press.

Chemsec. (2018). Circular economy needs trust, transparency and traceability. https://chemsec.org/circular-economy-needs-trust-transparency-andtraceability/?utm_source=ChemSec+newsletter&utm_campaign=f7bb1e99a3-EMAIL_CAMPAIGN_2018_11_13_12_28&utm_medium=email&utm_term=0_03a9107408-f7bb1e99a3-376791197

Christensen, C. M., & Bower, J. L. L. (1996). Customer power, strategic investment, and the failure of leading firms. *Strategic Management Journal*, *17*(3), 197–218. https://doi.org/10.1002/(SICI)1097-0266(199603)17:3<197::AID-SMJ804>3.0.CO;2-U

Corvellec, H., Böhm, S., Stowell, A., & Valenzuela, F. (2020). Introduction to the special issue on the contested realities of the circular economy. *Culture and Organization*, *26*(2), 97–102. https://doi.org/10.1080/14759551.2020.1717733

De Gooyert, V., Rouwette, E., van Krankenburg, H., & van Breen, H. (2014). *Dynamiek van de energietransitie. Naar een gedeeld beeld van kansen en uitdagingen in modelvorm*. Next Generation Infrastructures. Alliander, Radboud Universiteit Nijmegen.

Diercks, G., Larsen, H., & Steward, F. (2019). Transformative innovation policy: Addressing variety in an emerging policy paradigm. *Research Policy*, *48*, 880–894. https://doi.org/10.1016/j.respol.2018.10.028

Esmailzadeh, M., Noori, S., Aliahmadi, A., Nouralizadeh, H., & Bogers, M. (2020). A functional analysis of technological innovation systems in developing countries: An evaluation of Iran's photovoltaic innovation system. *Sustainability*, *12*(5), 2049. https://doi.org/10.3390/su12052049

Financiele Dagblad (FD). (2020). Kledingmarktplaats Vinted slokt Nederlandse branchegenoot op. https://fd.nl/ondernemen/1362068/kledingmarktplaats-vinted-slokt-nederlandse-branchegenoot-op

Fischer, A., & Pascucci, S. (2017). Institutional incentives in circular economy transition: The case of material use in the Dutch textile industry. *Journal of Cleaner Production*, *155*, 17–32. https://doi.org/10.1016/j.jclepro.2016.12.038

Gunderson, L. H., & Holling, C. S. (2002). *Panarchy: Understanding transformations in human and natural systems*. Island Press.

Harvard Business Review. (2019). What supply chain transparency really means. https://hbr.org/2019/08/what-supply-chain-transparency-really-means

Hekkert, M. P., Janssen, M. J., Wesseling, J. H., & Negro, S. O. (2020a). Mission-oriented innovation systems. *Environmental Innovation and Societal Transitions*, *34*, 76–79. https://doi.org/10.1016/j.eist.2019.11.011

Hekkert, M. P., Negro, S. O., Heimeriks, G. J., & Harmsen, R. (2011). *Technological innovation system analysis. A manual for analysts*. Copernicus Institute of Sustainable Development.

Hekkert, M. P., Reike, D., Rainville, A., & Negro, S. O. (2020b). Transition to circular textiles in the Netherlands: An innovation systems analysis. https://www.government.nl/documents/reports/2021/01/12/transition-to-circular-textiles-in-the-netherlands-an-innovation-systems-analysis

Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, *74*(4), 413–432. https://doi.org/10.1016/j.techfore.2006.03.002

Hill, C. W. L., & Rothaermel, F. T. (2003). The performance of incumbent firms in the face of radical technological innovation. *Academy of Management Review*, *28*(2), 257–274. https://doi.org/10.5465/amr.2003.9416161

Infrastructuur en Waterstaat (I&W), Ministerie van. (2020). Beleidsprogramma circulair textiel 2020–2025. https://www.rijksoverheid.nl/documenten/rapporten/2020/04/14/beleidsprogramma-circulair-textiel

Jacobsson, S., Sandén, B., & Bångens, L. (2004). Transforming the energy system—The evolution of the German technological system for solar cells. *Technology Analysis & Strategic Management*, *16*(1), 3–30. https://doi.org/10.1080/0953732032000199061

Janssen, M. J., Ladeia Torrens, J. C.; Wesseling, J., Wanzenböck, I., & Patterson, J. (2021). Position paper—Mission-oriented innovation policy observatory. https://www.uu.nl/sites/default/files/MIPO%20position%20paper%20-%20v21-05-2020.pdf

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., & Schösler, H. (2016). Transition towards circular economy in the food system. *Sustainability*, *8*(69), 1–14. https://doi.org/10.3390/su8010069

Kanda, W., Geissdoerfer, M., & Hjelm, O. (2021). From circular business models to circular business ecosystems. *Business Strategy & the Environment*, *30*(6), 2814–2829. https://doi.org/10.1002/bse.2895

Kieft, A., Harmsen, R., & Hekkert, M. P. (2021). Heat pumps in the existing Dutch housing stock: An assessment of its technological innovation system. *Sustainable Energy Technologies and Assessments*, *44*, 101064. https://doi.org/10.1016/j.seta.2021.101064

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232.

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: The concept and its limitations. *Ecological Economics*, *143*, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

Lewandowski, M. (2016). Designing the Business Models for Circular Economy—Towards the Conceptual Framework. https://doi.org/10.3390/su8010043

Ljungkvist, H. & Elander, M. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Mistra Future Fashion Report. http://mistrafuturefashion.com/wp-content/uploads/2016/06/MFF-report-2016-1-Critical-aspects.pdf

Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research: Transforming science and practice for societal change.

Annual Review of Environment and Resources, *42*, 599–626. https://doi.org/10.1146/annurev-environ-102014-021340

Maldini, I., Duncker, L., Bregman, L., Piltz, G., Duscha, L., Cunningham, G., Vooges, M., Grevinga, T., Taps, R., & van Balgooi, F. (2017). Measuring the Dutch clothing mountain: Data for sustainability-oriented studies and actions in the apparel sector. https://pure.hva.nl/ws/files/3144178/Measuring_the_Dutch_Clothing_Mountain_final_report_002_.pdf

Markard, J., & Hekkert, M. (2013, June 19–21). Technological innovation systems and sectoral change: Towards a TIS based transition framework [Conference presentation]. Paper No. 330, 4th Conference on Sustainability Transitions, Zurich.

Markard, J., Hekkert, M., & Jacobsson, S. (2015). The technological innovation systems framework: Response to six criticisms. *Environmental Innovation and Societal Transitions*, *16*, 76–86. https://doi.org/10.1016/j.eist.2015.07.006

Mazzucato, M. (2018). Mission-oriented innovation policies: Challenges and opportunities. *Industrial and Corporate Change*, *27*(5), 803–815. https://doi.org/10.1093/icc/dty034

McKinsey & Company. (2021). The state of fashion 2020. https://www.mckinsey.com/~/media/McKinsey/Industries/Retail/Our%20Insights/State%20of%20fashion/2021/The-State-of-Fashion-2021-vF.pdf

Negro, S. O., & Hekkert, M. P. (2008). Explaining the success of emerging technologies by innovation system functioning: The case of biomass digestion in Germany. *Technology Analysis & Strategic Management*, *20*(4), 465–482. https://doi.org/10.1080/09537320802141437

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2020). The environmental price of fast fashion. *Nature Reviews Earth & Environment*, *1*(4), 189–200. https://doi.org/10.1038/s43017-020-0039-9

Politico. (2020). Because of coronavirus, Europe is drowning in secondhand clothes. https://www.politico.eu/article/coronavirus-europe-drowning-secondhand-clothes/

Poole, M. S., van de Ven, A. H., Dooley, K., & Holmes, M. E. (2000). *Organizational change and innovation processes, theories and methods for research*. Oxford University Press.

Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2017). Circular economy: Measuring innovation in the product chain. https://www.pbl.nl/sites/default/files/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf

Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0?—Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, *135*, 246–264.

Reuters. (2020). Height of fashion? Clothes mountains build up as recycling breaks down. https://www.reuters.com/article/us-health-coronavirus-textiles-recycling-idINKBN26L0QQ

Rijksoverheid. (n.d.). Rijksinkopers gaan voor 100% circulair inkopen. https://www.werkenvoornederland.nl/organisaties/ministerie-van-economische-zaken-en-klimaat/rijksdienst-voor-ondernemend-nederland/rijksinkopers-gaan-voor-100-circulair-inkopen

Smink, M. M., Hekkert, M. P., & Negro, S. O. (2015). Keeping sustainable innovation on a leash? Exploring incumbents institutional strategies. *Business Strategy and the Environment*, *24*, 86–101. https://doi.org/10.1002/bse.1808

Smith, A., & Stirling, A. (2008). Social-ecological resilience and socio-technical transitions: Critical issues for sustainability governance. Economic and Social Research Council. Steps Centre. https://steps-centre.org/wp-content/uploads/STEPS-Working-Paper_Transitions.pdf

Smith, K. (2016). Dutch coalition commits to responsible garment production. https://advance-lexis-com.proxy.library.uu.nl/api/document?collection=news&id=urn:contentItem:5J9W-F021-F14X-V3CM-00000-00&context=1516831

Strauss, A., & Corbin, J. M. (1998). *Techniques and procedures for developing grounded theory*. Sage.

Suwa, A., & Jupesta, J. (2012). Policy innovation for technology diffusion: A case-study of Japanese renewable energy public support programs. *Sustainability Science.*, *7*, 185–197. https://doi.org/10.1007/s11625-012-0175-3

Textielnet. (n.d.). Nederlandse textielindustrie. https://www.textielnet.nl/nederlandse-textielindustrie.html

UNEP. (2018). Putting the brakes on fast fashion. https://www.unep.org/news-and-stories/story/putting-brakes-fast-fashion

UNEP. (2021). In the textile industry, old is increasingly becoming new. https://www.unep.org/news-and-stories/story/textile-industry-old-increasingly-becoming-new

Vermeulen, W. J. V., Backes, C. W., de Munck, M. C. J., Campbell-Johnston, K., de Waal, I. M., Rosales Carreon, J., & Boeve, M. N. (2021). Pathways for extended producer responsibility on the road to a circular economy. https://www.uu.nl/sites/default/files/White-paper-on-Pathways-for-Extended-Producer-Responsibility-on-the-road-to-a-Circular-Economy.pdf

Vinit, J., O'Brien, W., & Gloria, T. B. (2021). Improved solutions for shared value creation and maximization from used clothes: Streamlined structure of clothing consumption system and a framework of closed loop hybrid business model. *Cleaner and Responsible Consumption*, *3*, 100039. https://doi.org/10.1016/j.clrc.2021.100039

Wanzenböck, I., Wesseling, J. H., Frenken, K., Hekkert, M. P., & Weber, M. K. (2020). A framework for mission-oriented innovation policy: Alternative pathways through the problem–solution space. *Science and Public Policy*, *47*(4), 474–489. https://doi.org/10.1093/scipol/scaa027

Wesseling, J. H., & Meijerhof, N. (2021). Development and application of a MISs (MIS) approach [Working paper]. https://www.uu.nl/sites/default/files/Wesseling%20and%20Meijerhof%202020_working%20paper.pdf

Wieczorek, A. J., Negro, S. O., Harmsen, R., Heimeriks, G. J., Luo, L., & Hekkert, M. P. (2013). A review of the European offshore wind innovation system. *Renewable and Sustainable Energy Reviews*, *26*, 294–306. https://doi.org/10.1016/j.rser.2013.05.045

Wittmann, F., Hufnagl, M., Lindner, R., Roth, F., & Edler, J. (2021). Governing varieties of mission-oriented innovation policies: A new typology. *Science and Public Policy*, *48*, 727–738. https://doi.org/10.1093/scipol/scab044

REFERENCES FROM THE DATABASE

Policymakers and policy documents

Centraal Planbureau. (2019). Textiel als secundaire grondstof. https://www.researchgate.net/publication/338645672_Textiel_als_secundaire_grondstof_CPB_Achtergronddocument#read

CirkelWaarde - AVU, ROVA, CirculusBerkel -, NVRD, Rd4, MidWaste, OMRIN, Twente Milieu, Metropool Regio Amsterdam, Gemeente Amsterdam, Gemeente Utrecht, MidWaste, Zaanstad, HVC. (2020). Visie Circulair Textiel Onze publieke visie op een circulaire textielketen. https://www.circulus-berkel.nl/upload/file/Visie%20Circulair%20Textiel.pdf

EU (European Parliament). (2019). Environmental impact of the textile and clothing industry—What consumers need to know. https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633143/EPRS_BRI(2019)633143_EN.pdf

European Environmental Agency. (2019). Textiles and the environment in a circular economy. Eionet Report - ETC/WMGE 2019/6. https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-reports/textiles-and-the-environment-in-a-circular-economy/@@download/file/ETC-WMGE_report_final%20for%20website_updated%202020.pdf

GIZ (Deutsche Gesellschaft fuer internationale Zusammenarbeit). (2019). Circular economy in the textile sector. https://www.adelphi.de/de/

system/files/mediathek/bilder/GIZ_Studie_Kreislaufwirtschaft_Textilsektor_2019_final.pdf
Infrastructuur en Waterstaat (I &W), Ministerie van. (2020). Beleidsprogramma circulair textiel 2020 – 2025. https://www.rijksoverheid.nl/documenten/rapporten/2020/04/14/beleidsprogramma-circulair-textiel
Infrastructuur en Waterstaat (I&W), Ministerie van. (n.d.-a). Roadmap circulair textiel. http://publicaties.minienm.nl/download-bijlage/110837/roadmap-circulair-textiel.pdf
Infrastructuur en Waterstaat (I&W), Ministerie van. (n.d.-b). Beleidsprogramma Circulair Textiel 2020-2025. (Policy Program Circular Textiles). https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/kamerstukken/2020/04/14/beleidsprogramma-circulair-textiel-2020-2025/beleidsprogramma-circulair-textiel-2020-2025.pdf
Rijksoverheid. (2012). Green Deal inzameling textiel. https://www.greendeals.nl/sites/default/files/downloads/GD142-Duurzame-inzameling-textiel.pdf
Rijksoverheid. (2014). C-177. Green Deal Natuurvezels. https://www.greendeals.nl/sites/default/files/downloads/GD177-Natuurvezels.pdf
Rijksoverheid. (2016a). Nederland circulair in 2050. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2016/09/14/bijlage-1-nederland-circulair-in-2050/bijlage-1-nederland-circulair-in-2050.pdf
Rijksoverheid. (2016b). Rijksbreed programma Circulaire Economie. https://www.rijksoverheid.nl/documenten/rapporten/2016/09/14/bijlage-1-nederland-circulair-in-2050
Rijksoverheid. (2019). Regio Deal Twente. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/kamerstukken/2019/07/15/regio-deal-twente/Regio_Deal_Twente.pdf
SER. (2016). Convenant Duurzame Kleding Convenant Duurzame Kleding en Textiel. https://lap3.nl/publish/pages/138145/ser_convenant_duurzame_kleding_en_textiel.pdf
Tweede Kamer. (2019, October). Grondstoffenvoorzieningszekerheid. https://www.tweedekamer.nl/downloads/document?id=c1fe18c9-6c5f-409b-8faa-e468ffb81b26&title=Circulair%20textiel.pdf

International fashion/textile magazine: Just Style

Just Style. (2019a, December). VF Corp eyes 30% in supply chain carbon emissions by 2030. https://www.just-style.com/news/vf-corp-eyes-30-in-supply-chain-carbon-emissions-by-2030/
Just Style. (2019b, October). Sustainability centre stage at upcoming Bangladesh apparel events. https://www.just-style.com/news/sustainability-centre-stage-at-upcoming-bangladesh-apparel-events
Just Style. (2019c, October). Apparel rental market disrupting fashion industry. https://www.just-style.com/news/apparel-rental-market-disrupting-fashion-industry
Just Style. (2019d, October). H&M and Ikea study chemicals in recycled textiles. https://www.just-style.com/news/hm-and-ikea-study-chemicals-in-recycled-textiles
Just Style. (2019e, October). First circulose recycled cotton clothes due next year. https://www.just-style.com/news/first-circulose-recycled-cotton-clothes-due-next-year
Just Style. (2020a, November). Mexican government urged on apparel circularity framework. https://www.just-style.com/news/mexican-gov-urged-on-apparel-circularity-framework
Just Style. (2020b, November). Africa apparel sector takes steps towards sustainability. https://www.just-style.com/features/africa-apparel-sector-takes-steps-towards-sustainability
Just Style. (2020c, October). October Worn Again secures EUR8m to accelerate polymer recycling. https://www.just-style.com/news/worn-again-secures-eur8m-to-accelerate-polymer-recycling
Just Style. (2020d, October). Dow project to divert sports shoes from landfill in Singapore. https://www.just-style.com/news/dow-project-to-divert-sports-shoes-from-landfill-in-singapore
Just Style. (2020e, October). Bestseller brands among first to produce Circulose garments. https://www.just-style.com/news/bestseller-brands-among-first-to-produce-circulose-garments
Just Style. (2020f, September). Lenzing co-founds Renewable Carbon Initiative. https://www.just-style.com/news/lenzing-co-founds-renewable-carbon-initiative
Just Style. (2020g, September) Project to scale cellulosic chemical recycling aims to close the loop. https://www.just-style.com/news/project-to-scale-cellulosic-chemical-recycling-aims-to-close-the-loop
Just Style. (2020h, September). The business case for chemical recycling of cellulosics. https://www.just-style.com/features/the-business-case-for-chemical-recycling-of-cellulosics/
Just Style. (2020i, July). UK fashion industry to be hit "twice as hard" in Covid-19 recession. https://www.just-style.com/news/uk-fashion-industry-to-be-hit-twice-as-hard-in-covid-19-recession
Just Style. (2020j, July). Crystal focuses green future on circular economy and Industry 4.0. https://www.just-style.com/news/crystal-focuses-green-future-on-circular-economy-and-industry-4-0
Just Style. (2020k, June). Puma explores eco-friendly dyeing in new biodesign project. https://www.just-style.com/news/puma-explores-eco-friendly-dyeing-in-new-biodesign-project/
Just Style. (2020l, April) PVH Corp GHC targets get science based approval. https://www.just-style.com/news/pvh-corp-ghc-targets-get-science-based-approval
Just Style. (2020m, April). EU urged to redesign textile industry's broken model. https://www.just-style.com/news/eu-urged-to-redesign-textile-industrys-broken-model
Just Style. (2020n, March). Textile sector faces 'green' rules under EU circularity plan. https://www.just-style.com/news/textile-sector-faces-green-rules-under-eu-circularity-plan
Just Style. (2020o, April). Textile waste focus of accelerating circularity project. https://www.just-style.com/news/textile-waste-focus-of-accelerating-circularity-project/
Just Style. (2020p, February). H&M Conscious collection to feature Circulose. https://www.just-style.com/news/hm-conscious-collection-to-feature-circulose

Dutch fashion magazine: Textilia

Textilia. (2013, May). Dutch spirit komt met leasepak. https://www.textilia.nl/dutchspirit-komt-met-leasepak
Textilia. (2015a, Oktober). Winnaar Dutch Retail Experience Award 2015: Lena the Fashion Library [Interview]. https://www.textilia.nl/winnaar-dutch-retail-experience-award-2015-lena-the-fashion-library-interview/
Textilia. (2015b, June). Geopened: De Claudia Sträter Vintagewinkel. https://www.textilia.nl/geopend-de-claudia-strater-vintagewinkel/
Textilia. (2016, October). Nederlandse modemerken liggen op kop met circulaire mode. https://www.textilia.nl/nederlandse-modemerken-liggen-op-kop-met-circulaire-mode
Textilia. (2017, January). Op trend safari. Jan Agelink over zomertrends 2018. https://www.textilia.nl/op-trendsafari-jan-agelink-over-zomertrends-2018
Textilia. (2018a, October). Winnaar green fashion talent award bekend. Ronnie flex brengt kledinglijn uit en Amcat festival gecanceld. https://www.textilia.nl/winnaar-green-fashion-talent-award-bekend-ronnie-flex-brengt-kledinglijn-uit-en-amcat-festival-gecanceld
Textilia. (2018b, June). Buining fashion failliet familiebedrijf Nomad verkocht en Guess oprichter stapt op wegens aantijgingen. https://www.textilia.nl/buining-fashion-failliet-familiebedrijf-nomad-verkocht-en-guess-oprichter-stapt-op-wegens-aantijgingen/
Textilia. (2018c, April). Claudia Sträter opent vintage store. 8 nieuwe modemerken in Nederland in JFK kleding. https://www.textilia.nl/claudia-strater-opent-vintage-store-8-nieuwe-modemerken-in-nederland-en-jfk-kledinglijn

Textilia. (2018d, March). ABN Amro. De fysieke winkel blijft belangrijkste verkoopkanaal. https://www.textilia.nl/abn-amro-de-fysieke-winkel-blijft-belangrijkste-verkoopkanaal

Textilia. (2019a, November). Victoria's Secret modeshow. Essentiel stopt met mannenmode en Secrid naar Rotterdam. https://www.textilia.nl/victorias-secret-cancelt-modeshow-essentiel-stopt-met-mannenmode-en-secrid-naar-rotterdam

Textilia. (2019b, October). Viktor & Rolf X Hema voor kers, H&M stapt in tweedehandskleiding en Otto verkoopt about you niet. https://www.textilia.nl/viktor-rolf-x-hema-voor-kerst-hm-stapt-in-tweedehandskleding-en-otto-verkoopt-about-you-niet/

Textilia. (2019c, October). WE Fashion lanceert speciaal recycle programma. https://www.vakbladvrouwenmode.nl/we-fashion-lanceert-speciaal-recycle-programma/

Textilia. (2019d, June). Nederlandse denimindustrie op Italiaanse handelsmissie met koning. https://www.textilia.nl/nederlandse-denimindustrie-op-italiaanse-handelsmissie-met-koning

Textilia. (2019e, May). DCTV voor een circulaire nederlandse modebranche. Benetton wil 100 nieuwe winkels en S oliver gaat voor duurzaam. https://www.textilia.nl/dctv-voor-een-circulaire-nederlandse-modebranche-benetton-wil-100-nieuwe-winkels-en-s-oliver-gaat-voor-duurzaam

Textilia. (2019f, February). Ontslagen bij Hema. Stradivarius en Tinder werken samen en modeuitgaven via smartphone stijgen. https://www.textilia.nl/ontslagen-bij-hema-stradivarius-en-tinder-werken-samen-en-modeuitgaven-via-smartphone-stijgen

Textilia. (2019g, January). Kledingzaak stopt na 134 jaar. Weekday komt met influencers collectie en eerste vegan fashion week. https://www.textilia.nl/kledingzaak-stopt-na-134-jaar-weekday-komt-met-influencers-collectie-en-de-eerste-vegan-fashion-week

Textilia. (2020a, September). Hunkemöller wil minder schulden, doorstrart voor Go-Britain en daling retailfailissementen. https://www.textilia.nl/hunkemoller-wil-minder-schulden-doorstart-voor-go-britain-en-daling-retailfaillissementen/

Textilia. (2020b, June). Clan Banlieue en Allbirds openen winkels in Amsterdam en nieuwe duurzame modecadeaukaart gelanceerd. https://www.textilia.nl/clan-de-banlieue-en-allbirds-openen-winkels-in-amsterdam-en-nieuwe-duurzame-modecadeaukaart-gelanceerd

Dutch fashion/textile magazines: Vakblad Mannenmode and Vakblad Vrouwenmode

Vakblad Mannenmode. (2019, June). 100% gerecycled maatpak. https://www.vakbladmannenmode.nl/100-gerecycled-maatpak

Vakblad Vrouwenmode. (2020a, April). Spin-off Hogeschool Saxion brengt circulaire textielketen stap dichterbij. https://www.vakbladvrouwenmode.nl/spin-off-hogeschool-saxion-brengt-circulaire-textielketen-stap-dichterbij

Vakblad Vrouwenmode. (2020b, March). Dutch Circular Textile Valley brengt Nederlandse circulaire textiel- en modemarkt in kaart. https://www.vakbladvrouwenmode.nl/dutch-circular-textile-valley-brengt-nederlandse-circulaire-textiel-en-modemarkt-in-kaart

Vakblad Vrouwenmode. (2020c, September). Zalando breidt uit met doorverkoop tweedehandskleding. https://www.vakbladvrouwenmode.nl/zalando-breidt-uit-met-doorverkoop-tweedehandskleding

Other newspapers articles, magazines, reports

Business Day (South Africa). (2018, April). Circular economies help to close the loop. https://advance-lexis-com.proxy.library.uu.nl/api/document?collection=news&id=urn:contentItem:5S5X-CNS1-DYT4-K2DF-00000-00&context=1516831

ICIS. (2018, February). Bio-capro, infinite recycling can secure nylon's future in the circular economy - Aquafil CE. https://www.icis.com/explore/resources/news/2018/02/06/10190458/bio-capro-infinite-recycling-can-secure-nylon-s-future-in-the-circular-economy-aquafil-ceo

Impact News Service. (2020, March). UCA Farnham hosts Repair Cafe Conference. https://advance-lexis-com.proxy.library.uu.nl/api/document?collection=news&id=urn:contentItem:5YFW-CY41-F0YC-N1Y9-00000-00&context=1516831

Indian Retail news. (2018, June). Speakers to share visionary ideas at FashionSustain forum. https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:5SNV-0MC1-JBYT-H2CN-00000-00&context=1516831

OTS Deutschland. (2020, May). European Commission announces the 30 Semi-Finalists for the 2020 European Social Innovation Competition - Reimagine Fashion. OTS Deutschland (Englisch). https://advance-lexis-com.proxy.library.uu.nl/api/document?collection=news&id=urn:contentItem:5YV0-P7R1-JCSW-K3T4-00000-00&context=1516831

The Huffington Post. (2016, September). Why this company wants you to fall in love with people's old jeans. https://advance-lexis-com.proxy.library.uu.nl/api/document?collection=news&id=urn:contentItem:5KPK-F281-JCMN-Y138-00000-00&context=1516831

Trouw.nl. (2019, April). Dit sorteerbedrijf geeft onze afgedankte vodden weer waarde. https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:5VYJ-MYC1-JBHV-K402-00000-00&context=1516831

WWD. (2018, April). Circular Fashion Games Reward Sustainability, Circular Economy Ideas. https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:5S2T-2GC1-DYJW-X15W-00000-00&context=1516831

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APPENDIX A: LIST OF 10 CIRCULARITY STRATEGIES (VALUE RETENTION OPTIONS) BASED ON REIKE ET AL. (2018)

R#		Examples of (market) actor activities
R9	Re-mine	e.g., grubbing, cannibalizing, selling old products and materials (global South)/ high-tech extraction, reprocessing of waste in landfills or sewers (global North)
R8	Recover (energy)	e.g., energy production as by-product of waste treatment
R7	Re-cycle	e.g., separate, sell, buy and use secondary materials
R6	Re-purpose	e.g., acquire non-virgin products/materials to, redesign, reproduce and sell product with new function
R5	Re-manufacture	e.g., use or sell replacement of key modules or components which includes wider decomposing and recomposing of products
R4	Re-furbish	e.g., use or sell replacement of key modules or components, in particular: to bring a product in line with latest technological development
R3	Repair	e.g., making the product work again by repairing or replacing deteriorated parts
R2	Re-commerce/re-use	e.g., buy or sell secondhand items, or find buyer for non-used products
R1	Reduce	e.g., use less products and materials, use longer, in particular: redesign processes/ products
R0	Refuse	e.g., refrain from using specific inputs, in particular: redesign processes/products

APPENDIX B: LIST OF THE 29 CONSULTED STAKEHOLDERS (INTERVIEWEES AND WORKSHOP PARTICIPANTS)

#	MIS actor (type)	Organization	Consultation type and duration
1	Branch organization non-commercial secondhand shops	BKN	Shared online interview (1 h)
2	Branch organization non-commercial secondhand shops	BKN	Shared online interview (1 h)
3	Branch organization textiles Belgium; company	European Spinning Group; Symaco	Workshop participant (3 h)
4	Branch organization textiles Netherlands	InRetail	Online interview (1 h)
5	Branch organization textiles Netherlands	Modint	Workshop participant
6	Company (investment, finance knowledge)	ABN Amro	Workshop participant (3 h)
7	Company (both consultancy and network organization supply chain impacts, labels)	Alcon Advies; REMO	Workshop participant (3 h); online interview (1 h)
9	Company (circular textile)	Blue Loop Originals	Workshop participant (3 h)
9	Company (collection and mechanical recycling steps)	Boer Groep	Online interview (1 h)
10	Company (knowledge intermediary)	Circle Economy	Workshop participant (3 h)
11	Company (textile brand/seller)	C&A	Online interview (1 h)
12	Company (mechanical recycling)	Frankenhuis	Online interview (1 h)
13	Company (textile brand/seller)	Jolo Fashion Group	Online interview (1 h)
14	Company (take-back logistics and management for brands)	Lizee	Online interview (1 h)
15	Company (circular textile)	Loop a Life|Brightloops	Workshop participant (3 h)
16	Company (circular textile)	MUD Jeans	Workshop participant (3 h)
17	Company (investment, finance knowledge)	PwC	Online interview (1 h)
18	Company (chemical recycling)	SaXcell	Online interview (1 h)
19	Company (circular textile)	Schijvens	Workshop participant (3 h)
20	Company (textile brand/seller)	WE Fashion	Workshop participant (3 h)
21	Company (textile brand/seller)	WE Fashion	Online interview (1 h)
22	Company (collection and mechanical recycling steps)	Wieland Textiles	Workshop participant (3 h)
23	Company (textile brand/seller)	Anonymous large Dutch brand	Workshop participant (3 h); online interview (40 min.)
24	Government of the Netherlands	Ministry of Infrastructure and Water Management	Workshop participant (3 h), several phone consultations (45 min.)
25	Network organization/platform	Fashion for Good	Online interview (1 h)
26	Network organization scientists (knowledge intermediary)/ platform	Groene Brein	Online interview (1 h)
27	Network organization, innovation center circular textile	Stichting Texperium	Online interview (1 h)
28	Network organization circular textile	Stichting Texplus	Shared online interview (1 h)
29	Network organization circular textile	Stichting Texplus	Shared online interview (1 h)
30	Standard organization	GS1	Online interview (2 h)

APPENDIX C: OVERVIEW OF CATEGORIES ("INDICATORS") USED IN THE EVENT ANALYSIS TO CLASSIFY DATA ACCORDING TO THE NINE SYSTEM FUNCTIONS

Function 1	1- Circular projects (start/stop)	Function 4	1- Expectations/future trends	Function 7	1- Opinion/attitude of public, businesses, lobby groups (in relation to solution)
	2- Circular companies*(start/stop) *also includes webshops/ apps/ platforms		2- Targets/goals		2- Consumer awareness/interest/care
	3- New (and old) entrepreneurs experimenting with circular principles/models		3- Priority on agenda	Function 8	1- Discourse/activism against current practices
Function 2	1- Scientific and professional publication about CE		4- Naming challenge/solution		2- Naming "wrong" consumer behavior
	2- Circular knowledge projects (start/stop)		5- Stimulating legislation/ regulations		3- Regulations stating existing activities/subsidies are being phased out
	3- Research programs		6- Guidance/structure (documents, legal instruments, tools)	Function 9	1- Formation of coalitions around transitions
	4- New tech developed	Function 5	1- Demand (consumers or businesses)		2- Deals/agreements in the industry
	5- New insight/knowledge gained		2- Sales quantity		3- Leading organizations bringing field together
Function 3	1-Symposia/ conferences/seminars		3- Market instruments (tax, subsidy)		4- Cooperation between parties in the field
	2- Knowledge sharing (events, network, platform, publication, campaign)		4- Standards		5- Coherent visions of the transition
			5- Mandatory application of solutions (from regulation)		
		Function 6	1- Available financial resources (investment, donations, crowdfunds)		
			2- Available human resources (sufficient staff, training staff, sufficient graduates in the field)		
			3- Available material resources (infrastructure, raw materials, machinery)		

APPENDIX D: STATEMENTS FROM THE INTERVIEWS SHOWING SHARED PROBLEM VIEWS

Problem	Quote (partially translated from Dutch)	Quote original (if in Dutch)	
Root problem			
	Each party has its own business model to work in that chain. And one thing we now know for sure is that those business models are no longer acceptable. They have to change and that means that the parties have to interact in a different way, but also that the consumer plays a very important role in this.	Iedere partij heeft zijn eigen businessmodel om in die keten te werken. *En één ding weten we inmiddels zeker: Die businessmodellen kunnen niet meer*. Die moeten anders en dat betekent dat partijen op een andere manier op elkaar moeten inspelen, maar ook dat de consument daar een heel belangrijke rol in speelt.	Networking organization circular textile
Fast fashion (dominant business model in sector)	In the last 15 years, the consumption of clothing or textiles doubled. And I don't see that trend changing. I think it's still people buy clothing faster and yeah, faster and more than ever before.	Interview in English	Collector and sorter
	Fast fashion defined as fast, cheap, from a lot of virgin material, offered regularly and enticing consumers to buy as much as they can whether they wear it or not, and then unworn or barely worn, right away put it into the waste disposal – that's what we don't want, but that actually [would] transform[s] the whole chain.	Fast fashion gedefinieerd als snel, goedkoop van heel veel virgin materialen, regelmatig aanbieden en de consument verleiden om zo veel mogelijk te kopen of hij of zij het nou wel of niet draagt en vervolgens ongedragen of nauwelijks gedragen, al meteen in de afvalverwerking brengen - dat is wat we niet willen, maar dat vormt dus eigenlijk de hele keten om	Networking organization
	But the quality of the of textile, textiles as a whole has also decreased in recent years. So, also that causes lower prices. Through this [trend] profitable sales possibilities basically disappear, in fact, an increasingly large percentage of textiles, is not much more than waste.	Maar de kwaliteit van het gezamelijk textiel is de afgelopen jaren ook minder geworden, dus ook dat zorgt voor lagere prijzen. Omdat de afzetmogelijkheden daardoor eigenlijk gewoon verdwijnen. In feite is een steeds groter percentage textiel niet heel veel meer dan de afval.	Non-commercial secondhand store
(Global) key problems			
Issues from textile material properties and scarcity	You have a cotton problem, you have a cellulose problem, you have a polyester problem, so that's much broader [than one material].	Je hebt een katoen probleem, je hebt een cellulose probleem, je hebt een polyester probleem, dus dat is veel breder [dan één materiaal].	Chemical recycler
	It is a problem because we are dealing with all these different types of materials. So in the end, we will need to find circular solutions for each separate material. [E]everyone is more or less concentrated on the cotton fiber now, because that's […] a great impact on the environment production of cotton […]. But there are so many more different fiber types that we need to be looking at.	Interview in English	Networking organization circular textile
	It is also much too late, actually huh. We know that the raw materials are almost exhausted. It's not about price, but we see that the raw materials are running	Het is ook veel te Laat, eigenlijk hè. We weten dat de grondstoffen bijna uitgeput zijn. Het gaat niet om prijs, maar we zien dat de grondstoffen opraken. Dus we moeten zuinig omgaan met ons grondstoffen.	Textile brand

(Continues)

Problem	Quote (partially translated from Dutch)	Quote original (if in Dutch)	
	out. So we have to act carefully in dealing with our raw materials.		
Waste and environmental impact from production, consumption	A large producer creates a lot of environmental impacts.	Bij een grote producent ontstaan heel veel milieuimpacten.	Investor
	There's an incredible amount of environmental impact there, in dyeing, growing textile [s materials], chemical aspects – there's a lot of environmental stress from that, there's an incredible amount being produced, and also more and more being thrown away, often lower quality [textile] that is, and still a lot is being burned.	Daar komt ongelofelijk veel milieuimpacten, bij het verven, textiel kweken, chemische aspecten – daar komt heel veel milieudruk uit. Er wordt ongelofelijk veel geproduceerd en ook steeds meer weggegooid, slechtere kwaliteit is dat vaak, en nog steeds veel verbrand.	Networking organization
	There is an enormous amount of consumer clothing which is not being processed in any way.	Interview in English	Textile company (intermediary)
	[…] the collected materials, that's going to the incineration, normally. It should be - it is - a national problem, it's not something that we (start-ups and networking organizations) should actually solve at our own costs.	Interview in English	Networking organization circular textile
Market and fairness issues	If there's no level playing field, and the market is about shareholder value, so it's about short-term returns, you go for economic KPIs.	Als er geen level playing field hebt, en de markt gaat over aandeelhouderswaarde, dus het gaat over rendement op korte termijn, je gaat voor economische KPIs.	Investor
	There's a lot of power within the large retail companies, for instance. If there's a factory in Bangladesh collapsing, then the first thing everybody's shouting “we have to get everything safe,” but who's going to pay for it?	Interview in English	Collector and sorter
Consumer awareness	The older generation, 50–60 years old, needs to adapt and do not understand concepts like reuse, and these days they are the backbone of the economy.	De oudere generatie, 50-60 jaar oud, moet zich aanpassen en begrijpt concepten als hergebruik niet, en deze generatie vormt wel het ruggengraat van de economie.	Textile company (paraphrased)
	You know that waste problem is very big, is fine, but you certainly don't reach a young person there anymore, that [person] just wants to buy.	Weet je dat dat afvalprobleem heel groot is, is prima, maar een jongere bereik je daar zeker niet meer, die [persoon] Wil gewoon kopen.	Networking organization circular textile
	You don't pay for the for the social disturbance you cause. And you're not paying for carbon dioxide. You're not paying for the waste management. You're not paying for lots of things.	Interview in English	Textile company (intermediary)
	If you look at what the consumer, what is being purchased, what is being consumed. I think there's still a very big chunk to be achieved there.	Als je kijkt naar wat de consument, wat er wordt aangeschaft, wat er wordt verbruikt. Ik vind daar nog een heel groot stuk te halen.	Networking organization circular textile
Existential threat supply chain actors	Especially in retail, you have to keep your head above water, you don't even know if [retail] will still exist in 5 years time.	Zeker in de retail, je moet je hoofd boven water houden, over vijf jaar weet je niet eens of [retail] nog bestaat	Investor

APPENDIX E: EXAMPLES OF SPECIFIC ACTORS AND INSTITUTIONS IN THE DUTCH MIS

Actors	Examples
Collectors and sorters	Boer Groep, Wieland Textiles, Sympany, Curitas, Textielbank, Kringloopwinkel (i.e. Dutch name of labelled non-commercial secondhand stores)
Mechanical recyclersF	Frankenhuis, Boer Groep Recycling Solutions, Marbo Used Recycling, Wieland Textiles, Wolkat
New fibers	StexFibers, Undiemeister, Mestic/Inspidere, Zoutbeach, Fruitleather Rotterdam (Blue City), Mylium, Neffa
Secondhand recommerce	Tardis Vintage
Textile rental providers (online)	Bieby, Circos, Gibbon, MUD Jeans, Wauwcloset, Hulaaloop, Iconic Wardrobe, Borrow a Brand
Clothing libraries (stationary rental)	BijPriester, Outfit Library LESS, Lena the fashion library, Kledingbieb Gaia
Universities	Wageningen University; TU Delft; Utrecht University; Universiteit van Amsterdam; Erasmus University Rotterdam; Hogeschool Saxion (hbo: Fashion and textile technologies); AmFi/HvA; Hogeschool Rotterdam Hogeschool Utrecht; Hogeschool the Hague; ArtEZ; Hanze Hogeschool Groningen; Avas Hogeschool; Fontys Hogescholen Eindhoven; Christelijke Agrarische Hogeschool Dronten
Other knowledge providers	Alcon Advies, Circle Economy, Metabolic, MVO Nederland (all private); Blue City Rotterdam, CircleHub, Groene Brein, duurzamheid.nl; PBL; TNO; Pianoo; Waag; Ellen Mac Arthur Foundation, Studio Circulair
Network organizations circular textiles	Dutch Centre for Circular Textiles, Stichting TexPlus (chemical recycling), House of Denim Foundation, Jeans School/Denim City, TextileLab Amsterdam (Waag) Texperium (Open Innovation Center)
Network organizations textile	Fashion for Good; Afval Circulair, duurzamheid.nl; ECAP
Retailers, brands, large local producers	C&A, G-star, H&M, Tommy Hilfiger, Nike, WE fashion, Zeeman
Assisting technology/tool/take-back providers	Ecochain; Fizyr; GoodShipping program; Neopost; Nopac; re:Turnista; Lizee (France), Valvan Baling Systems (Italy, Belgium)
Repair/repurposed goods shops	Bij Priester, Ambachtscentra (craft center)
Standard and label providers	GS1, REMO
Branch organizations	Modint, Inretail, VGT, the European Apparel and Textile Confederation – EURATEX (170.000 companies), CreaModa (Belgium)
Investors	ABN Amro, Accenture, PWC, Rabobank, C&A Foundation, H&M Foundation; Sitchting Doen, Enviu
Governmental actors	Rijksoverheid (national government), Ministry of Infrastructure and Water Management (I&W), Ministry of Economic Affairs and Climate Policy (EZK), regional government, municipal governments, Economic Boards of municipalities (e.g., Amsterdam)
Institutions (initiatives)	
Policy initiatives	Rijksbreed Programma Circulaire Economie (national circular economy policy); Uitvoeringsprogramma Circulaire Economie 2019–2023 (national circular economy execution plan); Beleidsprogramma Circulair Textiel (national policy circular textiles); IMVO Convenant Duurzame Kleding en Textiel (covenant sustainable textiles); Roadmap Circulair Textiel; Icoonprojecten (icon projects); Ambachtscentra (craft center)
Government instruments and institutions for support	DEI+: Circulaire economie; Subsidie Circulaire Ketenprojecten WBSO; NWO; Directoraat-generaal agro en Natuur (LNV)
Industry initiatives	Transitieagenda Consumptiegoederen (transition agenda consumption goods), sector plan
Conferences or regular events	Sustainable fashion week, Amsterdam fashion week, Circular fashion games

APPENDIX F: DIFFERENT ACTORS IN THE SECONDHAND TRAJECTORY AND THEIR PRICING, VALUE PROPOSITIONS AND RESOURCE ACCESS

Business actor	Pricing	Value proposition	Resource access
Brands	Highest, protect brand	Reputation	Challenge, low secondhand high quality access from consumers, large access to "outlet" items
Vintage/secondhand commercial	High (refurbished/upgraded products), medium (secondhand)	Exclusivity	Challenge, low to medium access to high quality, depends on consumers or access to recollection channels
B2C platforms	Medium, lower than brands	Quality	Medium to high access depending on the platform and business model, dependent on access to recollection channels
Secondhand (Kringloop)	Medium-low	Accessibility	Very high secondhand high quality access, dependent on consumers and municipalities (tenders)

Note: This assessment is based on triangulation of various data but has not been verified further with scientific literature. A dark shaded background stands for "high," grey for "medium to high," light grey for "medium to low."